THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH

MINISTRY OF SCIENCE, TECHNOLOGY AND ENERGY

MESSAGE FROM THE GOVERNOR

Having been in existence now for more than two decades, the Thailand Institute of Scientific and Technological Research may be said to have come of age. During the past years, TISTR has re-aligned its R & D priorities in accordance with and in response to the country's needs. In addition to the increases in manpower, financial subsidy as well as other essential facilities, the increased experience and professional skill of our personnel are also vital to the competence of TISTR. It is necessary that TISTR continues to enhance its capability in order to serve the industrial development policy of the Minister of Science, Technology and Energy who has cleary emphasized that the provision of services, the promotion of employment and the important role in national development are the major responsibilities of TISTR

(Dr. Smith Kampempool)
Governor

HISTORY

The Thailand Institute of Scientific and Technological Research (TISTR) is a non-profit making state enterprise under the Ministry of Science, Technology and Energy (MOSTE). TISTR was originally set up by the Applied Scientific Research Corporation of Thailand Act B.E. 2506 (1963) which was repealed and replaced by the Thailand Institute of Scientific and Technological Research Act B.E. 2522 (1979) following the establishment of MOSTE in the same year.

OBJECTIVES

TISTR has the following objectives:

* To initiate and conduct research and to provide scientific and technological services to state agencies and private enterprises for economic and social development of the country;

* To conduct scientific and technological research in order to promote the utilization of natural resources appropriate to the economic conditions, environment, health and welfare of the people;

* To improve productivity in accordance with the Government policies by propagating the results of scientific and technological research to benefit the country in agriculture, industry and commerce;

* To train scientific and technological researchers;

* To provide for the testing and measuring services and other scientific and technological services.

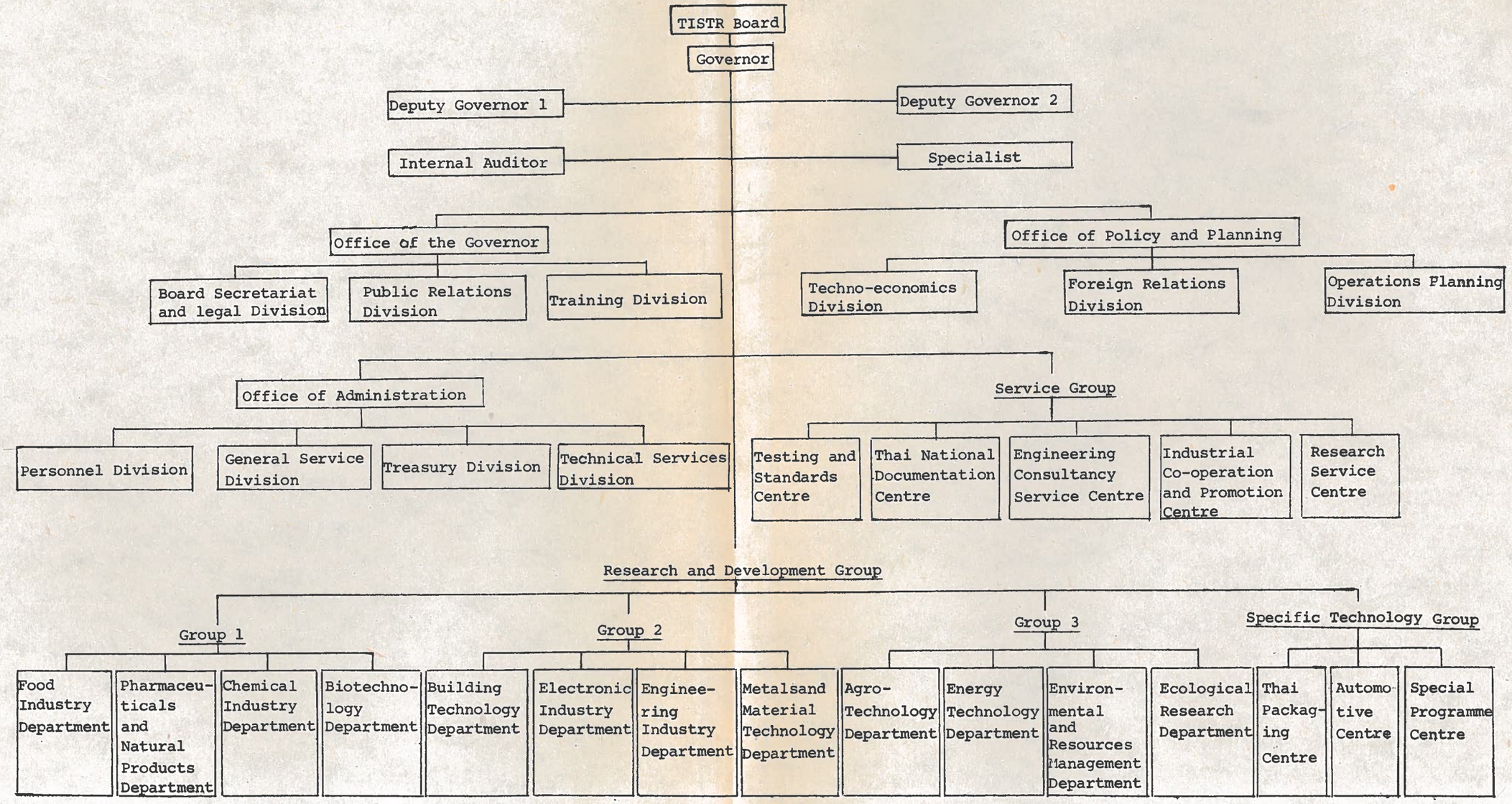
TISTR'S MAIN POLICIES

* To expedite the policies of the Ministry of Science, Technology and Energy dedicated to promoting the country's scientific and technological efficiency with the aim of self-reliance. This will be done by giving encouragement, incentive, assistance and support for the use of the results of research and development to tackle economic and social problems on all fronts.

* To mobilize the country's human resource to work for the development of scientific and technological research in order to effect practical operational results. This includes measures for screening, controlling and distributing technology systematically, and also for encouraging local inventions and high technology productions in future.

* To operate as a "center of excellence" responsible for the provision of scientific and technological services, such as in testing and standards, supply of relevant information and consultation to the government and private sectors, both locally and regionally.

* To work in close cooperation with the private sector engaged in various enterprises and with research and development units in order to build up an atmosphere in which science and technology are seen as means by which the national problems may be solved.


TISTR Board
Governor
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Deputy Governor 2
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Technical Services Division
Service Group
Testing and Standards Centre
Thai National Documentation Centre
Engineering Consultancy Service Centre
Industrial Co-operation and Promotion Centre
Research Service Centre
Research and Development Group
Group 1
Group 2
Group 3
Specific Technology Group
Food Industry Department
Pharmaceuticals and Natural Products Department
Chemical Industry Department
Biotechnology Department
Building Technology Department
Electronic Industry Department
Engineering Industry Department
Metalsand Material Technology Department
Agro-Technology Department
Energy Technology Department
Environmental and Resources Management Department
Ecological Research Department
Thai Packaging Centre
Automotive Centre
Special Programme Centre

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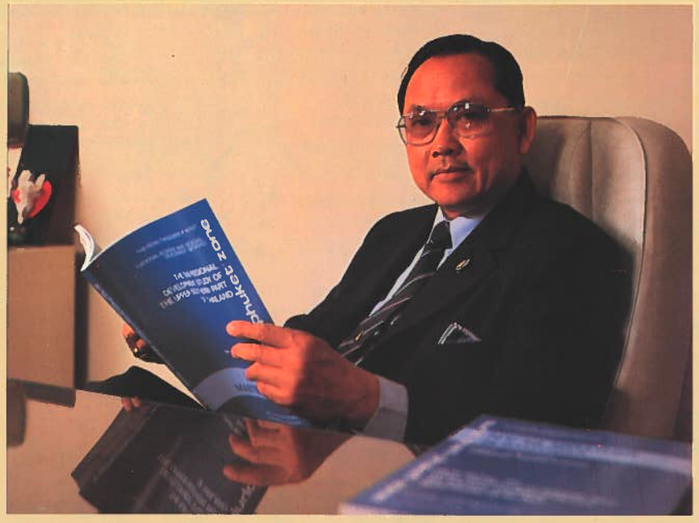
Lt. Gen. Phya Salwidhannidhes October 16, 1964 - October 15, 1969	Governor	
Mr. Insee Chandrastitya November 16, 1969 - October 7, 1971	Governor	
Mr. Tab Nilanidhi October 7, 1971 - October 3, 1975	Governor	
Mr. Wadanyu Nathalang October 6, 1975 - June 22, 1979	Governor	
Mr. Smith Kampempool June 23, 1979 - March 23, 1980	Acting Governor	
Mr. Smith Kampempool March 24, 1980 - Present	Governor	

EXECUTIVE ADMINISTRATORS



Governor

Smith Kampempool, Ph.D.

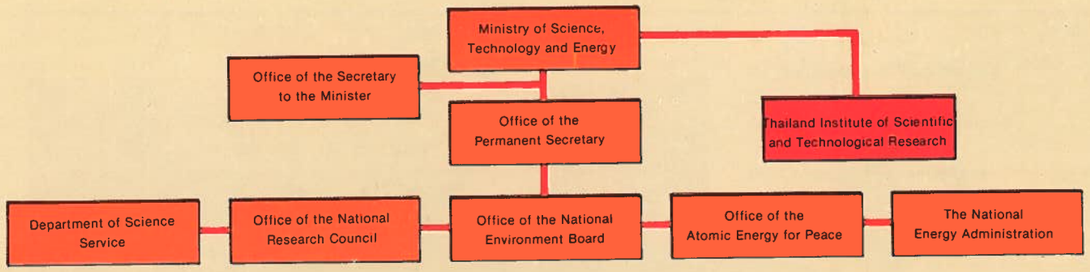
Deputy Governor

Santhad Rojanasoonthon, Ph.D.

Deputy Governor

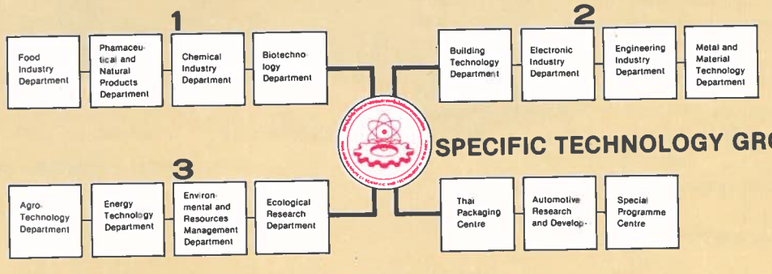
Yenchai Laohavanich, Ph.D.

THE MINISTRY OF SCIENCE,TECHNOLOGY AND ENERGY (MOSTE) ORGANIZATION CHART



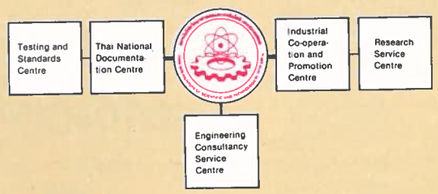
TISTR ORGANIZATION CHART : RESEARCH AND DEVELOPMENT AND SERVICES

RESEARCH AND DEVELOPMENT GROUP

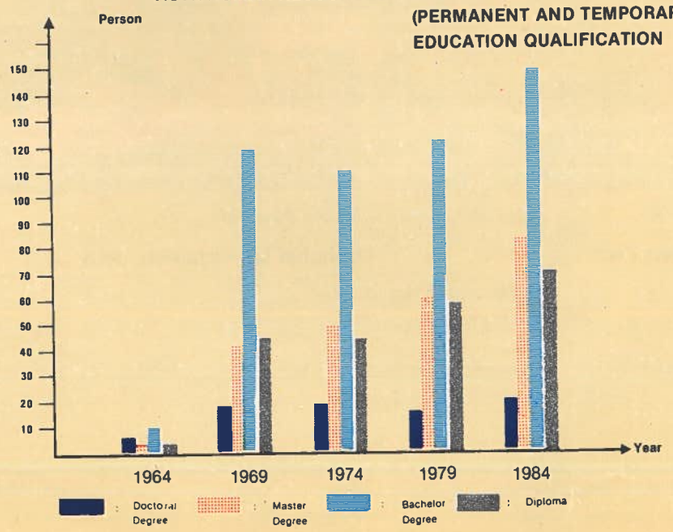


SPECIFIC TECHNOLOGY GROUP

SERVICES GROUP

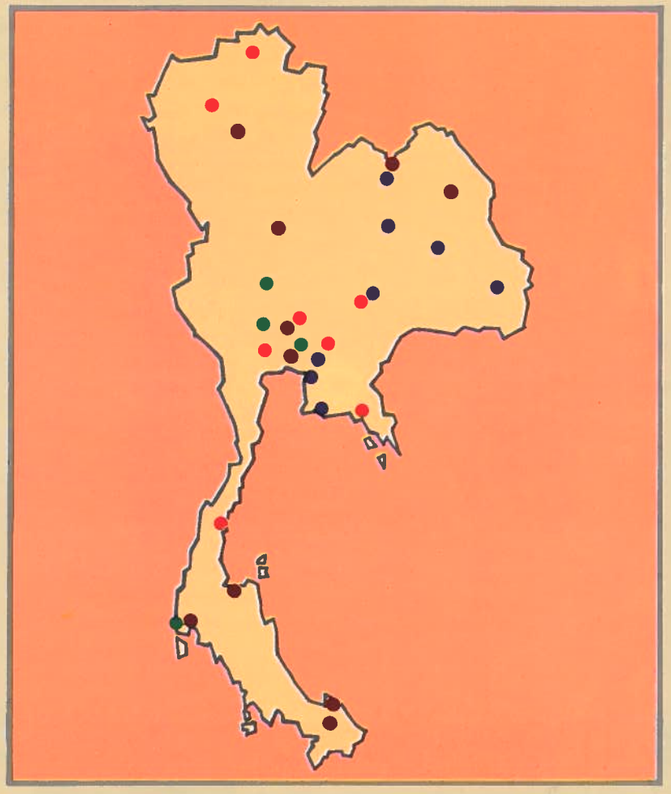


TISTR HUMAN RESOURCES : SCIENCE AND TECHNOLOGY STAFF (PERMANENT AND TEMPORARY) BY EDUCATION QUALIFICATION



ACTIVE RESEARCH AND DEVELOPMENT PROJECTS

TITLES OF ACTIVE RESEARCH AND DEVELOPMENT PROJECTS BY SOURCES OF FUND



TISTR FUND

GOVERNMENT BUDGET

PRIVATE SECTOR FUND

OTHER GOVERNMENT AND STATE ENTERPRISES FUND (CONTRACTS)

- Development of Cassava Products
- Research and Technology for Rural Development in Khlong Muang Land Reform Area at Saraburi Province
- Low-Cost Portable Well Drilling Equipment up to 200 ft for Self-Help Village Uses
- Design of Low-Cost Reverse Osmosis Desalination Equipment for Brackish Water
- Process Improvement for Small-Scale Food Industry
- Fruit and Vegetable Postharvest Technology Implementation System
- Pre-Feasibility Studies on Some Potential Industries
- Study on Utilization of Alternative Energy Technologies for Rural Development
- Development of Bamboo Utilization in Rural Housing Construction
- Research and Development in Industrial Production of Essential Oils, Perfumery and Spices
- Pilot Project on Technology Transfer of Shiitake Mushroom Cultivation in the Northern Highlands
- Rural Housing Development of Piedmont Plateau Area of Prachinburi Province
- Development of Agricultural Technology for Coastal Sandy Soil According to His Majesty's Desire
- Establishment of Thai Packaging Centre
- Alcohol Production for Alternative Energy from Agricultural Materials
- Production of Solid Fuel to Substitute Firewood for Rock Salt Industry
- Facial Moisturizing Cream Development
- The Development of Rose Preparations
- Papain Production from Papaya Latex
- The Development of Garlic Natura Coating Tablets
- The Development of Lime Preparations from the Lime Waste
- The Development of Odourless Garlic Natura
- Aloe Preparation
- The Utilization of Papaya Waste
- The Development of Capsicum Oleoresin (Pilot Scale)
- The Development of Cream Mask
- The Development of Cleansing Cream
- Acute Toxicity and Male Sterility Tests of Epibloc on Six Rat Species
- Water Quality Monitoring Programme for Impact Evaluation of the Mining in Mangrove Forest, Bang Nai Si, Ta-kua Pa, Phangnga
- Electronic Smoke Precipitator
- Development on the Industrial Production of Pharmaceuticals from Thai-Traditional Pharmacopoeia
- Feasibility Study on Alcohol Production for Energy Substitution
- Environmental Impact Assessment of SEA PORT and LPG Distribution Depot Project, at Surat Thani Province
- Environmental Impact Assessment of Natural Gas Separation Plant Project, Map Ta Phut, Rayong (Petroleum Authority of Thailand, PTT.)
- Environmental Impact Assessment of Offshore Mining, Provincial Administration Organization
- Master Plan for Tourism Development of Surat Thani Province, Tourism Authority of Thailand
- Supervision of Construction of Waste Water Treatment Plant at Ayutthaya Distillery, Liquor Distillery Organization
- The Development of the Production of Protincture Ginger
- The Study on Anti-fertility Medicinal Plants
- The Development of "H.R.H. Princess Mahachackri Sirindhorn Medicinal Plant Arboretum" of P.T.T. at Map Kha, Rayong
- Pre-Feasibility Study on Utilization of Alternative Energy for Water Lifting
- Feasibility Study of Biogas Application in Rural Areas
- Collection of Plants and Animals of Thailand
- Dusit Zoo Museum
- Sewage System and Solid Waste Management at Lampang Municipality
- Post Environmental Evaluation of Bang Lang Dam, Electricity Generating Authority of Thailand (EGATT)
- Survey of Priority Products in Chemical and Agro-Based (Food) Industries

OVERSEAS GRANTED RESEARCH PROJECTS

PROJECT TITLE	SOURCE OF FUND
Fruit and Vegetable Post Harvest Technology Implementation System	IDRC, Canada
Physiological, Chemical and Storage Characteristics of Mangoes (and some other tropical fruits) in South East Asia	ACIAR, Australia
Processing and Preservation of — Fruit and Vegetable — Cereal, Legumes	Australian Government (ASEAN)
Process Improvement in Small Scale Food Industry (Extension) : Mung Bean Noodle Factory	IDRC, Canada
Study on Grain Amaranth Production in Thailand : Utilization as Food Products	NAS, U.S.A.
Development of Microbial Culture Collection	UNESCO
Alcohol Production for Alternative Energy from Agricultural Materials	JSPS, Government of Japan
JSPS - NRCT Cooperation in Biotechnology	Government of Japan

PROJECT TITLE	SOURCE OF FUND
Development on the Industrial Production of Pharmaceuticals from Thai Traditional Pharmacopoeia	UNIDO
Study on Vesicular-Arbuscular Mycorrhiza and Their Combined Effects with Nitrogen-Fixing Bacteria in Legumes	IFS, Sweden
Field Trials and Testing of Selected Species of Fast Growing Nitrogen-Fixing Tree in Thailand	NAS, U.S.A.
Production of Animal Feed from Cassava and Agricultural By-product in Thailand	KAIST, Korea
Oil Seed Crops Development Programme	EEC
Fruit and Vegetable Container (ASEAN Project)	Australian Government
Winged Bean Seed Multiplicatior	IBPGR, FAO
Development of Agricultural Technology for Coastal Sandy Soil According to His Majesty's Desire	FAO/RAPA

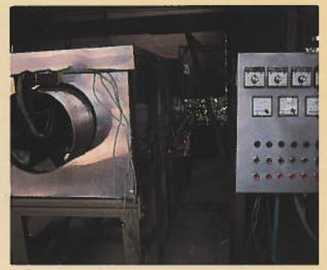
FOOD INDUSTRY DEPARTMENT (FID)

The Food Industry Department (FID) sets targets for research and development of the food industry to serve the demands of local market and/or export - oriented production and to solve problems encountered by industrial entrepreneurs. Operation of the FID includes R,D,E & I facilitating with laboratory and pilot plant; consultations for commercial production; transfer of technology to industrial sectors; and the analysis and testing of food products.

FID places emphasis on the following R & D activities:

* Post-harvest technology of agricultural produce to reduce loss through handling, transportation and storage; and to achieve suitable quality for export as primary commodities and for use as raw materials in the food industry;
* Production technology of small - and medium - scale processed food factories in order to achieve quality and efficiency;
* Processing of agricultural produce in order to add to their value and to permit export of processed food products;
* Design of processes, equipment and plant layout.

Processing of tangerine juice.



Garifier designed by TISTR for pilot-scale production of Gari.

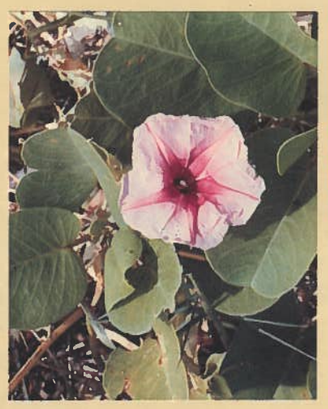
High nutrition and low cost snack products.

PHARMACEUTICAL AND NATURAL PRODUCTS DEPARTMENT (PND)

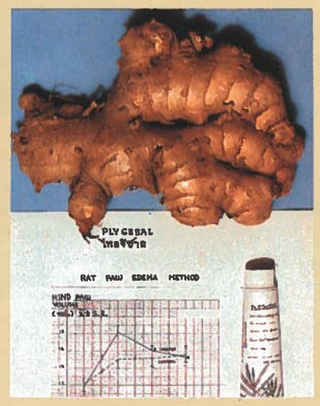
The Pharmaceutical and Natural Products Department (PND) carries out research and development activities leading to commercial production of medicinal plants in the form of raw materials, extracts, and drugs; as well as indigenous natural products which include essential oils, perfumeries, cosmetics, cleansing agents, other toiletries, and household preparations. Services for the analysis and testing of products under these categories are also available.

The operation targets of PND are as follows:

* To develop technology for the production of indispensable drugs from indigenous raw materials;
* To develop technology for the production of standard medicinal plants use as raw materials in the drug industry, both for export and for import substitution;
* To develop potential utilization of agricultural and industrial wastes; and
* To promote basic scientific and technological knowledge dealing with pharmacology, toxicology and clinical tests generally.



Ipomea pes-caprae has been proved by pharmacological and toxicological studies plus preliminary clinical test, to possess antagonistic effect against histamine, certain insects bites and jelly-fish burns, without side-effects. Production of a drug from this medicinal plant is being developed.



Anti-inflamatory active substance extracted from *Zingiber cassumunar* has been confirmed for its pharmacological property and therapeutic uses without undesirable side effects. Plygesal cream is being developed for economic evaluation and industrial production.

CHEMICAL INDUSTRY DEPARTMENT (CID)

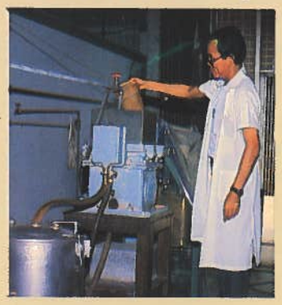
Research and development conducted by the Chemical Industry Department (CID) are aimed at developing commercial products in response to the demands of local and foreign markets. Operations include the potential use of surplus and waste materials from the chemical industry to alleviate problems concerning production cost, process efficiency and pollution abatement, and improvement of existing technology appropriate to local chemical industries, as well as selection and modification of advanced technology for transfer to various industries.

CID places its main emphasis on the following R & D activities:

* Fat and oil industry with special attention on the potential use of oil-bearing vegetables and improvement of processes for vegetable oil industry;
* Chemical industry in relation to fibers and textiles focusing on the potential use of tropical plants in chemical and paper pulp industries;
* Development of chemical formulary and processes; and
* Manufacture of certain products as import substitutes in the chemical industry.

Standard quality test of paints.

Simple process for prevention of aflatoxin in peanut oil by means of activated clay which increases the production cost by only 60 baht per ton of peanut oil.



Research on the pulp production from fast growing plants and agricultural wastes.

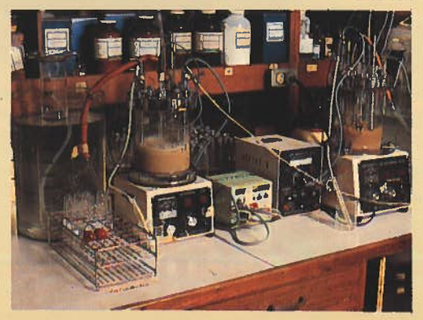
BIOTECHNOLOGY DEPARTMENT (BID)

The research and development activities of the Biotechnology Department cover all areas of technology based on biological processes with the main aim to promote industrial application. Services are given in solving the technical and microbiological problems in production processes and quality control. The BID also serves, under the UNEP/UNESCO/ICRO Program, as the Microbiological Resources Center for Southeast Asia (BANGKOK/MIRCEN) in the areas of fermentation, food and waste recycling. The BANGKOK/MIRCEN maintains a collection of bacteria and fungi including yeasts and selected tissue cultures important for industrial use, biotechnological development, applied research and education.

R & D activities of the BID include the following:

* Microbial biomass for feed;
* Enzyme production;
* Production of fuel ethanol from agricultural produce;
* Waste treatment, waste recycling; and
* Scale-up of fermentation process.

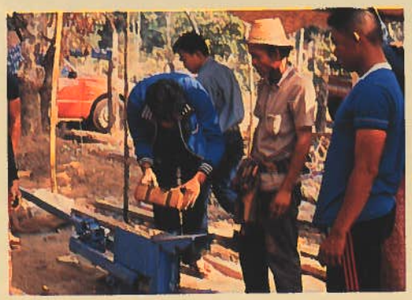
The first alcohol pilot plant from agricultural produce as alternative source of energy is an achievement of the cooperative project between TISTR and the Japanese Association of Industrial Fermentation. The application of innovative technology and sophisticated equipment facilitates energy saving process with the production of 99.5 v/v % ethanol suitable as gasoline substitute for automotive use.



Bioconversion of cellulosic wastes by anaerobic fermentation.

BUILDING TECHNOLOGY DEPARTMENT (BTD)

Soil-cement blocks for low-cost rural housing construction.



Research in the Building Technology Department (BTD) is aimed at solving problems in the building industry. BTD places emphasis on the application of technology for the economical use of labour and materials, for time-saving construction methods, and for the maximum utilization of locally available resources as construction materials.

Project plans of the BTD are:

* Research and development of building technology in relation to national development, such as the production of low-cost construction materials from local resources;
* Development of the technology of construction and the design of building components most suitable to the local environment;
* Development of high quality construction materials to encourage local commercial production;
* Transfer of developed technology; and
* Cooperation and coordination with government agencies and the private sector in the development of building technology.

