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9. ABSTRACT
A workshop was held in Seoul in July 1977 to assist A.I.D. in its program to foster systems analysis in Korea and to focus on the systems aspects of energy, environment, and transportation planning. This report includes the agenda, a list of participants, and comments. The main part of the report is the following appendices: biographical data on National Academy of Sciences panelists, presentation paper for the workshop on systems development, participant list, and the reports of the workshop in the Korean Herald and Korea Times. The presentation paper discusses the methodological problems of urban transport systems, energy supply and demand modeling, power system planning analysis, and environmental problems in Korea. Existing environmental legislation is insufficiently detailed and comprehensive as a basis for the management of current problems. It is recommended that: responsibility for all aspects of environmental management should be coordinated under a single ministry of central government responsible to the prime minister; management of water resources should be the responsibility of central government through management boards set up on single river basin area bases; a national environmental research center accompanied with a national environmental information system should be established; and more emphasis should be placed on applied research rather than fundamental research. Solar energy has potential in Korea for water and space heating but is too expensive to use for electricity. Korea must try to develop local, conventional resources such as coal and wind power to supply the energy needed for industrialization.

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STAFF SUMMARY REPORT

WORKSHOP ON SYSTEMS DEVELOPMENT

Held in Seoul, Korea
July 12-15, 1977

Sponsored by

Ministry of Science and Technology
Republic of Korea

and

Board on Science and Technology
for International Development
Commission on International Relations
National Academy of Sciences - National Research Council
United States of America

NATIONAL ACADEMY OF SCIENCES
Washington, D.C.

This report is a staff-prepared summary of the Workshop on Systems Development held in Seoul, Korea, July 12-15, 1977. This workshop is part of a series of activities sponsored by the Ministry of Science and Technology and the U.S. National Academy of Sciences through a Joint Committee on Scientific Cooperation.

Participation by the National Academy of Sciences was made possible through funds provided by the Office of Science and Technology, Bureau for Technical Assistance, Agency for International Development (Contract AID/csd-2584, Task Order 1) for administrative expenses; and by the Ministry of Science and Technology, Republic of Korea, which provided international travel and all costs within Korea for the NAS participants and staff.

CONTENTS

I. INTRODUCTION

The Republic of Korea, eager to continue the impressive development record of the past 15 years, is attempting to focus on a number of complex problems related to its industrialization. The modern methods of systems analysis offer promise for tackling current problems and formulating future development plans. The Ministry of Science and Technology (MOST) has recently created the Bureau of Information Industry, with responsibility for stimulating more general appreciation of the potential of applying systems analysis and fostering development of the professional expertise necessary for implementation.

Since 1973, a program of scientific cooperation between MOST and the National Academy of Sciences - National Research Council (NAS-NRC), operating through a Joint Committee on Scientific Cooperation has made recommendations on the application of science and technology to economic and social development in Korea. Exploration of particular topics or problems is undertaken through workshops or advisory groups. Within this framework, MOST called upon the NAS-NRC Board on Science and Technology for International Development (BOSTID), which is responsible for the NAS-NRC participation in the Joint Committee, to assist in the development of systems analysis capabilities in Korea.

Dr. Harvey Wagner of Yale University, visiting Seoul in 1975 (under Joint Committee auspices), provided initial advice to the

Bureau of Information Industry. The Bureau also was particularly interested in the BOSTID study, Systems Analysis and Operations Research: A Tool for Policy and Program Planning for Developing Countries (1976). In early 1977, MOST requested BOSTID to select three U.S. experts to participate in a Workshop on Systems Development to be organized by the Bureau of Information Industry.

The purpose of the workshop, which took place in Seoul July 12-15, 1977, was to assist the Bureau in its program to foster systems analysis in Korea, and, in particular, to focus on the systems aspects of energy, environment and transportation planning. The BOSTID participants were to provide an understanding of the current status of systems analysis in the chosen topics, both in the United States and elsewhere. BOSTID participants were: Dr. Philip F. Palmedo, Brookhaven National Laboratory, for energy systems; Dr. Daniel P. Loucks, Cornell University, for environmental systems; and Dr. Richard De Neufville, Massachusetts Institute of Technology, for transportation systems, (Biographical data is given in Appendix A.)

The workshop was planned as an educational exercise, with potential for catalyzing further Korean efforts to apply systems analysis. It provided a forum in which to bring together Korean scientists, engineers, economists and officials, who though they share a concern with the same problems, have not worked together in an integrated approach to problem analysis. Instead of aiming at formal recommendations, the organizers planned for the workshop to help establish a framework to increase appreciation of 1) the complexity of the problems to be addressed, and 2) the prerequisites for sophisticated analysis, including governmental and institutional support and coordination.

II. PERSPECTIVE

More than 60 Koreans from government ministries and agencies, research institutes, and universities participated in the workshop. The workshop format (including division into three sections corresponding to the problem areas being addressed) facilitated candid discussion and interchange, which would have been impossible in a more formal meeting. BOSTID participants were impressed by the caliber of the Korean participants, the talents already available in Korea for systems work, and the level of professional interest in the problem areas.

All indications from the Korean hosts and the BOSTID participants show that they regarded the workshop as a stimulating and successful undertaking. The workshop provided a meeting ground for exploring the integrated and multidisciplinary requirements for valid systems studies of complex problems. Many Korean participants expressed hope that the interchange stimulated by the workshop would continue. One effect of the workshop should be support for efforts to develop institutional mechanisms to insure the policy coordination and multidisciplinary cooperation required for a broad systems approach in energy, environment, and transportation areas.

The Bureau of Information Industry is expected to play a major role in encouraging the integrated efforts pointed out by the workshop for analyses in these areas. Government coordination and institutional responsibility will be necessary not only in the areas discussed in the workshop, but also in efforts to apply systems analysis to other problems of development. The workshop had the strong endorsement of the Minister for Science and Technology, Hyung Sup Choi. The Ministry's support for the efforts of the Bureau of Information Industry can be expected to continue.

The U.S. participants, in the workshop sessions and upon the invitation of the hosts at the concluding review session, offered reflections and opinions on some immediate priorities. Each of the BOSTID experts noted that there are highly qualified professionals in his field in Korea.

Regarding energy planning analysis, Dr. Palmedo found that in Korea two basic requirements appear to have been met: 1) recognition by the government of the importance of energy planning, and 2) recognition by professionals that such planning is essential. The first phase of methodological work undertaken by the Koreans is of high caliber. What appears lacking is an institutional framework to coordinate energy planning analysis and to ensure adequate utilization of an interaction between economists, engineers, and environmentalists.

With regard to environmental concerns, Dr. Loucks noted needs for clarification of authority, definition of appropriate standards, more extensive data collection, and more clearly defined and comprehensive regulations on environmental standards. More extensive research of a systems nature, including quantification of damages and risks, would be helpful to decision makers weighing the necessary trade-offs. Korea is at a stage in development where preventive planning would provide for significant future savings. Dr. Loucks also remarked on the need for incentives to encourage more professionals to enter the field of environmental management, citing as an example the lack of career government positions in environmental engineering. While the professional community is aware of the problems, adequate government initiative and public awareness would be essential for the types of programs required. Dr. Loucks suggested that a specific project focus, such as an analysis of various alternatives for managing the quality of the Han River and its tributaries, would be an effective and educational way of demonstrating the potential and the limitations of systems analysis in environmental problems.

In the discussions on transportation, which focused primarily on the planning needs of the City of Seoul, the need for institutional coordination was evident. Dr. De Neufville suggested that a comprehensive transportation system planning effort could incorporate shortcuts from experience in other cities. The planning effort should be reviewed as a collective educational experience, bringing all the diverse agencies concerned with aspects of transportation into the process at the beginning. A steering group of representatives from the sectors concerned, with the authority and funding needed for the research, might provide the necessary institutional framework.

The Korean hosts were eager to take advantage of the momentum of the workshop. It is expected that they will suggest joint project activities in their development of systems analysis. Proposals in this regard will probably be presented through the mechanism of the MOST-NAS Joint Committee. While AID plans to phase out activities in Korea, some provision for funding joint Korean-American cooperation in systems development merits consideration. For an intermediate-stage developing country, enchancement of its own systems analysis capabilities promises significant benefits for planning and dealing with the complex problems of modernization. Funding of a cooperative effort would require a relatively small budget, but the results would reinforce the development gains from previous foreign assistance.

III. AGENDA AND PARTICIPANTS

Dr. Young Wook Kim, Director of the Bureau of Information Industry, organized and coordinated the workshop. As noted, the flexible format encouraged candid discussion and a maximum of interaction between the U.S. and Korean participants.

The workshop formally opened the afternoon of July 12, at a plenary session in the modern conference hall of the Korea Institute for Science and Technology (KIST). The NAS-NRC participants each provided an introductory overview of their fields, the utilization of systems analysis in the problem areas, the issues which needed to be addressed, the methodologies available, and the limitations which should be recognized. Their talks cited case studies, illustrating that approaches to the solution of problems in the energy, environment, and transportation sectors require integrated planning that encompasses all three areas.

Separate workshop groups for energy systems, environmental systems, and transportation systems met on July 13 and 14. Korean coordinators led the sessions, which opened with the topics in the detailed agenda that follows but which were purposefully flexible in structure. Prior to the workshop, the papers listed below (and presented in Appendix B) had been prepared by the Korean hosts to provide an understanding of the problems and the current stage of analysis and effort in Korea:

Methodological Problems of Urban Transport Systems

Mr. Kyu-Bok Hwang, Korea Institute of Science and Technology (KIST)

Energy Supply and Demand Modeling

Dr. Poong-Eil Juhn, Korea Atomic Energy Research Institute (KAERI)

Power System Planning Analysis

Dr. Poong-Eil Juhn (KAERI)

Environmental Problems in Korea

Dr. Chae-Shik Rho (KAERI)

A concluding session, held the morning of July 15, brought the NAS-NRC participants together with Dr. Kim of MOST, the subgroup coordinators, and other key Korean participants to review the workshop efforts and provide an occasion for observations by the BOSTID participants.

The full schedule for the workshop and the preliminary meetings held for BOSTID participants follows:

<u>July 12 (Tuesday)</u>

09:30 Courtesy call at Ministry of Science and Technology (MOST)

10:00 - 11:40 Details and arrangements of workshop procedure
U.S. Guests and host coordinators

12:00 - 13:30 Visit to Korea Institute of Science and Technology (KIST)

Luncheon (Hosted by Minister of Science and Technology)

GUEST LECTURES (at KIST)

<u>Guest Speaker</u>

14:00 - 15:00 Dr. Philip F. Palmedo
(On Energy Systems)

15:00 - 16:00 Dr. Daniel P. Loucks
(On Environmental Systems)

16:00 - 17:00 Dr. Richard L. De Neufville
(On Transportation Systems)

July 13 (Wednesday)	Workshop
Transportation Systems	(KIST International Conference Room)
Coordinator:	Mr. Kyu - Bok Hwang
10:00 - 12:50	Testing Methods of Determining Urban Transport Demand
12:50 - 14:00	Luncheon
14:00 - 17:00	Survey of Methodologies of Urban Transport
Energy Systems	(KDI Conference Room)
Coordinator:	Dr. Yoon - Hyung Kim
10:00 - 12:50	Basic Direction Toward World Energy Policy (Focus on Energy Policy of U.S.A.)
12:50 - 14:00	Luncheon
14:00 - 15:30	Institutional Reform for Energy Policy Formulation (Role of Department of Energy in U.S.A.)
15:30 - 17:00	Status and Planning for Global Energy Systems
Environmental Systems	(KORSTIC Conference Room)
Coordinator:	Dr. Sook - Pyo Kwon
10:00 - 12:50	Current Status of Environmental Problems in Korea
12:50 - 14:00	Luncheon
14:00 - 17:00	General Discussion
July 14 (Thursday)	Workshop
Transportation Systems	(KIST International Conference Room)
Coordinator:	Mr. Kyu - Bok Hwang
10:00 - 12:50	Methodology of Determining Transport Capacity
12:50 - 14:00	Luncheon
14:00 - 17:00	Evaluation Criteria for the Addition of Links in the Transport Network

<u>Energy Systems</u>	(KAERI Conference Room)
Coordinator:	Dr. Poong - Eil Juhn
10:00 - 12:50	Energy Supply and Demand Modeling
12:50 - 14:00	Luncheon
14:00 - 17:00	Power System Planning Analysis
<u>Environmental Systems</u>	(KORSTIC Conference Room)
Coordinator:	Prof. Tae - Jun Kwon
10:00 - 12:50	Administrative Aspects of Environmental Systems
12:50 - 14:00	Luncheon
14:00 - 17:00	General Discussion
<u>July 15 (Friday)</u>	<u>General Session</u>
	(KIST International Conference Room)
Coordinator:	Dr. Young W. Kim
10:00 - 12:00	Concluding remarks

The list of workshop participants and their institutional affiliations is found under Appendix C.

IV. COMMENTS

Planning and Preparation

Discussion about a joint MOST-NAS/NRC workshop to assist in developing Korean systems analysis capabilities was begun in late 1976 and MOST's specific proposal that the workshop focus on energy, environmental, and transportation concerns was received in March 1977. In view of the conflicting schedules of potential U.S. participants, the April workshop proposed by MOST was not feasible. The 12-15 July dates then were agreed upon, and Mr. Augustus Nasmith of BOSTID arrived in Seoul on July 7 to discuss final arrangements with the hosts. MOST covered travel and local costs for the BOSTID participants.

In addition to the papers prepared by the Koreans, the three BOSTID participants were provided background information by the BOSTID staff, including the following documents:

Scientific Cooperation Program, Korean Ministry of Science and Technology - U.S. National Academy of Sciences;

Korea (South), Background Notes, U.S. Department of State;

"Pedalling faster in hot pursuit of growth targets" (an assessment of Korea's economic situation), Far Eastern Economic Review, May 20, 1977;

"Systems Development in Korea" (presentation paper for the 1976 annual meeting of the Joint Committee on Scientific Cooperation), November, 1976.

Because of the U.S. participants' summer commitments and travel plans, a briefing session in Washington prior to their departure for Korea was not possible. On July 11 in Seoul, prior to the opening of the workshop, the NAS participants and Korean coordinators met at MOST to review the workshop plans.

Korean participation from government ministries, in addition to MOST, included representatives from the ministries of Transportation, Commerce and Industry, Construction, the Office of Forestry, and the Economic Planning Board, which has responsibility for preparing the national plan. The following research institutions were represented: Korea Atomic Energy Research Institute (KAERI); Korea Development Institute (KDI); Korea Institute of Science and Technology (KIST); and Korea Scientific and Technological Information Center (KORSTIC). Professors and researchers from Seoul National University and eight other universities and colleges attended workshop activities. In addition, the Korea Electric Company and departments of the City of Seoul were represented.

Organization and Facilities

Dr. Kim's coordination of the workshop was skillful, insuring a broad base of Korean participation and allowing for flexibility in each of the working groups. Facilities were excellent, with comfortable conference and meeting rooms provided by KIST, KAERI, KORSTIC and KDI. Lodging for U.S. participants was provided in fine guest facilities at KIST. The Public Relations staff at KIST did everything possible to make the stay an enjoyable one.

The strong support given the Bureau of Information Industry by Minister

Choi and the Bureau of Technical Cooperation was evident throughout the workshop meetings. Dr. Kim's able staff in the Bureau of Information Industry provided valuable assistance in coordinating the logistics of holding sessions in different institutions, and in assisting the U.S. participants in their individual needs while they were in Seoul. In addition, the hosts and staffs at the KAERI, KORSTIC and KDI welcomed the opportunity to inform the NAS-NRC visitors of their institutions' research and activities and hosted lunches for the working sessions.

Minister Choi was host at a luncheon at the KIST Guest House for the NAS-NRC participants and Korean coordinators just prior to the opening of the workshop. The Minister stressed his personal support of the activity and his hope that cooperation in systems development would continue in the future. On July 14, the KDI gave a dinner for the NAS-NRC participants, with the Chairman of the Economic Planning Board joining the group for the evening. On July 15, the Korea Electric Company gave a farewell dinner for the NAS-NRC participants and Korean coordinators. These social affairs, along with individual invitations from Korean participants to the visiting Americans added to the diversity of the experience and the understanding of Korea; they also enabled fruitful continuation of interactions begun in workshop sessions.

Press Coverage

On July 11 at MOST, approximately 15 representatives of the media attended a press conference on the workshop. Press coverage was extensive; there was radio coverage as well. Reporters conducted individual interviews with NAS-NRC participants as the workshop progressed. The accounts of the July 13 Korea Herald and July 17 Korea Times are included as Appendix D.

Contact with U.S. Officials

Mr. Dennis Barrett, AID Representative in Seoul, was informed of the workshop but was in the United States when it took place. Mr. Nasmith briefed Mr. Robert Stella, Science Attache at the U.S. Embassy, by telephone, but scheduling problems precluded a meeting between Mr. Stella and the BOSTID participants.

Appendix A

Biographical Data
NAS Panelists
MOST-NAS WORKSHOP ON SYSTEMS DEVELOPMENT

Transportation

DE NEUFVILLE, RICHARD LAWRENCE b Jamaica, N Y, May 6, 39; m 64; c 1. SYSTEMS ANALYSIS, OPERATIONS RESEARCH. Educ: Mass Inst Technol, SB & SM, 61, NSF fel, 62-65, PhD(civil eng systs), 65. Postdoctoral Fels & Grants: White House fel, Off Secy Defense, 65-66; NATO grant, Europe, 70; Guggenheim fel, 73-74. Prof Exp: Asst prof civil eng, Mass Inst Technol, 66-70, assoc dir urban systs lab, 68-70, ASSOC PROF CIVIL ENG & DIR SYSTS LAB, MASS INST TECHNOL, 70- Concurrent Pos: Mem, Hwy Res Bd, 66- & Transp Res Forum, 67-; consult, Commonwealth of Mass, 67-70; dir, Urban Data Processing, Inc, 69-; consult, Ministry Pub Works, Mex, 70-; assoc ed, J Systs Eng, 71- Mil Serv: C Engrs, USAR, 61-62, 1st Lt. Mem: Fel AAAS; Am Soc Civil Eng; Opers Res Soc Am; Inst Mgt Sci. Res: Application of systems analysis to planning and design of large-scale engineering systems, particularly airports. Publ: Co-auth, Systems analysis for engineers and managers, McGraw, 71; co-ed, Systems planning and design, case studies, Prentice-Hall, 73. Add: Dept of Civil Engineering, Massachusetts Inst of Technology, 77 Massachusetts Ave, Cambridge, MA 02139.

