3. ISSUES AND STRATEGIC ELEMENTS FOR ENERGY SECTOR PLANNING

3.1 Issues

The recent rapid industrial expansion in the UCR gives some difficulty in electricity supply. A substation in Region C.1 of PEA recorded 100% consumption increase in 1988. This rapid demand growth compels unsatisfactory electricity supply services. Observing these situation, PEA and EGAT have already taken remedical measures by constructing new substations in Ayutthaya and Sara Buri. Upon completion of ongoing and planned projects of EGAT and PEA, the growing demand will be adequately serviced.

These expanded configuration of electricity supply system should be able to meet a demand twice as large as that today. Our projection of electricity demand shows 5.6 times increase by the year 2010. Therefore, system expansion and improvement should continuously gather due attention.

In Thailand as a whole as well as in the UCR, where basic electricity supply system is almost completed, it will be crucial to improve efficiency in management and operation of the total power supply system by applying modernized measures of management so as to meet the expanding demand adequately with the reduced overall supply costs.

In particular, techniques in sound transmission operation should be given a due focus. When the demand/supply structures are considered by region in the nationwide power sector planning, it is desirable that a balance is kept between power supply capacity and load demand in each region in view of the investment cost, transmission and distribution losses, and power supply reliability.

In Thailand, however, regional demand/supply imbalances will be apparent, and in future this tendency is widened over time with demand growth. In these instances, the transmission management should gather due attention in relation to the achievement of efficient power generation. The UCR electricity supply should be planned in accordance with this national system expansion and management plan.

In line with the reduction of supply costs through implementation of the measures to achieve efficiency in management and operation in the overall power supply system, a particular attention should be given to quality of supply. Thus the operation of distribution by PEA has a room for continuous efforts to improve.

Although current energy supply and demand structure of the UCR is well diversified, it is unclear that whether such diversified energy supply system brings economic benefit to the nation as a whole. The costs associated with environmental measure for lignite use as well as the economic cost of lignite transportation may exceed economic benefits of lignite use. On-shore natural gas in ESSO field development is being anticipated. Thus the above economic aspects of lignite use should be compared with this new option.

By its very nature, objective of the energy sector is to eventually maximize economic benefits of the total national energy system. The total energy demand in the UCR accounts for 9% of the total national energy demand in the year 2010. However, each energy resource demand is significantly small to plan energy replenish system individually. Thus the energy planning in the UCR should be directed towards the utilization of the national energy development plan. This is the point where the national economic benefit consideration comes in.

Energy pricing is a main energy policy implementation measure. It is possible to set the financial price attractive to the energy users so that multiplier effects of different user industries bring about more benefits to the aggregate economy than in the case where price is set attractive to the energy producers. Pricing of the natural gas for the industrial sector should be given with the above consideration especially when new natural gas development is realized. Looking into the direct fuel demand, the UCR is possible to absorb a

natural gas volume of 130 MMSCFD in 2001 and 170 MMSCFD in 2010 by the cement industry alone.

Another important factor is a total energy balance of the system. Especially for the direct fuel use, it is important to consider this factor. Even if a particular energy replenish system looks financially attractive, there would be a situation where the nation as a whole is consuming a rather significant amount of energy to support such a system. In view the growing demand for energy in this nation with limited energy resource availability, it is felt necessary to consider the total energy balance of the direct fuel supply system options.

3.2 Strategic Elements for Energy Sector Planning

It is quite difficult to envisage energy system independently for the UCR with the least to none energy endowments and the limited energy consumption. However, the UCR is blessed with strategic geographical location. The energy sector development in the UCR should take this advantage.

In view of spatial energy endowments and energy demands through industrialization in Thailand from now on, the issue in the energy sector is and will be directed towards stable, secured and efficient logistic systems of energy products and their efficient management. In this respect, the UCR should utilize its strategic location on the national energy logistic structure to the fullest extent. Towards the year 2010, the following national level energy sector developments are anticipated.

- Petroleum product pipeline and a distribution center for the Bangkok Metropolitan Region (BMR), northern and northeastern region;
- On-shore natural gas resource development and its pipeline system;
- Ultra high voltage trunk transmission system development with domestic large thermal and international hydro power development.

The geographical location of the UCR can effectively capitalize on each of the above national level projects.

As for the petroleum products distribution, the UCR is expected to play a strategic role to be a distribution center, having the product pipeline from

Eastern Seaboard (ESB) refineries and dispatching those products to northern, northeastern and the upper part of the BMR in the future.