ELECTRONICS INDUSTRY DEPARTMENT (EID)

The Electronics Industry Department (EID) services electronics research and development in order to assist the production and the promotion of electronic devices for local consumption and also for export.

R & D activities of EID are intended to encourage capability in the following categories;

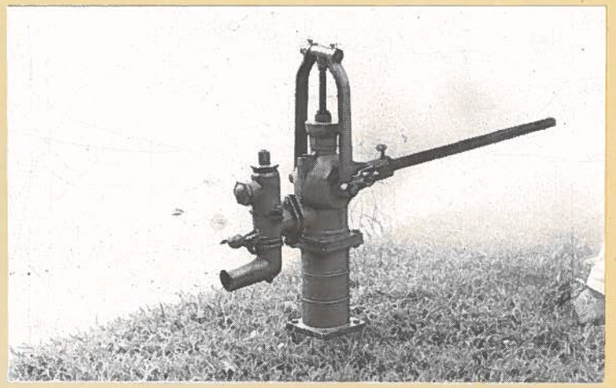
* Manufacturing of electronic products such as microwave ovens, car telephones, electronic control water heaters, electronic control system for industry and electronic distant-measurement meter.
* Manufacturing of electronic components.
* Giving advice on electronic production control in industrial plants.

ENGINEERING INDUSTRY DEPARTMENT (END)

The Engineering Industry Department (END) is responsible for research and development of machinery products. Emphasis is placed on high quality products by developing the quality of raw materials and production technology most suitable to the available resources and economic condition of the country.

END is targeted to develop capabilities for effective R & D in the following fields:

* Special alloy products;
* Machine parts, machine tools and engineering products, etc.;
* Industrial plant machinery and pilot plants.



METAL AND MATERIAL TECHNOLOGY DEPARTMENT (MMTD)

The Metal and Material Technology Department conducts research and development to increase capabilities and performance cf the metal and material industry in accordance with:

* The use of local resources and essential imported materials in the production of high quality metal products, machine components and parts for the engineering and electronics industries;
* The effective exploitation of industrial minerals to gain maximum benefit instead of exporting the raw ores;
* The production of ceramic products for use in engineering, electrical and electronics industries, automotive spare parts and construction materials; and
* The analysis and solution to the problems in production technology for metals, minerals and ceramic industries in order to improve the product quality and to minimize the production costs.

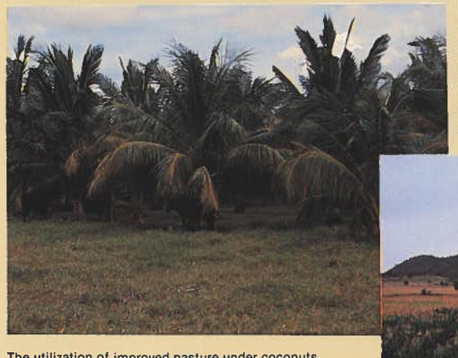
Metal casting by vacuum process moulding technique.

Sewer clay pipes will last longer than the cement pipes.

AGRO-TECHNOLOGY DEPARTMENT (ATD)

The Agro-Technology Department (ATD) carries out multi-disciplinary research on industrial and economic crops in order to develop appropriate technology and to integrate the agro-industry with the large-scale processing of agricultural products. Consultancy services and research by contract are provided for government agencies and private sectors.

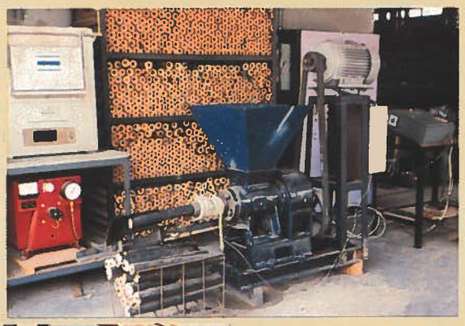
Study of species composition, establishment and management of pasture to ensure the year round high quality animal feeds for the development of dairy cattle husbandry at Lam Phaya Klang in Changwat Saraburi.



The utilization of improved pasture under coconuts for grazing.

Experiments of cropping system at Lam Phaya Klang to increase farmers' income by developing efficient use of resources.

ENERGY TECHNOLOGY DEPARTMENT (ETD)



Production of industrial solid fuel from agricultural wastes.

Pyrolysis of rice husk demonstration plant at Koocharoen rice mill, Changwat Saraburi.

The primary research direction of the Energy Technology Department (ETD) is aimed at efficient utilization of indigenous energy resources as alternative energy to help reduce the country's dependence on imported energy. The emphasis of ETD, therefore, is on research and development of energy technologies in terms of equipment and process design, feasibility study for industrial application, and also formulating policy guidelines for energy research.

ETD is capable to provide the following services:

* Research and development on conversion of energy raw materials into utilizable forms of fuel;
* Plant design and installation of synthetic fuels production process;
* Energy consultancy on energy conservation techniques for efficient utilization of energy in industry and building; and
* Fuel property analysis of various fuel materials.

ENVIRONMENTAL AND RESOURCES MANAGEMENT DEPARTMENT (ERMD)

The Environmental and Resources Management Department has the capability to carry out integrated research projects for government agencies and the private sector using the expertise of personnel in multidisciplinary fields such as policy makers, social scientists, geographers, engineers, economists and environmental scientists.

ERMD focuses on services for contract research in the following areas:

* Environmental and resources management plans;
* Research into and evaluation of environmental impacts; and
* Design of pollution control system, especially waste water treatment and garbage disposal.

Study of the environmental impact of the Map Ta Phut Natural Gas Separation Plant of the Petroleum Authority of Thailand in Changwat Rayong.

Planning for water quality management in the Tha Chin River, Amphoe Nakhon Chaisi, where widespread growth of water hyacinth is one among several acute problems.

ECOLOGICAL RESEARCH DEPARTMENT (ERD)

The Ecological Research Department (ERD) aims to identify the structure and the dynamics of the ecosystem. The results of research are applied in minimizing environmental degradation. As such studies have increased, the national socio-economic development has benefited particularly in relation to agricultural activity, energy-technology, medical services, and education.

Operations carried out by the ERD include the following:

* Study of the environmental biology with special attention to environmental quality control and the impact of pollution on living things;
* Study of the structure of the ecosystem as an essential element in effective planning for cultivated crops management, pest control and wild life conservation;
* Seeking solutions to specific environmental problems, such as the prevention of the bird and bat of hazardous to aviation;
* Establishment of the national reference collection of biological specimens for baseline data of ecological research studies and educational purposes, such as natural science museum exhibition.

Study of birds' ecology for preventive planning of aviation accidents at Bangkok International Airport.

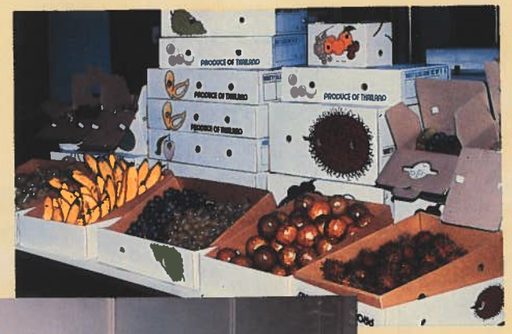
Study of rodents' ecology for pest control planning at Bang Pla Ma in Changwat Suphan Buri.

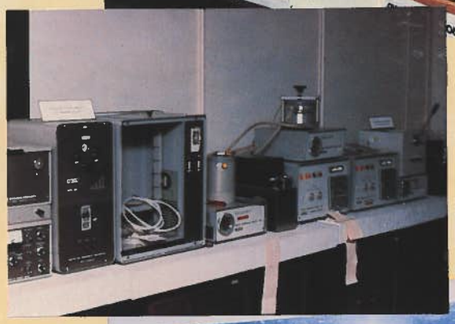
THAI PACKAGING CENTRE (TPC)

The Thai Packaging Center (TPC) serves as a nucleus for research and development oriented toward the improvement of packaging technology and standards. The goals of the TPC are to minimize economic loss and to promote the export of agricultural commodities and industrial products.

Activities of the TPC focus on the following:

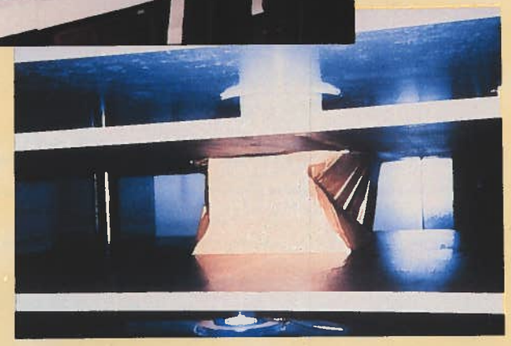
* Research and development on the quality of materials, package design, durability, packaging processes and economic feasibility;
* Services for technical advice, testing and certifying standards to the structure of packages;
* Compilation and dissemination of information on packaging technology; and
* Organization of training sessions, workshops, seminars and exhibitions to upgrade packaging expertise and standards.





Export package for fresh fruits accepted in foreign markets to minimize loss.

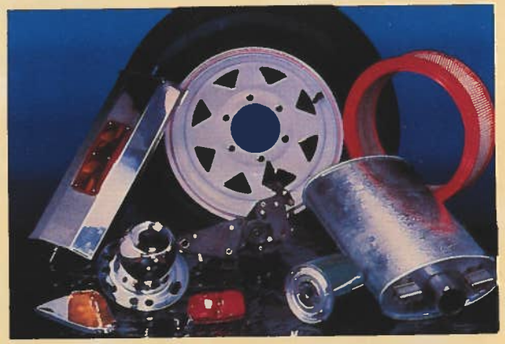
High efficiency analyzer to measure water vapour and gas diffusion rate through plastic films and containers as an indication of suitable plastic types for different product packages.



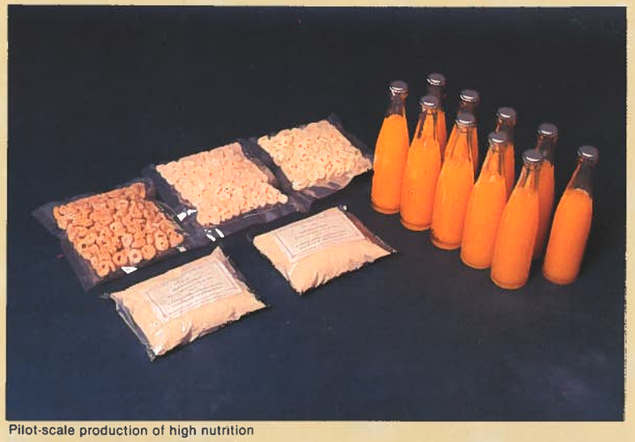
Compression testing machine for durability test of stacking packages in transportation and storage.

AUTOMOTIVE R & D CENTRE (AUC)

The Automotive R & D Centre (AUC) is responsible for the introduction of innovative technology in the production line and the improvement of quality control to internationally acceptable standards. The functions of AUC also include the inspection and the setting of quality standards for locally produced automotive components and spare parts as well as the provision of services for testing and certification of products.



INDUSTRIAL COOPERATION AND PROMOTION CENTRE (ICPC)



Pilot-scale production of high nutrition snack products and pure tangerine juice

Product samples of garlic natura and dried Chinese chrysanthemum for market trials.

The Industrial Cooperation and Promotion Centre (ICPC) has been established to facilitate the transfer of technology developed or improved by TISTR for commercialization.

The principal responsibilities of the ICPC include:

* Provision of the research results of TISTR and operational support facilities such as training, testing, analysis, quality control, as well as the design and installation of equipment and machinery in order to serve the private sector;
* Assistance for urban and rural industrial establishment using the results of research and development carried out by TISTR;
* Provision of services for marketing surveys and feasibility studies; and
* Market trial operation for products developed from prototype on R & D activities of TISTR.

RESEARCH SERVICE CENTRE (RSC)

The Research Service Centre (RSC) is responsible for the arrangement of contract research requested by government agencies and the private sector. To render its services, the RSC coordinates with the various research departments of TISTR to carry out R & D for products innovation, improvement of industrial processes and feasibility studies.

Certain commercial products developed through the services of TISTR.

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MINISTRY OF SCIENCE, TECHNOLOGY AND ENERGY

196 Phahonyothin, Bang Khen, Bangkok 10900
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Thai National Documentation Centre	579-3511
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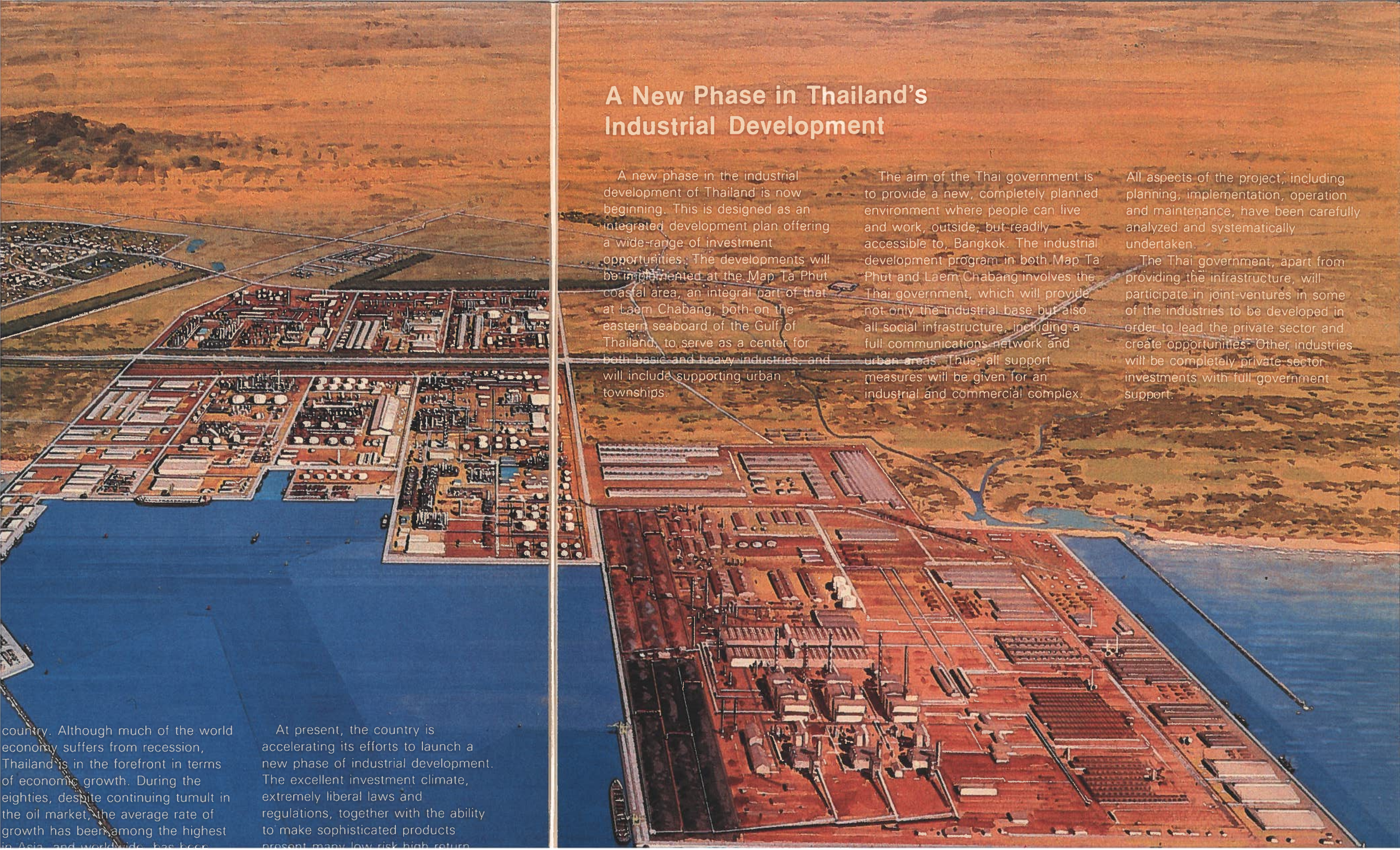
Map Ta Phut INDUSTRIAL ESTATE NEW TOWN AND INDUSTRIAL PORT in Thailand

The Industrial Estate Authority of Thailand
Ministry of Industry



country. Although much of the world economy suffers from recession, Thailand is in the forefront in terms of economic growth. During the eighties, despite continuing tumult in the oil market, the average rate of growth has been among the highest in Asia, and worldwide, has been

At present, the country is accelerating its efforts to launch a new phase of industrial development. The excellent investment climate, extremely liberal laws and regulations, together with the ability to make sophisticated products present many low risk high return

A New Phase in Thailand's Industrial Development

A new phase in the industrial development of Thailand is now beginning. This is designed as an integrated development plan offering a wide-range of investment opportunities. The developments will be implemented at the Map Ta Phut coastal area, an integral part of that at Laem Chabang, both on the eastern seaboard of the Gulf of Thailand, to serve as a center for both basic and heavy industries, and will include supporting urban townships.

The aim of the Thai government is to provide a new, completely planned environment where people can live and work, outside, but readily accessible to, Bangkok. The industrial development program in both Map Ta Phut and Laem Chabang involves the Thai government, which will provide not only the industrial base but also all social infrastructure, including a full communications network and urban areas. Thus, all support measures will be given for an industrial and commercial complex.

All aspects of the project, including planning, implementation, operation and maintenance, have been carefully analyzed and systematically undertaken.

The Thai government, apart from providing the infrastructure, will participate in joint-ventures in some of the industries to be developed in order to lead the private sector and create opportunities. Other industries will be completely private sector investments with full government support.

The Map Ta Phut Industrial Site

The Map Ta Phut Industrial complex is located 200 km. south-east of Bangkok. It will be developed for gas related and heavy industries and served by its own industrial deep sea port — The Map Ta Phut Industrial Port.

The Map Ta Phut Industrial Estate

Map Ta Phut industrial estate offers an advantageous industrial location. It is connected to the Gulf of Thailand gas field by the world's longest submarine gas pipeline which comes ashore at Map Ta Phut and continues through the eastern seaboard region to Bangkok.

Map Ta Phut Industrial Estate is served by an industrial deep-sea port which is divided into two segments. The western portion of the port is a common user facility to serve industrial estate development which do not require wharfage. It serves exports of bulk mineral and agricultural products, as well as exports of manufactured bulk and packaged products, imports and exports of hazardous and other liquid cargos.

Location Map

Industrial Land Use

*** Waterfront Industrial Zone**
Industrial plots with water-frontage are suitable for shipyard and other marine-oriented industries requiring waterfront land for their manufacturing and servicing operations.

*** Inland Heavy Industrial Zone**
Large plots of inland industrial land are also available for the establishment of heavy industries such as petrochemical and related downstream plants, chemical plants and steel fabrication plants. These industries will have access to multiuser facilities in the port.

*** Medium and Light Industrial Zone**
Smaller sites are available for the manufacture of plastic products, machine tools, food and pharmaceuticals, electronics, other processing of agricultural products and supporting industries.

Land Cost

Land can be purchased or leased competitively, both regional and international.

A low down payment would be required for land purchase; and interest at a competitive rate would be obtained for industrial investments.

Resources

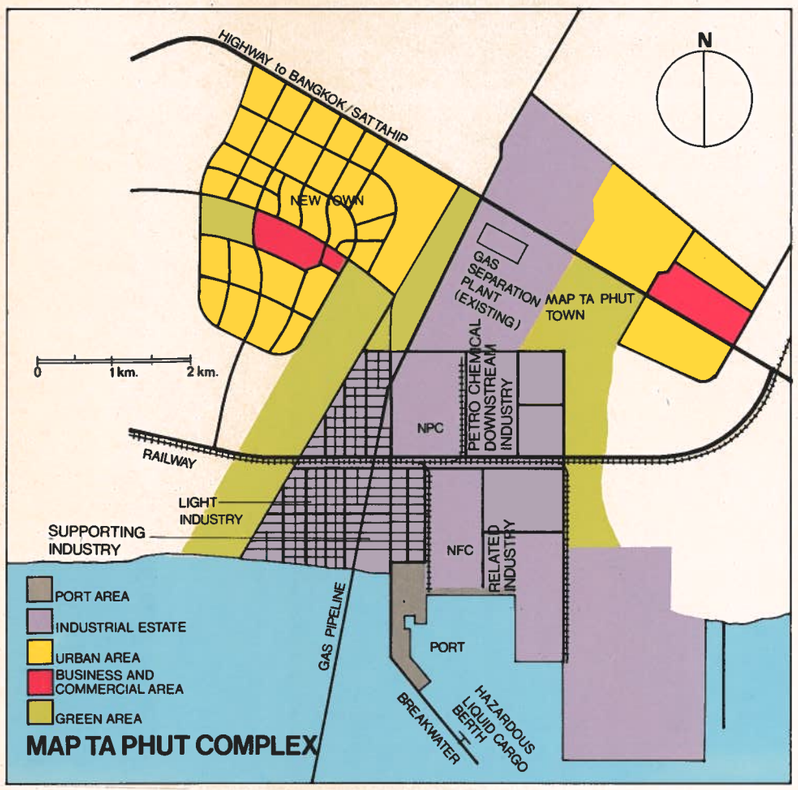
Newly discovered gas fields in the Gulf of Thailand have increased the potential for industrialization in a country already abundant in such natural resources as rich farmlands and various mineral deposits. The proximity to population centers ensures a ready supply of both skilled and unskilled labor.

These factors together with a thorough communications network will make industries sited there competitive with those in Bangkok, while the industrial port at Map Ta Phut and commercial deep-sea ports in Laem Chabang to be constructed will provide a new gateway to Thailand and a new exporting zone.

Infrastructure

Besides the Map Ta Phut port, the Thai government is giving priority to providing full and efficient infrastructure to ensure integrated development which is supported by new and upgraded roads, railways, water supplies, electricity supplies, telephones, and telex services. Complementing this is a fully planned and integrated social infrastructure, which will include environmentally controlled urban centers together with schools, hospitals, residential and recreational facilities, to provide an attractive urban area for the anticipated population.

Industrial Land Use



Map Ta Phut Industrial Port:
There are two berths planned on the eastern portion. The first one is an agricultural/mineral berth 330 meters long and 15.20 meters below mean sea level. It can accommodate 6,000 DWT ore carriers and 150,000 DWT tapioca carriers. The second berth is for loading and unloading hazardous and flammable liquids and can accommodate vessels up to 47,500 DWT.

The western portion of the port is for industrial development requiring their own water frontage. The loading berth is 210 meters long and 12.70 meters below mean sea level, capable of accommodating vessels up to 60,000 DWT.

Airport:
Nearby U-Tapao airport, has been opened to commercial traffic. The 3,500-meter runway is built for the heaviest aircraft.

The complex will be linked to the existing Bangkok-Sattahip one-meter gauge railway line.

The total amount of cargo to be capably handled in the Map Ta Phut Industrial Port will be about 22 million tons a year. The Map Ta Phut scale of the water front which will be required to handle this cargo volume scale is indicated below:

Total Cargo Volume by Shipping (1,000 tons per annum)	23,000

	Domestic Shipping	Foreign Shipping
Size of Vessels (DWT)	3,000	20,000 ~ 100,000
Berth Depth (m)	—6.5	—14 ~ —18
Total length of Berth (m)	4,200	1,550

Water Pipeline :
The Pipeline in the Map Ta Phut industrial complex can provide 75 million cubic meters a year of water.

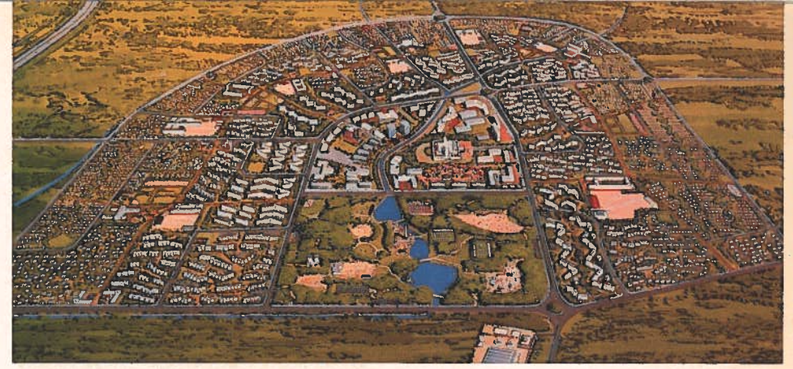
Railway :
The 140-kilometer railway line from Chachoengsao right down the western fringe of the Eastern Seaboard to Sattahip, is under construction and will be opened very soon to traffic. A spur of some 20 kilometers to connect this line with the industrial estate is in the developing state.

Waste Treatment:
A treatment plant is to be provided by IEAT for the supporting industries.

Power Supply:
Power supply to the industrial complex will come from a substation to be located in EGAT's Rayon g Substation No. 3 situated south of a gas separation plant. The Rayong Substation No. 3 is in turn connected to the Rayong Substation No. 2 by a 230 Kv power line. The power distribution lines to the industrial complex from the Rayong Substation No. 3 will be 22 Kv lines.

Telecommunication System:
Telephones, telex and telegram service facilities will be available for worldwide communication.

Urban Area:
A planned urban area is to be developed to provide housing and other facilities for the new residents.



Present Land Use at Map Ta Phut Industrial Estate

176 hectares (1,100 rai) for the National Petrochemical Corporation. 147 hectares (920 rai) for the National Fertilizer Corporation. 32 hectares (200 rai) for the Thailand Tantalum Industry Corporation Limited.

Industries Designated for Map Ta Phut Industrial Complex.

* Shipyard facility
* Ship breaking
* Petrochemicals and related products
* Multipurpose pharmaceutical active ingredients, synthetic products
* Chemical Industries
  - Titanium Dioxide
  - Sodium Tripolyphosphate
  - Ammonium Nitrate
  - Formic Acid
  - Caprolactum
  - Melamine
* Foundry and forging operations
* Processing of livestock and poultry
* Production of animal feeds
* Processing of freshwater/marine fish
* Processing of agricultural products
  - Coconut, cassava, sugarcane, fiber crop (kenaf, jute, cotton)
  - Rubber trees
* Basic heavy industries

Investment Incentive Structure

- To strengthen your capability to export
- To build up your internationally harmonious industrial structure

Export Infrastructure

Provision of export-oriented industrial base and related industrial infrastructure (main infrastructure, training center, export test center, R&D center, exhibition center, warehouse, etc.)

Tactical Aspects

* Favorable incentives in taxation and foreign investment
* General promotion of the selected subsector of export oriented industries

Marketing Cooperation

* American Chamber of Commerce
* Board of Trade of Thailand
* JETRO

etc.