Now Professor and Chairman, MIT Technology and Policy Program

Energy

PALMEDO, PHILIP F, b New York, NY, Mar 11, 34; m 61. NUCLEAR PHYSICS, SYSTEMS ANALYSIS. Educ: Williams Col, BA, 56; Mass Inst Technol, MS, 58, PhD(nuclear eng), 62. Prof Exp: Instr nuclear eng, Mass Inst Technol, 60-61; vis researcher reactor physics, Saclay Nuclear Res Ctr, France, 62-63; asst physicist, Nuclear Eng Dept, 64-66, assoc physicist, 66-68, PHYSICIST, DEPT APPL SCI, BROOKHAVEN NAT LAB, 68-, HEAD ENERGY POLICY ANAL DIV, 76- Concurrent Pos: Assoc ed, Energy Systs & Policy, 74- Res: Reactor physics, energy systems and policy analysis, regional energy planning, environmental assessment, energy in developing countries. Mailing Add: Dept of Appl Sci Brookhaven Nat Lab Upton NY 11973

Member NAS panel for 1976 Workshop on Science Planning and Policy in Pakistan

Environment

LOUCKS, DANIEL PETER, b. Chambersburg, Pa, June 4, 32; m. 67; c. 2. ENVIRONMENTAL ENGINEERING, SYSTEMS ANALYSIS. B.S. Pa. State, 54; M.S, Yale, 55, fel, 61-62; Columbia, 61; U.S. Pub. Health Serv. fel. & Ph.D. (systs. eng, econ), Cornell Univ, 65. Asst. prof. water resources eng, CORNELL UNIV, 65-70, ASSOC. PROF. ENVIRON. ENG, 70- Prin. investr. Off. Water Resources Res. Grant, 67-; sem. assoc, Columbia Univ, 67-; re[illegible] fel, Harvard, 68; consult, dept. econ. & soc. affairs, div. transport & res[illegible]s, UN; consult. to several fed, state, & private agencies. U.S.N.R, 55-5[illegible], Comdr. AAAS; Soc. Am. Foresters; Am. Soc. Civil Eng. (res. award, [illegible] Water Pollution Control Fedn; Am. Water Works Asn; Opers. Res. Soc. Am; Int. Mgt. Sci. Applications of operations research to problems in environmental and water resources engineering; public policy analysis. Address: Hollister Hall, Cornell Univers[illegible]y, Ithaca, NY 14850.

Now Professor and Chairman, Department of Environmental Engineering, Cornell University

Appendix B

Presentation Paper for the Workshop on Systems Development

July 12 ~ 15, 1977

Ministry of Science and Technology
Republic of Korea

CONTENTS

I. Methodological Problems of Urban Transport System

Prepared By
Kyu-Bok Hwang
Coordinator, Transportation Economics Group
Korea Institute of Science and Technology

I. Methodological Problems of Urban Transport System

1. Introduction

This paper is intended to bring forth subjects for the workshop on systems approach. Among varying urban problems of housing, water supply, sewerage, energy, and communication, deterioration of transport service presents one of acute problems of Seoul. Owning to the vital effects of the transport service on urban activities and employment, it is imperative to improve transpôrt services. The deterioration of transport service is attributable to a rapid increase in urban population and relatively slow expansion of transport facilities.

Nonethless, it is apparent to pursue a course of expanding transport facilities at least a decade to come. In order to help the system expanded, methodological problems of urban transport planning have to be improved.

Following a brief description on the prevailing problems of the urban transport systems in Seoul, details of methodological problems are presented for discussion in the last two chapters.

2. Congestion and Deficiencies of Urban Transport System

Frequent traffic stall and reduction in travelling speed of vehicles demonstrate deficiencies in urban transport system. Under the prevailing conditions, the travelling speed levels off at 15 KPH and peak traffic pressures extend well over all day. In addition to the cogestion of arteries, an excessivecrowding in city buses demonstrates compounding problems of urban transportion system in Seoul.

Having recognized the limited avilability of space and need for expansion of public transport capacity, a subway line was constructed and opened in 1974. The relative share of the subway is born by a little beyond the faction of the total load of public transport. Bus routes are transversed practically over the entire area. They are geared to a flexible number of routes and distance as need arises. However, excessive convergence of the routes into the central business districts causes congestion of traffic, unsystematic transfer, and inefficient operation of buses.

Heavy reliance on public transport has an advantage of relieving pressures on faster expansion of roadway facilities. Sustaining the advantage is not anticipated to last long because evidences of model change from the public transport to private mode are begining to emerge.

In order to maintain a manageable investment roadway facilities and to alleviate an explosive conversion of the usage of public mode to the private, priority of expansion and improvement of public transport service appears due.

3. Review of Urban Transport Planning Model

The urgency of project implementation, lack of understanding, and vast data preparations and requirements have prevented urban transport planning model from its use and development in developing countries. In a limited way, the concept of advanced model has been introduced in the planning process of transport sector.

The recent publication suggests in the following stepes for the planning:

Stage 1 Preliminary Recognition and Definition of Problem

Stage 2 Decision to Act and Definition of the Planning Task

Stage 3 Data Collection, Analysis, and Forecasting

Stage 4 Determination of Contraints and Objectives

Stage 5 Formulation of Operational Criteria and Objectives

Stage 6 Plan Design

Stage 7 Testing of Alternative Plans

Stage 8 Plan Evaluation

Stage 9 Decision Taking

Stage 10 Plan Implementation

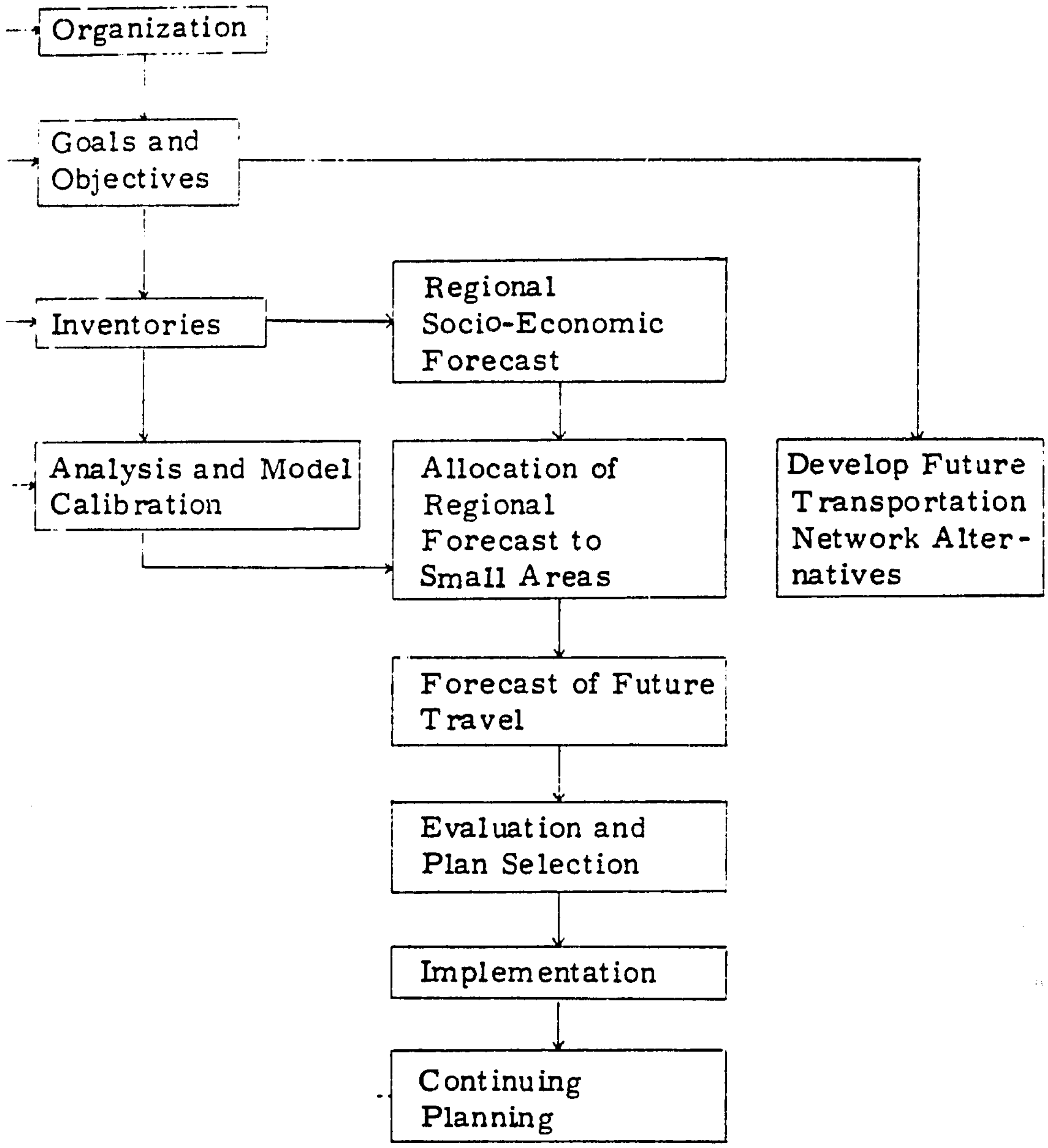
Stage 11 Review of Planned Development Through Time

(Nathaniel Lichfield, Peter Kettle, and Michael Whitebread, Evaluation of the Planning Process, Pergamon Press, Oxford, 1975 p. 40)

The Preceding stages are by and large applicable to a planning process in a broader context. Before going into sectoral planning which is unique to a particular sector, recognition of sequential planning process, of contraints and objective in the stage 4, of testing of alternatives, and plan evaluation are particularly useful concept.

4. Methodological Problems

The classical urban transport planning process is depicted in the following diagram.



(Louis J. Pignataro, Traffic Engineering, Prentice-Hall, Inc, Englewood Cliffs, 1973 p.45)

The classical model is geared to a stable city with a fair degree of change in population, and use, and trip pattern. Cities in dynamic growth such as Seoul, the applicability of the classical model is very cumbersome. It raises doubt on the vality or applicability of the model when the population doubles in ten years and a brand new trip pattern emerges as a result of change in land use and new development of industrial site.

The model is to accommodate on incremental to the existing facilities thus inapt to addition of a new transport system.

It is often questioned if base year pattern of trips can sustain in face of a brand new system of transport. For these reasons it would be necessary to take an "Outline approach" or "Stratigic approach".

Another drawback of the classical model is high cost factor for running numerous zones and systems links in computer whenever one wishes to introduce a change in links or demand for trips. There are frequent requirement of evaulating addition in the system such as construction of bridge, tunnel, and new settlement of population. It would also be necessary to develop a simplified model for evaluation of additional change in the system.

In the process of alternative generation and evaluation, imaginative and creative generation of alternatives are particularly weak in urban transport planning. It is partly owe to lack of expertise in the planning profession and meager allocation of budget for the planning study. It seems worthwhile to encourage rich generation of alternatives in order to update and take advantage of the advanced technologies in transportation.

As to non-measurables, it is true that there are many kind of nonmeasurable impact or effect such as comfort or discomfort, time value, amenity and others. Planners tend to shy away from identify these nonmeasurables to avoid biased or subjective judgment. However, it appears necessary to identify those qualitative factors in evaluation of transport project.

Consideration should also be given to politics of transport project. Bulk of transport projects are to render their effect on citizens, it thus is necessary to have involvement of politics at the setting of objectives.

II. Energy Supply and Demand Modelling

Prepared By
Dr. Poong-Eil, Juhn
Acting Head, Reactor Core Design and
System Engineering Division
Korea Atomic Energy Research Institute

II. Energy Supply and Demand Modelling

1. Introduction

a. Energy resources in the Republic of Korea are limited and there are relatively a little prospects that new resources would be discovered and developed economically in the near future. At the moment, domestic energy resources are anthracite coal and hydro electric power.

b. Due to the rapid economic growth in the recent years, however, energy demand in Korea increased significantly. Because of the limitation of domestic resources, the overall energy demand are met by imports.
The heavy reliance on imports may affect domestic economic stability and industrial growth, for example, owing to sudden curtailment or price hike of imported energy. Besides, according to recent international study, world oil shortages could begin as early as 1981 and it is urgently required not only to develop alternative energy supply, but also to conserve energy consumption.

c. In this topic, an energy supply and demand modelling by using input-output model and linear programming model is briefly mentioned, which was tentatively studied by the author and the members under his supervision at Korea Atomic Energy Research Institute (KAERI). It aims to recommend future policy direction on energy supply and consumption and to show how to formulate effectively energy programs.

d. In order to analize the mutual impacts between energy consumption structure and industrial structure, the energy input-out model has been formulated. From this model energy intensities of 18 industrial sectors were calculated.

e. A linear programming model of the domestic energy system has been developed to provide a framework for planning and technology assessment. It needs to take full account of inter-fuel substitutability and includes both electrical and non-electrical energy focussing on the technical, economical and environmental characteristics of conversion, delivery, and utilization.

f. In view of the complexity and importance of the energy systems analysis and planning, KAERI is planning to organize Energy Task Force (ETF) team, with an assistance of foreign consultants. The ETF team will be composed of energy specialists mainly from KAERI, the Korea Advanced Institute of Science, the Korea Development Institute and the Korea Electric Company. Suitably qualified foreign experts will be recruited through the Asian Development Bank with assistance of the Ministry of Science and Technology and Economic Planning Board of Korea.

2. General Aspect for Energy Systems

1) Characteristics and Problems of Energy Supply-Demand System

- Heavy dependence on oil (see. Table 1)
  (in '73, 53.4% total energy consumed was oil)
- Oil is imported wholly
- Limitation of Domestic Energy Resources (see. Table 3)
- High Consumption of Energy on Residual Part
  (in '73, 45.9% of total energy)
- Low Efficiency of Energy Use
  (in '73, loss was about 65%)

Table 1. Raw Energy Consumption in Korea (1955-1974)

Unit : 10 Million Won (1970 base)
Kilo-M/T of Coal Equivalent

Period	Source / Year	GNP	Coal	Oil	Hydro	Fire Wood	Total
	1955	938.24	3,649(16.6)	405(2.5)	234(1.5)	12,696(79.4)	15,984
	1956	941.21	3,223(18.8)	991(5.8)	254(1.5)	12,698(73.9)	17,166
	1957	1,014.44	3,216(18.5)	991(5.7)	205(1.2)	12,966(74.6)	17,378
	1958	1,067.15	3,528(19.5)	1,145(6.3)	301(1.7)	13,120(72.5)	18,094
	1959	1,108.33	4,426(23.8)	1,448(7.8)	382(2.1)	12,300(66.3)	18,556
	1960	1,129.72	4,868(26.3)	1,410(7.6)	284(1.5)	11,947(64.6)	18,509
	1961	1,184.48	6,120(32.1)	1,549(8.1)	320(1.7)	11,052(58.1)	19,041
		[3.96]	[9.00]	[25.05]	[5.36]	[-2.28]	[2.96]
1st FYP	1962	1,220.98	7,449(36.9)	1,930(9.5)	344(1.7)	10,489(51.9)	20,212
	1963	1,328.31	8,821(41.1)	2,157(10.1)	357(1.7)	10,094(47.1)	21,429
	1964	1,441.99	9,642(43.2)	2,139(9.6)	367(1.6)	10,161(45.6)	22,309
	1965	1,529.70	10,497(44.2)	2,827(11.9)	348(1.5)	10,083(42.4)	23,755
	1966	1,719.18	11,886(46.4)	4,192(16.4)	483(1.9)	9,041(35.3)	25,602
		[7.74]	[9.80]	[22.03]	[8.58]	[-3.94]	[6.10]
2nd FYP	1967	1,853.01	12,070(42.9)	7,014(24.9)	467(1.6)	8,615(30.6)	28,166
	1968	2,087.12	10,654(35.1)	10,084(33.2)	455(1.5)	9,164(30.2)	30,357
	1969	2,400.49	11,177(32.8)	13,689(40.1)	700(2.1)	8,540(25.0)	34,106
	1970	2,589.26	11,933(30.7)	13,011(46.2)	597(1.5)	8,335(21.4)	38,876
	1971	2,826.82	12,061(28.7)	21,263(50.6)	646(1.5)	8,051(19.2)	42,021
		[10.46]	[0.29]	[38.37]	[5.99]	[-2.29]	[10.42]
3rd	1972	3,023.63	12,366(28.3)	22,776(52.2)	670(1.5)	7,824(18.0)	43,636(3.84)
	1973	3,522.72	15,537(31.0)	26,718(53.3)	629(1.3)	7,200(14.4)	50,084(14.78)
	1974	3,810.41	16,032(31.6)	26,938(53.0)	869(1.7)	6,981(13.7)	50,820(1.47)

Note : increasing rate per year averaged for each period given in [ ]
Composition rate for total energy consumption in ( )

Sources : EPB, Long term total energy counterplan, 1974
The Bank of Korea, Economic Statistics Year-Book, 1975

Table 2. Prospect of Energy Consumption (1975-1981)

Unit: Kilo-M/T of Coal Equivalent

Source / Year	Coal	Oil	Hydro and Nuclear	Subtotal	Fire Wood	Total
1975	16,955 (31.3)	29,728 (54.8)	825 (1.5)	47,508 (87.6) -8.4-	6,706 (12.4)	54,214 -6.7-
1976	19,037 (32.8)	32,284 (54.8)	919 (1.6)	52,510 (89.2) -10.5-	6,375 (10.8)	58,885 (8.6)
1977	20,943 (33.2)	34,849 (55.3)	1,063 (3.9)	56,855 (90.2) -8.3-	6,212 (9.8)	63,067 (7.1)
1978	21,992 (32.2)	37,684 (55.2)	2,639 (3.9)	62,315 (91.3) -9.6-	5,957 (8.7)	68,272 -8.3-
1979	26,164 (35.9)	39,387 (54.6)	2,634 (3.7)	68,185 (93.2) -9.4-	5,719 (6.8)	73,904 -8.2-
1980	27,933 (34.9)	43,696 (54.6)	2,959 (3.7)	74,588 (93.2) -9.4-	5,408 (6.8)	79,996 -8.2-
1981	29,487 (34.1)	48,896 (56.5)	2,959 (3.4)	81,342 (93.9) -9.1-	5,243 (6.1)	86,585 -8.2-
increasing rate per year averaged in 77-81	8.8	8.7	26.3	9.1	-3.8	8.0

Note : Figures in ( ) are composition of energy consumption
Figures in - - are increasing rates to last year

Sources : EPB, Prospect of Korean long term energy supply and demand. (Transaction of energy symposium in 1976.)