As for the natural gas pipeline system, the UCR also covers a strategic point of the national natural gas pipeline system, where the on-shore and the off-shore gas will be met. Then, the stable and easily controllable fuel source will readily be available in the UCR.

As for electricity, the UCR is a power supply gateway to the BMR as having ultra high voltage transmission lines from primary power resources in the north and the northeastern region. Electricity demand in the UCR can easily be satisfied with branch lines from those trunk transmission lines.

All of these projects are expected to be completed within next 5 to 10 years. Energy is one of the factors for regional economic development, and the UCR does have advantages in accessibility to the energy with least investments based its strategic location (See the attached conceptual map in Fig. 3.1). This aspect should be considered in the regional development strategies, with special attention to industrialization program.

When the Thai economy will be bloomed after having successfully achieved second import substitution and export substitution, the security in energy supply will increase its importance. In this respect, dependence of the national economy on imported energy especially oil will inevitably call for careful review, and then utilization of indigenous renewable resources should gather due attention as one of the energy source options. In this regard, the UCR holds a potential to apply such renewable energy utilization system in view of its role of agroprocessing, where agricultural transaction and agroprocessing industries are concentrated.

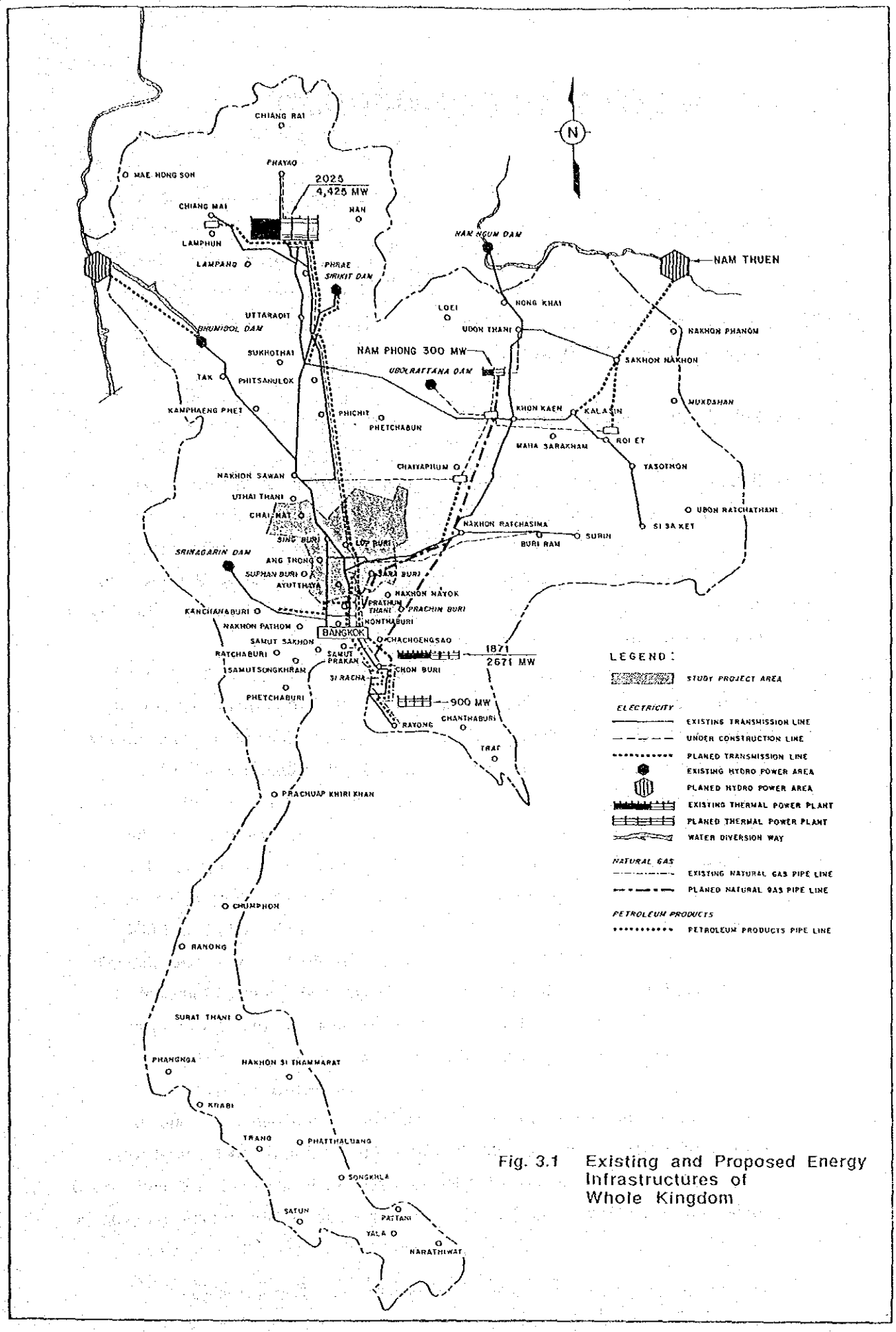

Fig. 3.1 Existing and Proposed Energy Infrastructures of Whole Kingdom

4. PROJECTS RECOMMENDED

4.1 Fossil Fuel Distribution*

4.1.1 Petroleum Product Pipeline

1) Background

Toward the year 2010, the overall petroleum products demand is expected to grow at 6.1% per annum on average. Among the products, diesel oil and gasoline show the highest growth rate of 6.9% reflecting a fast growth of transportation sector.

As for spatial demand structure, a current BMR dominant pattern of consumption has remained unchanged. However, BMR's consumption will expand from 56% of the national total in 1988 to 63% in 2010.