Financing

* Special financing system for export-oriented enterprises
* Extension of Loans for Development Financing

Promotion of Joint Ventures and Technical Tie-Ups

* Assistance in direct investment and technical collaboration arrangement and coordination

Simplified Administrative Structures

* Simplify and expedite administrative services, including customs, immigration, labor, and police, for occupant enterprises
* Transactions cleared in five days

Investment Promotion Incentives & Privileges

Guarantees
- Against nationalization
- Against competition of new state enterprises
- Against state monopolization of the sale of products similar to those produced by promoted person
- Against price controls
- Permission to export
- Against imports by government agencies or state enterprises with taxes exempted

Protection measures
- Imposition of surcharge on foreign products
- Import ban on competitive products
- Authority by the Chairman to order any assisting actions or tax relief measures for the benefit of promoted projects

Permissions
- To bring in foreign nationals to undertake investment feasibility studies
- To bring foreign technicians and experts to work under promoted projects
- To own land for carrying out promoted activities
- To take or remit abroad foreign currency

Tax Incentives
- Exemption or reductions of import duties and business taxes on imported machinery
- Reduction of import duties and business taxes on imported raw materials and components
- Exemption of corporate income taxes from 3 to 8 years with permission to carry forward losses and deduct them as expenses for up to 5 years
- Exemption of up to 5 years on withholding tax on goodwill, royalties or fees remitted abroad
- Exclusion from taxable income of dividends derived from promoted enterprises during the income tax holiday

Additional Incentives
For enterprises in the Investment Production
- Maximum reduction of 90% of business tax on the sales of products for 5 years
- Reduction of 50% of corporate income tax for 5 years after the termination of a normal income tax holiday or from the date of income earning
- Allowance to double the cost of transportation, electricity and water supply for deduction from taxable corporate income
- Allowance to deduct from the taxable corporate income up to 25% of the investment in the cost of installing infrastructural facilities for 10 years from the date of income earning

For export enterprises
- Exemption of import duties and business taxes on imported raw materials and components
- Exemption of import duties and business taxes on re-export items
- Exemption of export duties and business taxes
- Allowance to deduct from the taxable corporate income the amount equivalent to 5% of an increase in income derived from export over the previous years, excluding costs of insurance and transportation

Published in 1987

The Industrial Estate Authority of Thailand

The Industrial Estate Authority of Thailand is a public enterprise under the Ministry of Industry. Originally created in December 1972 by Revolutionary Council Decree No. 339, it is currently established under the Industrial Estate Authority of Thailand Act of 1979. The Authority is an operational agency concerned with industrial development in both industrialized and non-industrialized areas of the country. In cooperation with other government agencies, it helps deal with the problem of locating industrial plants that do not coincide with the master plans of major cities by establishing industrial estates throughout the country.

An industrial estate is an area set aside for siting industrial plants and is provided with infrastructure and utilities, i.e., roads, drainage and flood protection systems, a central waste-water treatment plant, electricity, water supply, communications systems, as well as other facilities, such as post offices, commercial banks, commercial centers, housing for workers, etc. It is a self-contained community.

The Industrial Estate Authority of Thailand

The Governor
618 Nikhom Makkasan Road,
Phayathai, Bangkok 10400, Thailand
Tel : 253-051, 253-2965
Cable Address : IEAT BANGKOK

Ministry of Industry

Minister of Industry
Rama VI Road,
Bangkok 10400, Thailand
Tel : 245-7790, 245-8033
Telex : 84375 MOITHAI TH

Office of the Eastern Seaboard Development Committee

The Director
Office of the Eastern Seaboard
618 Nikhom Makkasan Road,
Phayathai, Bangkok 10400 Thailand.
Tel : 253-3533, 253-3575
Telex : 72391 ESB TH

CONTACT ADDRESSES

On Investment matters

BANGKOK

Secretary-General
Office of the Board of Investment
16th Floor, Thai Farmer Bank Bldg.
400 Phaholyothin Road
Bangkok 10400 Thailand
Tel: 270-1400, 270-1410, 270-1420
Cable Address: "INVEST BANGKOK"
Telex:TH 82542, TH 81159 TH 84798
TH. 84799 (ATTENTION : B O I.)

FRANKFURT

Economic Counsellor (Investment)
Office of the Economic
Counsellor (Investment)
Thai Trade and Investment Center
Bethmann Strasse 58
6000 Frankfurt Am Main
Federal Republic of Germany
Tel: (0611) 281-091-2
Cable : THAICENTER FRANKFURT
Telex : 4189399 ttic d

NEW YORK

Economic Counsellor (Investment)
Office of the Economic
Counsellor (Investment)
Five World Trade Center,
Suite 3443
New York, N.Y. 10048 U.S.A.
Tel: (212) 466-1745-6
Telex : 645690 THAI CCM NYK
Cable : THAIBOI, New York

SYDNEY

Economic Counsellor (Investment)
Office of the Economic
Counsellor (Investment)
Thailand Board of Investment
12th Floor, Royal Exchange Bldg.
56 Pitt Street, Sydney
N.S.W. 2000 Australia
Tel : 278905-6
Cable : THAIBOI SYDNEY
Telex : THAITC AA 23467

TOKYO

Economic Counsellor (Investment)
Office of the Economic
Counsellor (Investment)
3rd Floor, Akasaka Brighton Bldg.
1-5-2 Akasaka,
Minato-ku, Tokyo 107, Japan
Tel : (03) 582-1806
Cable : THAIBOI TOKYO
Telex:TH 82542, TH 81159, TH 84 798
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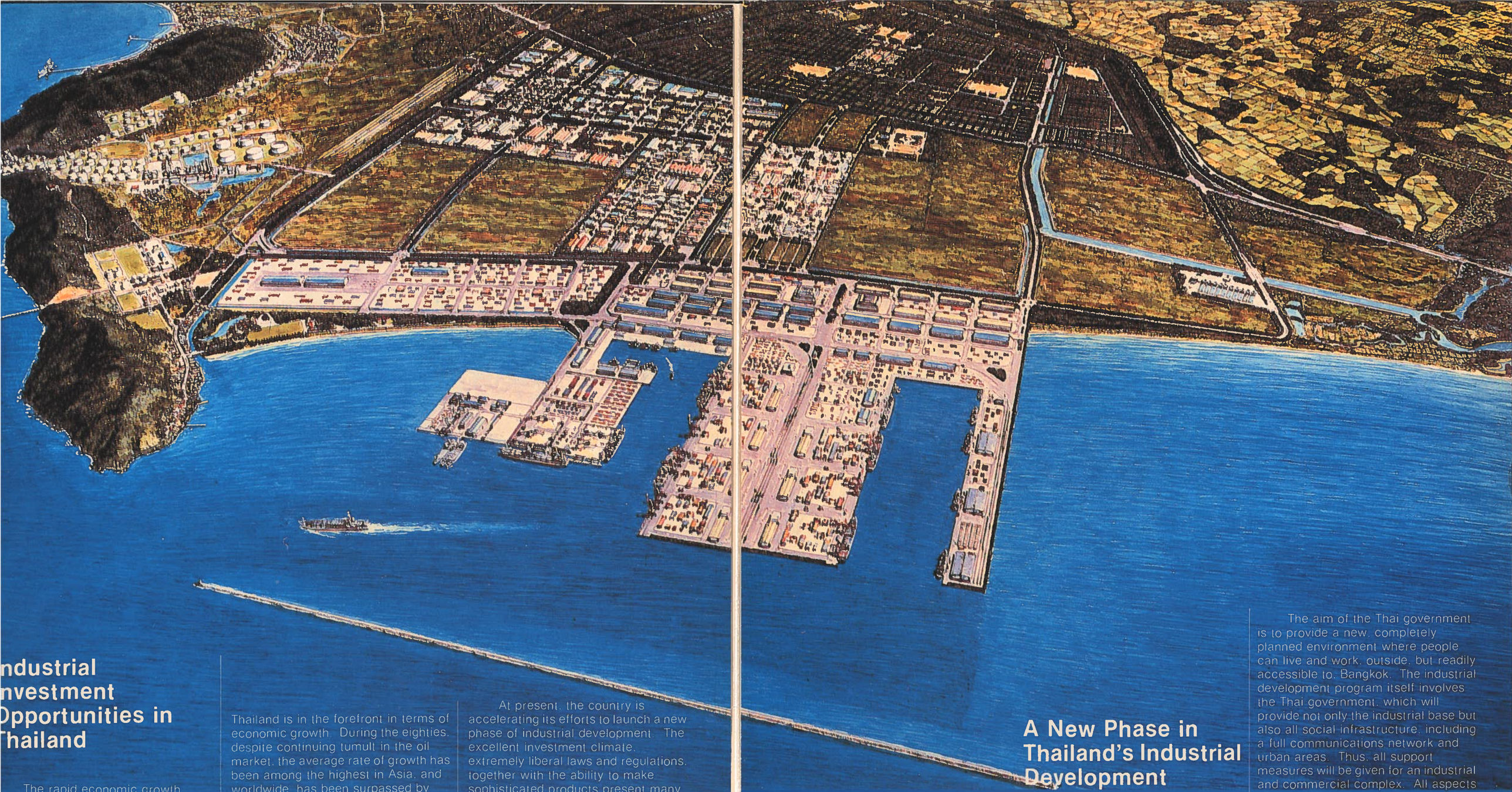
Laem Chabang
INDUSTRIAL ESTATE AND EXPORT PROCESSING ZONE
in Thailand

The Industrial Estate Authority of Thailand
Ministry of Industry



ndustrial nvestment Opportunities in Thailand

The rapid economic growth hailand has achieved over the past vo decades is viewed by many ternational observers as a success iracle. The Thai economy has grown om its strong agricultural base into he in which industry and external ade constitute major components.

Thailand is regarded as an -and-coming industrializing nation. nd the course has been set for further dvance as an international trading untry. Although much of the world conomy suffers from recession.

Thailand is in the forefront in terms of economic growth. During the eighties. despite continuing tumult in the oil market. the average rate of growth has been among the highest in Asia. and worldwide. has been surpassed by few.

Plans for further economic development call for expanding foreign sources of materials. capital. equipment. and new technologies to provide increasing employment opportunities for the people. The Thai government advocates a free trade approach. and in making an industrial investment in Thailand. be it for export or for import substitution. one can expect that international criteria are adopted with maximum flexibility.

At present. the country is accelerating its efforts to launch a new phase of industrial development. The excellent investment climate. extremely liberal laws and regulations. together with the ability to make sophisticated products present many low risk-high return opportunities which have been attracting increasing capital from abroad.

In the course of its economic development. Thailand has opened to the world excellent investment opportunities. This portfolio decribes in brief the industrial environment. the industrial activities. and other basic information about the Laem Chabang industrial zone to serve as an initial guide to all those interested in industrial development in the area.

A New Phase in Thailand's Industrial Development

A new phase in the industrial development of Thailand is now beginning. This is designed as an integrated development plan offering a wide range of investment opportunities. The development will be implemented at the Laem Chabang coastal area on the eastern seaboard of the Gulf of Thailand to serve as a center for both basic and light industries, and will include supporting urban townships.

The aim of the Thai government is to provide a new, completely planned environment where people can live and work, outside, but readily accessible to, Bangkok. The industrial development program itself involves the Thai government, which will provide not only the industrial base but also all social infrastructure, including a full communications network and urban areas. Thus, all support measures will be given for an industrial and commercial complex. All aspects of the project, including planning, implementation, operation and maintenance, have been carefully analysed and systematically undertaken.

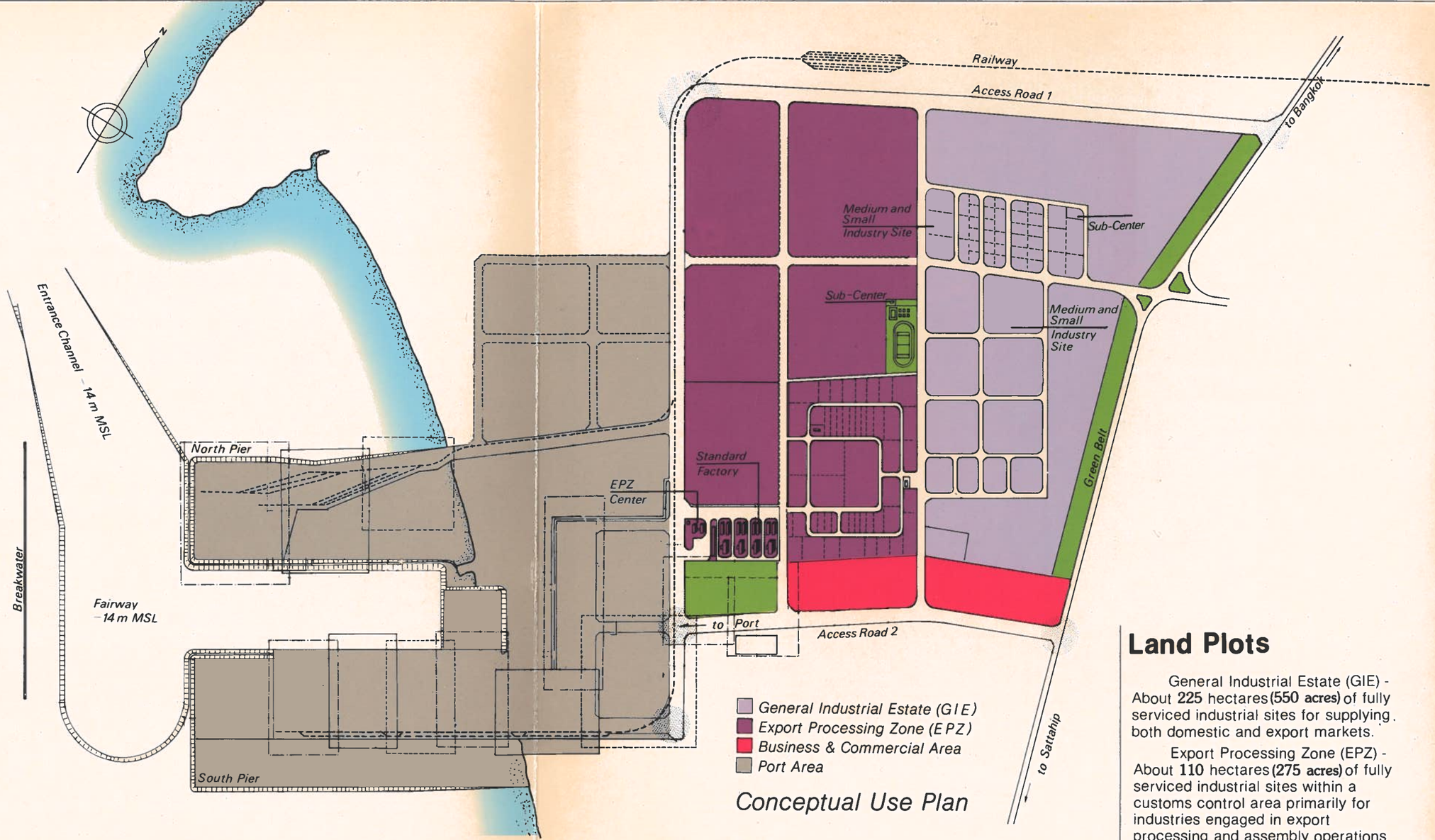
The Thai government, apart from providing the infrastructure, will participate in joint-ventures in some of the industries to be developed in order to lead the private sector and create opportunities. Other industries will be completely private sector investments with full government support.

The Laem Chabang Industrial Site

Situated halfway down the eastern coast of Thailand, about 130 km southeast of Bangkok and approximately 10 km north of the city of Pattaya, the Laem Chabang complex will be an industrial estate and export processing zone with a commercial deep-sea port, backed up by a complete urban center and essential infrastructure. A communications network will link Laem Chabang to the hinterland, from which much of the raw materials for industries will come. The Laem Chabang commercial port will be able to handle container and break bulk cargo vessels of up to 120,000 tons, and there is substantial space for future expansion and for establishing ship repair facilities.

Industrial Mix

The Laem Chabang Industrial Estate will house such agriculture-based industries as food processing, animal feed, production, leather and rubber product manufacture, as well as other export-oriented industries, such as electronics, auto parts, toys and sporting goods. Larger industries projected include ship repair and assembly of off-shore drilling platforms. The industrial mix envisaged for the Estate is given in the chart.



Conceptual Use Plan

Category	Type	GIE	EPZ
Consumer product related group	Foods, textiles, apparel, wood, wood products, furniture, rubber and plastic products leather products, miscellaneous products	10% 30%	40%
Basic materials group	Chemicals, ceramics, non-metallic minerals, iron and steel, non-ferrous metals		15%
Processing and assembly group	General machinery, electrical machinery, transportation equipment, precision instruments	60%	45%

Infrastructure

Besides the Laem Chabang port, Thai government is giving priority to providing full and efficient infrastructure to ensure integrated development which is supported by new and upgraded roads, railways, water supplies, electricity supplies, telephones, and telex services. Complementing this is a fully planned and integrated soical infrastructure, which will include environmentally controlled urban centers together with schools, hospitals, residential and recreational facilities, to provide an attractive urban area for the anticipated population.

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These factors together with a thorough communications network will make industries sited here competitive with those elsewhere, while the Laem Chabang commercial deep-sea port to be constructed will provide a new gateway to Thailand and a new exporting zone.

Land Plots

General Industrial Estate (GIE) - About **225** hectares **(550 acres)** of fully serviced industrial sites for supplying both domestic and export markets.

Export Processing Zone (EPZ) - About **110** hectares **(275 acres)** of fully serviced industrial sites within a customs control area primarily for industries engaged in export processing and assembly operations

Business Area

To serve the industrial estates and port, a business area with a full range of necessary facilities will be established alongside the industrial area.

Land Cost

Land can be purchased or leased competitively both regional and international

A Low down payment would be required for land purchase; and interest at a competitive rate annum could be obtained for industrial investments.

Investment Incentive Structure

- To strengthen your capability to export
- To build up your internationally harmonious industrial structure

Export Infrastructure

Provision of export-oriented industrial base and related industrial infrastructure (main infrastructure, training center, export test center, R&D center, exhibition center, warehouse, etc.)

Tactical Aspects

* Favorable incentives in taxation and foreign investment
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Simplified Administrative Structures

* Simplify and expedite administrative services, including customs, immigration, labor, and police, for occupant enterprises
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Investment Promotion Incentives & Privileges

Guarantees

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The Governor
618 Nikhom Makkasan Road,
Phayathai, Bangkok 10400, Thailand
Tel : 253-051, 253-2965
Cable Address : IEAT BANGKOK

Ministry of Industry

Minister of Industry
Rama VI Road,
Bangkok 10400, Thailand
Tel : 245-7790, 245-8033
Telex : 84375 MOITHAI TH

Office of the Eastern Seaboard Development Committee

The Director
Office of the Eastern Seaboard
618 Nikhom Makkasan Road,
Phayathai, Bangkok 10400 Thailand.
Tel : 253-3533, 253-3575
Telex : 72391 ESB TH

CONTACT ADDRESSES

On Investment matters

BANGKOK

Secretary-General
Office of the Board of Investment
16th Floor, Thai Farmer Bank Bldg.
400 Phaholyothin Road
Bangkok 10400 Thailand
Tel: 270-1400, 270-1410, 270-1420
Cable Address: "INVEST BANGKOK"
Telex:TH 82542, TH 81159 TH 84798
TH. 84799 (ATTENTION : B O I.)

FRANKFURT

Economic Counsellor (Investment)
Office of the Economic
Counsellor (Investment)
Thai Trade and Investment Center
Bethmann Strasse 58
6000 Frankfurt Am Main
Federal Republic of Germany
Tel: (0611) 281-091-2
Cable : THAICENTER FRANKFURT
Telex : 4189399 ttic d

NEW YORK

Economic Counsellor (Investment)
Office of the Economic
Counsellor (Investment)
Five World Trade Center,
Suite 3443
New York, N.Y. 10048 U.S.A.
Tel: (212) 466-1745-6
Telex : 645690 THAI CCM NYK
Cable : THAIBOI, New York

SYDNEY

Economic Counsellor (Investment)
Office of the Economic
Counsellor (Investment)
Thailand Board of Investment
12th Floor, Royal Exchange Bldg.
56 Pitt Street, Sydney
N.S.W. 2000 Australia
Tel : 278905-6
Cable : THAIBOI SYDNEY
Telex : THAITC AA 23467

TOKYO

Economic Counsellor (Investment)
Office of the Economic
Counsellor (Investment)
3rd Floor, Akasaka Brighton Bldg.
1-5-2 Akasaka,
Minato-ku, Tokyo 107, Japan
Tel : (03) 582-1806
Cable : THAIBOI TOKYO
Telex:TH 82542, TH 81159, TH 84 798
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Thailand's petrochemical complex takes off

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Thai Petrochemical Industry Co., Ltd.
Thai Polyethylene Co., Ltd.
Thai Plastic and Chemical Co., Ltd.
HMC Polymers Co., Ltd.
Bangkok Industrial Gas Co., Ltd.

Olefins Construction Project

G I Process Plant.

G II Utility Plant.

G III General Facilities.

G I & II.

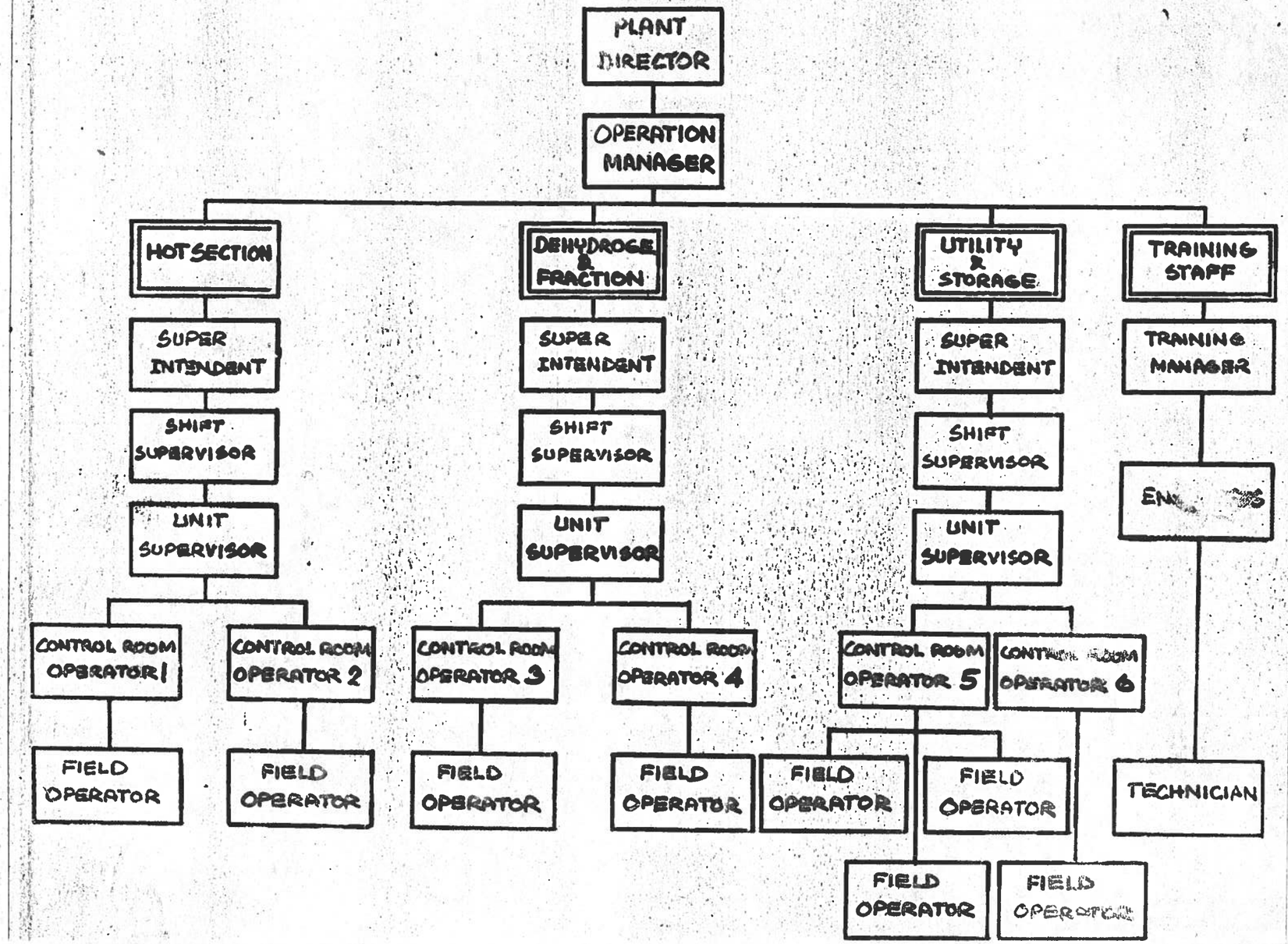
CONSORTIUM OF TOYO / MITSUI.

Contract Paize 145, 438 462 US.D.

Start 1. Dec 1986.

Finished 20 Oct. 1989.

Retual 43.44 %.