Table 3. Domestic Resources of Energy

Source	Amount of Resources	Available resources	Production in 1973	Usable Year
Coal (anthracite)	1450 Million-M/T	500 Million-M/T	13.5 Million-M/T	40 years
Hydro Power	2,500-3,000 MW	2170 MW	620 MW (only for generation)	-
Nuclear	4.5 Million-M/T (U^{308}:0.043%) Cleaned: 2,146 M/T			

Sources : MOST, Superintendence of Resources, 1974.

Geological and Mineral Institute of Korea, Geology and Ore Deposit, No. 29, June, 1975.

2) Objectives of Study for Energy Problem

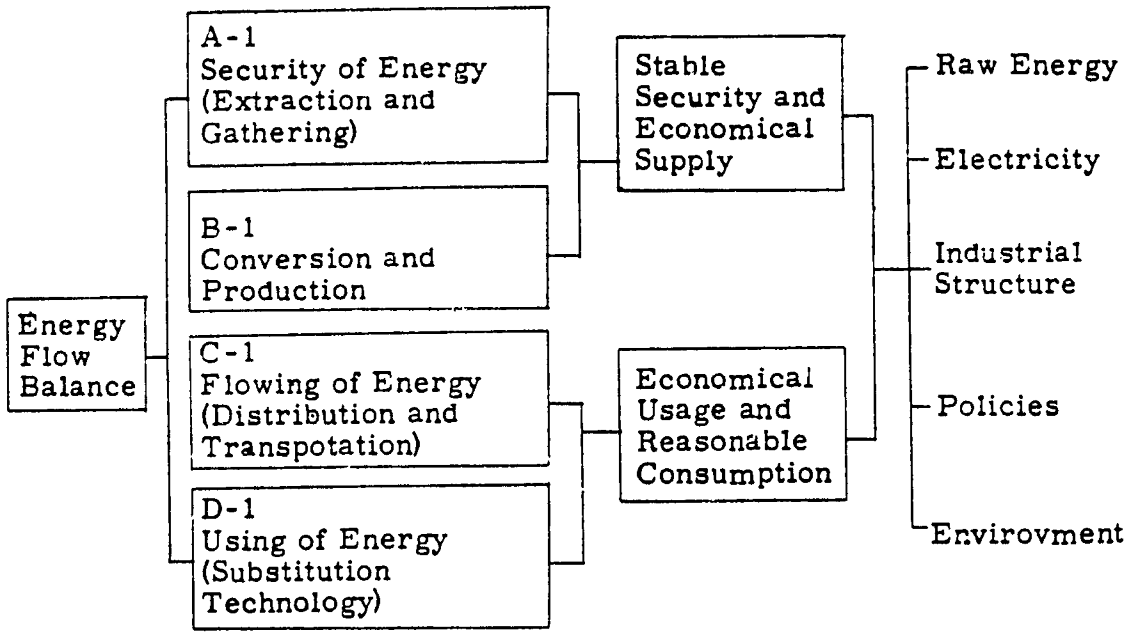
Basic Purpose	Direction of Policy	Objectives
Stabilization of Supply	Diversification of Energy Supply	Development of Domestic Energy Resources
		Development of New Energy
		Diversification of Imported Energy
	Rationalization of Energy Supply	Appropriate Energy Supply Scale
		Diversification of Supply Method
		Raising the Production Efficiency
Appropriate Energy Flowing	Appropriate Energy Saving	Appropriate Saving Scale
		Diversification of Saving Method
		Security of Funds for Saving
	Rationalization of Distribution and Transportation	Diversification of Energy Transport Method
		Efficient Transport Process
		Rationalization of Distribution Process
Appropriate use of Energy	Improvement of Energy Utilization	Improvement of Utilizing Efficiency (Techical development, substitutional effect, etc.)
		Utilization of Wast Energy and Material
		Improvement of Consumption System

(Continued)

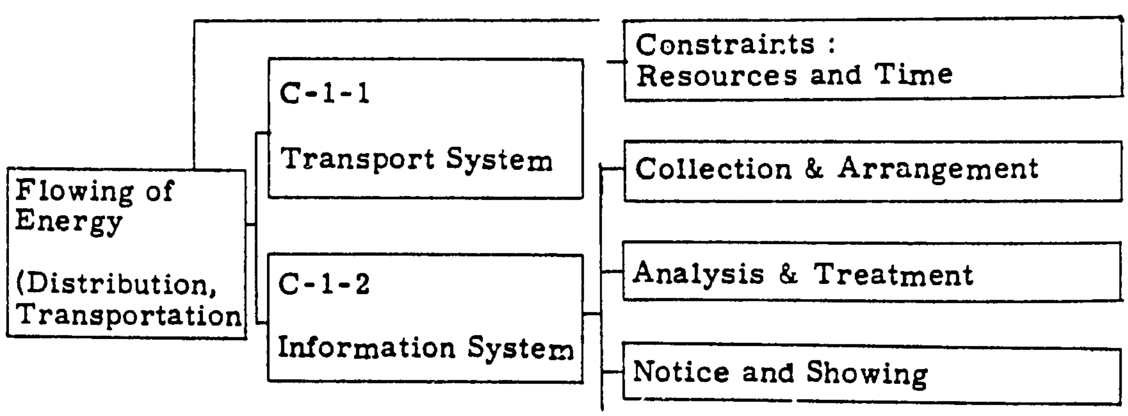
- Systematic Analysis for Total Energy System
  - Reduction of Energy Consumption
    - Limitation of Requirement of Productions and Services
    - Quality Improvement of Productions and Services
    - Limitation of Comsumption in Residual Part
  - Optimization of Energy System
    - Analisis of the Energy Consumption Structure
    - Optimization of Energy Flow Balance System
    - Study of Industrial Structure for Energy Conservation
  - Systematic Analysis for Future Energy Research and Development
    - Forecast of Energy Demand and Supply
    - Prediction of Energy Supply-Demand System and Industrial Structure
    - Establishment of Energy Policy
    - Determination of R & D Priority for New Energy Sources

3) Relationship of Energy Systems

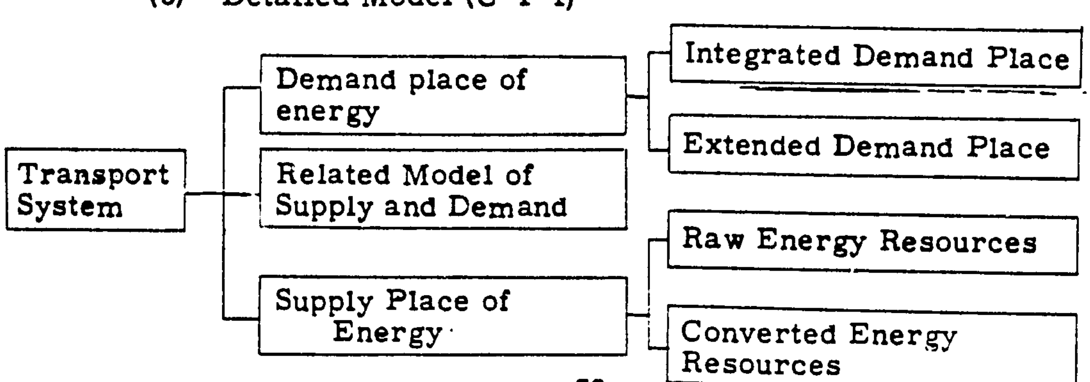
(1) Basic Model



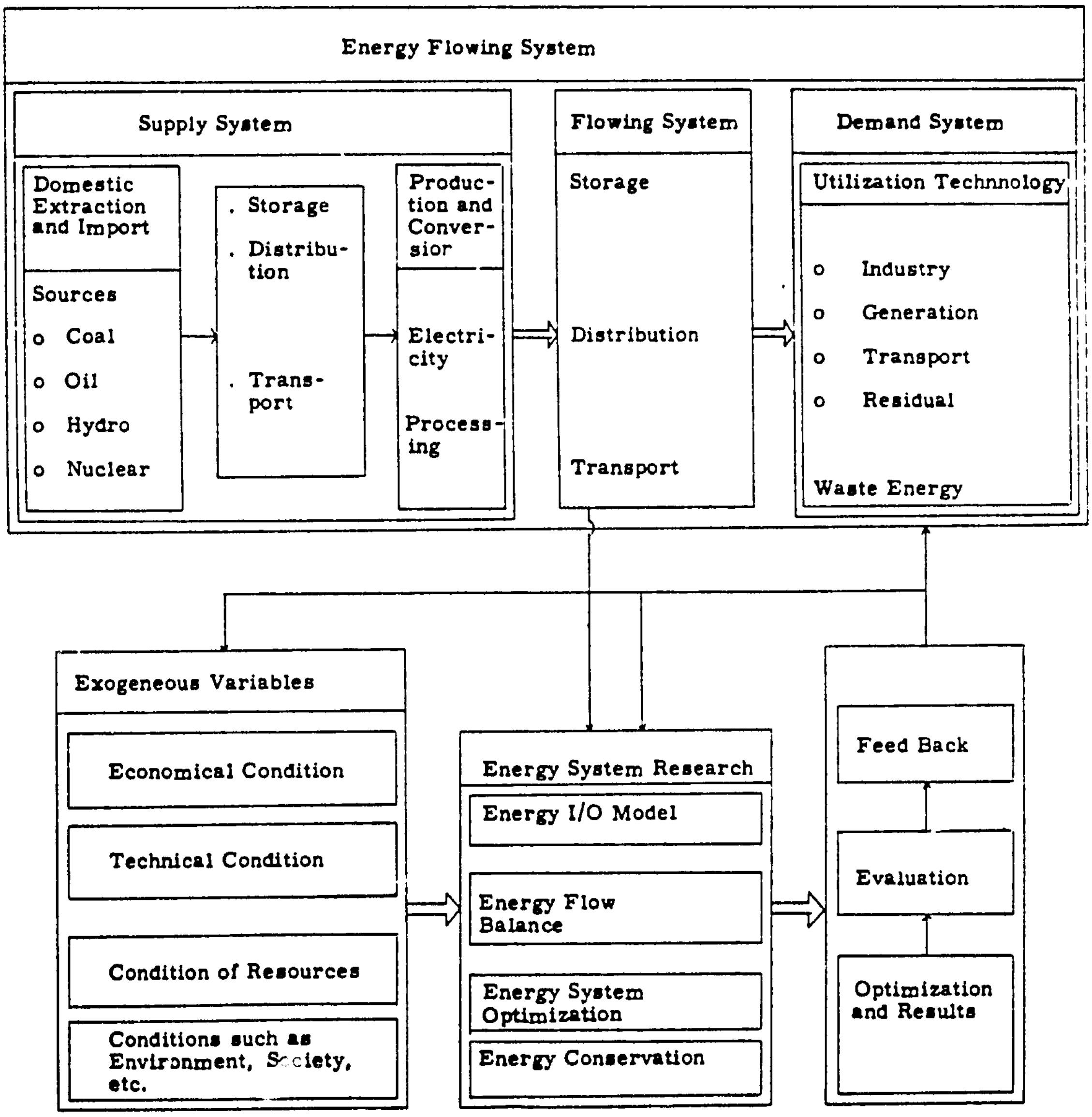
(2) Sub-Model (C-1)



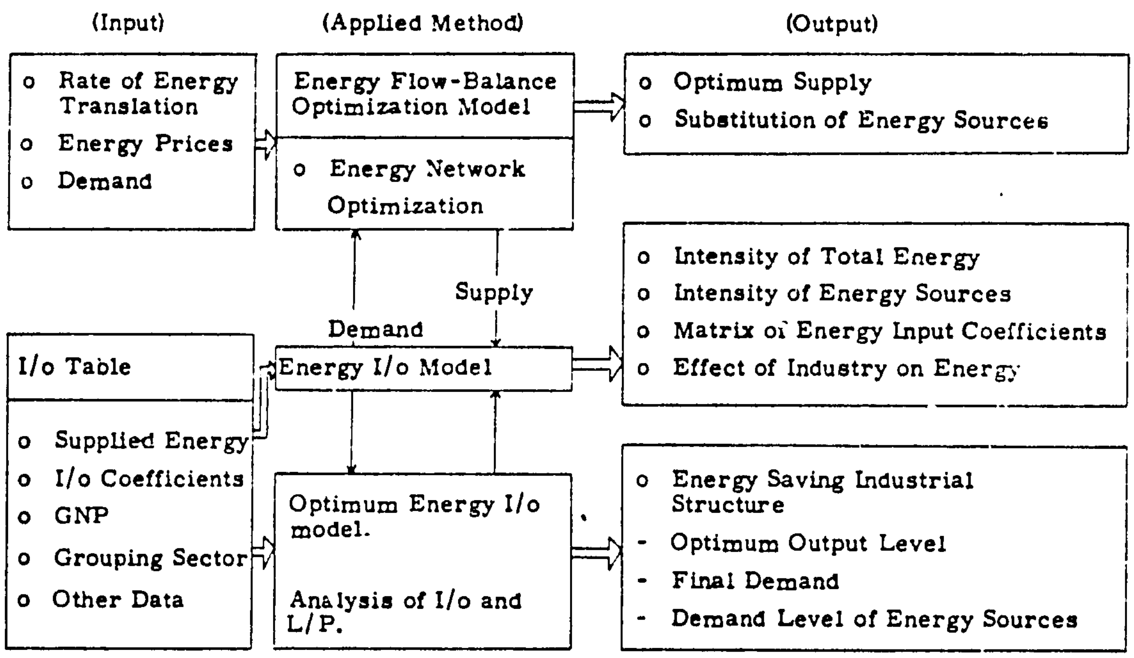
(3) Detailed Model (C-1-1)



4) Schematic Flow of Energy System Research

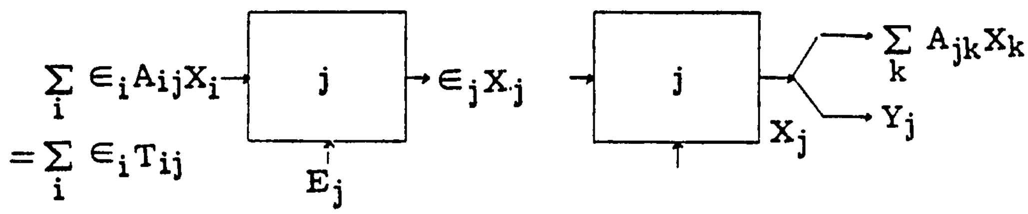


5) Related Structure of Models



3. Energy I/o Model

1) Basic Equations



$$X_j = \sum_{k\ 1}^{N} A_{jk} X_k + Y_j$$

$$\sum_{i=1}^{N} \in_i A_{ij} X_j + E_j = \in_j X_j \qquad \in = EX^{-1}(1-A)-1$$

$$T_{ij} = A_{ij} X_j$$

X_j : Total Output of j^{th} Industry

Y_j : Final Consumption of j^{th} Industry's Production

E_j : Primary Input Energy into j^{th} Industry

T_{ij} : Transaction amount from i^{th} industry to j^{th} industry

A_{ij} : T_{ij}/X_j: I/o coefficient, depend on industrial technology

$\in_i$: Energy Intensity of i^{th} Industry, depend on energy technology only

* If we know $\in$, A, and one of X, Y, and E, we can calculate all other quantities.