In the current domestic distribution practice, tank trucking is the predominant and prevailing mode of transportation because of its financial cost advantage to railway and river barges. According to an extensive survey of Thailand Development Research Institute (TDRI), trucking is more cost-advantageous than railway by over ten satangs per litter for distributing petroleum products from South Bangkok to the north and northeast regions though degree of the differential varies from one route to another.

This predominant mode of the transportation contributes as one of factors of traffic congestion in Bangkok. In addition, the social costs associated with this means of transportation such as road accidents, road surface deterioration and pollution will increase, if this mode is kept in

* See the projects schemative map of Energy Logistic System/Highway proposal on Diagram 4.1

use in response to the growing regional demand. Traffic problem will surely be intensified.

In these instance, the petroleum product pipeline from Sriracha to the terminal in Sara Buri to serve North, Northeast and North Bangkok regions has been studied by PTT. We strongly endorse this study outcome in view of utilizing strategic geographical location of the UCR for benefitting both regional economy and national energy logistic system.

2) Project Objective and Feature

To establish an efficient and socially beneficial petroleum products replenishment system for the northern, the northeastern, and a part of the BMR markets(a total energy demand of those regions represents nearly 40% of the national demand at present), is the objective of this project.

The project consists of six components as follows;

(1) The main 185Km trunk pipeline from Sriracha pump station to Sara Buri terminal with 18 inches diameter,
(2) 20Km lateral pipeline from the trunk line to East Bangkok Depot,
(3) Sriracha pump station with three 1.1MW pumps
(4) Intermediate pump station 115Km away from Sriracha pump station also with three 1.1MW pumps,
(5) East Bangkok Depot serving jet fuel for the airport as well,
(6) Sara Buri terminal with rail and truck loading facilities, products storage tanks (3*1500 KL of diesel, 3*5000 KL of regular, 2*5000 KL of premium, 2*2000 KL of kerosene, and 3*1000 KL of interface storage), pipeline receiving facilities, and pipeline control/maintenance center.

3) Project Location

The Bechtel's feasibility study for PTT " Industry Fuel Product Pipeline Project" November 1989, recommends the following pipeline route after analyzing the several alternative routes.