PLANT DIRECTOR
OPERATION MANAGER
HOT SECTION
DEHYDROGE & FRACTION
UTILITY & STORAGE
TRAINING STAFF
SUPER INTENDENT
SUPER INTENDENT
SUPER INTENDENT
TRAINING MANAGER
SHIFT SUPERVISOR
SHIFT SUPERVISOR
SHIFT SUPERVISOR
UNIT SUPERVISOR
UNIT SUPERVISOR
UNIT SUPERVISOR
CONTROL ROOM OPERATOR 1
CONTROL ROOM OPERATOR 2
CONTROL ROOM OPERATOR 3
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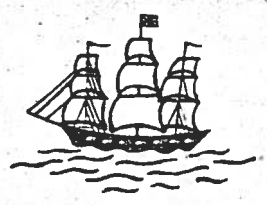
VISUAL NO. 10

SUBJECT Mounting Frame

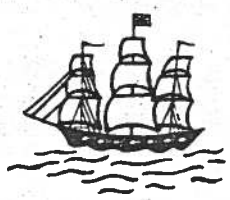


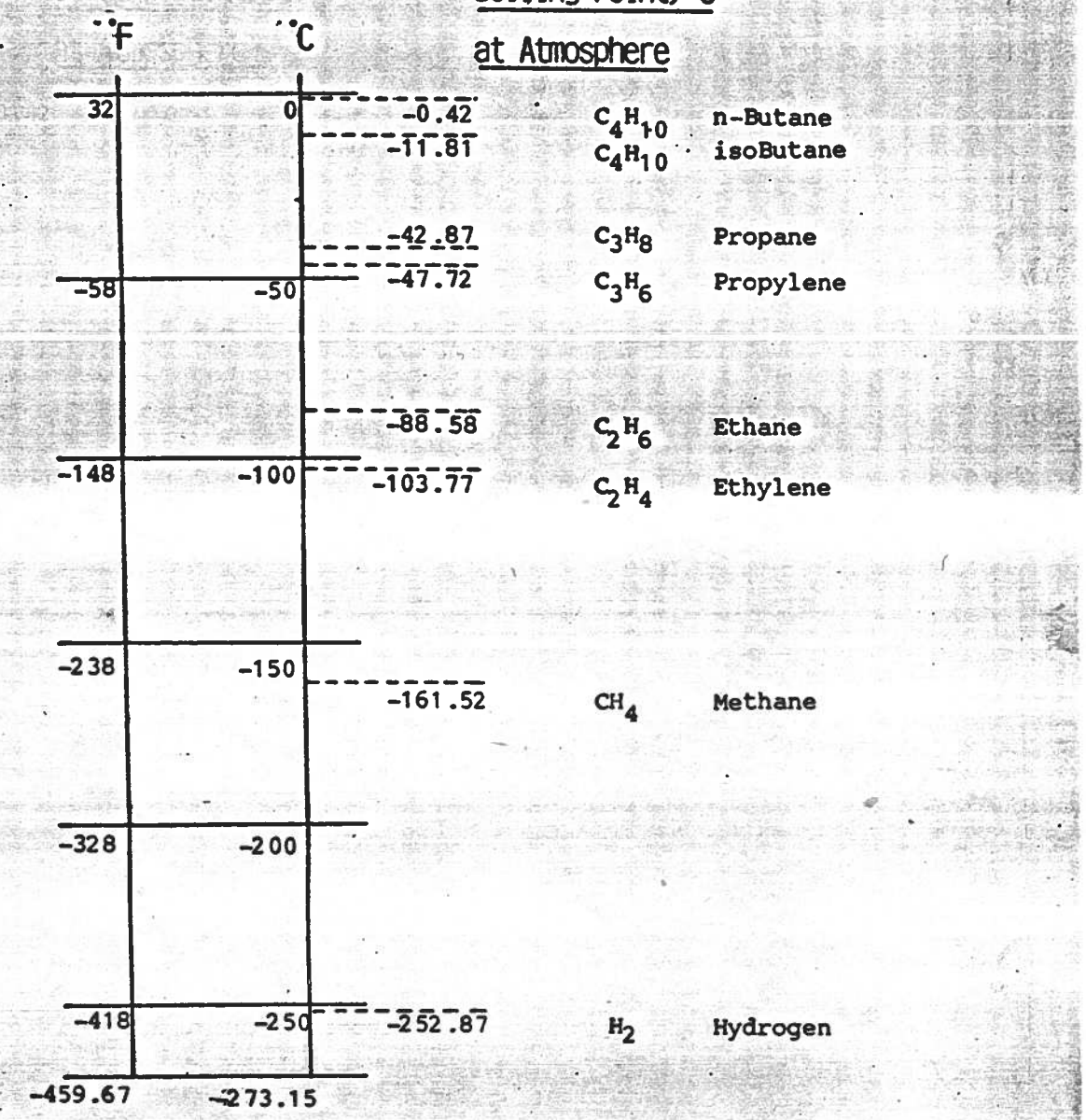
COMPONENTS	KMOL/H	AVG MWT
HYDROGEN	2.016	2506.
CARBON MONOXIDE	28.010	104.
CARBON DIOXIDE	44.010	53.
HYDROGEN SULFIDE	34.082	2.
METHANE	16.042	3137.
ACETYLENE	26.036	193.
ETHYLENE	28.052	33440.
ETHANE	30.068	21957.
MAPD (C3H4'S)	40.062	30.
PROPYLENE	42.078	758.
PROPANE	44.094	154.
BUTADIENES	54.088	882.
BUTENES	56.104	127.
BUTANES	58.120	126.
C5 HYDROCARBONS	70.130	198.
C6-C8 HC'S	88.719	191.
BENZENE	78.108	341.
TOLUENE	92.134	62.
XYLENES/ETHYLBZ	106.160	1.
STYRENE	104.144	4.
C9-204C	123.707	12.
204C PLUS	248.420	6.
STEAM/WATER	18.016	19149.
TOTAL, KMOL/H		4489.16
KG/H		83431.
MOLECULAR WEIGHT		18.59
TEMPERATURE, DEG C		197.0
PRESSURE, KG/CM2 G		.88

VISUAL NO. 11

SUBJECT .....

Mounting Frame





NOTE

VISUAL NO. 5.

SUBJECT .....

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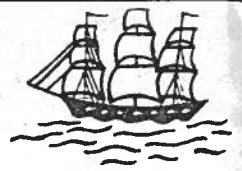
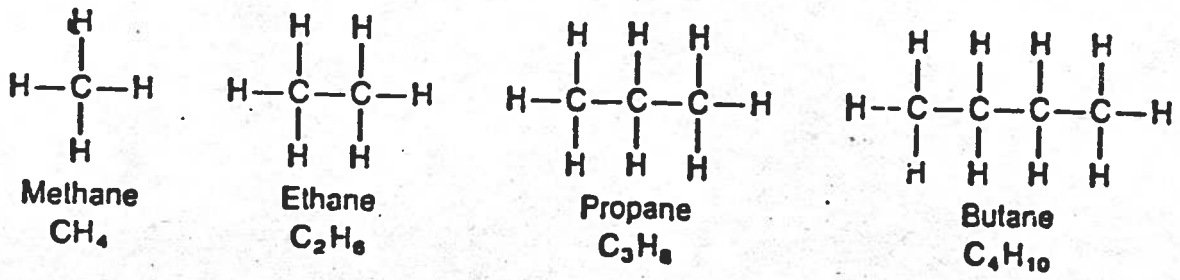
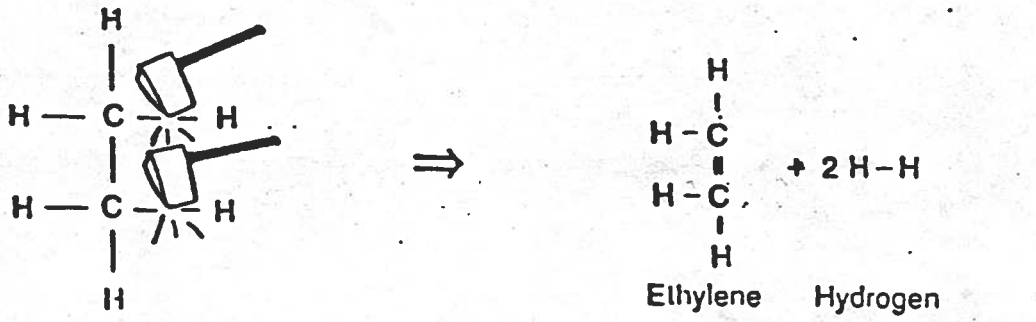
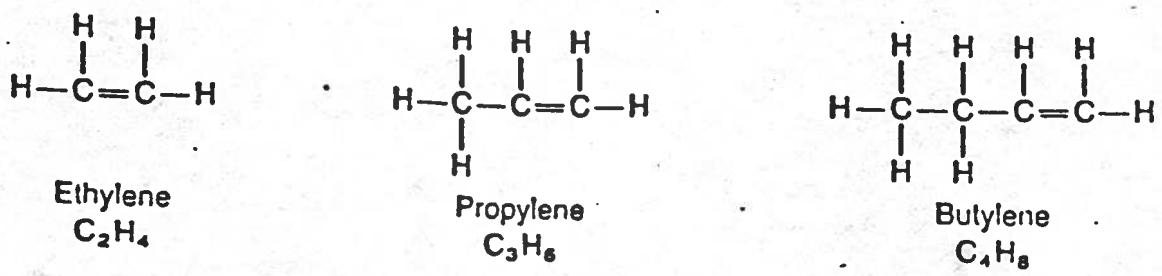




Paraffins





Olefins

VISUAL NO. 8.2

SUBJECT

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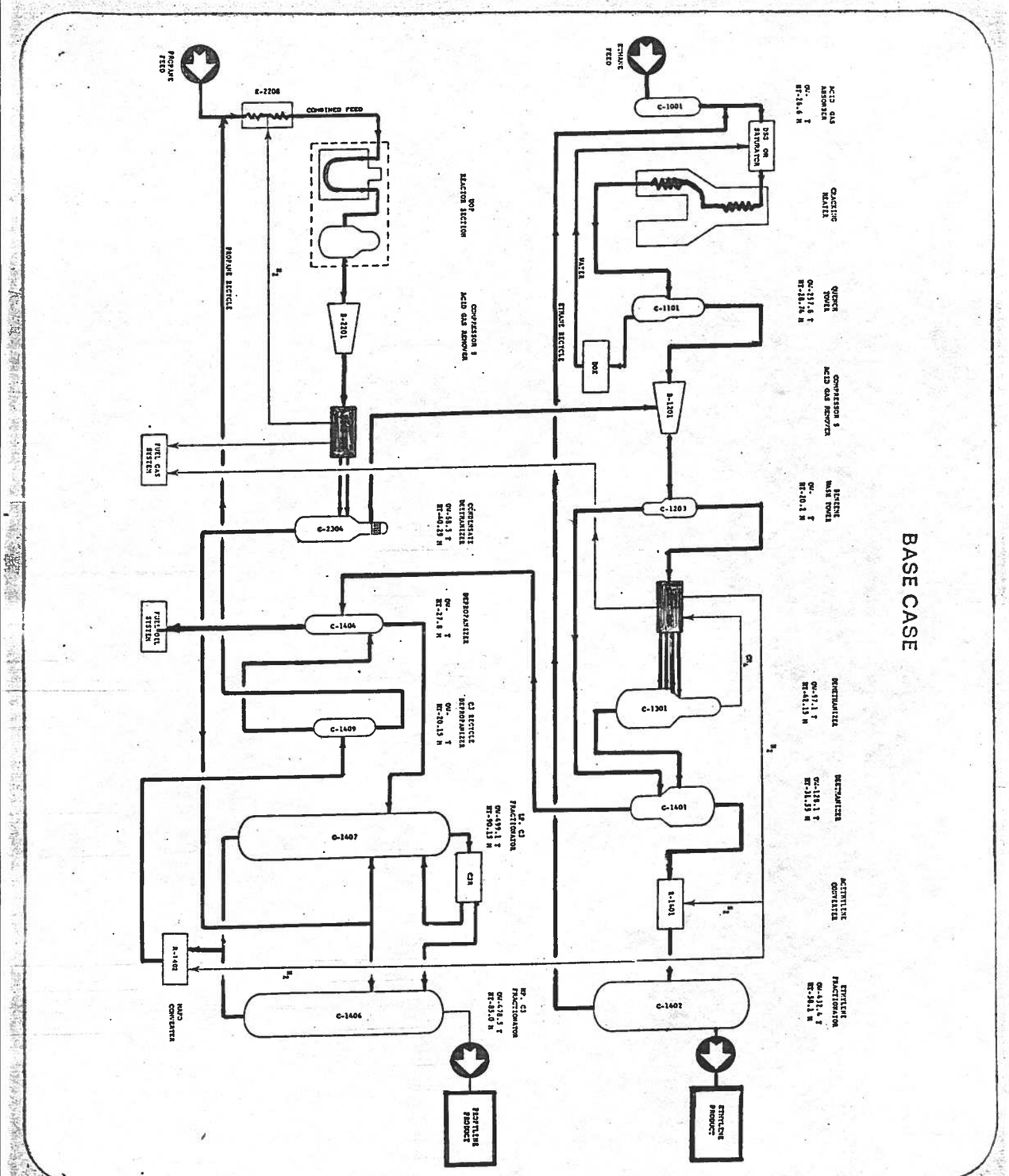


The Complex:

By October 20, 1989, Thailand's first, fully-integrated, upstream-downstream petrochemical complex will become operational. Representing a total investment of Baht 26,000 million (US$ 1 billion), this entity will be the kingdom's largest industrial centre.

An integral part of Thailand's Eastern Seaboard Development Programme, it will enable the Kingdom of Thailand to step boldly forward into a new era of economic growth and self-sufficiency, and to move very much closer to the goals of...

☐ the fullest possible utilisation of domestic resources,

☐ creating jobs

☐ fostering new industries,

☐ conserving foreign exchange, and

☐ giving a strong boost to the development of domestic technology.

The Corporation:

Established in February 1984, the National Petrochemical Corporation Limited (NPC) is a public/private venture set up to provide the impetus and general planning for a fully-integrated petrochemical complex scheduled to begin operation in late 1989.

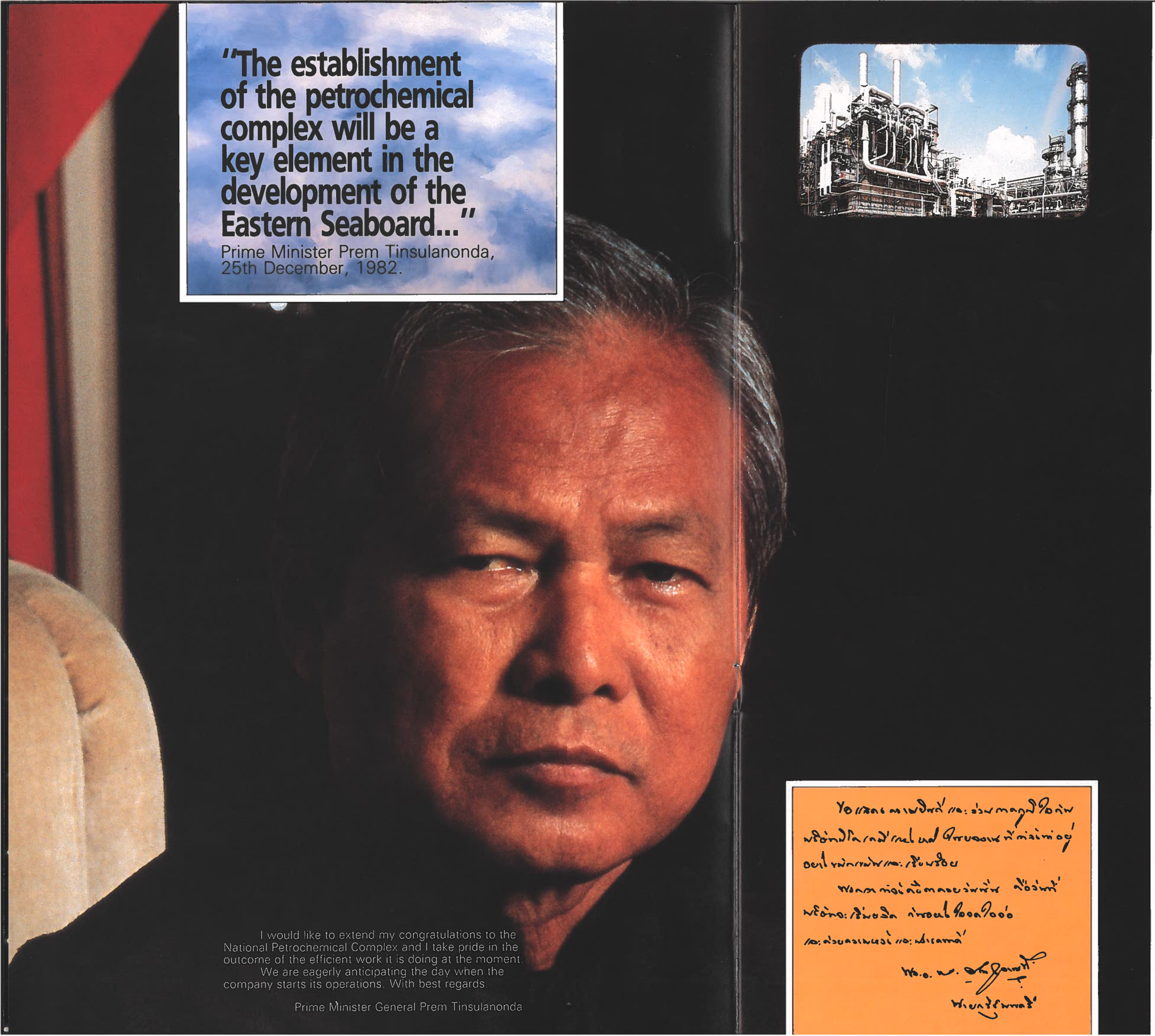
NPC, with a registered capital of Baht 2,000 million (US$76.9 million), will build and operate the upstream, or olefins unit, and a comprehensive utilities centre to supply the entire complex.

The Royal Thai Government through the national oil company—the Petroleum Authority of Thailand—holds a 49-percent share of equity. The four private, downstream operating companies together hold 45.82 percent, while the Crown Property Bureau and the World Bank's International Finance Corporation hold the remainder.

Contents:

"The establishment of the petrochemical complex will be a key element in the development of the Eastern Seaboard..."

Prime Minister Prem Tinsulanonda,
25th December, 1982.



I would like to extend my congratulations to the National Petrochemical Complex and I take pride in the outcome of the efficient work it is doing at the moment.
We are eagerly anticipating the day when the company starts its operations. With best regards.

Prime Minister General Prem Tinsulanonda

The commercial operation of NPC's upstream facilities, scheduled to begin in mid-October 1989, will culminate a process set in motion when the Royal Thai Government first awarded offshore petroleum exploration rights in 1968. It will also change the structure of the petrochemical industry in Thailand from relatively small-scale conversion operations using imported monomer intermediates and some polymers, to an integrated, full-scale complex using local basic feedstocks to supply polymers, then resins to produce final plastic products.

One of the key structural vehicles guiding this long-term vision is the Eastern Seaboard Development Programme (ESDP). ESDP calls for creating a new economic zone located and organised to take the fullest possible advantage of Thailand's resource-based assets: plentiful natural gas, abundant agricultural and fishery products, and an inexpensive, skilled, and loyal labour force.

Fully realised by the early 1990s, the ESDP will represent a total investment of Baht 100,000 million (US$3.8 billion).

Centred in Rayong Province, 200 kilometres southeast of Bangkok on the Gulf of Thailand, the ESDP is an integral part of Thailand's Fifth and Sixth, Five-Year National Economic and Social Development Plans. It combines substantial government investment in infrastructure with private investment in processing and manufacturing, frequently with promotional privileges granted by the Board of Investment.

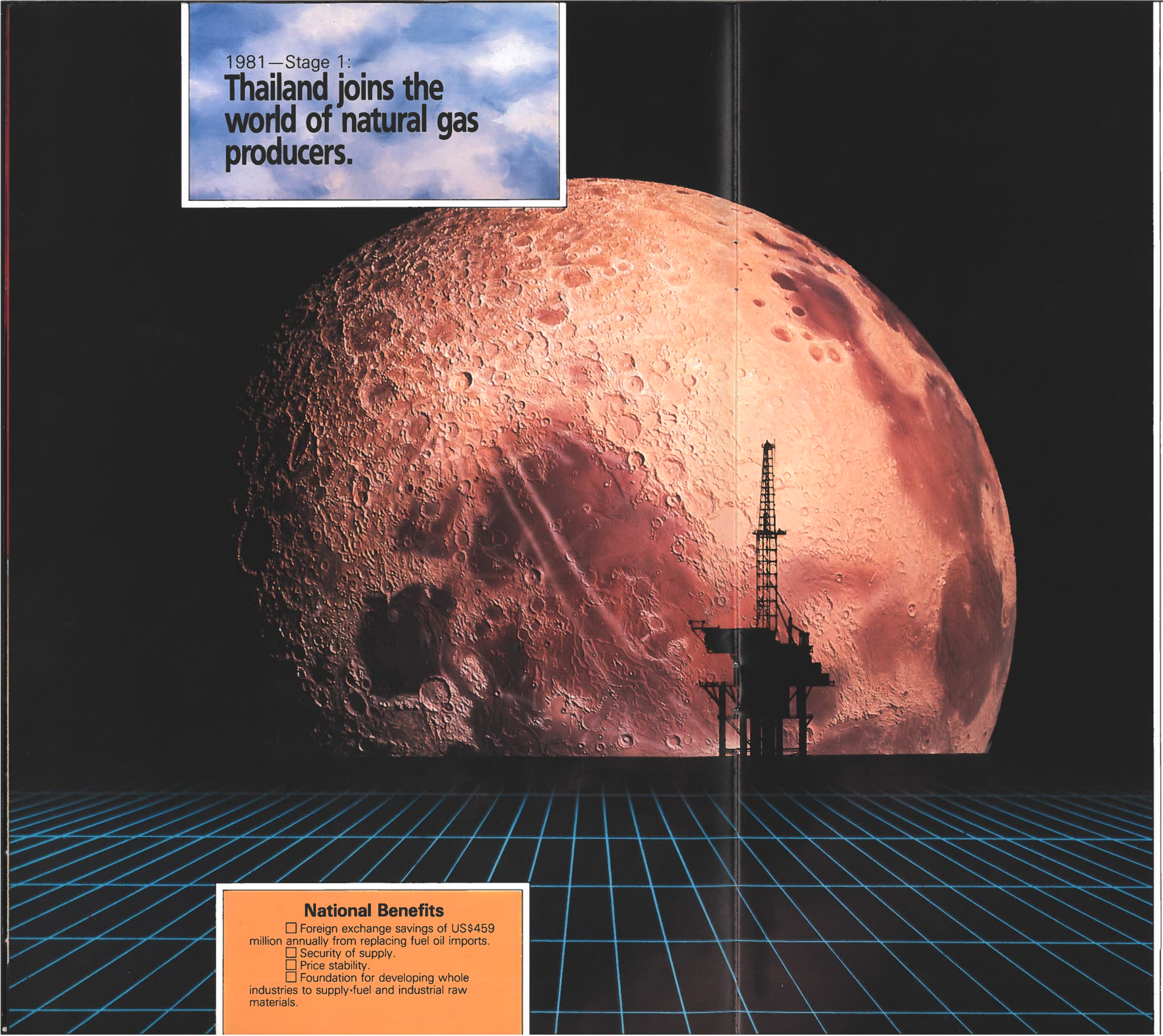
Thailand will derive many benefits from the full realisation of the ESDP:

- ☐ A dramatic reduction in foreign exchange payments by eliminating a whole category of imports.
- ☐ A substantial increase in foreign exchange earnings through exports of manufactured goods.
- ☐ Greater economic stability through industrial diversification and more secure supplies of critical raw materials.
- ☐ Increased employment opportunities for Thai workers.
- ☐ Increased national wealth through adding value to domestically-produced manufacturing input.

NPC is a critical link in fulfilling the ESDP's potential. By providing an assured market for ethane and propane feedstock produced by the natural gas separation plant operated by the Petroleum Authority of Thailand (PTT)—the Kingdom's national oil company—and an assured supply of ethylene and propylene to four downstream plastic resin operations, NPC will usher in a new era of self-sufficiency and industrial integration.

1981—Stage 1:

Thailand joins the world of natural gas producers.



National Benefits

☐ Foreign exchange savings of US$459 million annually from replacing fuel oil imports.
☐ Security of supply.
☐ Price stability.
☐ Foundation for developing whole industries to supply fuel and industrial raw materials.

The sustained, rapid growth of the Thai economy and its evolution away from traditional agriculture into manufacturing and services has meant a dramatic rise in energy consumption. The international oil companies had begun active exploration offshore and onshore in the late 1960s, while the government had encouraged the development of alternative energy sources, such as hydroelectric power and lignite.

In 1973, just five years after exploration began, Union Oil Company (UNOCAL) made the first natural gas discovery—in the Erawan Field of the Gulf of Thailand. The oil crisis of 1973-74 added momentum to government programmes, since the kingdom still depended on petroleum imports for 80 percent of its total energy needs, making the nation's vulnerability to supply disruptions and upward price spirals clear.

Natural gas production began in 1981, when H.E. Prime Minister General Prem Tinsulanonda commissioned the then world's longest submarine natural gas transmission pipeline (425 kilometres), delivering natural gas at an average daily rate of 350 million cubic feet to two power plants near Bangkok.

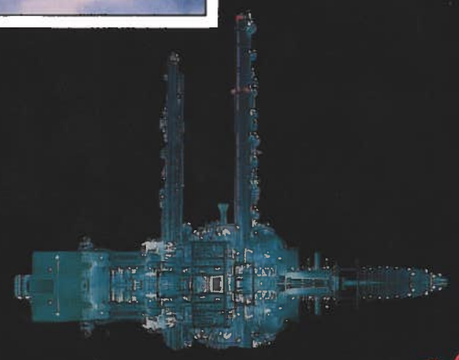
Then, in 1983, The first crude oil production began—at Shell Oil Company's Sirikit Field in Kamphaeng Phet Province—soon reaching 20,000 barrels per day.

By 1987, average daily production of natural gas exceeded 400 million cubic feet. Plans call for this volume to rise to 500 million cubic feet by 1988, then 700 million cubic feet by 1991, based on current proven and probable economically recoverable reserves, both onshore and off-shore, of 3,720 billion cubic feet, of which some 3 trillion cubic feet are already under development.

This level of reserves covers all the projected demand of Thailand's petrochemical complex.

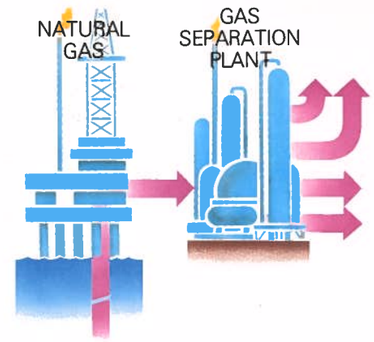
1984—Stage 2:

Vertical integration begins: The first Gas Separation Plant comes on stream.



National Benefits

☐ Lower dependence on imports.
☐ Foreign exchange savings.
☐ Greater security of supply.
☐ Greater price stability.
☐ Basis for establishing new industries and expanding the existing.
☐ Greater added value for a domestic raw material.



Representing an investment of Baht 7,360 million (US$273 million), PTT commissioned Thailand's first gas separation plant in November 1984. This quantum leap in industrial capability permanently expanded Thailand's economic horizons by setting the stage for even greater energy independence and for broadening the kingdom's industrial base.

To get immediate benefits from the plant, PTT simultaneously constructed an LPG distribution system, reaching into all four geographic regions of the country. LPG's increasing popularity as a substitute fuel for cooking and automotive purposes justified setting up six depots with a combined storage capacity of 11,000 cubic metres, each with a cylinder-filling plant. Within nine months of operation, all propane/LPG imports ceased, bringing a savings of some Baht 2,920 million (US$ 110 million) in foreign exchange in the first year.