2) Application to the Industry in 1970

Input Data:

- o Amount of Domestic Extraction and Input of Energy Sources (see. Table 4)
- o I/O Table (340 sectors ⟶ 56 sectors ⟶ 18 sectors)

Results :

- o Intensity of total energy (see. Table 4);
- o Intensity of energy sources (see. Table 4);
- o Matrix of energy input coefficients;
- o Energy demand for each final consumption sector; and
- o Energy demand for each sector

3) Characteristics and Further Proposal of Energy I/O Model

- o Energy problems connected with domestic industrial structure;
- o Consideration of the indirect energy use as well as direct energy use;
- o Static relation-ship between energy problems and invariant industrial structure ⟹ Difficult to consider the substitutability of energy sources;
- o Detailed sectoral classification;
- o I/O table with natural unit of each sector; and
- o Dynamic model

Table 4. Energy Intensity

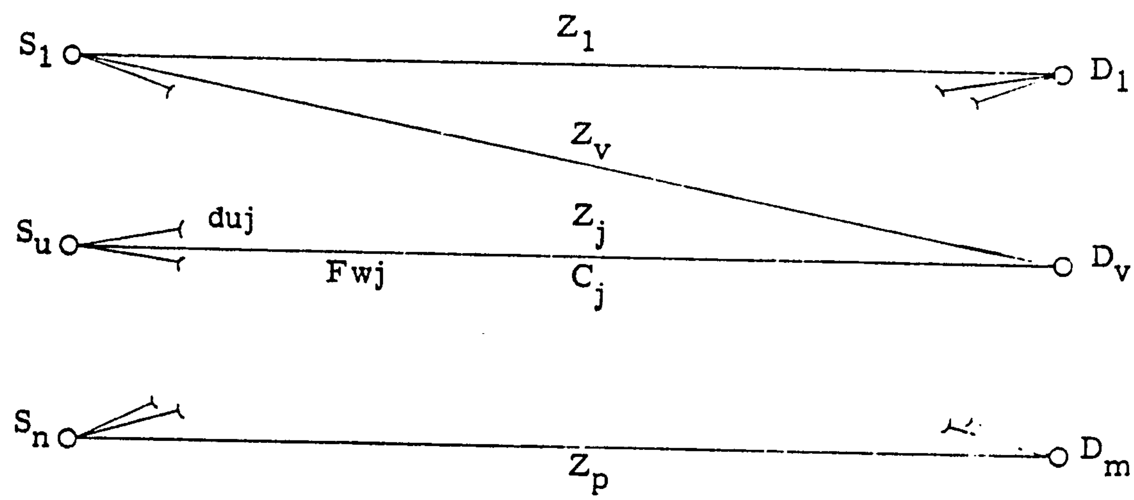
Unit: 10^9Kcal/Million Won

Secto	Energy Extraction	Coal	Oil	Hydro	Fire Wood	Total
Coal mining	6,338,804.7600	254.567505	2.017454	.292216	.048932	256.9261071
Petroleum products	8,388,781.9140	.634903	92.387178	.110770	.081669	93.2155198
Electric Utilities	298,582.8475	9.886345	12.755043	5.32213	.022644	27.9861613
Fire Wood	4,250,849.8500	.050469	.114566	.004288	373.773464	373.9427868
Coal Products	0.0	135.222984	4.03809	.218757	.038266	139.5180981
Self-Feeding Generation	0.0	21.844383	29.721236	.105975	.060794	51.7323874
Transportation & Warehousing	0.0	.686115	10.685104	.059704	.028716	11.4596385
Other Mining	0.0	.901689	2.620066	.17003	.159595	3.8513532
Agriculture Fishery	0.0	.298570	1.283403	.025843	.045294	1.6531106
Food	0.0	.739690	1.89687	.100080	.049055	2.7856951
Textile	0.0	1.154454	3.071942	.171442	.033529	4.4313659
Chemical	34,252.66	1.983567	6.896184	.246651	.054052	9.1804542
Nonmetalic	0.0	4.712791	7.340883	.410830	.212251	12.6767556
Metalic	0.0	8.059509	5.082449	.560865	.247316	13.9506390
Machinary	0.0	3.098810	3.710969	.263417	.104134	7.1773305
Other Manufac-ture	0.0	1.093481	2.751667	.138816	.054863	4.0397272
Construction	0.0	1.951561	4.081877	.163086	.436988	6.6335130
Services and other industry	0.0	.995221	1.338992	.052485	.056126	2.4428240
Total	19,305,272.0315					

4. Energy Flow-Balance Optimization Model

1) Basic Equations

Energy Supply Categories	Production, Transpo Conversion, Distribution etc.	Energy Demand Categories



S_u : Supply constraints, $u = 1, \ldots, n$

D_v : Demand constraints, $v = 1, \ldots, m$

Z_j : Quantity of intermediate energy form j delivered from S_u to D_v ; $j = 1, \ldots, p$ where $p = nm$

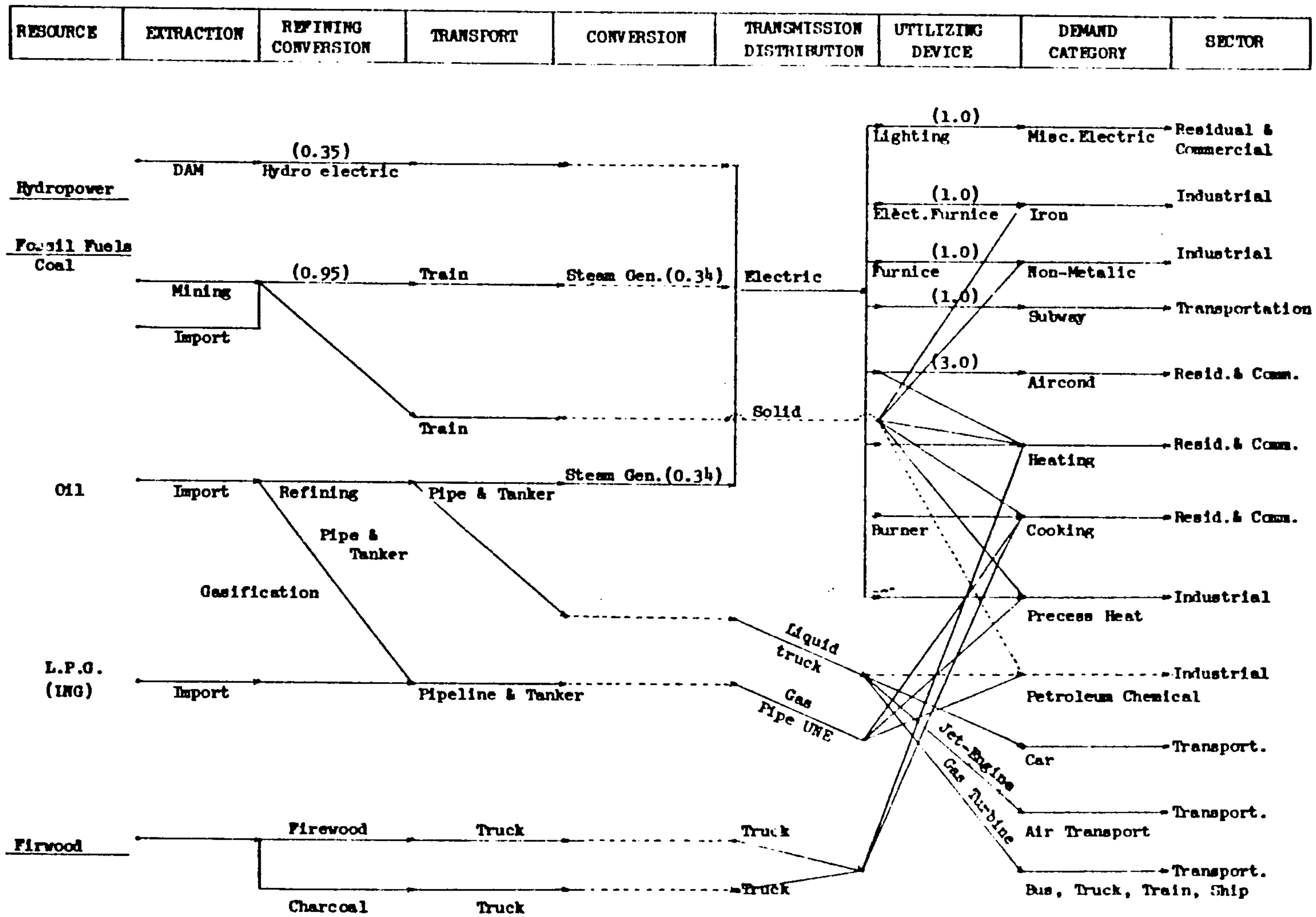
$1/duj$: Supply efficiency for energy Z_j

e_{jv} : Utilization efficiency for energy Z_j

f_{wj} : Other constraint equation coefficients for variables Z_j, constrained by B_w, $w = 1, \ldots, 1$

C_j : Objective equation coefficients for variables Z_j, e.g., cost per unit quantity of energy Z_j when Objective is cost minimization

(Fig.1) Reference Energy System, Year 1973



* Themal efficiency is given in ( )

Objective Function :

$$\text{Min} \quad \left\{ \sum_j C_j Z_j \right\}$$

Subjective Function :

$$\text{Supply :} \quad \sum_j d_{uj} Z_j \leq S_u, \qquad u = 1, \ldots, n \quad ;$$

$$\text{Demand:} \quad \sum_j e_{jv} Z_j = D_v, \qquad v = 1, \ldots, m \quad ;$$

$$\text{Others :} \quad \sum_j f_{wj} Z_j \leq B_w, \qquad W = 1, \ldots, 1 \quad ; \text{and}$$

$$Z_j \geq O$$

2) Characteristics :

- o Directly related with energy network ;
- o Enable to establish energy technology assessment, direction of energy policy, and substitutability of various energy sources ;
- o Linearlized ;
- o Not related with industrial structure ; and
- o Considered only direct energy use.

5. Energy System Optimization Model (ESOM)

1) Main Purposes

- o Study and find out the conservative energy supply-deman system
- o Establish the feasibility and priority of the study for improvement of energy technology
- o Extablish the direction of energy policy

Related with

- o Energy network (e.f., Energy Flow-Balance Optimization model)
- o Domestic industrial structure (c.f., Energy I/O model)
- o And other conditions (Environment, Resources, economic, policies, etc.)

2) Formulation by using Energy I/O Model

Energy system optimization model may be formulated by using energy I/O model, which was already established, since T_{ij} from energy product sector is related with Z_j in energy network. (See. Fig. 2)

The basic variables in ESOM are as follows:

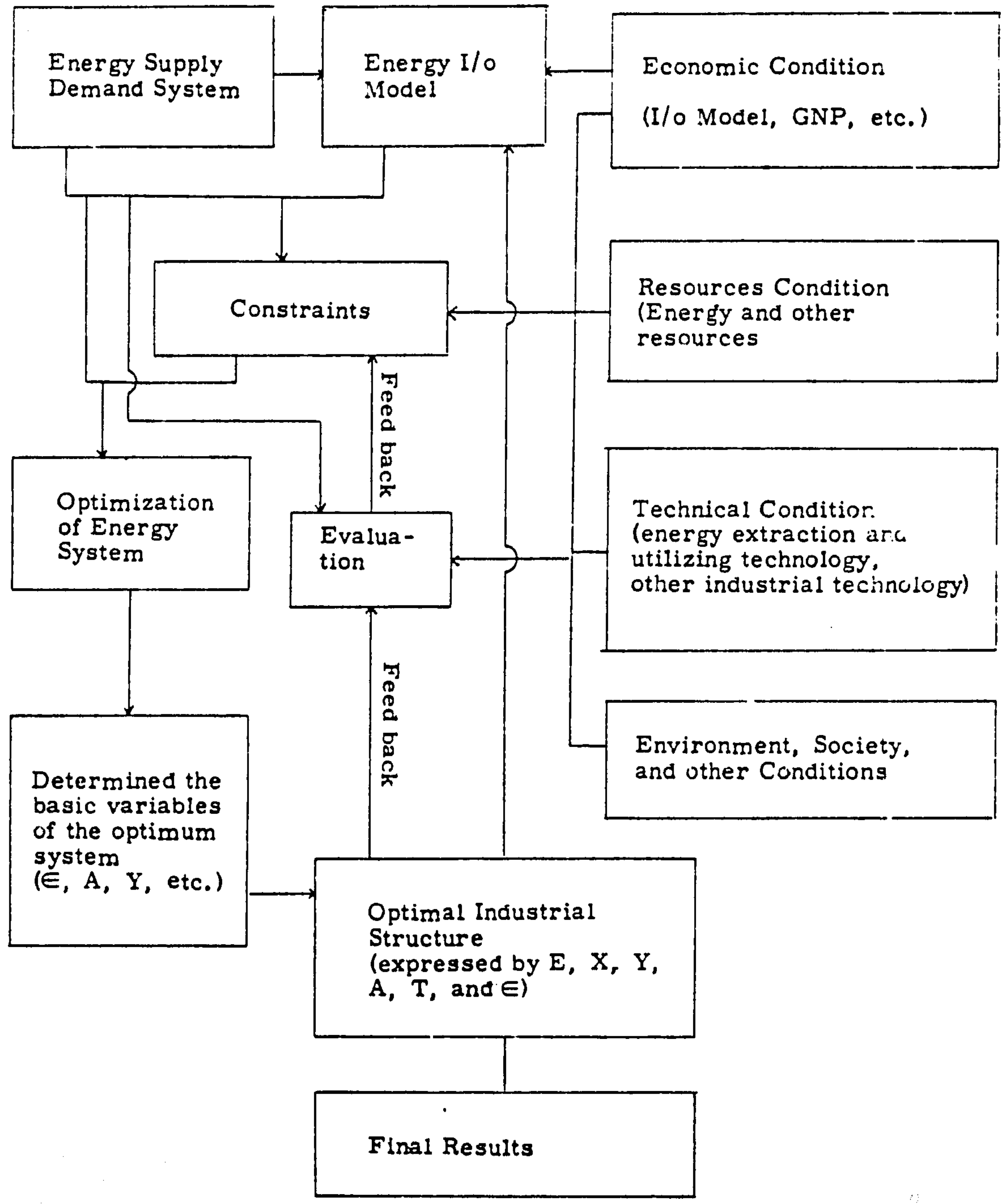
(a) Y_i (which is equivalent to X_i since $X_i = \sum_{k=1}^{N} A_{ik} X_k + Y_i$ and A is invariant) when energy technology and industrial structure are invariant, i.e., $\in$ and A are constant;

(b) $\in_i$ when industrial technology is invariant and final consumption is unchanged, i.e., A and Y are constant; and

(c) A_{ij} when $\in$ and Y are unchanged.

The objective function and all constraint functions for ESOM must be expressed in terms of Y, A, $\in$, and other constants. By optimization of these functions with afore-mentioned basic variables three each optimum value can be obtained, in term optimal industrial structure and energy flow-balance are resulted.

(Fig. 2) Flow of Energy System Optimization Model

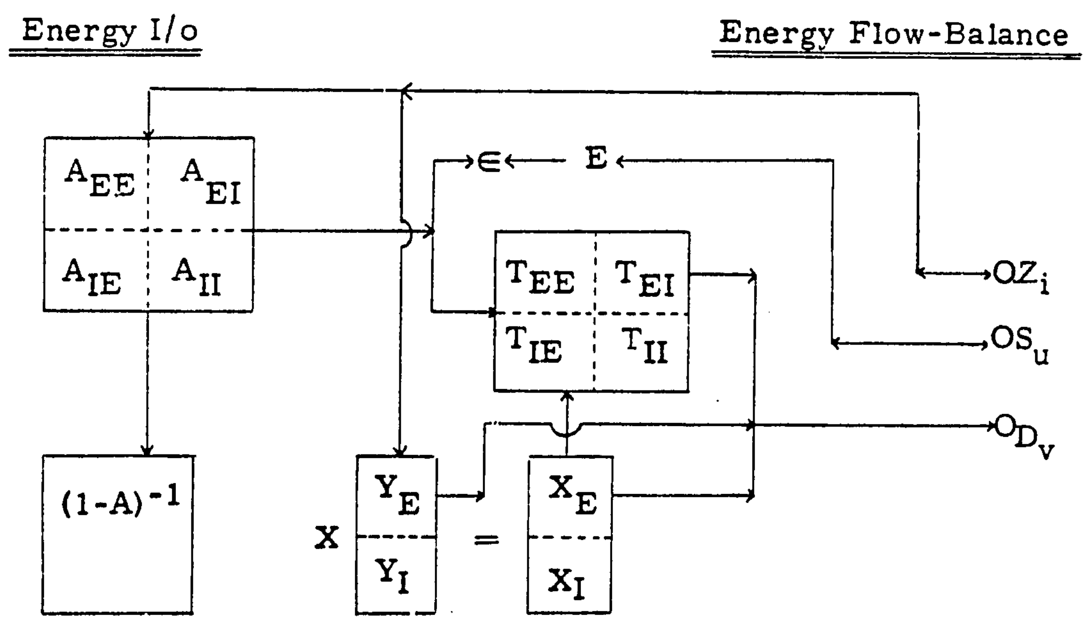


3) Formulation by using Energy Flow Balance Optimization Model

A) Energy I/o Sectors

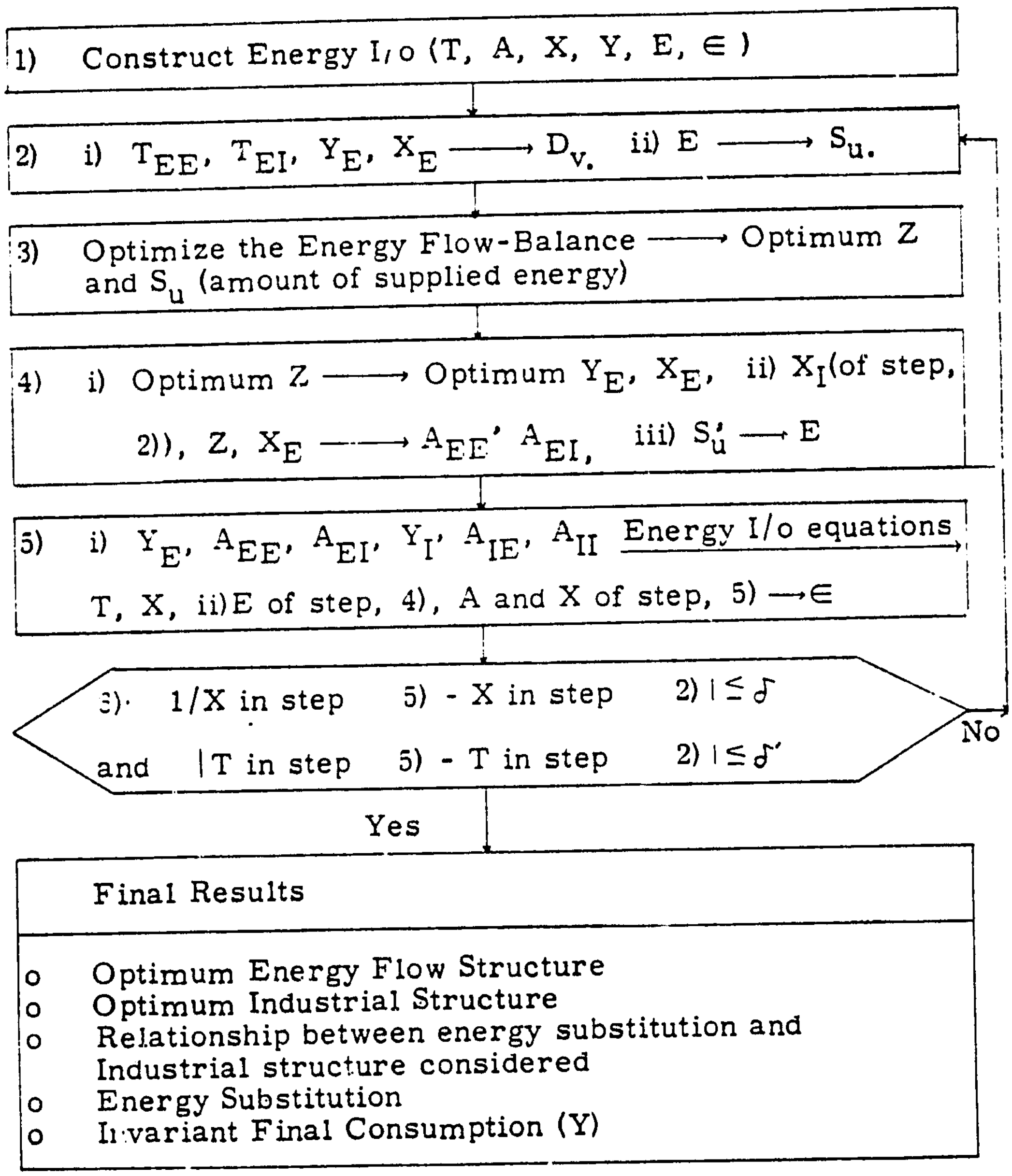
	Energy Part	Non-Energy Part	Final Consumption	Total output
Energy Part	T_{EE} (A_{EE})	T_{EI} (A_{EI})	Y_E	X_E
Non-Energy Part	T_{IE} (A_{IE})	T_{II} (A_{II})	Y_I	X_I
Primary Energy Input	E_E	E_I		

B) Relation between Energy I/o and Energy Flow-Balance



C) Procedure of Optimization

When A_{IE}, A_{II}, Y_I in Energy I/O Model are constant, and all constants in Energy Flow-Balance Optimization model except D_v and S_u are invariant, the ESOM can be formulated according to the fallowing schematic procedure.