The wider use of natural gas as a substitute fuel has the added benefits of replacing wood as fuel and helping to reduce air pollution.

Capacities

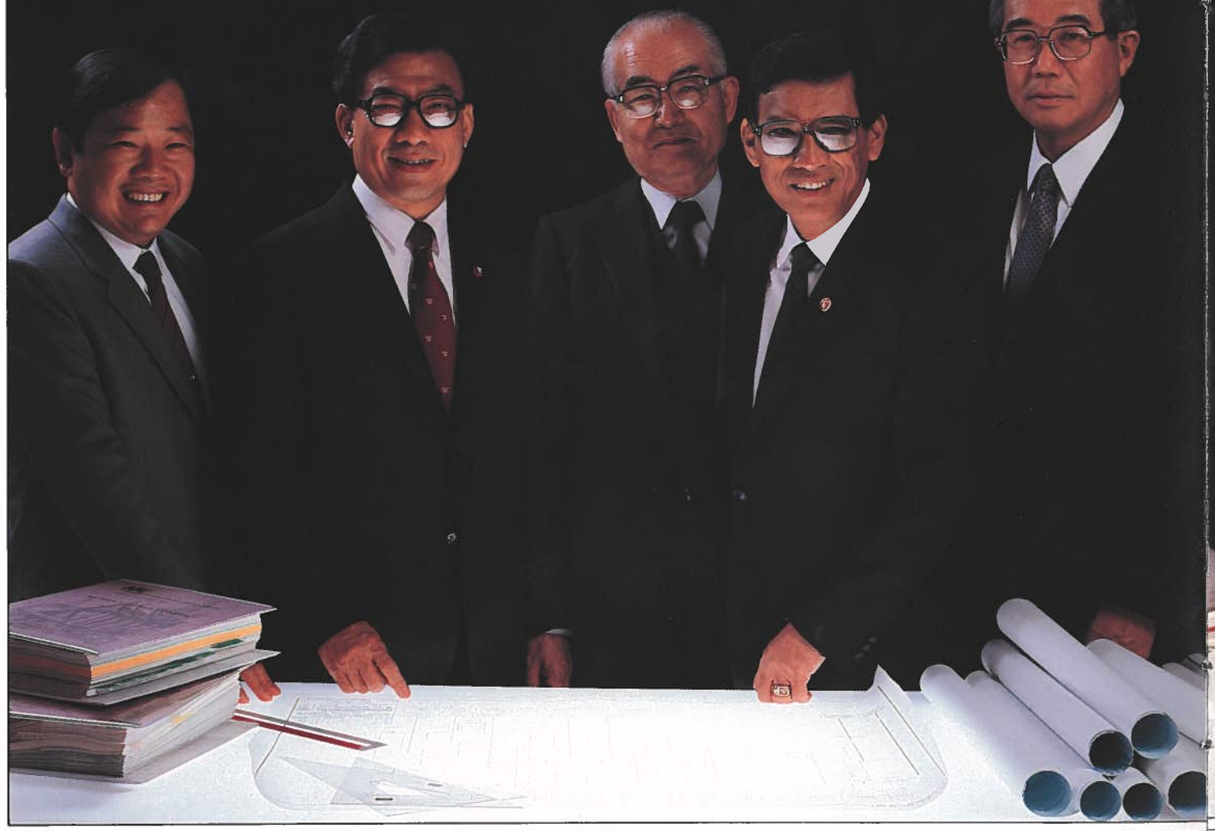
Input	Output	
350 million ft³/day	LPG/propane	450,000 tons/year
	Methane	289,000 million ft³/day
	Ethane	350,000 tons/year
	NGL	66,000 tons/year

In another demonstration of a planned response to growing consumer and industrial demand, PTT will phase in its second gas separation plant in 1989, nearly doubling current capacity, just as the kingdom's US$1-billion petrochemical complex comes on stream.

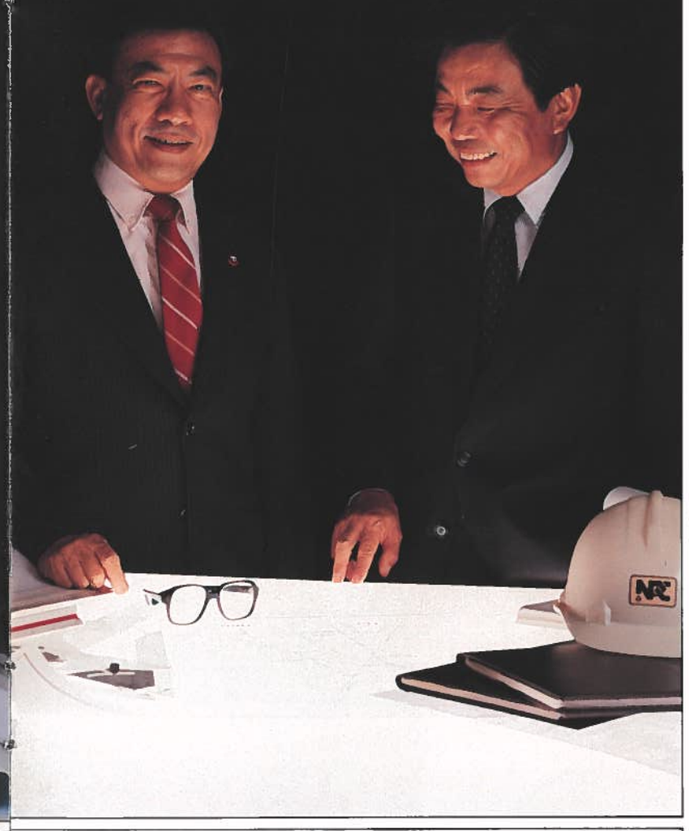
1986—Stage 3:

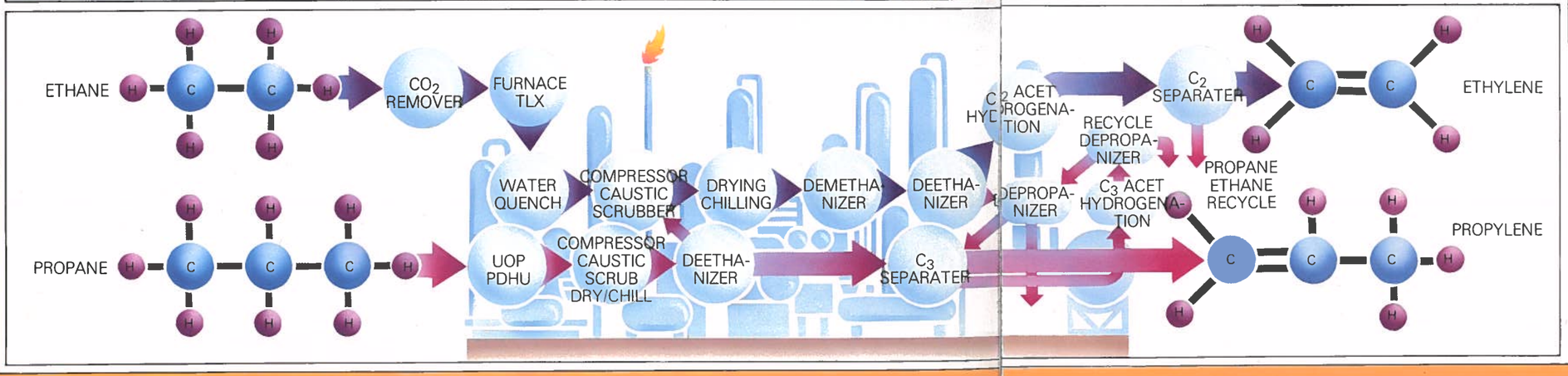
NPC begins constructing the olefins plant.

On January 6, 1987, NPC awarded a 4,570-million-Baht (US$176 million) contract for the construction of the olefins plant and central utilities and storage (Groups I & II) in the petrochemical upstream unit to the Japanese consortium of Toyo Engineering Corporation and Mitsui and Co., Ltd. Attending the signing agreement are, from left to right, 1.) DR. PICHIT NITHIWASIN, Managing Director of HMC Polymers Co., Ltd. and representative of Private Sector in National Petrochemical Corporation Limited, 2.) DR. SIPPANONDHA KETUDAT, President of NPC, 3.) MR. MASAO SAKURAI, President of Toyo Engineering Corporation, 4.) DR. CHAOVANA NA SYLVANTA, Chairman of NPC and 5.) MR. KIYOSHI ITO, Executive Managing Director of Mitsui & Co. Ltd.



On January 16, 1987, NPC signed a 268-million-Baht (US$10 million) contract for the construction of general facilities (Group III) in the petrochemical upstream unit, with the Thai consortium of Sino-Thai Engineering and Construction Co., Ltd. and Metric Co., Ltd. Representing NPC is the President, DR. SIPPANONDHA KETUDAT and MR. CHAVARAT CHARNVIRAKUL, Chairman and Chief Executive Officer of Sino-Thai Engineering and Construction Co., Ltd.





With the maximum Board of Investment promotional privileges possible, NPC started constructing the upstream facilities in December, 1986.

Just over five years before in 1980, the Eastern Seaboard Development Programme's Petrochemical Subcommittee initiated the planning phase of the project. By June 1982, they concluded that raw material supply and final product demand were sufficient. A final feasibility study completed in February 1985 set the expected return on investment at 22 percent.

The choice of the processing technology grew out of a study performed jointly by Lurgi GmbH of Germany and Trichem Consultants Ltd. of the United Kingdom.

On completion, the olefins plant will consist of two main processing units: an ethane/propane cracker, using C.E. Lummus technology, and a propane dehydrogenator, using the "oleflex process" licensed from Universal Oil Products Inc. (UOP) of USA and Nikki Universal Co. of Japan. NPC's plant will be the first-ever commercial installation of the UOP's catalytic dehydrogenation process. At full production, the plant will crack:

- ☐ Ethane: 354,800 tons/year
- ☐ Propane: 86,800 tons/year and dehydrogenate:
- ☐ Propane: 117,500 tons/year

These levels will use the entire production of the existing gas separation plant.

Combined, these two units will produce 265,000-315,000 tons/year of polymer-grade ethylene and 105,000 tons/year of propylene. Those levels will meet existing market demand in 1989, but will require expansion almost immediately, if current rates of demand growth continue.

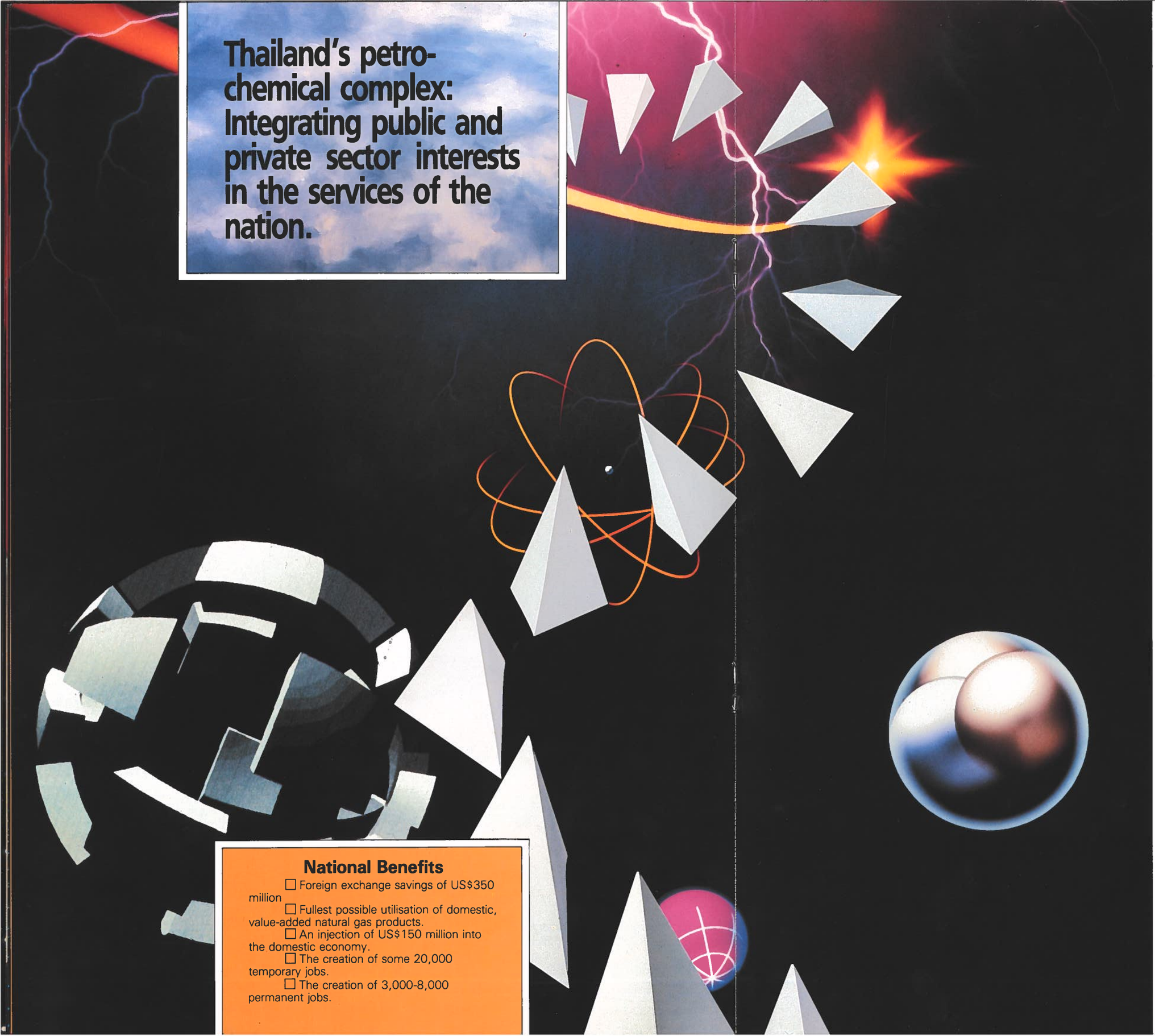
NPC has divided the construction of the upstream unit into three groups. Group I covers the olefins plant. Group II covers the central utilities and storage facilities. Group III covers the general facilities and off site facilities.

The construction contract for Groups I & II went to the consortium of Toyo Engineering Corporation and Mitsui & Co., Ltd. Worth Baht 4,570 million (US$176 million), construction began in December 1986 with completion scheduled for October 1989. Offshore funds will finance this phase of the project. NPC has retained Lurgi GmbH of Germany and Trichem Consultants Ltd. of the United Kingdom as consulting engineers.

The construction contract for Group III went to the consortium of Sino-Thai Engineering and Construction Co., Ltd. and Metric Co., Ltd. Worth Baht 268 million (US$10 million), construction began in April 1986, with completion scheduled for October 1989. Funds for this phase of the project, plus pre-operating expenses and working capital during the start-up period will come from a combination of equity and local financing. NPC has retained Metropolitan Engineering & Consultant Co., Ltd. as consulting engineers.

In all, the complex will take up an area of 1,076 rai (430 acres), of which 350 rai are for the olefins plant with the balance available for the downstream plants and expansion.

Thailand's petrochemical complex: Integrating public and private sector interests in the services of the nation.



National Benefits

☐ Foreign exchange savings of US$350 million

☐ Fullest possible utilisation of domestic, value-added natural gas products.

☐ An injection of US$150 million into the domestic economy.

☐ The creation of some 20,000 temporary jobs.

☐ The creation of 3,000-8,000 permanent jobs.

Thailand's petrochemical complex—upstream, downstream, plus facilities and services—reflects a most favourable cooperation between public and private interests. In fact, in developing domestic energy and petroleum-derived industrial raw materials sources, the Royal Thai Government has followed a pattern of providing incentives to private enterprises where commercially viable, and of investing in infrastructure where feasible from the standpoint of national economic objectives.

From the very beginning, the Royal Thai Government has carefully tailored its role in the petrochemical complex to what fits its overall involvement in petroleum-related activities. Through PTT, a state enterprise, the Government is the sole supplier of raw materials to the upstream unit—ethane and propane from PTT's own gas separation plant. As the major shareholder in the upstream olefins plant, PTT derives additional revenues from ethylene and propylene sales to the downstream operators.

NPC has a supply and price guarantee from PTT's gas separation plant and a 15-year offtake guarantee from the four downstream companies worth Baht 6,000 million/year (US$138 million).

The mix of shareholders PTT has brought together in NPC links and balances mutual interest.

Each of the four downstream shareholders holds an equity interest in the upstream unit in proportion to its percentage of the upstream offtake.

Participation by the two remaining shareholders and proportionately the smallest—the Crown Property Bureau and the International Finance Corporation of the World Bank group—demonstrates support at the highest level, both in the kingdom and internationally, while giving the project access to sources of expertise.

The actual holdings are as follows:

Entity	%	Baht (millions)
PTT (Petroleum Authority of Thailand)	49.0	980.0
TPE (Thai Polyethylene Co., Ltd.)	15.9	317.5
TPI (Thai Petrochemical Industry Co., Ltd.)	14.4	288.0
HMC (HMC Polymers Co., Ltd.)	10.1	202.9
TPC (Thai Plastics and Chemicals Co., Ltd.)	5.4	108.0
The Crown Property Bureau	4.5	90.0
IFC (International Finance Corporation)	0.7	13.5
Total:	100.0	2,000

In December 1986, NPC increased its registered capital from the initial level of Baht 70 million (US$ 2.7 million) to Baht 2,000 million (US$ 76.9 million).

NPC has further diversified the involvement of the Thai private sector. A syndicate of six Thai commercial banks—Bangkok Bank Limited, Thai Farmers Bank Limited, The Siam Commercial Bank Limited, Krung Thai Bank Limited, Bank of Ayudhya Limited, and The Thai Military Bank Limited—have developed the financing package for the Baht-6,000-million (US$ 218 million) complex with a 3:1 debt/equity ratio:

Source	Baht (millions)	US$ (millions)
Suppliers' credit:	3,884.0	149.4
Commercial term loans:	1,800.0	68.8
Equity:	2,000.0	74.5

For the suppliers' credits from Japan, the banks will issue irrevocable and unconditional letters of guarantee. The banks will arrange commercial term loans in either baht or US$ and working capital for NPC's commercial operation phase.

1989—Stage 4:

All elements of Thailand's world-scale petrochemical complex come on stream.

National Benefits

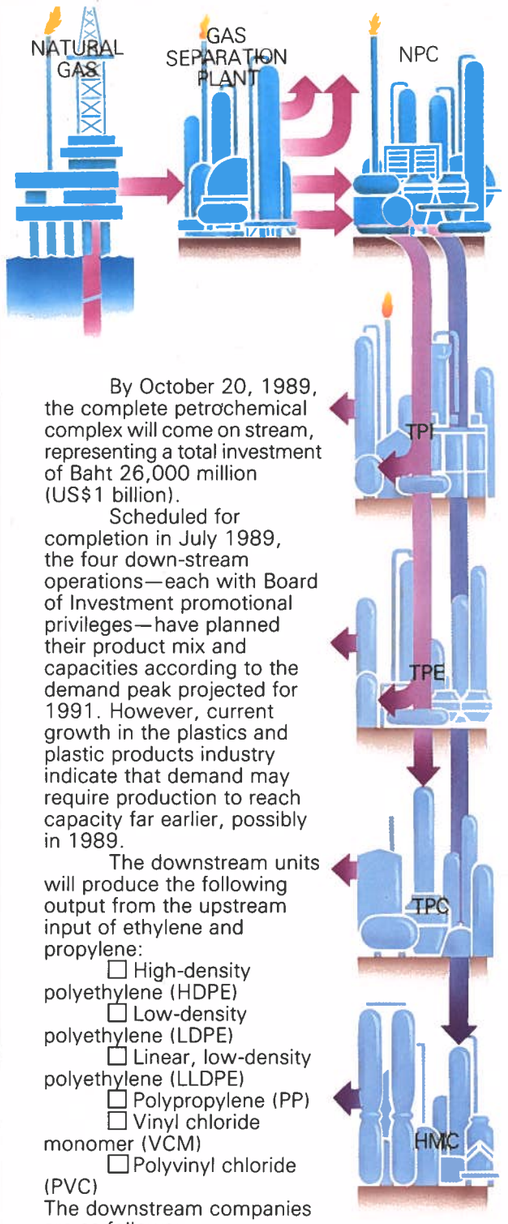
☐ Annual foreign currency savings of US$ 355 million.

☐ Value added to indigenous natural gas: more than four fold.

☐ Equal or lower raw materials cost to plastics industry.

☐ Stimulate plastics industry with stability of supply and price.

☐ Creates between 3,000-8,000 jobs directly and indirectly within the petrochemical industry.



By October 20, 1989, the complete petrochemical complex will come on stream, representing a total investment of Baht 26,000 million (US$1 billion).

Scheduled for completion in July 1989, the four down-stream operations—each with Board of Investment promotional privileges—have planned their product mix and capacities according to the demand peak projected for 1991. However, current growth in the plastics and plastic products industry indicate that demand may require production to reach capacity far earlier, possibly in 1989.

The downstream units will produce the following output from the upstream input of ethylene and propylene:

☐ High-density polyethylene (HDPE)

☐ Low-density polyethylene (LDPE)

☐ Linear, low-density polyethylene (LLDPE)

☐ Polypropylene (PP)

☐ Vinyl chloride monomer (VCM)

☐ Polyvinyl chloride (PVC)

The downstream companies are as follows:

Thai Petrochemical Industry Co., Ltd.

A distributor of petrochemical products since 1980 and a manufacturer since 1982 (LDPE: 65,000 tons/year; HDPE or LLDPE: 60,000 tons/year)

Thai Polyethylene Co., Ltd.

Thai Polyethylene Co., Ltd. (TPE) is a wholly-owned subsidiary of Siam Cement Co., Ltd., one of Thailand's largest industrial concerns. In November 1983, five months after the Eastern Seaboard Development Committee's decision on the selection of various downstream sponsors, TPE was incorporated as a government-promoted company to implement the polyethylene project.

This project involves an annual production of 137,500 metric tons of all three types of polyethylene, namely, high density polyethylene (HDPE), medium density polyethylene (MDPE) and linear low density polyethylene (LLDPE), and requires an investment of approximately 2,300 million baht.

Much benefit will be accrued to the Kingdom from the project, including an expected annual foreign exchange savings of 2,500-2,800 million baht that would otherwise have to be spent importing polyethylene resins.

Thai Plastic & Chemical Co.,Ltd.

TPC, now a company listed at the Securities Exchange of Thailand, has been the country's only major manufacturer and supplier of polyvinyl chloride (PVC) resins and compounds since 1971. Today, it is capable of producing 100,000 tons a year of PVC resins together with 35,000 tons a year of PVC compound.

In addition, as an integrated part of the NPC petrochemical complex, TPC was assigned by the Government to undertake a project to produce 140,000 tons a year of vinyl chloride monomer (VCM) and 60,000 tons of PVC resin.

As a result, more than 1,300 million baht are saved in the form of VCM import substitution.

HMC Polymers Co.,Ltd.

HMC Polymers Co.,Ltd. (HMC) was established in December 1984, by the Metro Group, Thailand's leading agro-and chemical-based conglomerate, to develop a polypropylene (PP) project in the Kingdom.

In May 1985, Himont Inc., the world's largest producer and supplier of PP, joined Metro for the venture which aimed to produce 100,000 tons a year of the highest quality PP resins. Engineering design work then commenced under Himont's expertise and a construction tender was consequently issued. That resulted in the consortium of Technimont, Kobe Steel and Nissho Iwai being chosen and awarded the engineering contract in September 1987. Himont's Spheripol process was selected for the production. Site preparation work was completed by the contractor Tesco, in April 1987. In July 1987, Stancon was appointed contractor for the civil work. Construction of the plant is progressing satisfactorily towards the onstream date in June 1989.

Among other direct benefits the HMC project will provide to the country is that more than 2,600 million baht in foreign exchange will be saved each year in the form of import substitution.

Bangkok Industrial Gas Co., Ltd.

Talks commenced in 1985 with Bangkok Steel Industry Co., Ltd. and the US-based Air Products and Chemicals Inc. establishing facilities to process and supply oxygen and nitrogen to NPC's upstream petrochemical unit. In 1986, four additional partners, the Metro Group, Thai Sunrock, Huakee and the Bangkok Bank joined. Shortly after, BIG, incorporated early in 1987, was awarded the contract to supply about 2,500 cubic metres per hour (cmh) of gaseous oxygen and 2,500 cmh of gaseous nitrogen to NPC representing a savings to NPC of over 212.5 million baht and assuring the continued needed supply of oxygen and nitrogen.

Thailand's petrochemical complex: Planting the seeds of a new industry and increasing national self-sufficiency.

By the end of 1989, Thailand will have taken a giant step toward self-sufficiency in petroleum-related products, ensuring greater stability of price and supply. The kingdom will have a sufficient and secure domestic supply of natural gas that will lead to near independence from imports of fuel and raw material alternatives. At full commercial operation, the petrochemical complex will eliminate the need to import ethylene or propylene, or any of its derivatives (especially, polymer resins) that supply the growing demand of a burgeoning plastics and plastic products industry.

The advantages derived from Thailand's increasing production and processing capacities will combine with the kingdom's other advantages —cost-effective, efficient labour; social and political stability; plus a plentiful domestic supply of both mineral and agricultural resources— to further enhance the competitiveness of Thailand's exports in world markets.

Thailand currently has more than 1,000 plastics processing plants employing some 15,000 people. The petrochemical complex's polymer and resin production will more than satisfy the diversity of input the plastics industry requires. An additional benefit available to the industry from the downstream processors will be technical assistance.

Many of the Thai plastics manufacturers lack the technical expertise necessary to select the proper types and grades of raw materials for the applications they require. Moreover, these manufacturers may not fully understand which machines are most appropriate, nor how to operate them for optimum quality and production.

The end-user market for downstream polyethylene and polypropylene divides into five product sectors: film, extrusion, injection, blow moulding, and lamination, according to a Lurgi-Trichem field market survey. Their findings yielded the following profile of the plastics industry:

Process	Raw Material	Products
Film	LDPE/PP	bags, packaging
Extrusion	HDPE/PP	ropes, nets, tapes, straws, pipes
Injection	LDPE/HDPE/PP	lids, crates, utensils
Blow moulding	HDPE/PP	containers
Lamination	LDPE/PP	consumer product packaging

Products made from PVC cover a wide range with a rapidly growing demand: pipes, fittings, hoses; film and calendered sheet; wires and cables; bottles; shoes and sandals; and construction applications.

Projections indicate that with the favourable factors, the petrochemical complex will create for the plastics and plastic products manufacture, the industry will grow in size, diversity, and quality, generating some 20,000 new jobs and leading to zero imports and growing exports, because of increased competitiveness in quality, service, and price.

NPC's Board of Directors: Experienced, skilled, and committed.

The distribution of seats in NPC's board of directors reflects the shareholdings and roles of the institutions involved. Each has strong credentials that together provide knowledgeable and disciplined guidance to the NPC's evolution as one of the most important commercial entities in the kingdom.

Dr. Chaovana NaSylvanta
Chairman

Positions
- ☐ Privy Councillor
- ☐ Chairman of the Board of Directors, Electricity Generating Authority of Thailand (EGAT)
- ☐ Chairman of the Board of Directors, Petroleum Authority of Thailand (PTT)
- ☐ Chairman of the Board of Directors, The Institute for Management Education for Thailand Foundation (IMET)
- ☐ Chairman of the Council of Trustees, The Petroleum Institute of Thailand (PTIT)
- ☐ Member of the Court of Directors, The Bank of Thailand
- ☐ Member of the Board of Directors, The Siam Cement Co., Ltd.

Education
- ☐ B. Eng. (Hons.) in Mechanical Engineering, Chulalongkorn University
- ☐ B. Eng. in Electrical Engineering, Chulalongkorn University
- ☐ Master of Science in Mechanical Engineering (S.M.) Massachusetts Institute of Technology
- ☐ Professional Degree, Mechanical Engineer (Mech. E.), Massachusetts Institute of Technology
- ☐ Doctor of Science Degree in Mechanical Engineering (Sc. D.), Massachusetts Institute of Technology
- ☐ Degree of National Defence College
- ☐ Honorary Doctorate in Engineering, Chulalongkorn University
- ☐ Honorary Doctorate in Business Administration, Chiang Mai University
- ☐ Honorary Degree of Doctor of Technology, Asian Institute of Technology (AIT)

Experience
- ☐ Deputy Governor for Engineering, The State Railway of Thailand
- ☐ Minister of Communications, Ministry of Communications.

Dr. Anat Arbhabhirama
Vice Chairman

Positions
- ☐ Governor of the Petroleum Authority of Thailand
- ☐ Senator

Education
- ☐ Bachelor of Engineering (Civil Engineering) Chulalongkorn University, Bangkok
- ☐ Master of Engineering (Hydraulic Engineering) Asian Institute of Technology (AIT), Bangkok
- ☐ Doctor of Philosophy (Civil Engineering) Colorado State University, Colorado, U.S.A.

Experience
- ☐ Research Associate in Hydraulic Engineering SEATO Graduate School of Engineering, Bangkok
- ☐ Assistant Professor, North Dakota State University, North Dakota, U.S.A
- ☐ Assistant Professor, Chulalongkorn University, Bangkok (specially assigned to teach and conduct research at the Asian Institute of Technology)
- ☐ Teaching staff of the Asian Institute of Technology, Bangkok
  - Assistant Professor and Chairman, Mathematics and Computer Center
  - Associate Professor
  - Chairman, Division of Water Resources Engineering
  - Vice President for Academic Affairs and Provost
  - Head, Regional Research and Development Center
- ☐ Deputy Minister of Agriculture and Cooperatives
- ☐ Minister of Agriculture and Cooperatives
- ☐ Advisor to the Prime Minister Prem Tinasulanonda
- ☐ President, Thailand Development Research Institute

Dr. Somchai Kongsala,
Second Vice Chairman

Position
- ☐ General Manager, Thai Plastic & Chemical Co., Ltd.

Education
- ☐ Ph.D (Automatic Control), London University
- ☐ Advanced Management Program, Harvard Business School

Experience
- ☐ Project Manager, Thai Plastic & Chemical Co., Ltd.
- ☐ Manufacturing Director, Thai Plastic & Chemical Co., Ltd.
- ☐ Marketing and Assistant Managing Director, Thai Plastic & Chemical Co., Ltd.
- ☐ General Manager and Chief Operating Officer, Thai Plastic & Chemical Co., Ltd.

Dr. Tongchat Hongladaromp

Positions
- ☐ Former Governor, Petroleum Authority of Thailand.
- ☐ Chairman, Board of Directors, PTT Exploration and Production Co., Ltd.
- ☐ Vice Chairman, Council of Trustees, The Petroleum Institute of Thailand.
- ☐ Director, Thai Oil Co., Ltd.
- ☐ Director, Bangchak Petroleum Co., Ltd.
- ☐ Director, The Thai LNG Co., Ltd.
- ☐ Director, Thai LNG International Co., Ltd.
- ☐ Member, The Petroleum Committee.

Education
- ☐ B.Eng. (Civil), 2nd Class Hons., Chulalongkorn University
- ☐ M.Eng (Civil), Asian Institute of Technology
- ☐ Ph.D. (Civil Engineering), Northwestern University, USA.

Mr. Sirin Nimmanahaeminda

Position
- ☐ Deputy Governor, Finance, & Acting Deputy Governor, Administration; Petroleum Authority of Thailand.

Education
- ☐ B.A. (Economics), University of Michigan, USA.
- ☐ M.B.A., (Finance & Accounting), Graduate School of Business, Stanford University, USA.

Mr. Pala Sookawesh

Position
- ☐ Deputy Governor for Logistics and Refining, Petroleum Authority of Thailand

Education
- ☐ B.Eng. Hon., (Electrical-Power), Chulalongkorn University.
- ☐ Cert. in Systems Analysis, US Army Corps of Engineers, USA.
- ☐ M.S., Industrial Engineering (Operations Research), Oregon State University, USA.

Mr. Chumpol Nalamliang

Position
- ☐ Senior Vice President - Finance, The Siam Cement Co., Ltd.

Education
- ☐ B. Sc. (Mechanical Engineering), University of Washington, USA.
- ☐ M.B.A., Harvard Business School, USA.

Mr. Prachai Leophairatana

Positions
- ☐ Chief Executive Officer, Thai Petrochemical Industry Co., Ltd.
- ☐ Managing Director, Hong Yiah Seng Co., Ltd.
- ☐ Managing Director, Saraburi Ginning Mill Co., Ltd.
- ☐ President, United Grain Jute Mill Co., Ltd.
- ☐ President, Cathay Finance Co., Ltd.
- ☐ Director, Bangkok Union Insurance Co., Ltd.
- ☐ Director, International Trading Development Corp., Ltd.
- ☐ Director, K. Cotton & Gauge Co., Ltd.

Education
- ☐ B.E., 1st Class Hons., Canterbury University, New Zealand
- ☐ M.S.EE., University of California (Berkeley)

Dr. Pichit Nithiwasin

Positions
- ☐ Managing Director, Bangkok Steel Co., Ltd.
- ☐ Manging Director, HMC Polymers Co., Ltd.
- ☐ Director, Thai Union Paper Co., Ltd.
- ☐ Director, Union Asia Finance Co., Ltd.
- ☐ Director, Association of Thai Industries.

Education
- ☐ B.S. (Industrial Engineering), University of California, Berkeley, USA.
- ☐ M.S. (Industrial Engineering, Operations Research), University of California, Berkeley, USA.
- ☐ M.S. (Electrical Engineering and Computer Science), University of California, Berkeley, USA.
- ☐ Ph.D. (Operations Research), University of California, Berkeley, USA.

Structured and managed for efficiency and growth.

NPC's corporate structure includes one line and two staff departments with policy authority residing in the board of directors and executive authority residing in the president. Reflecting NPC priorities, the training and development division is part of the line department.

Dr. Sippanondha Ketudat
President

Positions
- President, National Petrochemical Corporation, Ltd.
- Senator, National Legislative Assembly
- Member, National Economic and Social Development Board
- Member, National Research Council, and the Physical Science Research Section
- Member, National Environment Board
- Member, National Education Commission
- Member, Science and Technology Development Board
- Member, National Commission for Unesco
- Member, Committee for the Promotion of Science Talent
- Member, Chiang Mai University Council
- Member, Mahidol University Council
- Member, Sukhothai Thammathirat Open University Council
- Member, Chulalongkorn University Council
- Member, Council of Dhurakijpundit University
- Member, Council of Rangsit College
- Member, Council of Trustees of the Petroleum Institute of Thailand
- Member, Council of Trustees of Thailand Development Research Institute
- Chairman, Selection Committee for Outstanding Thai Scientists
- President, Harvard Club of Thailand
- Member, John F. Kennedy Foundation of Thailand

Education
- B.S. in Applied Physics, University of California, Los Angeles
- A.M. in Physics, Harvard University
- Ph.D. in Physics, Harvard University
- Post-doctoral Fellow, M.I.T., Cambridge, Massachusetts, USA
- Research Affiliate Argonne National Laboratory, Argonne, Illinois
- Alexander von Humboldt Research Fellow, Eduard Zintl Institut, Technische Hochschule Darmstadt, Federal Republic of Germany
- Diploma, National Defense College
- Ed.D. Hons. Silpakorn University
- Ed.D. Hons. Prince of Songkla University

Experience:
- Senior Lecturer-Associate Professor, Chulalongkorn University
- Professor of Physics, Chulalongkorn University
- Secretary, Graduate School, Chulalongkorn University (dual appointment)
- Director, University Development Commission, National Education Commission (dual appointment with Chulalongkorn University)
- Deputy Director, Southeast Asian Ministers of Education Secretariat (SEAMES)
- Chairman, Committee for Establishing the Framework for Education Reform
- Member, National Legislative Assembly
- Secretary General, National Education Commission
- Member, Advisory Committee of The Prime Minister
- Deputy Minister, Ministry of Education
- Minister, Ministry of Education
- Member, Board of Trustees, International Council for Educational Development (ICED), New York
- Member, Governing Board, UNESCO International Institute of Educational Planning (UNESCO IIEP) Paris
- Member, Advisory Council, Instituto Ajijic Sobre Educacion Internacional (IASEI), Universidad Autonoma de Guadalajara, Guadalajara Jalisco, Mexico
- Member, Advisory Board, Institute for Higher Education, The University of New England, Armidale, N.S.W. Australia.
- Member, Honorary Advisory Editorial Board, International Encyclopedia of Education: Research and Studies, Pergamon Press.

Mr. Kamolchai Pattarodom
Manager, Engineering & Construction Dept. and Project Director, Olefins Plant Construction Project

Positions
- Manager, Engineering & Construction Department
- Project Director, Olefins Plant Construction Project

Education
- B.S. in Electrical Engineering (Power), Chulalongkorn University
- Columbo Plan Scholarship Training Session Power Generation, Japan.
- Columbo Plan Scholarship Training Session, Problems in Management of Electric Power Industry Japan.
- French Government Scholarship, Nuclear Power Plant Operations, France.
- International Atomic Energy Agency Training, Nuclear Power Plant Construction and Operation Management, Argonne National Laboratory, Argonne, Illinois.

Experience
- Electrical Engineer, Electrical Section, North Bangkok Power Plant
- Turbine Controls Supervisor Engineer, North Bangkok Power Plant
- Shift Charge Engineer, supervising operations, EGAT 75MW North Bangkok Power Plant
- Chief Project Coordinator, 1000MW South Bangkok Power Plant Construction Project
- Chief Electrical Division, EGAT Thermal Power Plant Construction Department
- Project Director, 1920MW Bang Pakong Thermal Power Plant Construction Project.
- Acting Plant-Superintendent, Bang Pakong Thermal Power Plant

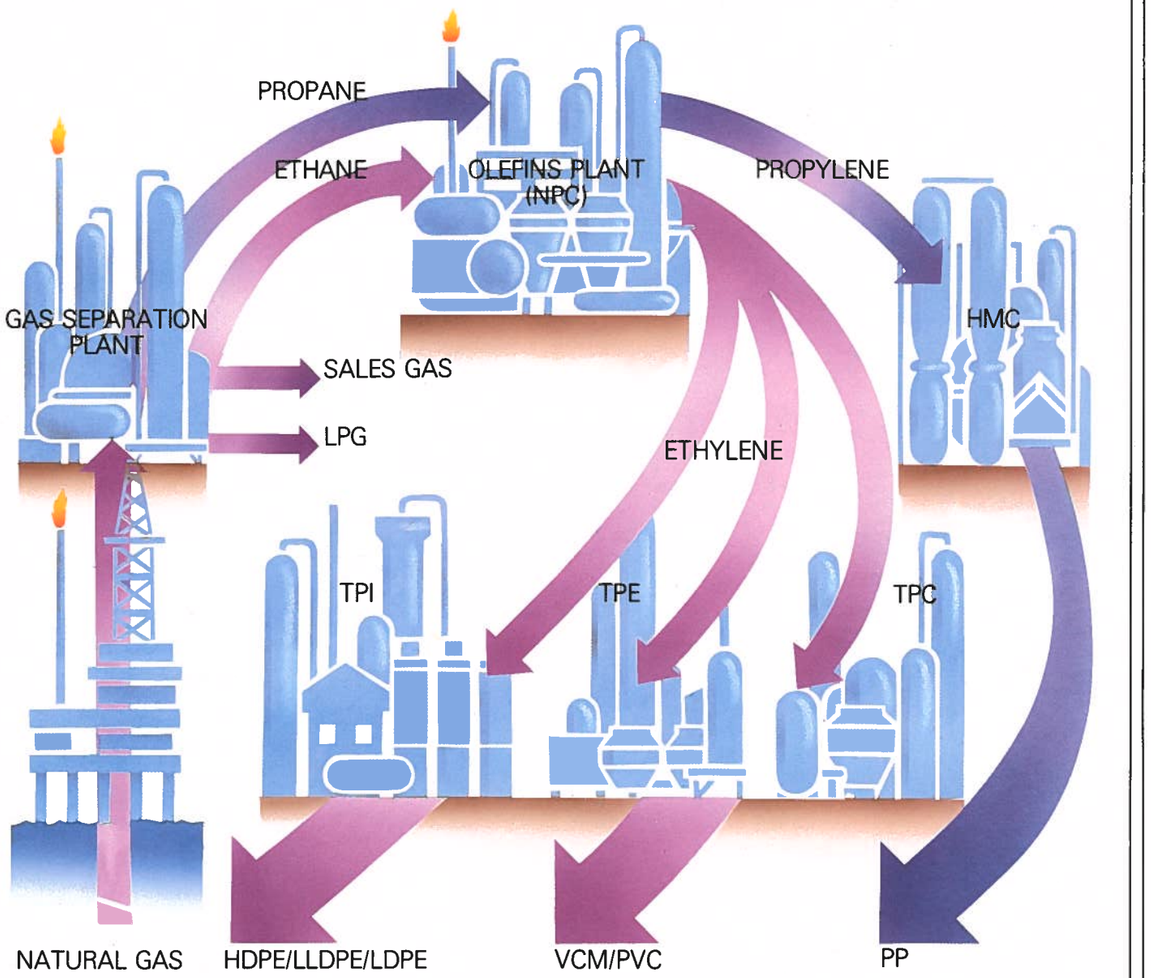
Dr. Siri Jirapongphan
Manager, Planning & Coordination Dept.

Positions
- Manager of Planning and Information Department, National Petrochemical Corporation Ltd.
- Director and Secretary to the Board of Directors, Petroleum Institute of Thailand Foundation
- Council of Trustees, Petroleum Institute of Thailand.

Education
- Sc. D. degree in Chemical Engineering, Massachusetts Institute of Technology (MIT)
- Minor in Business Administration, (MIT)
- M.I.T. Research Assistantship
- Member of American Institute of Chemical Engineers
- Member of Sigma Xi Scientific Research Society
- S.B. (Honor) degree in Chemical Engineering, California Institute of Technology

Experience
- The Aspen (Advanced System for Process Engineering) Project, Cambridge, Ma.
- Arthur D. Little Co., Cambridge, Ma.
- Process Simulation Associates Cambridge, Ma.
- Thai Petrochemical Industry Co., Ltd., Bangkok, Thailand
- Chulalongkorn University, Lecturer in Chemical Engineering
- Petroleum Authority of Thailand, Head of Systems Planning Division.

Why and how are plastics made?



Why Plastics?

In our present day lives, whether in a rural village or in a city, it is difficult to imagine lives without water supply and electricity. Very few realise that a major portion of water pipes and electric wire insulation are made of plastics. Small water ponds are now utilising plastic sheets as lining. Thirty per cent of components of cars, trucks and buses are made of plastics.

Thailand is no exception. Forests are depleting. Animal hides are becoming expensive. Plastic tables, chairs, screen, plates, spoons, household utensils as well as radio, television and computer cabinets are made of plastics. Plastics are cheaper, lighter and less expensive.

What are plastics?

Plastics are synthetic materials made from petroleum products as raw materials.

How are plastics made?

Petroleum, whether crude oil or natural gas found in nature, are mixtures of many types of hydrocarbon molecules which are made up from hydrogen and carbon atoms linked in various geometrical forms. A *gas separation plant* separates the hydrocarbon mixture into various types of hydrocarbon compounds, such as, ethane, propane, butane, etc. Propane and butane mixed and compressed becomes liquid petroleum gas (LPG) and can be delivered to households for cooking or used as fuel for cars. Ethane and propane are used as feedstock for an *olefins* or *upstream plant* making ethylene and propylene gas molecules. These gas molecules are then linked together or polymersed into plastic polymers by *downstream plants*. The polymers are in the form of a powder resin. When the resin is heated and blown it forms thin plastic film for bags; heated and extruded it forms pipes; heated and injected in molds it forms plastic bottles, etc.

NPC Ideal

Thailand is fortunate to be blessed with natural gas in the Gulf. Feedstock alone is useless without knowledgable people. Human resources in scientific, technological and managerial skills that have been built up through modern education by our ancestors over a century are adequate to harness these raw materials to serve the needs of our population. The attainment of this goal is our ideal. *NPC brings forth to the public a fair share of our natural resources.*

National Petrochemical Corporation Limited
21st Floor, Sino-Thai Tower,
32/51 Asoke Road, Sukhumvit 21, Bangkok 10110, Thailand
Tel: 260-1311-16
Telex: 21393 NAPETRO TH
Fax: 66-2-260-1318

Thai Petrochemical Industry Co., Ltd.
Bangkok Union Insurance Building,
175-177 Surawongse Road, Bangkok 10500, Thailand.
Tel: 235-0310
Cable: "POLYTHENE" BANGKOK
Telex: 72073 PETOKEM TH, 72075 PETOKEM TH

Thai Polyethylene Co., Ltd.
1 Siam Cement Road, Bangsue, Bangkok 10800
GPO Box 572, Bangkok 10501, Thailand
Tel: 586-4444
Telex: 72261 SIAMENT TH

Thai Plastic and Chemical Co., Ltd.
5th Floor, Asia Sathorn Building,
191 South Sathorn Road, Yannawa, Bangkok 10120
Tel: 286-4252, 287-2985-9
Cable: PLASTICHEM
Telex: 21279 PLASTIC TH
Fax: 287-2983

HMC Polymers Co., Ltd.
8th Floor, UFM Building,
205 Rajawongse Road, Bangkok 10100, Thailand
Tel: 223-0470-9, 224-5659, 224-5666, 224-5675

Bangkok Industrial Gas Co., Ltd.
5th Floor, UFM Building,
205 Rajawongse Road, Bangkok 10100, Thailand
Tel: 222-7166-7, 223-0114-20
Telecopy: 224-7698

RESEARCH NEWS

Thailand Institute of Scientific and Technological Research

1986 - 1987

Information Distribution Section

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phahonyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5791121–30

ENVIRONMENTAL PROBLEMS OF NONG HAN LAKE

Many environmental problems, including the deterioration of water quality, at Nong Han Lake in Sakon Nakhon Province have accumulated over the long period of time that the Lake has been in use. The problems are becoming more acute and if an appropriate solution and management programme are not implemented in the near future this trend will continue and may have a very adverse impact on the aquatic life of the Lake as well as on the inhabitants located around the Lake. Moreover the provincial economy may suffer.

The deterioration of water quality is caused mainly by the introduction of domestic wastes, agro-chemicals, toxic residues, and the growth of an excessive number of aquatic plants. The increased number of aquatic animals plays a part too as they are vectors of parasitic and pathogenic organisms which may eventually cause human and animal diseases over a wide area.

Such problems were recognized by Mr. Thaweewat Ritruechai who in his capacity as Secretary to the Minister of Science, Technology and Energy, and as MP for Sakon Nakhon, requested that a preliminary investigation of the Lake be made in order to construct guidelines for resolving the problems. In September 1985 he requested TISTR to conduct such a preliminary survey and study and as a result of this study the following guidelines were proposed :

1. Control waste generating sources, such as sewage from Sakon Nakhon Municipality. This should be treated before being discharged into the Lake. Moreover, improper use of pesticides for agriculture in the area around the Lake should also be controlled in order to reduce the toxic residues which eventually drain into the Lake.

2. To maintain the Lake in a favourable condition, regular monitoring of water quality should be conducted. Moreover, a survey and study of the ecological system, the growth of an excessive number of aquatic weeds, and dredged sediment at the bottom of the Lake should be carried out.

3. The full utilization of the Lake should be encouraged according to its potential in terms of fishing, animal husbandry, cultivation and tourism etc.

Moreover, TISTR has also suggested i-mediate action in campaigning for aquatic weeds harvestation at the outlet of the Lake and for monitoring water quality in the Lake on a regular basis. With regard to a long term management project for the Lake TISTR has suggested a study for the preparation of an integrated master plan for the environmental management of Nong Han Lake including the management of garbage and waste water generated from the Municipality. As a first step in implementing such a study a seminar on "Environmental Problems of Nong Han Lake" to be held in May 1986 has been proposed. This is to share the views and experiences of the local people and the various agencies concerned with the Lake.

An environmental management plan for Nong Han Lake is quite essential. This will not only help to maintain good water quality and smooth ecosystem functioning, but will also foster its sustainable development in terms of multiple uses. Moreover, the Lake, an important natural resource, may become an economic base for stimulating the permanent socio-economic development of the province.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phahonyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5791121–30

GRAIN AMARANTH PRODUCTION AND UTILIZATION

In Pre-Columbian times grain amaranth was one of the basic foods of the New World. It was nearly as important as corn and beans. Thousands of Aztec, Inca and other farmland areas were planted to this tall, leafy, reddish plants. Grain amaranth interwoven with legend and ritual. Apparently the use of amaranth grain in pagan rituals and human sacrifice shook the Spanish conquistadors, and with the collapse of South American Indian cultures following the conquest in the early 16th century, grain amaranth fell into dis-use.

The US National Academy of Sciences (US-NAS) had studied under-exploited tropical plants with promising economic value in 1975. Grain amaranth was selected from among 36 of the world's most promising crops. With protein content of about 16 per cent, amaranth seeds compare well with the conventional variety of wheat (12–14 per cent), rice (7–10 per cent), maize (9–10 per cent), and other widely consumed cereals. In addition, amaranth seeds contain protein of unusual quality. It is high in amino acid lysine which is nearly twice the lysine content of wheat protein, three times that of maize, and in fact as much as is found in milk.

The Agro-Technology Department of Thailand Institute of Scientific and Technological Research has received a research grant from US-NAS for the research on grain amaranth in Thailand in 1983. The objectives of the study were to select suitable grain amaranth varieties for Thailand, study on cultural practices, animal nutrition as well as grain amaranth product processing and development.

As a results of plant selection, 5 grain amaranth Mexican grain types were selected for further study. In addition, yield improvement programme has been carried out by means of plant breeding in which 10 F_2 hybrids of grain amaranth are currently under investigation. In processing study, it was found that amaranth seed flour can substitute wheat flour to certain portion for improvement of nutritional value of bakery products. Popped amaranth seeds can be made into confection or sweets when mixed with sugar syrup or honey.

With high nutritional value and that amaranth seeds can be extensively used in food production, it indicated that grain amaranth is one of the new crops of high economic potential. However, marketing development of grain amaranth products seems to be prime requirement before any attempt in commercial cultivation will be made.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phahonyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5791121–30

Sulfur Dioxide Fumigation in the Storage of Fresh Litchi

The litchi (*Litchi chinensis* Sonner) is a subtropical evergreen tree. It is native to south eastern China. The production of litchi is limited by its rather precise ecological requirements but is now spread throughout many tropical and subtropical regions including subtropical Asia (Taiwan, Vietnam), South East Asia (Thailand), north-central India, South Africa, Australia (Queensland, New South Wales), USA (Hawaii, Florida), the Antilles, Brazil, Madagascar, and others. It is one of the best known and highly esteemed subtropical fruits. The fruit has a thin attractive red rind. The edible translucent white aril encloses a dark brown seed. The fruit is eaten mostly as fresh fruit or canned. There are legends which romanticized the fruit. One of which says: a Chinese emperor, to please his empress, ordered fresh litchis to be sent from south China to his palace in the north by shifts and non-stop of the best and fastest horses-a legend indicating the extremely short shelf-life of litchi fruits. Indeed, the harvest season is short and the fruit is highly perishable.

Litchi fruits deteriorate rapidly after harvest due to desiccation and decay. High relative humidity is necessary to minimize the moisture loss of the rind. However, storage life is markedly shortened due to profound fungal growth on the fruit surface. At a low relative humidity, deterioration by decay is reduced but the rind losses the moisture which renders the fruit unattractive. Under an Australian Centre for International Agricultural Research (ACIAR) supported TISTR–CSIRO Cooperative Research Project on the Physiological, Chemical, and Storage Characteristics of Mangoes and Some Other Tropical Fruits in South East Asia, TISTR has undertaken studies on the postharvest handling and storage of tropical fruits including the litchi in Thailand.

The beneficial effect of sulfur dioxide as disinfectant in preventing rot of harvested fresh fruits has been developed into commercial practice for grape storage in many countries. Fumigation with sulfur dioxide of fresh litchi is known to be used in South Africa. Studies at TISTR covered: 1. Litchi respiration and ethylene production at 20° and 5° C. 2. Effect of sulfur dioxide fumigations at concentrations 0, 0.125, 0.25, 0.5, 1, and 2% on litchi with regards to respiration and ethylene production at 20° and 5° C and 3. Assessment of sulfur dioxide concentrations (0, 0.5 and 1%) and fumigation intervals (10 days and 20 days) on fruit qualities and rot control during long term cold storage at 5° ± 0.5° C.

Sulfur dioxide fumigation controlled the growth of surface mold. As the results, both CO_2 and ethylene production were lowered in treated fruits at both 20° and 5° C especially with fruits fumigated at sulfur dioxide 0.5, 1, and 2%. Immediately after fumigation, the rind turned from the original red colour to light pink or light creamy yellow depending on the sulfur dioxide concentrations used. However, there is a gradual restoration of rind colouration after 2 to 5 days at ambient. Rind bleaching and colour restoration occurred repeatedly even with more than ten fumigations (at 10 days intervals) at 20° C. The rind remains fresh and red.