4) Example : Case Applied on 1970 Korean Economic Structure

A) Conditions:

- o Minimize total energy consumption ;
- o Sumit the supply ability of energy sources ;
- o Maximize GNP ;
- o Maximize total export balance ; and
- o Minimize export of direct energy (coal, coal products, oil products, fire wood, electricity) because of the limitation of domestic energy resources.

B) Basic Variables:

Domestic final consumption $(YD)_i$ and export balance of each sector $(YE)_i$, where $Y = YD + YE$

C) Asumption: $\in$ and A of Energy I/o model are invarient

D) Equations :

Objective : $\text{Min } \{E_t\} = \text{Min } \left\{ \sum_i \in_i (YD_i + YE_i) \right\}$

Subjective to:

GNP : $GNP_L \leq \sum_i (YD_i + YE_i) \leq GNP_H$

Energy Supply : $E_{LS} \leq \sum_i \in si\, (YD_i + YE_i) \leq E_{HS}$

Export Balance: $YE_L \leq \sum_i YE_i \leq YE_H$

Energy Export Balance : $EE_L \leq \sum_k \in_k YE_k \leq EE_H$

where

s : for energy sources, i. e., coal, oil, hydro, and fire wood.

k : for energy product sectors such as coal mining, coal product, oil product, electricity, fire wood.

i : for all sectors

E) Flow Diagram

Optimize Above Equation ⟶ Optimum Y

Optimum Y, $\in$, A ⟶ X, E, T

Results

Optimum Industrial Structure

F) Results and Discussion

i) In a sense of energy conservation, it is more effective to reduce the output of large $\in$ than to reduce the final consumption ;

ii) For the maximization of GNP, it is desirable to increase the output of small $\in$ since the output of large $\in$ is required to be reduced in a sense of energy conservation as mentioned above; and

iii) The results show us how to optimize the energy supply and demand patterns. However, in order to have a good confindence on the results, organization of unified and comprehensive energy data collection and maintenance system is required, in which energy data will be recorded and analyzed systematically.

III. Power System Planning Analysis

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III. Power System Planning Analysis

1. Introduction

a. Many basically different types of generating units, such as nuclear, hydroelectric, and conventional units, could be added to a generating system to meet constantly growing installed-capacity requirement. Since each of these types may also vary considerably in capital cost, size, efficiency, fuel and site location, there are a very large number of possible choices each time a new generating unit is needed. Moreover, once a unit is purchased, its known capital fixed charges continue for the life of the plant, while its fuel and operating costs will initially depend on the composition and characteristics of the system prior to the istallation of the new unit, later depending also on the relative efficiencies of units added subsequently, since these will directly affect the future power and energy supplied by the unit to the system.

b. In order to evaluate the economic merits of a particular type and size of unit to be added to a particular system, it is necessary to determine the total costs associated with this choice over the projected life of the unit, in conjunction with each of the many thousands of combinations of future units that might be added during this lifetime to be studied.

c. The general objective of electrical system planning is to insure the provision of a reliable supply of electrical power at the lowest possible cost.
The basic procedures are :

(i) to forecast electrical demand adequately ;
(ii) to select proper types and capacities of the plants;
(iii) to have reliable reserve margin ;
(iv) to know in advance how to control unexpected load variations ; and
(v) to optimize the system loading order.

d. In order to do so, the long-term, the mid-term and the short-term plans are required, respectively, to be systematically established. Expecially due to such parameters as recent complexity of the electrical system, an introduction of large-size units and future uncertainties, it is desirable to introduce and to develop electrical systems expansion planning computer programs using simulation technique, such as WASP (Wien Automatic System Planning Package).

e. In this topic, a long-term electrical system expansion plan for 20 year period (1976-1996) is mentioned, which was tentatively studied by the author for the purpose of energy systems development in Korea. At the same time, Korean Government's 10 year power development plan is also described in this study. The Korea Development Institute has also studied similar plan as a part of "Long-term Management Plan for KECO", with an technical assistance of Korea Atomic Energy Research Institute. The result of KDI's study would be available by the end of 1977.

2. Basic Planning Procedures

a. The study procedures taken here are as follows:

(i) to forecast load demands;
(ii) to set the minimum and maximum reserve margins;
(iii) to analize the uncertainties ;
(iv) to generate equivalant load duration curves ;
(v) to calculate the loss-of-load probabilities ;
(vi) to determine maintenance and reloading schedules;
(vii) to calculate operating costs and capital costs; and
(viii) to review the acceptability of the plans obtained.

b. Figure 1 schematically shows the afore-mentioned procedures. The block diagram of calculation procedure in the computer programs is represented in Figure 2.

c. Future load demand can be forecasted conventionally, probabilistically or stochastically. The total installed capacity or gross electrical generation is assumed in this analysis to be exponentially proportional to the prices of energy, per-capita income and the population.
The load data obtained in this study are listed in Table 1, and, at the same time, these values are compared with other values studied by several institutes.

Figure 1 Schematic Representation of the Optimal Electric Expansion Plan.

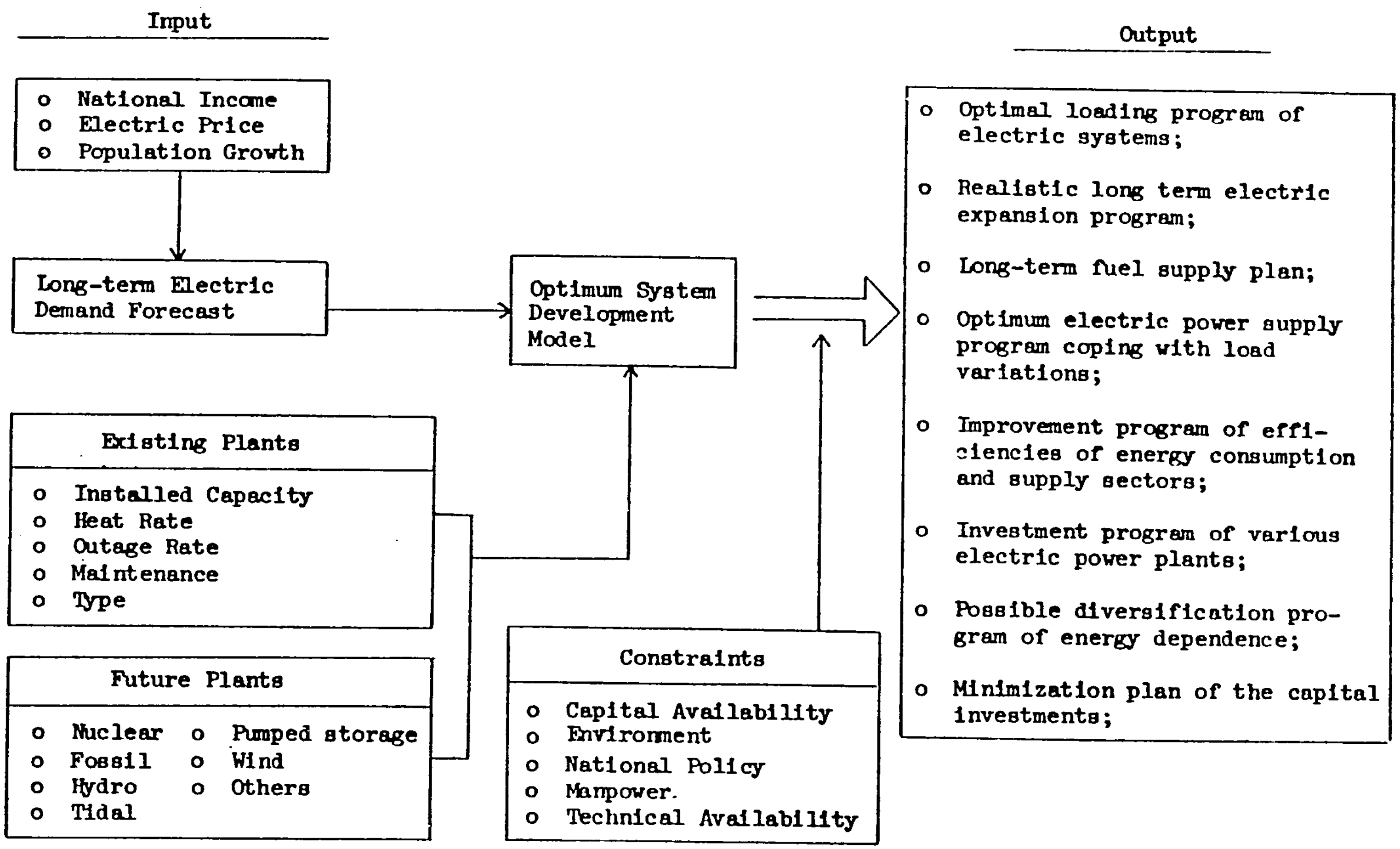
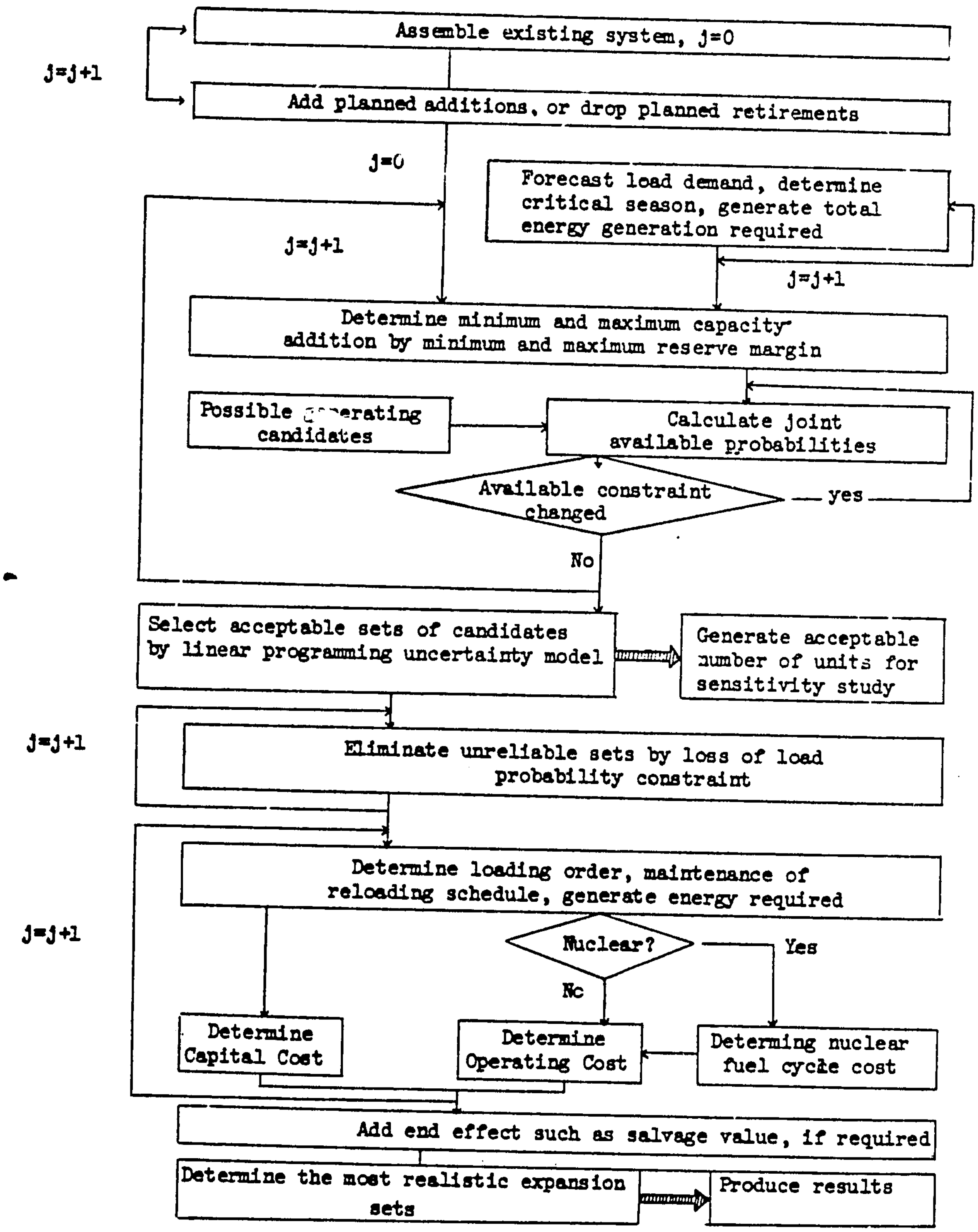


Figure 2. Block Diagram of Calculation Procedure.



Maximum Electric Demand Forecasts

Table 1.

(Unit: MWe)

Year	KAERI (1976)	MCI (1976)	KAERI (1974)	KECO (1975)	IAEA (1973)	Harza (1974)		
						Low	Medium	High
1976		3,930		3,851				
1977		4,488		4,445				
1978		5,109		5,083				
1979		5,751		5,797				
1980	6,810	6,517	6,694	6,594	5,360	6,651	7,076	7,522
1981	7,460	7,288	7,738	7,448	5,900	7,627	8,164	8,729
1982	8,270	8,185	8,725	8,257	6,500	8,726	9,392	10,095
1983	9,180	9,169	9,649	9,146	7,100	9,956	10,769	11,627
1984	10,090	10,252	10,651	10,094	7,800	11,328	12,304	13,334
1985	11,480	11,462	11,743	11,094	8,600	12,848	14,003	15,218
1986	12,800	12,769	12,844	12,171	9,400	14,521	15,867	17,277
1987	14,290				10,300			
1988	15,980				11,200			
1989	17,574				12,200			
1990	19,350				13,200			
1991	21,270		20,000		14,300	25,170	27,463	29,733
1992	23,290				15,500			
1993	25,380				16,800			
1994	27,549				16,000			
1995	29,940				19,400			
1996	32,750		30,000		20,900	38,555	41,077	43,302

3. Detemination of System Loading by Simulation Method

a. The basis of the simulation method is the use of probability distributions to describe the system load and forced outage rates of the generation units as well as the combination of these distributions to obtain the mathematical expectance of the energy generated by each unit in the system.

b. The input data for simulation program in WASP package are the base load heat rates, average incremental heat rates, fuel costs, operating and maintenance costs and forced outage rates of the existing and considering generation units, as shown in Table 2.

c. The generation units considered during 1986-1996 are 500 MWe, 800 MWe and 1,000 MWe fossil-fired units, 900 MWe and 1200 MWe nuclear units, and 200 MWe gas turbines, respectively. The 200 MWe gas turbines may be replaced by hydro electric units or pumped storage units.

d. Considering the outage rates of the generation units, operation and maintenance schedules, uncertainties of loads forecasted, and unexpected delay of construction schedules, reserve margins of 30% to 40% are taken herein.

e. Table 3 represents the possible expansion schedule and the loss-of-load probabilities satisfying reserve margin constraints. The government's 10 year plan is included in Table 4 as a reference.

f. The system loads are varying hourly, daily, weekly, monthly, seasonally or yearly.
To have an adequate long-term plan, seasonal load duration curves are desirable to be reasonably obtained throughout the planning years.