Sulfur dioxide fumigation at periodic intervals under cold condition provided excellent rot control to litchis. Control fruits showed some surface fungal growth after one month and profound fungal growth after two months. Treated fruits in cold store for more than 90 days remained mold free and fresh. External appearances, colouration and freshness, of 90-day fruits are excellent. Taste and flavour remain acceptable though with a slight off-flavour. There is also a slight change to the aril from the shining translucent of freshly harvested fruits to turbidly white of fumigated fruit, all not obvious to a non-expert eater.

Periodic sulfur dioxide fumigation has made long term cold storage of litchi possible. Sulfur dioxide fumigation on longan has also been reported by TISTR earlier (TISTR Research News on Longan Postharvest Handling and storage, March 1985). Determination of sulfur residues in treated fruits is being planned.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phahonyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5791121–30

ELECTROSTATIC AIR CLEANER

Another achievement has been reached by Thailand Institute of Scientific and Technological Research (TISTR) which has, for the first time among the ASEAN nations, successfully carried out a research and development work on the design of an Electrostatic Air Cleaner.

The Electrostatic Air Cleaner is an equipment that cleans dirt clouded in the air, such as dust, smoke, pollen, fungi, bacteria and small particles.

The Electrostatic Air Cleaner is composed of three basic sections: the power pack, the ionizing section and the collecting section. The combination of ionizing section and collecting section is called the electro cell. In operation, smoke and dust particles in the air passing through ionizing wire with high voltage direct current charge will acquire a positive charge. These positive charge particles will be attracted by the negative collector plate.

This Electrostatic Air Cleaner proves to be more efficient than other ordinary ventilators or air purifiers, as it is able to purify the air contaminated with smoke, dust and powder from small particles of 50 microns (1 microm = 1/25,400 of 1 inch), which can be seen with naked eyes, to very fine dust and smoke of 0.03 micron which must be detected by an electron microscope. These particles include ash, rough and fine dust, bacteria, pollen, oil, cigarette and other smokes.

Due to its high efficiency, the Electrostatic Air Cleaner is extensively used internationally, both in the US and Europe and also in Japan. It has been designed for air purifying against smoke and dust expelling cigarette smoke and nicotine, and destroying disease-producing bacteria in the air. Also the Cleaner is equipped with an ability to help relieve patients allergic to dust and pollen. Additionally it freshens up a working atmosphere.

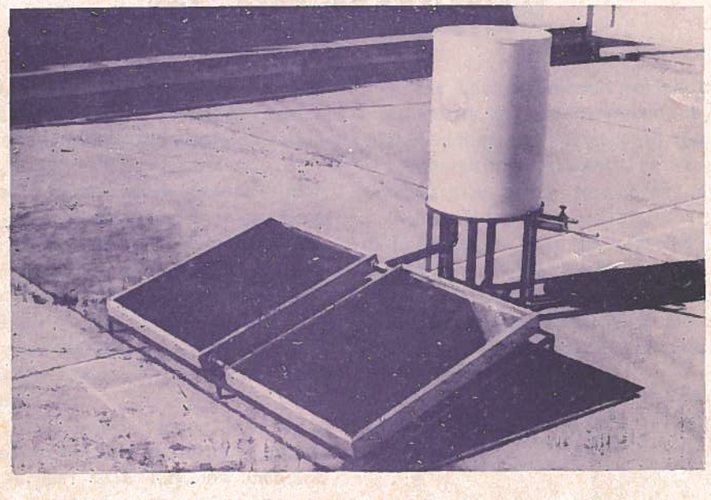
The Electrostatic Air Cleaner can be easily installed at any places ranging from assembly hall, meeting place, convention hall, computer room, restaurant, science equipment storage, electronics room and others.

The Electrostatic Air Cleaner which has undergone the research study and development by TISTR is to be put into market around June this year, with the Better Life Co. Ltd. being the sales distributor, both locally and abroad. For further particulars those interested are invited to contact the Industrial Cooperation and Promotion Centre of TISTR Tel. 579-0245.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phahonyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5781121–30

SOLAR WATER HEATER



Thailand, which is situated in the tropical zone just above the equator, has high potential of solar energy utilization. According that the sun constitutes as an unending energy resource and will not cause pollution, there have been many efforts to develop suitable devices to utilize solar energy as an oil-alternative energy source.

In order to initiate natural resource utilization and to save the country's foreign exchange for importing solar collectors, the Thailand Institute of Scientific and Technological Research (TISTR) has successfully designed and constructed a solar water heater with 200–1 hot water tank which is the most suitable size for household. The system performance is as efficient as the imported one but the price is cheaper.

A solar water heater consists of three main parts, two solar collectors and a hot water storage tank. Each collector has 1.2 m^2 surface area, with copper tube system and having glass wool as insulator. The collector is fabricated and framed with aluminium sheet. A hot water storage tank, which is made of polyethylene has 200–1 capacity, 55 cm in diameter and 94 cm in height. The tank is able to withstand the temperature up to 120°C and also can resist chemical corrosion very well.

The heating process requires no external energy sources. Water is circulated naturally, based on the fact that hot water has density lower than cool water. Then the flow is generated and controlled by level controller in the tank. The result of testing confirms that the rate of saving at 1,500 baht per year can be obtained when a solar water heater is used instead of an electric water heater.

Apart from the family-size solar water heater, TISTR is able to construct and install a larger system for hospitals, hotels and commercial buildings. For further information please contact: Energy Technology Department, Thailand Institute of Scientific and Technological Research (TISTR). Tel. 579-6517, 579-8593

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phahonyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5791121–30

ALGAL BIOFERTILIZER TECHNOLOGY FOR RICE PRODUCTION

Thailand Institute of Scientific and Technological Research (TISTR) has successfully found a practical application of biological nitrogen fixation for increasing productivity in agriculture.

A new species of blue-green algae with high potential of N_2-fixing capacity has been produced and used as biofertilizer of rice cultivation. The alga fixes substantially atmospheric nitrogen in ammonium and organic nitrogenous compounds which are available to rice plants. TISTR has developed a simple rural-oriented algal biofertilizer technology which is ideally suited for Thai farmers in rural areas.

At present, the main natural income of about 27,000 million baht comes from rice export. However, rice farmers have very low incomes. The best ways to increase incomes and to improve life-quality of marginal rice farmers are to improve the productivity of rice production and at the same time to reduce the cost of rice production.

The Thai government has felt that increasing productivity of rice production by introducing high yielding rice varieties to the rice farmers is economically relevant. However, the high yielding rice plants need heavy application of chemical N-fertilizers. Unfortunately, chemical N-fertilizers have to be imported and are very expensive for Thai rice farmers.

It is therefore, relevant to use biological nitrogen fixation as alternative resources to meet part or all of tremendous N-requirement and to

relieve the pressure on chemical N-fertilizers, For this purpose, TISTR will produce algal biofertilizer in plastic bags containing 10 kg algal inoculant and supply to the farmers for further multiplication. By using a simple rural-oriented open air method for producing algal inoculant in bulks which has been developed at TISTR, from the algal inoculant of 10 kg the algal seed for field use of 100 kg will be produced by farmers themselves. The basic principle is to grow the algae in natural sunlight for 2–4 weeks under conditions simulating those in the rice field.

The cost of production by rice farmers will be about 2 baht per kg algal seed. The beneficial effect of algal inoculation on rice yield estimated from our experiments is equivalent to the application of 50 kg/rai of ammonium sulfate. The farmers would reduce cost of chemical N-fertilizer of about 100 baht per rai.

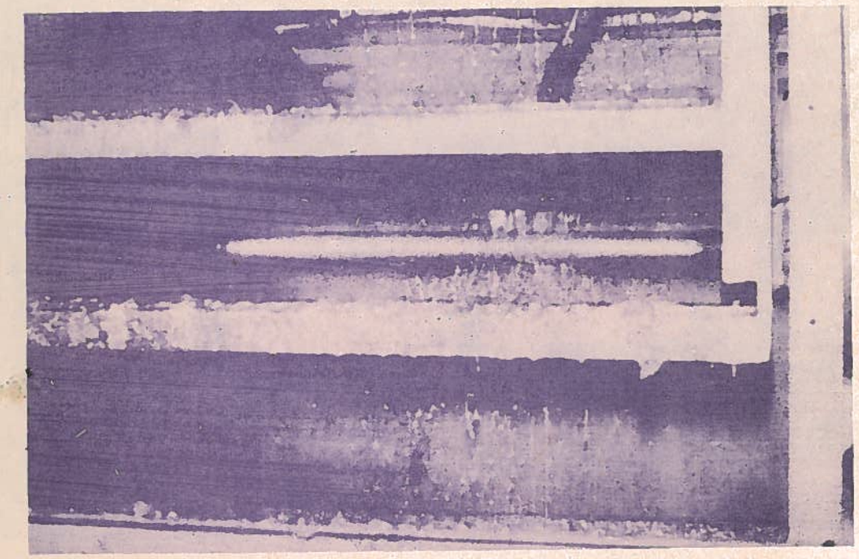
It can be seen that the return on investment on this technology seems to be fairly high. Therefore, it is reasonable to expect that in the near future biofertilizer will be extensively introduced all over Thailand. At present, Thailand has to import chemical N-fertilizer of about 2,500 million baht. If biofertilizer would be successfully utilized, the reduction of negative foreign trade balance of about 500–600 million baht yearly could be theoretically expected.

It is expected that the production of algal seed at industrial scale for supplying them to the Thai rice farmers will increase rice yield per rai and will reduce cost of rice production which is the way to improve the ability of competition in world trade. This will be a new hope for Thai farmers to make progress in new era of agricultural business.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phahonyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5791121–30

PROCESS IMPROVEMENT FOR SMALL-SCALE PALM OIL FACTORIES



Oil palm is one of the most important crops in the southern Thailand. Its growth is substantially increased. Apart from a very wide range of industrial utilization, establishing in oil palm plantation and a mill also give the high economic return. At present, the growing areas are about 455,000 rais and there are 29 mills in operation from which 70% are the small industry. From a survey, the problems encountered in small factories are improper raw material management resulting in high free fatty acid content in oil, low efficiency in production, high oil loss during processing and erratic quality of oil. Therefore, Thailand Institute of Scientific and Technological Research has conducted the research and development on process improvement for small-scale palm oil factories to assist them producing better oil quality and reducing production cost through multidisciplinary team in collaboration with the enterpreneur. Separation of residue from the oil to reduce oil loss was improved by the design and fabrication of a vibrating screen including modification of residue washing technique. The improved process resulted in increase in oil yield with high economic return.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phaholyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5791121-30

DEVELOPMENT OF BAMBOO FOR HOUSE CONSTRUCTION

At present housing problems have a great impact on the national economy and society. This is due to the population increase in the past decade by 10.9 million, most of whom are rural people. At the same time, wood which is a national resource for housing construction is reducing and rare that there is a great demand for its import. Besides, the deforestation is increasing.

Thailand Institute of Scientific and Technological Research (TISTR) has successfully applied bamboo for house construction, using simple technology, for rural people. With this technology, rural people are able to build their own houses to live permanently. For this construction work, TISTR has conducted a research study and developed bamboo already available for use by the people by applying technology to improve the value of bamboo, particularly for the wall part, which mostly requires bamboo. A simple method used by TISTR is called lath and plaster.

The lath and plaster process is done by chopping rice straw into pieces and mixing with lime and water and leaving for about 21 days. The next step is to mix fine aggregate (sand) with lime to be left for 12 hours. This mixture is then brought to blend with the cured straw and lime at the ratio of 2:1 adding a little cement and mixing well. Then this mixture is used to plaster

both sides of bamboo wall and left to set for about 7 days. Thereafter the wall is to be thinly coated by fine sand and cement. The final fine surface wall is thus obtained.

With this technological process, rural people are able to own permanent house to live in, thus changing their former attitude that living in bamboo house shows the owner's poor circumstance. Now they are pleased and willing to accept the bamboo-built house. Therefore, it is expected that more and more bamboo houses will be built if this multi-purpose material which is easily found locally be treated with suitable technology for its improvement in quality and endurance. This will help reduce the use of wood, thus alleviating the problem of wood shortage and illegal deforestation for building purpose. Apart from this, the bamboo construction will help promote the cultivation of this perennial of the rural people, so that they can earn their living by setting this product.

TISTR has built for experiment this kind of bamboo house at its Teen Tok Royal Project Research Station, Ban Mae Kampong, Tambon Huay Kaew, Amphoe San Kamphaeng, Changwat Chiang Mai. Its test results for the past 6 months has proved quite satisfactory. Therefore, the construction of bamboo house will be expanded among the rural people. Those interested are invited to contact the Building Technology Department of TISTR, Tel. 579-8581

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phahonyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5791121–30

HIGH-TEST MOLASSES

Due to the world sugar glut at present this commodity price in the international market has suffered a setback. As one of the major exporting countries of sugar, Thailand is adversely affected by this situation. In order to solve the problem of low sugar price now facing the country, it is considered appropriate to reduce the production of raw sugar, and at the same time to make other good use of sugar-cane, particularly as an industrial product. This will not only help tackling the problem in the long run, but will also expand the market for both sugar-cane and sugar.

In compliance with this idea, Thailand Institute of Scientific and Technological Research (TISTR) has conducted a research study on the use of sugar-cane, sugar, and its by-product for industrial purpose. As a result, the Institute has successfully produced high-test molasses from sugar-cane for export or as raw material to be used in the local fermentation industry.

The high-test molasses produced from sugar-cane is a heavy, partially inverted cane syrup having a Brix of about 85°. It is clear, brown in color and of controlled composition. High-test molasses is used largely for distilling, the high sugar content making it much more desirable for this purpose than blackstrap.

There is no need to build a new mill for high-test molasses as the now-available sugar mills can serve this purpose appropriately. Whenever there is a big sugar excess in the market causing low sugar price, the sugar mills could suspend their sugar production temporarily and produce instead high-test molasses from the sugar-cane firstly designed for producing sugar. With an addition of another two machinery equipments, the now-available sugar mills will be able to manufacture high-test molasses effectively.

The high-test molasses, the same as ordinary molasses, is in great demand by foreign market, thus it should be produced for export. Its quality is higher than that of the ordinary molasses (blackstrap) for its high sugar content and low ash content. Moreover, the high-test one could capture higher price. Many countries, such as Australia, the Philippines, and Brazil, have already produced the high-test molasses for export.

TISTR has utilized the high-test molasses from sugar-cane as raw material in the fermentation industry, starting from alcohol industry. Already produced from this raw material (high-test molasses) are 2 grades of alcohol : fuel alcohol and industrial alcohol, the processing of which has proved to be satisfactorily successful as performed at the alcohol pilot plant of TISTR. For further particulars you are invited to contact the Biotechnology Department, TISTR, tel. no. 579-3510.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
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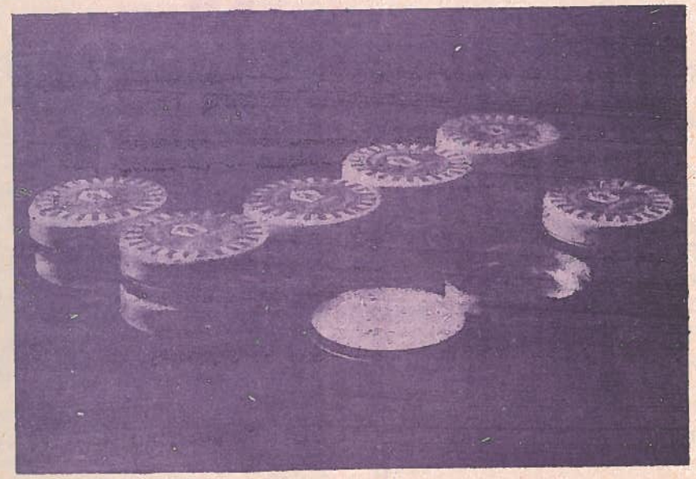
MATERIAL POLISH



Chemical Formulation and Processing Laboratory is a section of Chemical Industry Department (CID) at Thailand Institute of Scientific and Technological Research (TISTR). Her main R & D activities include development of chemical products and improvement of chemical formulation of products as import substitutes. Recently a product which has just been successfully formulated is a polishing paste of emulsion type. The polish can be applied well with various materials such as metal, glass, ceramics, plastics, etc. The pH of the paste is neutral and hence it causes no burn or damage due to acidity when touching. Some indigenous raw materials such as waxes are used. The polish which can also be applied as cleaner, is formulated in a simple mixer at a convenient temperature of less than 85°c. Other product formulations such as metal polishes, correction fluid, paints, etc. are among current projects being investigated in this laboratory.

Besides product formulation development and improvement, other R & D projects such as manufacturing processes of chemical industrial products, design and improvement of production-scale equipment are also carried on. Interested persons may contact CID at TISTR, 196 Phahonyothin Road, Bang Khen, Bangkok 10900 or call 579-1121–30 Ext. 357, or 579-8590, 579-8591, 579-7568.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
196 Phahonyothin Rd., Bang Khen, Bangkok 9, Thailand. Tel. 5791121–30

BLACK MUSHROOM OR SHIITAKE MUSHROOM (LENTINUS EDODES BERK SING) CULTIVATION

Shiitake or black mushroom has been known as a favourite delicacy of the Chinese gourmet for a long time. Its market demand is very high, next to champignon or button mushroom. The world's production sources are the People's Republic of China, Japan, Korea and Taiwan. Amongst them, Japan has the most modern research centre for black mushroom production. In Japan as well as Thailand the growing media is usually a variety of oak & chestnut trees which is the same family of Thailand's *Quercus* spp. called Konara (*Quercus serrata*) and Kunuki (*Quercus acutissima*). Thailand's import of dry shiitake mushroom is valued at about 30 million baht.

Jointly with the Highlands Agriculture Project launched by Kasetsart University under the Royal Project, Thailand Institute of Scientific and Technological Research (TISTR) has conducted a research study on black mushroom cultivation since 1981. For this particular research work, TISTR receives an allocation from the Government's budget and contributions from the USDA. Also, Taiwan has given a support for extension work to encourage hilltribes to grow black mushroom as a secondary occupation. This practice has a good source of income in place of shifting cultivation and opium growing in various watershed area in the northern part of the Kingdom. These areas are bound with several genera of oaks which grow well at about 600 metres above sea level. Among these species are e.g. ก่อเดือย (*Cartaropris accumimatissima*), ก่อตาหมู (*Quercus Kerrii* Craib), ก่อน้ำ (*Lithocarpus anriculatus* Barrett) These woods can be suitably used for shiitake mushroom cultivation. The returns derived from this kind of cultivation are higher than those done by deforestation for shifting cultivation of rice or corn by hilltribes people, if proper system with marketing outlets has been established.

The Shiitake mushroom project launched by TISTR is carried out in the form of research and development work for production of good quality mushroom spawn. This includes test, quality control, and efficient promotion of each produced species prior to its distribution to farmers. Also the project calls for the integrated system of research, development and promotion, ranging

from the spawning, cultivation, group formulation, transportation and marketing. Additionally, TISTR gives advices and support in the mushroom cultivation to other government agencies concerned, under the Royal Project in various areas, as well as to other agencies operating in the hill areas upon request.

The integrated system of Shiitake mushroom cultivation has 3 major working stages as follows

1. Demonstration : Group formulation of the villages is to be organized to test the interest of members and to train them for their proper roles of working together. Also the members will be taught to look after the cultivation of mushroom themselves.

2. Promotion : This is intended to increase the amount of mushroom growing wood logs. Also, there will be qualil control of the mushrooms under appropriate postharvest and proper packaging for market.

3. Production : For actual production, the group members are required to take full responsibility in conservation and reforestation of the oak or chestnut forest area. Concurrently with the mushroom production.

Therefore it can be concluded that under the Royal Project, the TISTR project on the promotion of mushroom cultivation carried out by R&D Mushroom Spawn Production Centre at Doi Pui together with the integrated system of black mushroom cultivation trials, starting from spawn making to marketing for farmers in the northern highlands, has enabled them to better understanding in this field. The villagers are able to take a good care and maintaining a well controlled watershed area in each village as the management of their resources are performed effectively. In the meanwhile, the deforestation, which creates problems to the lower plain will be simultaneously reduced. As a consequence, all these beneficial prospects would help save the Government's budget as well as help maintaining conservation practice in the watershed area of the country. Apart from this, if the production amount is ample, good quality with reliable quantity accordingly the mushroom product could be exported, the same as Japan where black mushroom production has been promoted so expansively that the product has become one of its national major export.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research,
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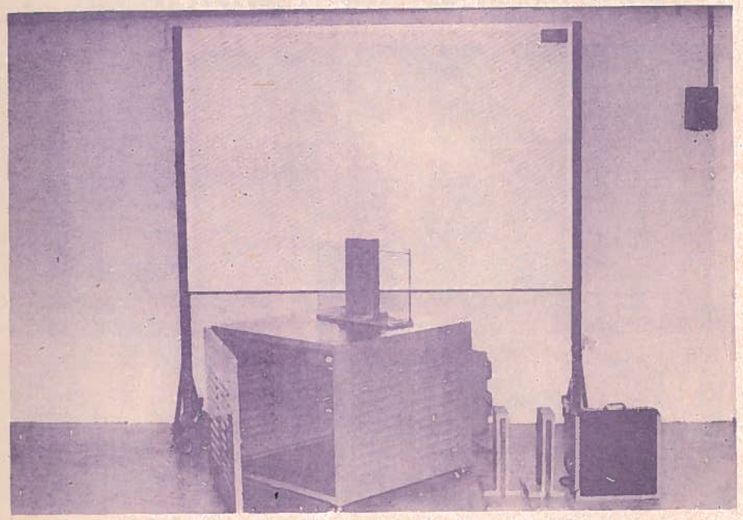
TESTING APPARATUS FOR AUTOMOTIVE SAFETY GLASS



Thailand Institute of Scientific and Technological Research (TISTR) has successfully designed and produced testing apparatus for automotive safety glass, using local materials. The apparatus, already utilized by private enterprises, have proved to be satisfactory and up to the standard required by the Thai Industrial Standards Institute.

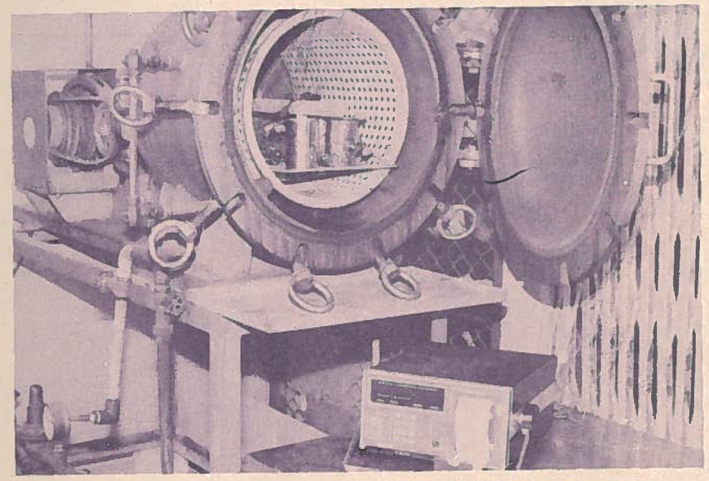
Normally, in order to reduce peril in driving, the automotive safety glass which is an industrial product would have to meet the standard requirement of the government. Therefore, the automotive safety glass manufacturers must have their quality checking unit at the manufacturing source for steady quality control. Since certain testing apparatus are not available in the market, the industrial enterprisers have requested cooperation from the Testing and Standards Centre of TISTR to give advice on the utilization of the testing apparatus being produced by the Centre.

The testing apparatus set comprises testing equipments for optical deviation, light stability and distortion of vision. The automotive safety glass manufacturers have already applied the testing apparatus set for their product and confirmed its highly favourable result. Moreover, it costs less. Thus, it can be said that TISTR plays a major role in promoting the national industrial standard.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research
196 Phahonyothin Rd., Bang Khen, Bangkok 10900 Thailand. Tel. 579-1121–30, Telex : 21392 TISTR-TH

DETERMINATION OF THERMAL PROCESSING PARAMETERS OF FOODS PACKED IN HERMETICALLY SEALED CONTAINERS



Why thermal processing parameters has to be determined ?

Canned food is one of the products that yields best values in terms of export goods. Food is usually packed in either tin cans, glass jars, or retortable pouches and it is hermetically sealed and thermally processed as a function of temperature and processing time. Nature of food and its ingredients to be packed together with the type of containers, for example, will influence the processing parameters in the sterilization process.

Hence, excessive heat or processing time, so called "over-processing", results not only in the loss of food quality such as browning, flavour, other aesthetic appearances, and nutritional value, but also in higher production cost.

On the contrary, using insufficient or fluctuating temperature and inadequate processing time, so called "under-processing", results in the spoilage of canned food due to the survival of pathogenic microorganisms in can after thermal processing.

Imported canned foods into U.S.A. are controlled through the Food & Drug Administration (FDA). Canned foods which are classified in either acidified or low-acid canned foods (i.e. pH higher than 4.6 and/or a_w (water activity) exceeds 0.85) have to be registered with the US FDA, and filed for scheduled process and any other necessary document to obtain FCE No. for the permission of foods to be entered to U.S.A.

Where can such service be obtained ?

Thailand Institute of Scientific and Technological Research (TISTR) has been giving assistance to local canners by providing consultation, information and service for thermal processing

parameters determination through the use of on-line data logger and microcomputer to monitor the process.

In addition, TISTR provides service for process filing and registration, water activity (a_w) measurement, seam analysis and consultation with food canners, as well as process improvement in the canneries to increase and control the quality of the products and to reduce the cost.

For more information, please contact Food Industry Department. Tel : 579-1121-30 ext. 139, or direct line, 579-8589

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research.
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SPIRULINA : AN IDEAL NATURAL HEALTH FOOD

The shortage of foodstuffs world-wide needs no emphasis. Many international organizations such as UNESCO, FAO and WHO, have made an attempt to intensify the production of protein and vitamins from unconventional sources, such as the so called "Single Cell Protein (SCP)" for world population.

Efforts are also being made at Thailand Institute of Scientific and Technological Research (TISTR), to solve the problem of nutritional deficiencies existing in Thailand, by developing an appropriate technology for utilizing microalgae as a vitamin-rich proteinous foodstuff. This health food, manufactured from microalgae produced at TISTR, has been registered and named "Spilin".

The natural product "Spilin" is made from blue-green algae of the genus **Spirulina**, known in Thai as "Sarai Klieo-Thong". The algae, taxanomically arranged into the family Oscillatoriaceae, appears as short filaments of size 50–60 μ by 3–8 μ, formed by single, spirally twisted cells. More than 1,500 species of the genus **Spirulina** are known.

The results of chemical analysis show that the algae contains 65–70% protein on a dry weight basis. Thus the protein content of the algae is considerably higher than that of meat or eggs, which are 20 % and 18 % protein respectively.

It has to be emphasized that algal protein is of a high nutritional value because it contains good ratios of all essential amino acids.

Moreover, the analytical data shows that 1 g (dry weight) of algae contains 114 mg of vitamin C and 1.13 mg of niacin. Vitamin B_3, B_1, B_6

and vitamin E are also found in the algae in amounts considerably higher than those found in vegetables or meat.

The algae also contains all of the important minerals necessary for efficient human metabolism, such as calcium, phosphorus, magnesium, iron and so on

The high nutritional value of the algae is drawing an increasing amount of attention from private enterprises.

Recently, financial support from a private enterprise has been granted to TISTR, for an investigation into the nutritional potential of the algae, and for a feasibility study of the economics concerning commercial scale production of "Spilin" tablets as a health food. The results of this two-step investigation are promising. "Spilin" tablets, as a natural health food, are currently being peoduced to investigate the market in Thailand. This algal product, developed by TISTR, has now been accepted as a health food and the present production cannot meet the demand.

TISTR, in cooperation with the private enterprise, is planning research activities with a view to developing an appropriate technology for algal production, on an industrial-scale, to suit the economic situation of Thailand. This will initiate a new branch of the biotechnology industry in the near future.

For further information, please contact Dr. Pongtep Antarikanonda, researcher 8, Department of Biotechnology, TISTR, Tel. 579-1121-30 ext. 222.

TISTR RESEARCH NEWS

Thailand Institute of Scientific and Technological Research.
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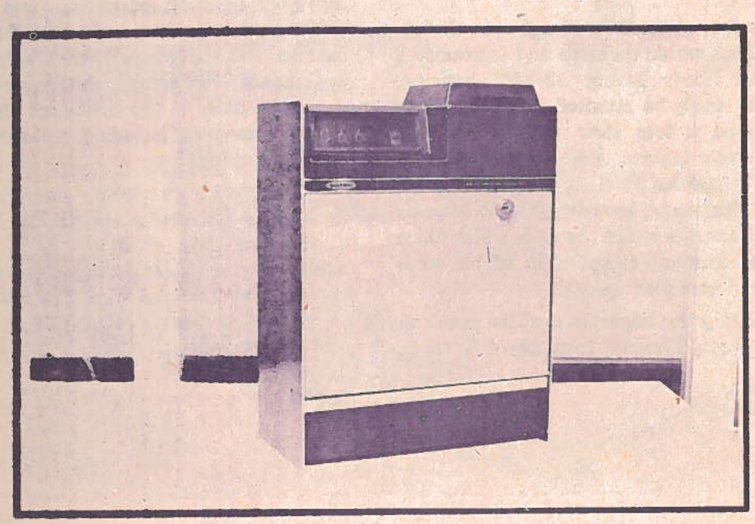
STORAGE OF SEEDS OF ECONOMIC CROPS



Quick moisture determination in the seed by computurized system

In addition to being used as propagules for future generation, seed has also nutritional value for both human and livestock because it is a part of plant which contains oil or fat and protein, as well as minerals, vitamins, essential oils, alkaloids and other chemicals. Numerous economic crops produce a yield in the form of seeds, such as cereals and legumes. The majority of these seeds must be stored for a period of time before being utilized later, e.g. (1) as seeds for planting in the next growing season, (2) as parents in the breeding programmes, (3) consumed as food by man or animal, and (4) processed into industrial products.

Stored seed deteriorates with time as well as storage condition. In the hot and humid atmosphere prevailing in Thailand, seeds stored in a less-than-optimum condition will quickly deteriorate. The most important cause of such deterioration of stored seed is the high humidity, both in the seeds and in surrounding atmosphere.

Influence of Humidity on Seed Quality

1. **Viability:** Seeds stored for planting must have high germination rate as well as uniform germination. Before storing, these seeds must have low moisture content about 10–14%. Storing seeds having less than 10% moisture content in hermatically sealed container would maintain low moisture condition rate for many years.

Generally, after harvest, seeds possess too high moisture content than optimum level for storage. Moreover, in humid atmosphere, seed would contain very high moisture content, such

that if kept in storage without being processed properly to reduce their moisture, they will quickly lose the viability. Some seeds may even germinate during storage. Humid atmosphere surrounding stored seeds will also transfer humidity to the seeds thereby causing them to quickly lose their viability.

2. Damages Caused by Fungi : In humid condition (both within the seeds and surrounding atmosphere), seeds having 12–14% moisture content will easily be attacked by fungi which cause the seed to lose their viability. Certain fungi also create toxicity, e.g. through the production of aflatoxin which is dangerous to the consumers. Moreover, humidity is also the cause of chemical changes within the seeds which alters the original chemical composition of the seeds thereby deteriorate seed quality.

Recognizing the importance of the problems in storing seeds, Thailand Institute of Scientific and Technological Research (TISTR) has established the National Genebank of Thailand since 1982 with the main purpose of storing plant germplasm in the form of seeds for future uses. Both active (medium-term) and base (long-term) storage facilities were installed in the Genebank. Although the facilities are aimed at storing seeds for future breeding purposes, extra capacity is available to store other seeds. TISTR has modern facilities and trained personnel to undertake the work in seed technology, and in providing guidance and advice in the techniques and procedure for seed storages, including moisture reduction and seed testing.

Government or private enterprises wishing to request the service in testing seeds or in determining seed moisture, or in any other matters related to seed may contact the National Genebank of Thailand, Agro-Technology Department, TISTR, Tel. 579-1121–30 Ext. 359 or 141, or Tel. 579-8582

TISTR RESEARCH NEWS

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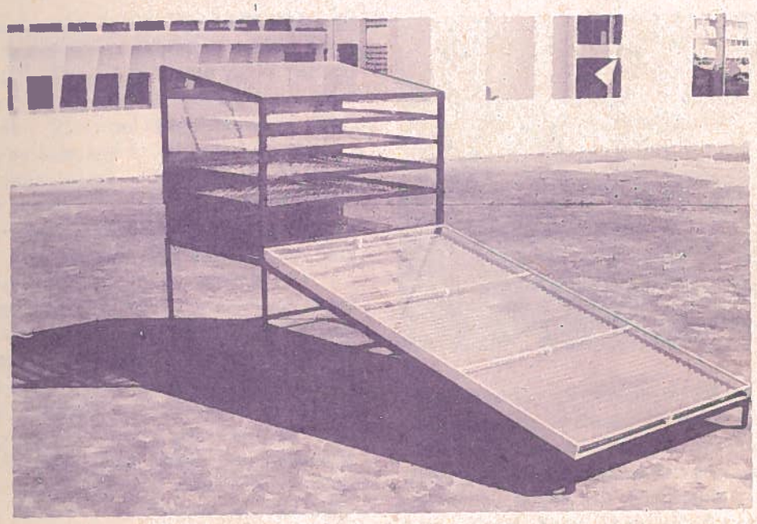
SOLAR DRYER



The Thailand Institute of Scientific and Technological Research (TISTR) has developed a solar dryer applied for drying agricultural crops and meat. The equipment allows the users to perform a hygienic drying of their products with less time consumption, compared to a typical sun drying.

The light-weight dryer is consisted of two parts; a solar collection panel and a heating container, which can be seperated or assemblied for ease of transportation and installation. The solar collector of 110 cm wide, 180 cm long and 8 cm thick, is built with an aluminium structure and installed inside a covered glass with a corrugated radiation absorption panel. The four-shelve container with steel structure capable of drying each time 300 bananas or 12 kg of meat, is a glass box of 80 cm wide, 110 cm long and 85 cm high.

In principle, the hot air produced in the radiation absorption panel will flow through the container to dry the materials inside, and the water vapour evaporated will be removed at the rear of the box.

To cope with personal business requirement, TISTR can provide a consultancy service to the requesting agencies or individuals in system design and construction of solar dryer.

For more information, please contact the Department of Energy Technology, TISTR, Tel. 579-6517 or 579-8593

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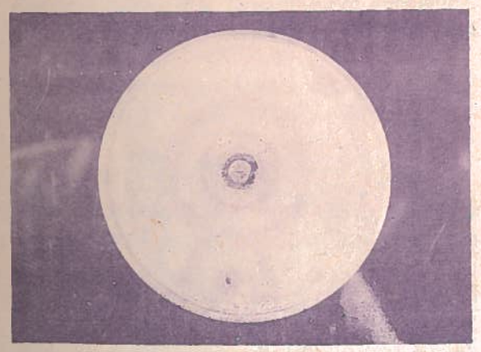
196 Phahonyothin Rd., Bang Khen, Bangkok 10900 Thailand. Tel. 579-1121-30, Telex : 21392 TISTR-TH

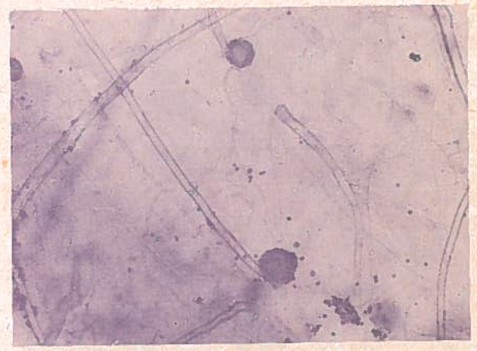
PHOSPHATE SOLUBILIZATION BY MICROORGANISMS

Phosphate solubilization by microorganisms is required in sufficient amounts to sustain plant growth and obtain higher yields. Chemical phosphorus fertilizers are not sufficiently produced in Thailand. Therefore P-fertilizers of more than 2 million baht had to be yearly imported.

At Biotechnology Department, Thailand Institute of Scientific and Technological Research (TISTR), several phosphate dissolving microorganisms have been isolated and some of the very promising cultures have been selected.

Amongst the fungi which have been tested for phosphate solubilizing activities in our laboratory, *Aspergillus* sp. No. 1 is found to be the most efficient phosphate solubilizer. In the same duration of incubation, it dissolved unsoluble rock phosphaste to soluble phosphate 10 times more rapidly than other fungi. The advantage of high efficient solubilizing ability of this fungus appears to be very promising for further development to use as P-biofertilizer. This P-biofertilizer from *Aspergillus* sp. No. 1 can be used by mixing it directly with rock phosphate before applying it to the soil, as well as by incubating it with rock phosphate for a certain period to increase available





phosphorus in rock phosphate before being used as raw material in chemical P-biofertilizer production processes. In Thailand, the sources of rock phosphate are found in many provinces, such as Lamphun, Sukhothai, Phetchaburi, Ratchaburi, Loei, Krabi, Surat Thani, Phuket and etc. In fact, Thai farmers use rock phosphate as P-fertilizer by grinding it to fine grain of lower than 200 mesh and apply it directly to the soil. However, the extent of the solubilization of rock phosphate is low and as the consequences, the amounts of available phosphorus are unadequate for sustaining good growth of plants.

These problems can be solved by inoculating phosphate dissolving microorganisms into the soil applied with rock phosphate. Gradually, the phosphorus nutrient status of the soil will be improved. At present, TISTR in cooperation with private sectors is preparing to carry out further research concerning low-cost production of fungal seed used as soil inoculants.

Indeed, if this research work is complete and the results could be successfully applied, the reduction of chemical P-fertilizers could also be expected.

TISTR RESEARCH NEWS

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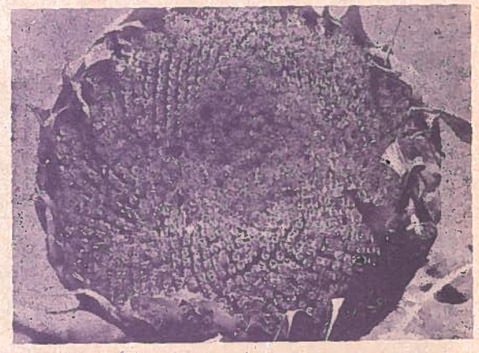
OILSEED CROPS DEVELOPMENT

In recent years, Thailand is severely facing with marketing constraints in connection with agricultural produces for export of rice, maize and tobacco. Therefore, alternative crops have to be found and it is expected that oilseed crops would be the answer. Thailand Institute of Scientific and Technological Research (TISTR) has carried out oilseed crops development project in which the main objective is to promote the production of annual arable oilseeds for higher yield by utilization of new technology.

Those oilseed crops are soybean, groundnuts, sesame, castor bean, safflower, rape and linseed. However, sunflower which is a newly promoted oilseed crops receives some attention to grow in Thailand.

Oilseed Crops Development Project is funded by the European Economic Community (EEC) of 65 million baht for the period of 3½ year beginning May 1984.

TISTR has responsibility for the overall coordination of the programme with full cooperation in operation through a series of research contracts with : Kasetsart University, Khon Kaen University, Chiang Mai University, Prince of Songkhla University, Department of Agriculture, and Department of Agricultural Extension and



TISTR. The first step of work has been directed toward basic research on germplasm collection and screening, pest and disease control, physiological aspects and general agronomic adaptive research.

The following step will primarily emphasize the research and development acceptance to farmers and will promote research and development on sunflower which is a potential new oilseed crops for the future. TISTR will subsequently categorize crop priorities for various regions on the basis of their agronomic suitability by establishing and quantifying the marketing potential, both internally and externally, for a range of oilseeds, as a prerequisite to formulating suitable research and development programme for the future production of the following oilseed crops : soybean, sesame and sunflower. Further study of the adverse effects of palm oil, cotton seed oil, kapok seed oil, coconut oil and rice bran oil in normal seasonal production and imports will also be conducted as well.

It is expected that once the complete cycle of the Oilseed Crops Development Project has been worked out from the production and processing to marketing, Thailand would be able to reduce import of oilseed meal no lesser than 1,800 million baht per year.

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196 Phahonyothin Rd., Bang Khen, Bangkok 10900 Thailand. Tel. 579-1121-30, Telex : 21392 TISTR-TH

FERMENTED FEED FOR CATTLE

Thai farmers generally raise their cattle, especially for draft purpose, by allowing them to graze freely in the natural pasture. During dry season when fresh stubble and grass are not available, the cattle are fed mainly on rice straw. Due to the poor nutritive values of rice straw, the growth of the cattle are found to be unsatisfactory.

In rural areas of Thailand, there are plenty of agricultural by-products with different nutritive values and animal wastes which can be used to produce feeds for cattle. These agricultural by-products and animal wastes when mixed and ensiled together will compensate the lacking nutrient of each with a high quality silage for ruminant animals. The high quality feeds are not only palatable but also easily digestible.

The Thailand Institute of Scientific and Technological Research (TISTR) has successfully developed high quality cattle feeds from cassava

and other agricultural by-products by ensiling. The formula I silage as prescribed by TISTR consists of rice straw, cassava meal, rice bran and chicken manure. After being ensiled for 2 months, the product is dark brown in color with a firm, non-slimy texture and without off-odors. The feeding trials results over a period of 22 weeks on crossbred growing dairy cattle (¾ Holstein Friesian × ¼ Native) showed that the acceptability of the silage was quite excellent and the performance of animals in terms of daily weight gain on silage diet was superior to the one on control feed (fresh para grass), being 0.48 kg/head/day and 0.43 kg/head/day respectively.

Those who are interested in obtaining particulars of this silage are invited to contact the Biotechnology Department of the Thailand Institute of Scientific and Technological Research. tel. 579-3510.

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UTILIZATION OF CASHEW NUT SHELL LIQUID

The cashew nut shell liquid (CNSL) is a by product being derived from the process of decortication of cashew nuts. The liquid is brown in color and has extremely blistering effect on the skin. Approximately 15 tonnes of raw nuts will contain 1 tonne of CNSL. It is used as a starting material for the manufacture of varnishes, paints, printing inks, wood preservatives and adhesives, etc.

TISTR has been interested in the utilization of CNSL since 1979 when a local CNSL production factory suggested TISTR to conduct a research on the production of varnish from CNSL and paraformaldehyde. Many attempts had been made until a dark brown color varnish for wood coating was obtained. After the success, TISTR has tried to produce other products, such as the adhesive from CNSL-tapioca starch and varnish from CNSL-formalin (37–41 % formaldehyde solution). Both products are produced from the processes which are almost the same conditions. The adhesive is solvent base, air-drying and suitable for plywood joining with 25 kg/cm^2 failing load while the varnish, also solvent base, is fast air drying with dark brown color and high gloss which is suitable for wood coating. The pilot scales are now being conducted by using the equipment of a half tonne capacity which was designed by TISTR. The production costs are being estimated and the products are also available to those who are interesting in their applications and processes. For further informations, please contact Chemical Industry Department, Thailand Institute of Scientific and Technological Research (TISTR). Tel. 579-1121–30 ext. 134 and 579-8591

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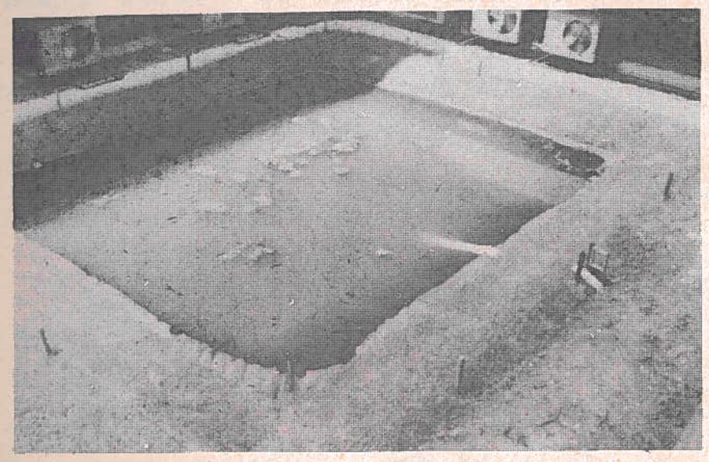
NATURAL RUBBER LINING FOR WATER RESERVOIRS



Thailand is the world third largest natural rubber-producing country and it presently exports raw rubber with low added value worth more than 10,000 million baht per year. However, Thailand still has to import rubber products valued at higher than 1,000 million baht per year, since only 5 percent of the natural rubber produced is used locally to make rubber products.

Thailand Institute of Scientific and Technological Research (TISTR) was assigned by Ministry of Science, Technology and Energy (MOSTE) to consider and solve the problem of decreasing price of raw rubber as concluded by the ministerial conference on 11 June, 1985. TISTR then started to investigate the possibilities of utilizing more natural rubber and considered that producing of watertight rubber lining is one of those.

Materials that are generally used for water reservoir lining are clay, concrete, plastic and synthetic rubber sheets. TISTR can be considered as the first organization to develop natural rubber for the reservoir lining. Basic compounds for making natural rubber lining consist of raw rubber, carbon black, vulcanizing agent, accelerator, activator and antioxidant. TISTR has also studied on the reduction of raw material cost by mixing the compound with reclaimed rubber and also adding antioxidant and/or synthetic rubber to increase the weather resistance of the sheets.

Installation can be easily proceeded by the following steps : reservoir digging, ground preparation to get rid of rock, stone, bough, etc., rubber sheets laying and other necessities completed such as water inlet and outlet. The working life of the sheets can be extended by overlaying with materials such as soil, concrete, etc.

Five water reservoirs have already been lined with natural rubber sheets by TISTR. Preliminary studies show that the linings are watertight, therefore plants and other livings such as fishes are found to exist.

It is expected that the rubber lining industry and its utilization for the water reservoirs would increase the consumption of natural rubber. Moreover, prompt planning and producing such products would also start up the export of rubber lining sheets, thus increasing the value-added natural rubber as well as relieving the scarcity of water sources in the upcountry areas.

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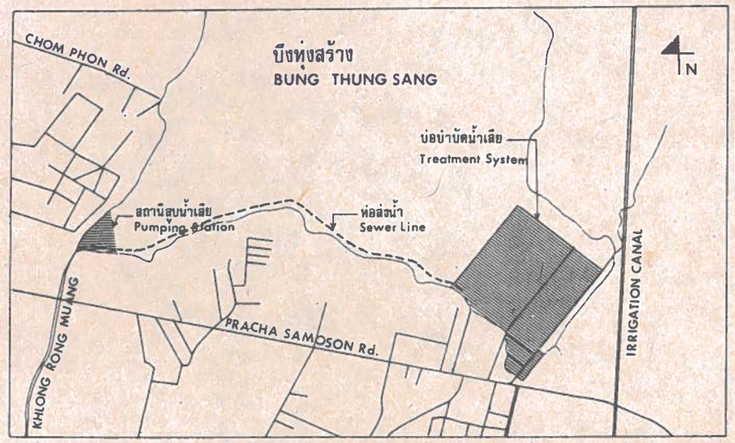
FEASIBILITY STUDY AND DETAILS DESIGN OF WASTE WATER TREATMENT PLANT OF KHON KAEN MUNICIPALITY



Khon Kaen province has been designated a principal development town in accordance with the 5th National Economic and Social Development Plan (1982–1986). Presently, pollution problem of water resources has become a major threat of the province. Therefore, in order to equip the town with a proper sewage system, the provincial administration has assigned the Thailand Institute of Scientific and Technological Research (TISTR) to conduct feasibility study and details design of a waste water treatment plant.

The design was already completed by TISTR in 1986, comprising the waste water collection system and the treatment system.

1. The waste water collection system : The sewage will be pumped from an interceptor at the end of Khlong Rong Muang into the treatment system. The waste water collection system consists of the following:

1.1 Pumping station : The pumping station is located near the end of Khlong Rong Muang and receives sewage from the interceptor. The pumping station consists of a control and laboratory room, a pumping well and a parshall flume. The pumping station occupies an area about 1.5 rai (2,400 m^2).

1.2 Sewer line : The sewer line is a reinforced concrete pipe ϕ 1,200 mm, 1,850 m long. The pipe line alignment follows the embankment on the southern side of Bung Thung Sang. This sewer receives waste water from the pumping station and discharges it to the treatment system.

2. The treatment system : The treatment system is a waste stabilization pond consisting of two facultative ponds followed by three maturation ponds. The waste stabilization pond is the most appropriate system since the construction cost is low when compared to other system. It is easy to maintain and has low operating costs. The total area for the whole treatment plant system occupies about 143 rai (0.229 km^2), retention time 11 days, flow rate 25,500 cum/day and BOD 160 mg/1. The final effluent will have a BOD value of less than 20 mg/1 and fecal coliform bacteria less than 1,000 MPN/100 ml. The median construct ion cost was estimated to be about 20 million baht. However, the construction company which was successful in bidding for the construction of this project estimated a total construction cost of 15.30 million baht and a construction period of 11 months. This system will be able to cope with the waste in the municipality until the year 2,000.

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MILITARY VEHICLE FOR DEMONSTRATION

Thailand Institute of Scientific and Technological Research (TISTR) conducted a joint effort with the Armed Forces Vehicle Rebuild Workshop of the Royal Thai Army Ordnance Department and the private sectors to build a military vehicle in order to demonstrate the production capability of automotive parts of the local automotive industry as well as the military capability to build and assemble military vehicles.

The project started from the data survey on the production of automotive parts and followed by the engineering design of the appropriate body structure. The final stage was to build, assemble and install various automotive parts together. At this stage, the Ordnance Department used the automotive parts provided by TISTR and assembled them according to TISTR's design by starting to install the engine, suspension system, transmission and steering system, steel body, windshield and window frames and brake system. The vehicle was then test run both on and off road to include fording. The efficiency test was expectedly quite satisfactory.

The production of military vehicle for demonstration revealed the market condition and the production capability of the automotive parts in Thailand, and it also demonstrated whether the automotive parts were of international standard. TISTR is ready to transfer this technology know-how in order to enable the Thais to manufacture automotive parts and to finally produce complete automobiles instead of having only the capability to assemble them as in case at present.

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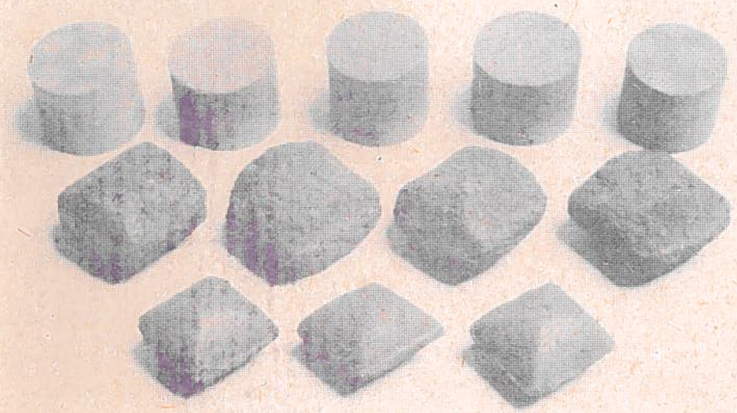
FUEL FROM PEAT



In Thailand, peat occurs in the southern provinces covering areas of about 500,000 rai along the east coast of the peninsula. The largest deposits of which were found in Narathiwat which are the so-called Pru (peat) Toh Daeng and Pru (peat) Bacho.

The development of peat existed widely in the swamp areas after infilling of the lagoons about 4,000 year BP. It mostly consists of a marine clay or blackish water deposit enriched in pyrite as well as fibric or hemic materials.

Most of peat in Narathiwat is featured by its medium-to-low decomposition with 80–90% humidity. Being an acid soil, it lacks nutrients necessary for plant development and is, therefore, not suitable for agricultural purpose. However, having high organic carbon content, it can be processed into upgraded fuels such as charcoal and coke to be utilized domestically as well as industrially. It is envisaged that both would be able to substitute for wooden charcoal as well as the imported coke.

The Energy Technology Department of Thailand Institute of Scientific and Technological Research (TISTR) has conducted a bench-scale study on processing peat for fuel use. The major trial process consisted of drying to reduce humidity, pyrolysis to increase car bon value and reduce volatile matter content, briquetting to intensify density and burning efficiency, and coking for solidification. The study aimed at determining optimum process parameters to produce charcoal and various grades of coke to be utilized in industries.

The study revealed that the peat frcm Bacho of Narathiwat had relatively low ash content, and thus it could be processed into charcoal and coke of good quality with high burning temperature. Both are also bearing well for transportation. Their heating value were about 6,000–7,000 kcal/kg (dry basis). Apart from being used as local fuel, the charcoal and coke can suitably substitute for imported solid fuels.

TISTR now has come up with a plan for research and development on the pilot-scale production of charcoal and coke. The study will determine optimum engineering design and cost parameters of the plant as well as demonstrate its viability in the peat coke and charcoal production. After completed, a promotion and investment plan would be set up to encourage commercial production.