Input Data on Plant Characteristics Scheduled Up To Year 1986

Table 2. (Base Year: 1976)

Name	Type	Capacity (MWe)	Base load Heat Rate (Kcal/Kwh)	Average Incremental Heat Rate (Kcal/Kwh)	Fuel Cost (¢/10^6 Kcal)	Operating and Maintenance Cost ($/Kw-month)	Forced Outage Rate (%)	Maintenance Day
H Y D R	Hydro	1,537	0	0	0	1.04	0.0	0
G O R I	Nuclear (Gori 1)	595 × 1	2,850	2,340	281	1.48	12.0	28
G O R 2	" (Gori 2)	650 × 1	2,636	2,366	281	1.48	12.0	30
H W R 1	" (Wolsung 1)	679 × 1	2,635	2,366	190	1.72	12.0	35
L W 56	" (LWR)	900 × 2	2,630	2,370	250	1.44	12.0	35
ϕ 500	Fossil (Oil)	500 × 9	2,326	2,135	850	1.04	6.5	28
ϕ 300	" (")	300 × 5	2,328	2,172	900	1.06	6.5	28
ϕ 200	" (")	300 × 1	2,280	2,146	990	1.08	6.5	28
Y ϕ C 1	Combined Cycle	200 × 2	2,415	2,273	1,000	1.05	6.5	28
Y ϕ C 2	" "	100 × 2	2,526	2,314	1,010	1.05	6.5	28
ϕ C 12	Fossil (Mixed)	200 × 2	2,306	2,160	850	1.15	6.5	28
I N 12	" (Oil)	250 × 2	2,360	1,970	926	1.04	6.0	28
Y E D ϕ	" (")	125 × 1	2,570	2,350	729	1.10	6.0	21
S E ϕ 5	" (Mixed)	250 × 1	2,342	2,044	916	1.10	6.0	28
D G H A	" (Oil)	220 × 3	2,172	1,882	1,071	1.08	6.0	21
H ϕ N M	" (")	300 × 2	2,530	2,2[illegible]8	909	1.06	6.5	28
Y G N M	" (")	200 × 2	2,251	2,083	997	1.08	5.4	21
K G I N	" (")	162 × 2	2,520	2,196	1,000	1.09	5.3	21
Y ϕ S I	" (")	200 × 1	2,450	2,078	940	1.08	5.4	21
P U 34	" (")	105 × 1	2,536	2,362	998	1.10	6.5	21
S E ϕ 4	" (Mixed)	138 × 1	2,600	2,322	853	1.16	7.5	21
Y G W L	" (")	50 × 2	3,180	3,180	500	1.25	8.6	21
G N S N	" (")	75 × 1	3,112	2,288	733	1.25	8.6	21
P U L M	" (")	62 × 4	2,912	2,912	893	1.25	8.6	21
P P Y G	" (Gas)	50 × 2	2,580	2,580	816	1.25	6.5	21
U L S N	Gas Turbine	50 × 3	4,000	4,000	1,148	1.25	2.0	4
I N 34	Fossil (Oil)	325 × 2	2,335	2,183	900	1.06	6.5	28
P U S T	Pumped Storage	1,100	0	0	0	1.16	0.0	0

Table 3.

Possible Expansion Schedule and loss of Load Probability (1986-1996)

Year	Cumulative Number of Plants						LOLP (10^{-4})	Total Installed Capacity (MWe)
	500 MWe Oil	800 MWe Oil	1,000 MWe Oil	900 MWe Nuclear	1,200 MWe Nuclear	200 MWe Gas Turbine		
1987	1	0	0	0	1	1	0.009	19,454
1988	2	0	0	0	2	2	0.025	21,354
1989	4	1	0	0	3	3	0.003	24,554
1990	5	1	0	0	4	4	0.007	26,454
1991	5	1	0	0	5	5	0.053	27,854
	5	2	1	0	6	6	0.024	31,054
1992	5	1	0	0	7	6	0.066	30,454
	5	1	1	0	6	7	0.055	30,454
	5	3	1	0	7	7	0.049	33,254
1993	5	2	2	0	7	7	0.040	33,454
	5	2	1	0	8	7	0.033	33,654
	5	3	2	0	8	9	0.059	35,854
1994	5	2	3	0	8	9	0.048	36,054
	5	2	2	0	9	9	0.039	36,254
	7	3	3	0	9	10	0.030	39,254
1995	6	3	4	0	9	10	0.018	39,754
	6	3	3	0	10	10	0.045	39,954
	6	3	3	0	9	11	0.046	38,954
	9	3	4	0	10	11	0.030	42,654
1996	7	3	5	0	10	11	0.037	42,654
	7	3	4	0	11	11	0.031	42,854

Table 4. Korean Government's 10 Year Plan (1976-1986)

Year	Istalled Capacity(MWe)			Available Capacity (MWe)	Maximum Demand (MWe)	Type
	Addition	Decommi-sion	Total			
1977	1, 320		6,430	4, 897	4,488	2 Conbined Cycle 1 Nuclear 1 Fossil
1978	525	13	6, 942	5, 998	5, 109	1 Fossil 2 Combined Cycle
1979	300		7, 242	6, 401	5, 751	1 Hydro 2 Fossil
1980	1, 310		8, 552	7, 824	6, 517	4 Fossil 1 Pumped Storage
1981	1, 353		9, 905	9, 040	7, 288	1 Hydro 4 Fossil
1982	1, 559	122	11, 342	10, 158	8. 185	1 Nuclear 1 Pumped Starage 1 Hydro
1983	2, 150	210	13, 282	11, 329	9, 169	1 Fossil 1 Nuclear 3 Fossil
1984	430		13, 712	12, 540	10, 252	1 Pumped Storage 1 Fossil
1985	2, 513		16, 225	13, 921	11,462	1 Nuclear 2 Hydro 3 Fossil
1986	1, 960		18, 185	15, 223	12, 769	1 Nuclear 1 Fossil 1 Hydro 1 Tidal

4. Determination of Optimum Plan by Dynamic Program

a. The dynamic programming method is based on Bellman's principle of optimality. It means that the global optimum over the study period is associated with that state in the final stage which has the lowest value of the final objective function.

b. The objective function is defined as the present worth discounted combination of capital costs, operating costs and salvage values for any state x in year j such

that :

$$\text{Minimize } J(x) = \left[\sum_{j=1}^{j} C_j + O_j - R_j \right]$$

Where

$J(x)$	=	Objective function for state x in year j ;
C_j	=	Total discounted capital costs in year j ;
O_j	=	Total discounted operating costs in Year j ;
R_j	=	Total discounted salvage values in Year j ;
X	=	State in year j

c. The global optimum over the study period is associated with that state in the final stage which has the lowest value of the objective function, and the optimum trajectory is determined by tracing backward to the initial stage.
Table 5 presents the most optimal system configuration during 1986 through 1996 obtained by using dynamic program among 22 possible states listed in Table 3.

Table 5. Optimum Power Plant Construction Plan (1987-1996)

Year	Optimum Number of Plants (Cumulative)					
	500MWe Oil	800MWe Oil	1000MWe Oil	900MWe Nuclear	1200MWe Nuclear	200MWe Gas Turbine
1987	1	0	0	0	1	1
1988	2	0	0	0	2	2
1989	4	1	0	0	3	3
1990	5	1	0	0	4	4
1991	5	1	0	0	5	5
1992	5	1	0	0	6	6
1993	5	2	1	0	7	7
1994	5	2	2	0	8	9
1995	6	3	3	0	9	10
1996	9	3	4	0	10	11

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IV. Environmental Problems in Korea

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IV. Environmental Problems in Korea

1. Introduction

Korea has committed to massive industrialization since 1962, and mobilized a full capacity of both human and natural resources for rapid economic growth. Economic development, which achieved an enormous expansion and modernization through three Five-year Economic Development Plans, has already contributed a significant share to the nation wide environmental deterioration.

The environmental problems that we face today are so complex and interwoven with national developments; urban development, industrial production, land utilization, agriculture, fisheries, and others. This national commitment for continuous economic growth has overshadowed a simultaneous need of proper environmental protection program. As a result of this one-sided policy, the quality of air, water, and soil has been deteriorating at an alram-ing rate, and irreparable damage is being made to the natural process of the human ecosystem.

Environmental pollution is a function of population and economic growth. In 1945 there were about 25 million people inhabited in the Korean peninsula. The Korean population in the south of divided country was estimated as 20 million in 1949, and increased to 29 million by 1966. During the period of last ten years additional 6 million people added to the Korean population with a mean annual rate of 1.8 percent.[1)]

At the same time, the gross national product (GNP) rose from $2.1 billion in 1961 to $25 billion, and the per capita national income increased from $83 in 1961 to $698 in 1976. This amounts to the almost 12 percent annual growth rate of GNP. This extraordinary economic growth accompanied with increasing population, despite of insufficient development capital and technology as well as almost complete dependence on imported industrials, show a dynamic national potential for Korea to become a self-sufficient, strong industrial nation.

As economic growth accelerates and industries concentrate in the large cities, many poorer dwellers in rural areas move to the larger cities out of economic necessity. Seoul, as the nation's capital, the center of political and economic decision-making and education, has attracted people from almost every parts of Korea. In 1976, Seoul contained approximately 20 percent of the Korean population. Average population density in its 627 square kilometer area was slightly over 12,200 per km^2. Seoul's population rose from slightly over 3 million in 1962 to 7.25 million in 1976. In fact, the city has been almost doubling in size every ten years since 1945, and the rapid population growth has not been slowed significantly. Annual growth rates averaged over 9 percent during 1966-1970.[2] Likewise, the number of motor vehicles in Seoul increased from 38,000 in 1969 to 80,248 in 1974[1] and to 96,557 in 1976. In fact, Seoul's current number of motor vehicles is larger than the Korean total of 1968. Seoul no longer dominates industrial produc as in 1966 when 45 percent of the national production came from the metropolitan area. Neverthless, Seoul with a rapid growth rate is facing enormous urban problems, such as public health, transportation, housing, and above all environmental problems.

2. Effects of Urbanization and Land Utilization

Urban and land-use plannings are important parts of the Korean development plan which should have an ultimate integration of the environmental protection. Although the Ministry of Construction is charged with primary responsibility of land-use and urban planning, this involves at least three additional ministries, Commerce and Industry, Transportation, and Agriculture and Fishery. In 1969 the Ministry of Construction undertook to chart a ten-year national land-use plan for the period between 1972 and 1981. This plan considers the requirement for preserving the natural environment as one of the objectives, but the main emphasis is placed on integrating the land use for economic development.[3]

Korea is one of the most densely populated country in the world with 320 persons per a square kilometer. When it is considered on the basis of cultivated land, which is only 23 percent of the total land area. The question is how we can maximize the use of this precious land for 50 million people in the year 2000 without seriously damaging the human environment.

Toward the year 2000 a rapid urbanization will continue and drastically change the structure and quality of life in urban areas. As metropolitan area expands, the use of uphill and lowland will be accelerated causing considerable environmental degradation like erosion. More high-rise buildings will go up in order to maximize the use of prime land. This creates new microclimatic conditions in the high density area; for example, "heat is land" over the central business district may be established due to heats generated by metropolitan transportation, heating of apartments, and office buildings, modification of ground level and change of atmospheric components. The air temperature in Seoul has been rising last 25 years. This has been attributed to the rapid growth and increasing amounts of various energy consumption within the city.[4] Intensive use of the high density land inevitably generates air pollution which consists of smoke, particulate matters and emission gases. These pollutants cause smog and reduction of sun light. No less serious is the water pollution and potable water supply in the city.

National priority has been given to the development of industrial bases in land-use planning. Land used for industrial bases is about 0.06 percent of the total national land in 1970, and is expected to increase to 0.8 percent in the year 2000. Although only the less than 1 percent of the total land area is used for industrial bases, the environmental impact of industrial activities in these bases is farreaching and this requires a close national attention. Environmental pollution related to industrial bases includes water pollution, air pollution, solid waste and noise from industrial plants. These pollutants affect not only workers in the plant but also neighbourhood areas.[5]

With the enactment of the Reclamation Promotion Law in 1962 cultivated land has been expanded by farmers with the aid of government loans and subsidies. These efforts made to reclaim mountain slopes and seashores as arable land. As a result, during the period of the First Five-Year Economic Development Plan a total of 110,000 hectares of farmland was newly developed. In 1972 large-scale hillside reclamation has expanded significant arable land; for example, 4,000 hectares were reclaimed at Geochang, Jeonbug Province. With these government measures, agricultural area increased by 170,000 hectares, from 2,050,000 hectares in 1961 to 2,200,000 hectares in 1973. Furthermore, the Government plans to reclaim an additional 110,000 hectares of convertible forest and other idle land during the period from 1975 to 1981.[6] This national effort will have significant impacts on watershed ecosystems, water resource, vegetation and other environmental parameters in the reclaimed areas. The magnitude of impacts by the land reclamation on the human ecosystem commends serious environmental consideration. A priori environmental study must be an integral part of the land reclamation planning.

To tap unique sightseeing resources in Korea, the Government has developed seven national parks and other natural areas for tourism. Ambitious plans are made to develop the Jeju Island, Mt. Seolag, Buyeo, and Gongju as resort areas.[6] As seen in the United States, the development of tourism industry and large influx of tourists to these areas will likely to make irreparable damage to the natural environment. Hence, vigorous national effort must also be made to preserve the natural environment in the development plan for tourism and national parks.

Korea is a mountainous country having 67 percent of the land occupied by mountains. Forests are the largest resources endowed by nature which provide water, lumber and habitats for wildlife. During the last half century, mountains have become denuded badly by reckless cutting. From the early 1960's concerted national effort has been promulgated for reforestation. Mutual financing associations and forestry cooperatives have been established in every village, myon and goon (county) with particular emphasis on reforestation and erosion control. However, an accomplishment of reforestation program has not been too significant. The result of this ineffective program led to another new national effort to beautify the land. Forestry Development Law was enacted in 1973 and the First Ten-year National Forest Plan was launched to systematically reforest the country. However, at present there is no significant legal and administrative mechanism for nature conservation and wildlife management through which natural environment be preserved and renewable biological resources be effectively utilized.

Following the world trends, there is a rapid urbanization taking place in Korea. The ratio of urban to total population which was 17.2 percent in 1949, increased to 48.4 percent in 1975. The Government promoted a national city planning program and broadly amended the City Planning Law in 1971 to combat overcrowding in urban areas. According to this law, areas adjacent to large cities, totaling 5,062 square kilometers (5% of the land) have been designated as green belts where no development is permitted in order to prevent the endless sprawl of these cities and to secure a healthier living environment for citizen. Despite of this effort the rapid urbanization continues and the environmental problems associated with it are accelerating at an alarming rate.

Rapid influx of population into cities naturally increases the demand and supply of water, energy, and transportation, and the volume of solid waste. This generates various environmental problems; for example, air pollution related to energy and motor vehicles, and water pollution to sewage and industrial wastes.

Seoul, which has more than 7 million citizens today, is facing serious environmental problems. Two of Seoul's most serious problems stem from heating and cooking which pollutes air, and the handling and disposal of night soil and industrial wastes which pollutes water and indirectly food.[2] Although the Metropolitan Government did not consider them as environmental problems in natural squatters and their settlements pose considerable environmental problems in Seoul. Pollution from industry and motor vehicles constitutes complicated environmental problems. Noise problem is considerable. The handling and disposal of solid wastes is carried out well, although a shortage of disposal sites is already realized.

The ondol[7] which is an unique Korean system for both heating and cooking, is used in houses and apartments at almost all income levels. In the rural areas wood and charcoal are burned, but in Seoul and other urban areas circular anthracite briquets with holes are used. The slow combustion of the briquets produce carbon monoxide which may contaminate kitchen air and sleeping chambers causing the danger of CO poisoning. The ondol is also a major source of ambient air pollution, and is generating 38 percent of all combustion-derived emissions in Seoul. The disposal of briquet ash and almost 30,000 metric tons of dust per year generated by burning the anthracite briquet also pose considerable problems.[8]

The collection and disposal of night soil in the Seoul metropolitan area are one of the difficult and expensive urban problems. Besides pollution from spillage during transfer and at disposal site, a portion of the total night soil collected is discharged into the Han River after fermentation. Food is easily contaminated by night soils. Pollution of the Han River by night soil, among other pollutants, essentially ruled out its recreational value, and perhaps more seriously, it generated special treatment problems for the city's water supply which is pumped from the Han River at five intakes and run through treatment plants. The cost of the Han River pollution is high both in terms of lost recreational resources as well as the cost of purifying the water.[8], [9]

3. Impacts of Industrial Development

Successful implementation of the First and Second Five-Year Economic Development Plans in the 1960's started a rapid development of the heavy and chemical industries in Korea. By 1971, the final year of the Second Five-Year Economic Development Plan, the total production capacity of iron, steel, and rolling plates reached 203,000 tons, 911,000 tons, and 2,025,000 tons, respectively. The total production capacity with construction of Pohang integrated iron and steel mill has been expanded by an annual production of 950,000 tons of iron, 1,032,000 tons of steel and 950,000 tons of the rolling plates.

Industrial bases have been located near harbor and estuaries in the coastal areas of the South and West and along the inland river basin, mainly the Han, Nakdong and Keum rivers. Industrial plants are now concentrated in Seoul, Inchon, Busan, Masan, Yeosu, Goonsan, Daejon, Ulsan and Pohans. The Ministry of Construction is usually instrumental in the site selection for industrial bases. The three major criteria are commonly used in selecting the site are: 1) water supply, 2) transportation, and 3) land value. In other words, industrial bases are located at rural farming areas or coastal areas where materials and products can easily be transported. Because of the way industrial bases are located, industrial pollution affects river system, coastal water, land and atmosphere.

According to the survey made in 1972 the Korean industry with more than 20 employees discharged 810,360m^3 of industrial waste water daily with 471.5 tons of BOD (biochemical oxygen demand), 337.5 tons of SS (suspended solids), 2.3 tons of CN (Cyanide), and 3.4 tons of Cr (Chromium). This is expected to increase to 1,134 tons/day of BOD and 834 tons/day of SS in 1980.[10)]

The Korean National Academy of Sciences reported in 1969 that industry emitted 348,700 tons of air pollutants per year.[11)] The 1973 estimate indicated that Korean industries discharged approximately 244,350 ton/year.[10)] The major sources of air pollution was identified as fuelburning from motor vehicles and heating.

The levels of NO_x and SO_2 in Ulsan, Seoul, and Busan are very high in comparison with rural and residential areas away from industry, although there are considerable differences between data collected by different monitoring groups. Impacts of industrial air pollution on agricultural crops and fruits are reported to be significant. For example, after the oil refinery and the Yongnam Chemical Plant began to operate in 1967, par orchards in Ulsan area had been ruined and agricultural production has suffered considerably.[12] Air pollution from Chinhae Chemical Plant caused considerable damage to agricultural production in Chinhae surrounding the plant.[13]

Although the Public Nuisance Prevention Law sets various emission standards since 1964, there is no way to accurately measure how well industries meet these standards. Further, the present law does not involve itself with matters related to industrial wastes as yet. Major river systems, the Han, Geum, Nakdong and Yungsan, are highly polluted.[19]

Waters of coasts and estuaries where industrial effluents are discharged or carried to by waterways are also seriously polluted. In recent years there have been frequent reports of massive fish kills in the coastal waters of Masan, Chinhae, Samchonpo, and Ulsan. Although there is little scientifically reliable data to support an allegation that they were caused by industrial effluents, it does not take too much imagination to establish a correlation between industrial production and marine pollution. A more detail account of water pollution will be made later in the following section.

At present, it is not possible to determine the existing status of industrial pollution and its environmental impacts or trends in environmental quality, because there are no reliable baseline data available for ambient air quality, water quality, human health, and industry.

Industrial pollution seems to contribute substantially to the total pollution in Seoul, although almost no accurate information is available. In 1976 there were a total of 5,834 registered industries and enterprises in Seoul. Most industries are located in the down stream portion of Seoul, along the Anyang River, and their effects on downstream users, especially in Inchon, were thought to be large. Industrial fuel combustion also contributes significantly to air pollution in the city. 8)

The motor vehicles are the primary polluters in any ground transportation system. Seoul had more than 96,500 automobiles in 1976, and the number has been growing fast, and the trip-making rate of exisiting autos made them equivalent to approximately ten times. They require inordinate amounts of space, and generates many air pollutants and noise. Gasoline combustion by automobiles was estimated to generate 57 percent of the total CO loading in the atmosphere over Seoul, and 41 percent of total hydrocarbons. Diesel combustion contributed another 34 percent to total hydrocarbons and 15 percent of the total dust fall. Since 1965 the level of nitogen oxide has gradually increased, and by 1969 this had risen to dangerously high level even in residential areas. Sulfur dioxide and dust fall have both been increasing since 1969 in all zones of the city, including parks and gardens. Spot checks of CO concentrations showed levels ranging from average values of 33 ppm to highs of 100 ppm in the central district. 3)

4. Air Pollution

Major sources of air pollution in Korea are the combustion of various fuel, automobile emission, and insufficient control of industrial discharges. The coal consumption increased 169.1 percent by 1975 to 10 million tons from the 1965 level, and likewise the consumption of petroleum products, such as gasoline, kerosene, diesel, and oil in 1975 was more than ten times of that in 1965. The anthracite burning is also a major source of ambient air pollution in large cities, generating 38 percent of all combustion-derived emissions in Seoul. Accordingly, the total amount of air pollutants emitted in 1975 is three times greater than in 1965. The monthly average of total dustfall in 1975 was 14.2 ton/km^2 which is higher than the 1965 U.S. level of 13.5 ton/km^2 10).

Seoul consumed about 4,273,000 kiloliters of oil in 1976 alone, which means about 475,000 kiloliters of carbon monoxide emitted into the air of Seoul during the year.[14] In 1976 the total fuel combustion pollutants emitted into the Seoul's atmosphere including SO_x, NO_x, CO, HC and dusts were estimated as 699,277 metric tons.[8] Major pollution sources in cities are fumes from the chimneys of houses, apartment and office buildings related to heating and cooking, and exhaust gases from motor vehicles for air pollution, and the handling and disposal of night soil and industrial wastes for water pollution.

The levels of air pollution in the vicinity of industrial bases in Seoul, Ulsan, and Busan areas are much higher than those of residential areas. In Ulsan the level of NO_x and SO_2 for 1973 were 0.51 ppm (range 0.29-0.92) and 1.59 ppm (1.04-2.46) for vicinity of industrial plants respectively, and on the other hand, the NO_x and SO_2 levels in residential areas were 0.02 ppm for NO_x and 0.038 ppm SO_2.[15] The air pollution in Busan was already bad enough for necessary measure in 1968 with NO_x level reaching 0.46 ppm and SO_2 of 1.51 ppm in the premise of factory and NO_x 0.34 ppm and SO_2 0.70 ppm in the vicinity of industrial plants.[16] Although there are considerable differences between data collected by different research groups, all the data indicated that the levels of air pollution in and near the premise of industrial plants have been much higher than the air quality standards of two industrial countries; 0.04 ppm for Japan and 0.02 ppm for the United States. High SO_2 concentrations in the air in both industrial and commercial areas of Seoul undoubtedly related to the use of Bunker-C oil for heating and power plants.[3]

In 1969 the total fuel consumption of Seoul amounted to 27 percent of the national total. Accordingly, the total emission of the air pollutants was 303,210 tons of 483.6 ton/km^2. This increased to 630 ton/km^2 in 1971. The level of total dustfall has gradually increased to 38.58 ton/km^2/month for industrial area and 18.29 ton/km^2/month for residential area in 1972 from the 1969 levels of 25.1 and 20.7 ton/km^2/month respectively[17]. Likewise, the highest concentration of SO_2 in the air of Seoul recorded for industrial area was more than 0.15 ppm in 1971 and even the annual mean of 0.068 ppm was too high, both of which were much higher than the Japanese standard of 0.04 ppm and the U.S. Federal Air Quality Standard of

0.02 ppm.[17] According to the data of the City Government of Seoul the level of SO_2 in Seoul has dropped considerably since 1973, although the National Institute of Health data showed otherwise. It is highly questionable whether these data truly represent the current level of SO_2.

An analysis of climatological data showed a rising trends of air temperature near ground level in urban area of Korea over the last 40 years. Rho[4] related this trend in Seoul to the population growth and increse of various energy consumption, particularly those of anthracite briquets. This trend will be aggravated by increasing number of automobiles in the city. Since there is no comprehensive baseline data on the existing condition of Korea's air quality, it is impossible to predict the future trends of air quality in different parts of the country. However, the situation of Seoul may examplify generally the air pollution problems in major cities in Korea.

In major cities the slow combustion of anthracite briquets produces carbon monoxide which may contaminate kitchen air and sleeping chambers, particularly when faulty contruction of flues and floors results in leaks. Because the affinity of hemoglobin for carbon monoxide is 200 times greater than for oxygen, uptake of carbon monoxide reduces oxygen-carrying capacity of the blood, exacerbating heart diseases and producing physical and mental sluggishness. Low blood hemoglobin levels, often traceable to parasite infection, also aggravate the effects of carbon monoxide pollution. Significant numbers of death and illness from sublethal carbon monoxide poisoning have been reported last few years, but the number of death and the extent of illness were not known.[8]

It is expected that the total fuel consumption in 1980 would be at least five times higher than the 1965 level and the air pollution level likewise be about six times higher.[18] With anticipated increase in population and the number of automobiles the future perspective of Seoul's air quality is groomy at best unless a definite air pollution control program is initiated. It is the urgent task of the government to set minimum ambient air quality standards as soon as possible. In formulating air pollution policy public health should be the principal criterion on which air quality standards be bases. Emphasis must be placed on ambient air quality related to climatic and seasonal factors of different areas and strict control of emission from mobile and stationary sources.[8]

Permissible concentration of industrial stack emission are excessive and undoubtedly affects the working environment in the industrial plants. It is strongly recommended that industries be made to improve working environment and practice safety procedure. New industries should be required to use the best available and feasible pollution control technology. The effects of air pollution should be viewed from two sides, ambient air pollution and the poor condition of the industrial working environment. Exposure of workers to high concentrations of various pollutants in the factory or workshop is perhaps the most serious aspect of industrial pollution.[8]

5. Water Pollution.

Water resources depend on the annual rainfall. The annual rainfall totals 114 billion m^3 which amounts to the annual mean rainfall of 1,159mm, and yet only 63 billion m^3 of the total rainfalls flow through the river systems in Korea after a loss of 51 billion m^3 due to evaporation. Furthermore, more than 60 percent of the available water resource is lost through annual summer flooding from June to August. After unusable flood water the normal river flows amount to only 24 billion m^3 and the real surface water supply is not more than 11 billion m^3.. In comparison with the current level of freshwater resources the water consumption by agriculture, industry and residential uses already exceeded 11 billion m^3 mark and showed a shortage of one billion m^3 in 1973.[19]

The present shortage of water supply is expected to rise as much as 17 times (i.e., 18 billion tons) in 1981. The national water resources development programs for four major river systems would help to alleviate the shortage but could not provided sufficient supply for rapidly increasing water needs expected by growing human population and industrial production. In addition, increasing human population and ever-growing industries will discharge much greater amounts of waste waters into the river systems and further aggravate water pollution. This will worsen the shortage of clean water.

The major sources of water pollution are sewage disposal and wastewater from residential uses, industrial wastes and wastewater, and agricultural runoffs. In addition, marine pollution is further aggravated by direct discharge of various effluents from coastal cities and industrial plants, and by wastewater and oil from navigating vessels.

In Korea major river and streams have been rapidly polluted last ten years, and adequate, high-quality water supply has been a focus of the national development plan.

Of the total 15,000 industrial plants causing environmental pollution across the nation approximately 7,000 plants are located in the Seoul and Busan areas. Wastewaters from houses and industrial plants flowing into four major rivers-the Han, Youngsan, Keum and Nakdong-were estimated to be about 4 million tons a day in 1971, and would reach about 10 million tons per day by early 1980.[20]

Approximately, 1.9 million tons of wastewater and sewage water go into the Han River a day, and these waters contain a high level of BOD (311 tons/day), a high concentration of heavy metals, and high coliform counts.[14] The level of BOD and heavy metals at all of six intakes were very high. For example, in 1971 the BOD level at Bokwang-dong pumping station was 40.2 ppm, and the BOD at Noryangjin station in the downstream was as high as 29.2 ppm.[17] The Han River with the present water quality is no longer qualified as a suitable source of city water. The sources of this pollution are residential wastewater, human wastes, and untreated industrial wastewaters discharged into the open sewer which flow into the Han River.

Night-soil collection and disposal is important source of water pollution in Korea. Pollution occurs through spillage during collection and transfer and also at the disposal site where the night soils are fermented in large basins but temperature is not too low to kill parasite eggs. Ground water in these areas was also contaminated threatening the health of people who obtains potable water from shallow wells. However, the concentration of waters with human wastes is not seriously taken into account in the control of water pollution.

Pollution of the Han River by night-soil among other pollutants essentially rules out its recreational value, and generates special treatment problems for the city's water supply. The cost of the Han River pollution is high in terms of lost recreational values, the cost of pollution control and the treatment costs. Although the contamination of the Han River with human wastes was recognized, this element of water quality had not been analyzed.[8)] Of course, it is not limited to the Han River. All the cities along the major river systems have no wastewater and sewage treatment plant, except for one and only sewage disposal plant which has a capacity of a quarter million tons per day, and discharge residential and industrial wastewaters into the river system. Although it is illegal to discharge raw night-soil into the water bodies, even today raw night-soils are being discharged directly into river or the total night-soil collection is dumped into the coastal water in several cities.

Integrated steel plant requires as much as 40,000 gallons of water for a ton of finished steel, and 180 tons of water for a ton of petroleum in oil refinery. When an expansion of seventeen major industries is considered for the period from 1965 to 1981, industrial water demand would increase to about 3.67 billion tons by 1981 from the 1973 level of 1.28 billion tons.

An increasing trend of heavy metal concentration in the river and coastal waters is alarming. According to the recent report of the National Institute of Health, heaviest metal contamination was found in the Yongchang-dong area south of the Second Han Bridge where the river water contained 0.0042 ppm of cadmium, 0.0002 ppm of mercury and 0.023 ppm of copper.[21] Under the Second Han River Bridge closer to the city center, the lead concentration was 0.0025-0.0035 ppm between May and November in 1974. The Anyang-chon, one of the dirtiest streams near Seoul, had 0.0176 ppm of cadmium, 0.00083 ppm of mercury, 0.28 ppm of copper and 0.144 ppm of lead. The maximum of 0.01 ppm of cadmium and 1.0 ppm of copper are permissible under the present regulation but no source of potable water is allowed to contain any mercury. It should be noted that over 0.01 ppm of lead in the water is hazardous to human health.[14), 21)]

The recent report of the Korea Atomic Energy Research Institute showed that marine samples from coastal waters of industrial cities, Daechun, Samchuk, Busan, Ulsan, Pohang, and Inchon, contained relatively high concentrations of mercury and cadmium.[22] This report showed that marine fish samples contained 7.2 ± 7.1 ppm (range 2.0-44) of arsenic and 0.31 ± 0.28 ppm (range 0.070-1.5) of mercury; and shellfishes had 6.6 ± 3.6 ppm (range 3.3-14) for arsenic and 0.18 ± 0.21 ppm (range 0.016-0.87) for mercury. Similarly, freshwater fish samples contained 0.35 ± 0.21 ppm (0.010-0.63) for arsenic, 0.61 ± 0.87 ppm (range 0.17-2.9) for mercury, and 0.40 ± 0.60 ppm (range 0.23-1.2) for cadmium.

Of freshwater fish tested the snakehead contained a highest mercury content of 1.9 ± 1.6 ppm (range 0.71-5.5). Carps collected at the Second Han River Bridge station showed much higher level of arsenic content by a factor of more than 50 compared with the sample from the Soyang River, Kangwon Province. The levels of cadmium and mercury tend to increase drastically toward a downstream of the Han River as industrial complex is located along the river between Seoul and the Han tributary. The mercury content of water at the Soyang River, Kangwon (upstream) was 0.12 ± 0.02 ppb; Paldang, Kyunggi Province (before Seoul), 0.63 0.07 ppb, and the Second Han River Bridge, 2.7 ± 0.2 ppb.

Similar pattern was also shown for cadmium and mercury in fish samples.[22]

Coastal waters of sea ports and major bays are getting highly polluted by industrial wastes and wastewaters discharged from industrial plants and oil and grease from boats and ships. The levels of industrial pollutants and oil and grease in Inchon Bay, Onsan Bay, Chinhae and Masan are much higher than the standard of 50 ppm set for conservation of marine resources. The level of floating oil and grease was highest in Inchon Bay with 95 ppm, and was much higher than standard in other areas; Ulsan Bay with 71 ppm, Onsan Bay 55.8 ppm, Chinhae Bay 60.2 ppm, Yeosu and Kwangyang Bay 65.6 ppm, Busah Harbor 61.8 ppm, and Keumkang Tributary 60.5 ppm.[23]

Because of water pollution of rivers and streams potable water supply of major cities is being or will be threatened. The cost for water treatment is rising rapidly, and expected to rise continually for Seoul and Inchon along the downstream of the Han River. The amounts of chemicals used for water treatment for the Special City of Seoul directly correlates with the level of pollution at intakes, and it increases toward the downstream where the water pollution is the worst. In 1976 the cost for treating 1,000 tons of water was ₩533.0 at Guuiri treatment plant but was ₩4,423.0 at Bokwang intake. Furthermore, the excessive costs of water treatment over the Guuiri Plant level has doubled every year since 1973, and is expected to reach ₩90 billion per annum by 1984.[9] As the present trend continues, the effects on downstream uses of the Han River water, particulary residents of Inchon, would be very large indeed in terms of rapidly increasing costs of health care and water treatments.

Although pollution of the Han River has not yet caused major disasters, various environmental indicators suggest the definite trends of worsening water quality of the river system. This would likely lead to unbearable major disasters with great social and political impacts, as long as the current approach to wastewater collection and treatment and the placing of emphasis on extending water supply rather improving water quality continues.[8]

Water pollution problem in Seoul is an inevitable outcome of shortsighted planning with lack of comprehensiveness and neglect of environmental and public health concern, probably reflecting the scarcity of human and financial resources rather than lack of awareness. Furthermore, it is clear that adequate policies, staff, and financial support are crucial to the interrelated problem of housing water supply and wastewater. It is essential for the Seoul City Government to develop a comprehensive planning for housing, water supply, sewage and wastewater treatment, in order to avert environmental disaster. Clearly, as industrial production and pollution increase the demand of industrial water will increase very rapidly. A special consideration must be made to adequately water to high-volume uses. At the same time, a definite policy must be implemented that only the best quality water be provided for food-processing plants, pharmaceutical industries, central markets, slaughter houses, and other activities that handle products ingested by humans.

6. Solid Waste and Noise Pollution.

Among the various environmental pollution problems facing Korea, solid waste is at present the least serious one. Abundant and, cheap labor, and scarce resources in most urban areas of the country so far prevent a serious solid waste problem. In Seoul, for example, solid wastes are efficiently collected and recycled by large numbers of collectors, scavengers or buyers who find value in wastes. However, it is believed that this situation is rapidly changing as per capita income rises.

The anthracite briquet burning for the ondol produces about 25 percent ash by weight, which are the large portion of the urban solid wastes in winter time. In Seoul an average of 7,000 tons of solid wastes was collected a day in 1973, and roughly 77.6 percent of this was briquet ashes.[24)] Also, the making, handling, and burning of anthracite generate almost 30,000 metric tons of dust per year. To find a suitable disposal site already becomes a real problem for Seoul.[8)]

There is little that can be done to improve on the urban solid-waste management as long as cheap labor and scarce resources exist. As shown in the United States, solid-waste management will become a considerable problem in terms of labor costs for collection, handling and disposal sites as the national per capita income rapidly rises. It will be necessary to develop a concerted policy and implementation plan for solid-waste management in urban areas with special emphasis on recycling of used materials.

If major components of solid wastes are properly recycled, a significant amount of foreign currency would be saved. For example, 140,000 M/T of copper amounted to $30 million and about 450,000 M/T of pulp and papers costing $160 million were imported in 1974. If they were recycled at the U.S. rate, there is a potential to save an estimate of $45 million from the import of these materials.[9)]

Noise is no less a problem than air or water pollution although a very little attention is given to it. In 1971, the mean daily level of noise pollution in Seoul was between 75 and 80 decibels, while the 1969 measurements showed 65.9 decibels, with peaks at the city center as high as 85.2 decibels. It has been known that such levels are not conducive to sound sleep, impair intellectual performance, and decrease productivity.[2)]

The mean daily level of traffic noise in Seoul appears to be decreasing since 1973 with its peak in 1972, while the noise level in residential area has an increasing trend.[9)] No analytical approach has been utilized to evaluate contribution-factors to the decreasing trend of traffic noise level. Enforcement of the Noise Control Act effective on March 14, 1973 and the opening of the metropolitan subways on August 15, 1974 could have contributed to the decrease. On the other hand, the increasing trend of noise level in the residential areas of Seoul may be explained by the rapid modernization of normal daily life accompanied by the use of various noise sources such as mixer, blender, vacuum cleaner, laundry machine, television set, hi-fi radiogramophone, motorcycles and automobiles. Scientists now tend to agree that the noise level for potential hearing loss begins at about 70 decibels, while, in the living room, the vacuum cleaner may put out 80 decibels; the television set, 70-80 and, if there is a hi-fi set in the house, the level can run upwards of 100. Outside in traffic, 70 decibels is a typical level; cars and trucks roar along at some 90 to 100 decibels with motocycles topping the noise parade at more than 100.[25]

7. Renewable Resources and Conservation[26]

In developing nations economic planners tend to think of natural resources only in terms of minerals and materials related to industrialization. Usually, the management and development of renewable biological resources are not considered in the context of economic development. Neverthless, a sound management of biological resources shall become very important in the maturing phase of economic development, since national development is geared to improve the living standard of the people and biological resources continually provide basic materils for man's survival such as foods, fibres and shelters.

Biological resources are uniquely renewable, unlike other material resources, under direct influences of the ecosystem processes. They include forests, wildlife, fish, domestic animals and crops. Management and improvement of these resources are an artificial manipulation of ecosystem dynamics.

Forests are the largest biological resources endowed for Korea by nature which provides water, lumber, and habitats for wildlife among many others. They supply basic materials for national development. To reforest the country the Forest Development Law was enacted in 1973 and the First Ten-Year National Forest Development Plan has been effectively initiated. This is a promising start for national conservation. Forest protection program should become an integral part of the national forest development plan in order to have this program more effective and fruitful.

Forest protection is an manipulation of the forest ecosystem functions to conserve forests. There is no quick solution to forest protection which requires, long-term research and planning. A short-sighted policy decision in forest protection and conservation is for the most instance counterproductive. For example, indiscriminated sprays of insecticides for pine gall-midges, whose heavy infestation makes serious damage to Korea's forests, further aggravated the situation.[27] Despite of insecticide sparys the range of infestation has increased year after year throughout the country.[28] Forest protection policy must be based on scientific data collected through continuous research, and the forest pest control should become truly a management of pest population in an integrated control approach.

For last twenty years the Korean agriculture has made more than 60 percent increase in food production through the introduction of highyield strains of food crops and the extensive application of fertilizers and pesticides. The consumption of chemical pesticides including fungicides and herbicides has increased an average of 20 percent every year since 1970, and by 1973 reached 36,000 M/T. According to the Government report 10.3 kg/ha would be applied to tillable farm lands this year. Nobody can predict at this time when the level of pesticide application will be stabilized. For chemical fertilizers the rate of increase was much greater, reaching an annual consumption of 350,000 M/T in 1973.

To maintain a high agricultural production requires greater demands for water, fertilizers, pesticides and machinery, and yet the effect upon productivity of various inputs gradually levels off beyond certain points and may even reverse itself. In addition, fertilizers and pesticides deteriourate the quality of the human environment in many ways. For example, excessive use of chemical fertilizers does not necessarily give more yields beyond optimum top production but results in overfertilization of the water bodies causing eutrophication in the aquatic ecosystem.

In Korea the first pesticide stirred up the public concern was PMA, an organic mercury-based pesticide which had been widely used for the treatment of seeds. Because of the mercury poisoning, PMA had been banned from using for seed treatment in Japan by 1968, and for spray in Korea by 1971. Neverthless, about 2,300 tons of methyl mercury contained in various pesticides were used in Japan and 216 tons in Korea for the period of last 15 years. ccoding to the report of the Japanese Ministry of Science and echnology the level of mercury for 1972 in the field without any application of mercurial pesticide was 0.06 ppm but the similar area with sprays of these pesticides was 0.13-1.04 ppm in rice field and 0.35-2.20 ppm in apple orchard.

The accumulation of pesticide residues is well examplifed by DDT. In 1968 a high concentration of BHC residues was found in milks in Japan, and the similar concentration was discovered in milks and foods in Korea by 1974.

At present, there is no legal standard in Korea for the residue tolerance in food stuff, and the only mean to regulate the residue level is a legal limit to the preharvesting intervals of insecticide spray. It is an urgent task of the government to set the minimum tolerance of pesticide residues for each pesticide in terms of the maximum acceptable daily intake (ADI), practical residue limit (PRI), and food factor (FF) as soon as possible.

The Office of Fishery listed the five major sources of marine pollution; 1) coastal industrial bases, 2) dam construction, 3) oil and grease spill from navigating vessels, 4) coastal power plants, 5) extensive use of fertilizers and pesticides. Since 1965 several major legal actions have been filed against the polluting industries. In September 1966 the amount of ₩17.5 million was paid by the Ulsan Refinery to coastal fishermen as a compensation for the pollution damage to the fishery. In january 1967 more than ₩59 million were paid to fishermen as a compensation for the damage made by construction of waterway from Sachun-Namkang Dam. There have been pollution damage suits too numerous to state all here, but it is a fact the number of cases is increasing every year.

The Korean coastal waters are increasingly contaminated with heavy metals. Marine samples from coastal waters of industrial cities, Daechun, Samchuk, Busan, Ulsan, Pohang, and Inchon, contained relatively high concentrations of mercury and cadimum in addition to other pollutants such as pesticides, oils, excessive nutrients and industrial wastes.[22] To protect marine resources industrial pollution should be curbed immediately by a definite national policy which includes legislation setting permissible tolerence for pesticide residues and trace metals.

Many species of plants and animals in Korea became extinct and many more are in danger of extinction. So far 108 species of plants and 40 species of animals and birds have been placed on the list of endangered species and protected from extinction by the government as a result of vigorous efforts of biologists and conservationists. Wild plants and animals are multi-purpose biological resources. For instance, they not only have aesthetic values but also are invaluable assets for tourism industry. Furthermore, properly managed wildlife and freshwater fish provide substantial protein supply and sports.

Korea lacks a clear mandate for conservation, and a sound national program is badly needed for conservation and wildlife management. Management of renewable resources and conservation is an artificial manipulation of ecosystem dynamics, and this requires a long-term planning. Accordingly, a national policy decision on biological resources along with environmental protection and conservation has to be made in the context of long-term benefits to the nation and the people of Korea.

8. Pollution control and Environmental Technology

The Korean environment is deteriorating and the present state of environmental pollution will be further aggravated as the nation pursues a rapid economic growth. The environmental condition of this nation primarily comes from the lack of national commitment and industry's willingness to control pollution. Most industrial plants have either inadequate pollution control facilities or none at all. Several largescale plants built within last ten years are equipped adequately with pollution control facility, and yet they are usually idle because of high operating cost and the lack of environmental zeal.

Before 1960 neither the government and nor industry recognized the need of pollution control. In recent years environmental deterioration has been noted and pollution control has been considered necessary. However, both the government and industry have not been willingly active in curbing industrial pollution mainly because there is no visible economic incentive in pollution control. The inital investment for pollution control is considered too costly and "unproductive" in real economic term, and thus pollution control is not included in the budget or even if it is budgeted the fund for pollution control is used for other activities. This economic shortsightedness is the major cause of today's industrial pollution, and this should be corrected soon.

As discussed already in previous sections, economic impacts of industrial pollution are innumerable. Damages to agriculture, fisheries and aesthtics and adverse effect on human health have been well documented. The present condition of environmental pollution will certainly be aggravated without definite national efforts, since large number of additional industrial plants are planned for construction in different parts of the country under the Fourth Five-Year Economic Development Plan.

Pollution control is expensive but it is an inevitable necessity for the national wellbeing. Dirty air and polluted water are not some thing we can live with too long, and they affect our health and ultimately our survival. We must have a clean environment.

The Hankook Caprolactam Corporation in Ulsan spent about $1.5 million for pollution control facility of the total construction cost of $39.6 million. This amounts to not more than 3.8 percent of the total construction cost. This includes a sulfur gas absorber, an oil separator, a biological waste-water treatment tank, and air incinerator. The Japanese-invested Ulsan Inorganic Chemical Company reported that 40 percent of its total investment was spent for antipollution equipments. Neverthless, the investment rate for pollution control facility in Korea is generally very low.[29)]

Much of the pollution control technology has to be imported from technologically advanced countries. As pollution control efforts by industries increase, public and private expenditures for pollution control equipments will be substantially high and will make a considerable drain on the foreign currency. At the same time, imported equipments for pollution control may not be suited for many old plants. For economic and practical reasons pollution control technology should be developed and the equipments be manufactured within the country with economic incentives and the governmental support.

Environmental technology can be developed by already existing technological capacity in Korea. Some national institutes are adequately equipped with both facilities and technology to develop pollution control equipments suitable to Korean industrial plants. Such equipments can be manufactured for foreign markets. In this way environmental technology not only contributed greatly to environmental protection and conservation becomes a potentially profitable industry.

9. Conclusion and Recommendations

It is a fact that the ultimate common goals of national development and environmental protection are the improvement of contemporary human life and the future well-being of Korean people. At present, the magnitude of environmental pollution warrants serious national attention and reassessment of national development goals to achieve the betterment of economic life with pollution-free environment for the Korean people.

In finding reasonable solutions to the perplexing problems of environmental pollution a strong national commitment must be made and reflected in national policy supported by strong fiscal backing. Not to repeat enormous environmental problems experienced by many developed countries, strong environmental planning must be implemented in every levels of national development plan and a comprehensive environmental policy should be formulated to clean up environmental pollution and to safeguard further deterioration of Korean environment. This is the only way to achieve economic wealth in a livable environment, and to do this demands nothing less than the full mobilization of all of our available brain power. However, there is a definite, measurable and progressive deterioration in Korean environment especially in and around urban areas, while little progress has been made in the effective management of industrial pollutions. Some anti-pollution facilities are well designed and operated but others are ill conceived, poorly designed or fail through overload. For example, the existing and planned sewage treatment capacity for the city of Seoul is inadequate to protect the river.[30)]

The emission standards applied under the Public Nuisance Protection Law are arbitrary and bear no relation to the condition of the receiving bodies, their self purification capacity or their designated use (in case of water). Therefore, unless more vigorous action is taken to protect the environment continued deterioration is inevitable. Such deterioration will increase the purification costs of water for domestic and industrial use and further endanger public health. Deterioration will further exacerbate difficulties caused to industrial production already observed in the Nakdong River, thus limiting industrial growth and hazarding attainment of current export targets.[30)]

The root problem is the lack of any short or long term plan for the effective management of environmental problems and the situation is exacerbate by the absence of effective central direction or unified control of environmental management under the aegis of a single Ministry with adequate legal authority.

Further difficulties in water pollution control in Korea arise from the lack of definitive data concerning water resources, existing and future demands for water supply and the present condition of the rivers under various states of flow.

Existing environmental legislations is also insufficiently detailed and comprehensive as a basis for the management of current problems.

It is, therefore, to be strongly recommended that:

1) In view of the magnitude and complexity of environmental problems in Korea, responsibility for all aspects of environmental management should be coordinated under a single ministry of central government responsible to the prime minister.

2) Management of water resources should be the responsibility of central government through management boards set up on single river basin (or catchment) area bases, and the same management boards should retain overall responsibility for monitoring and control throughout each river system. Neither executive nor administrative authority should be released to local government.

3) The relevant law should be revised and strengthened to prove the necessary powers which may in part be delegated by the Minister to the operating Boards.

4) A national environmental research and/or advisory centre accompanied with a national environmental information system should be established. The centre should have responsibility to the Minister for coordination of monitoring and survey studies; for fundamental and applied research for the definition of standard procedures; for evaluation of data and for advice on the technical bases of emission standards, forward planning and legal sanctions.

5) As for the research programmes, more emphasis should be placed upon applied rather than fundamental research and the national expertise should be coordinated through the national research and/or advisory centre.

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At KIST Workshop

Systems Development Studied

A four-day workshop for systems development was opened yesterday at the Korean Institute of Science and Technology auditorium with three Korean scientists as main speakers and three American scholars as guest speakers.

The workshop is divided into three parts: transportation systems, energy systems and environmental systems. The meeting was organized by the Ministry of Science and Technology with an eye to further public interest in the three fields closely related to everyday life and to seek close technical cooperation between Korea and the United States.

Speaking on transportation problems in modern society, Dr. Richard L. De Neufville, a professor at the Massachusetts Institute of Technology, viewed that policy makers are strictly required to pay much attention to the "quality of entire service" reliable, securable and comfortable to passengers.

Traffic Capacity

Everyone is apt to think only about the capacity of traffic vehicles and displacement, the visiting transportation expert said. City planners are asked to make maximum efforts to seek ways to attract passengers, he asserted.

Prof. Daniel P. Loucks of University Cornell said, "the environmental issues required us to be very careful with safety measures and measures should be taken to ensure we are not stepping into the unknown." "Unless we do something quickly to prevent further degradation, it will be very costly to meet the requirements," he continued.

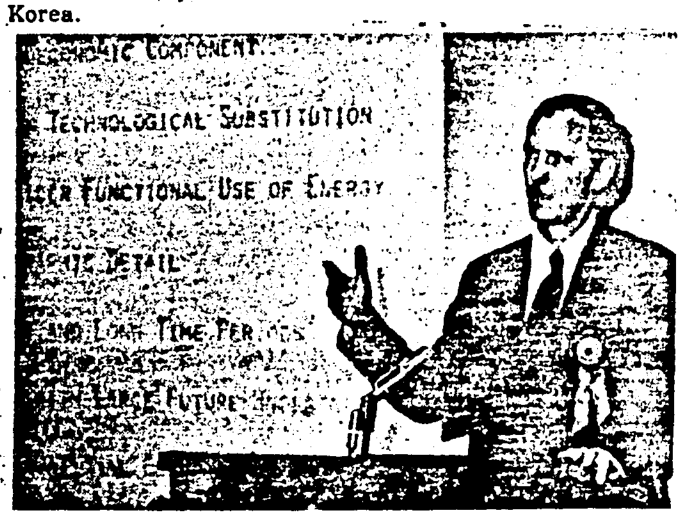
Dr. Philip F. Palmedo of the Brookhaven National Laboratory said Korea has to try to develop local, conventional resources such as coal, sun and wind to supply energy needed for the nation's industrialization.

He also noted that "social role of energy" must be respected in the course of working out energy policies.

Planners are required to consider the impacts of social, economic development and environmental factors prior to fixing their energy programs, he said.

One of the best energy policies is to recognize the need for energy conservation, he opined. In this context, he went on, the American policy to switch from oil to coal is well designed.

Meanwhile, four Korean specialists presented keynote speeches at the meeting — Hwang Kyu-bok of the Korean Institute of Science and Technology on methodological problems of urban transportation, John Poong-eil of the Korean Atomic Energy Research Institute (KAERI) on energy supply and demand modeling, and power system planning analysis, and Rho Chae-shik of KAERI on environmental problems in Korea.



Korea Herald Photo

Dr. Philip F. Palmedo of Brookhaven National Laboratory speaks on energy systems at a workshop for systems development which opened at the Korean Institute of Science and Technology auditorium yesterday. The workshop continues through Friday.

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US Expert Says

ROK Energy Systems Analysis Starts Well

By Hong Son-hi

A visiting American scientist cited that energy systems analysis had started very well in Korea.

"I'm very pleased to find a number of capable people in the field of systems analysis in this country. Those who work at the Korea Development Institute (K D I) and the Korea Atomic Energy Research Institute (KAERI) presented a good start on energy systems analysis," said Dr. Philip F. Palmedo from the Brookhaven National Laboratory in Upton, N.Y.

Palmedo

Dr. Palmedo, head of policy analysis division of the laboratory's energy systems center, discussed energy systems analysis and development at a four-day workshop sponsored by the Ministry of Science and Technology. The workshop ends on Friday.

The ministry organized the meeting to promote public interest in the three fields of transportation systems, environmental systems, and energy systems, which are closely related to daily life, and to seek close technical cooperation between Korea and the United States.

Other American scholars invited to the workshop were Prof. Richard L. De Neufville of the Massachusetts Institute of Technology on the transportation category, and Prof. Daniel P. Loucks of University of Cornell on the environmental category.

Palmedo said, "I think the difficulty now exists here is to get institutional framework mixed up with professional capabilities. In the planning phase of energy supply, engineers and economists have to get together."

He continued to say that economic, technical, and social problems people face were very different in each country, and there was no simple solution but only a systematic way of looking at all implications of a particular policy.

It is the systems analysis to understand relationships between all of the important elements of the problem," according to his explanation.

"Therefore, you must conserve energy, make efficient use of energy, and also respect the social role of energy," said the American nuclear engineer.

The American noted that expenses to prevent and solve possible environmental matters must be included in the budget for energy supply.

But decision-makers who are stingy in allotting only two or three percent of the total expense for environmental problems are not easily grasped in a short time, he opined.

Asked to give comments on the energy supplying means currently being used and to be used in a few years here, Palmedo pointed out the limited coal resources, totally imported crude oil, and also limited resources for hydro generation.

Meanwhile, he said that the major elements of the nuclear power plant are based on imported technology.

Solar energy is of good potential here for water and space heating, but it's too expensive to produce electricity.

Though a new-type of energy supply means like atomic, solar, tidal, and wind generation requires huge sums of money, but people must develop whatever resources they can use, Palmido disclosed.

He again stressed that there was no simple solution, and all conventional and new resources should be mobilized under an integrated system.

On the Carter energy policy, the doctor said, "It's good in a short-term aspect, but there is a problem in the long-term plan due to stop production of breed reactors."

He worried the Carter's policy of stopping development of breeder reactors would hamper technology for the improvement of nuclear reactors.