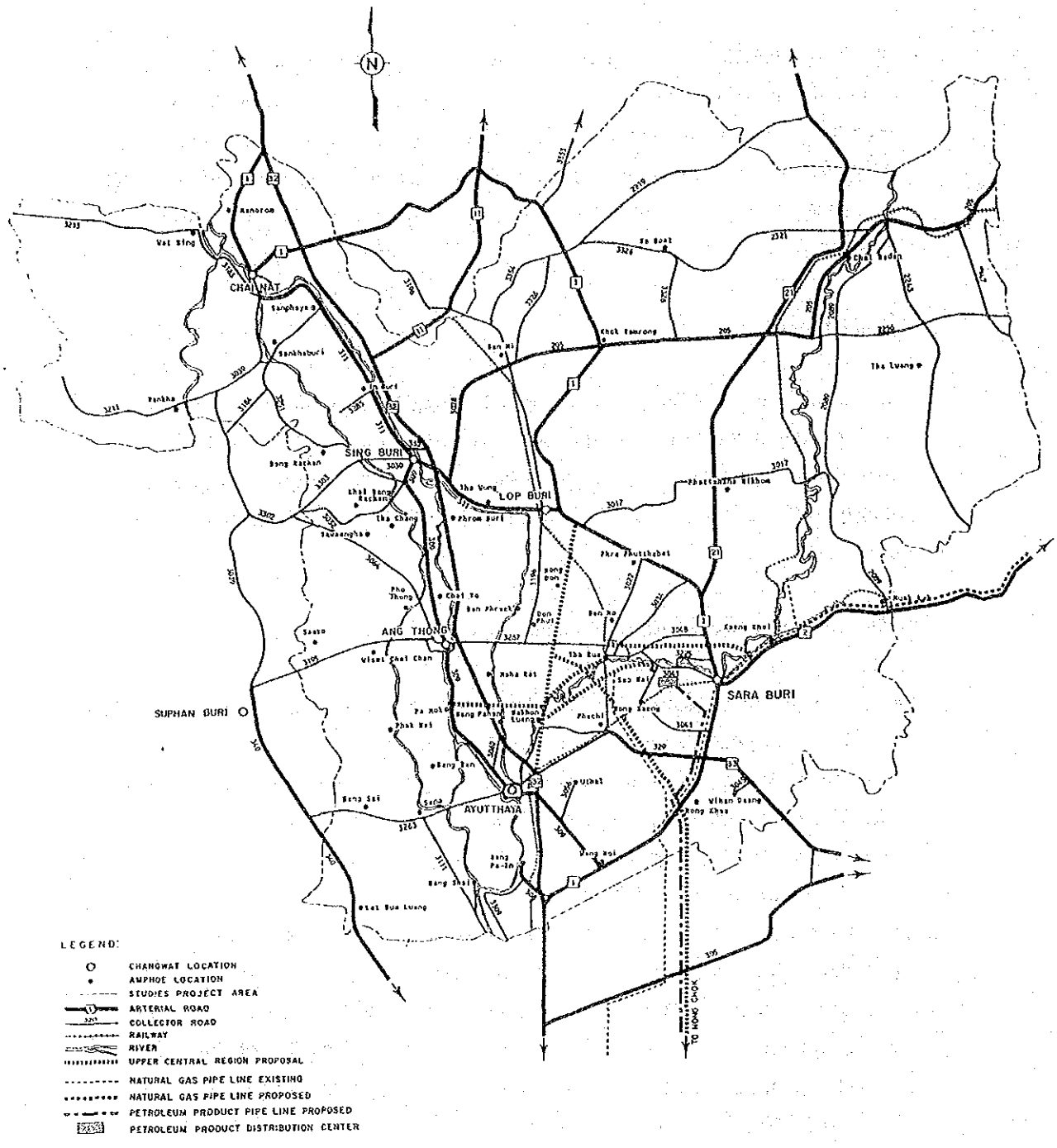

Fig. 4.1 ENERGY LOGISTIC SYSTEM HIGHWAY PROPOSAL

The recommended route originates near the Sriracha refineries and follows the EGAT Right of Way (ROW) of the high voltage power line north for approximately 85 km to Ban Nakhon Nuang Khet which is a northeastern part of Changwat Chachoengsao. The route then turns toward northeast paralleling Highway 304 for approximately 18 km to Khet Nong Chok. The pipeline then turns north along an existing road for 20km to Ban Khlong 13. The route extends approximately 35 km north along the existing Khlong 13 canal roads through Amphoe Nong Khae to Highway 1. The route then follows Highway 1 paralleling the existing gas pipeline to the new by-pass road outside the City of Sara Buri to the Sara Buri terminal site. The total length of the pipeline excluding the lateral would approximately be 185 km.

The PTT study also recommends Sara Buri terminal to be located on the new North/South By-Pass of Highway 1 between Highway 3041 and State Railway of Thailand (SRT) railway access just west of Sara Buri.

We also recommend this pipeline routing and location of the terminal. As for pipeline routing, we recommend Tha Rua-Nong Khae-Nong Chok road construction and upgrading in view of strengthening the linkage between the ESB and the UCR. Having these two projects (petroleum pipeline and road construction/ expansion project) together, they will bring the infrastructural investment cost efficiency. Incidentally, these routes, especially from Nong Khae to Sara Buri along the route No. 1, holds existing gas pipeline as well. Having these pipeline together should increase operational efficiency.

As for location of the terminal, we also agree with the proposed location on the ground that the Sara Buri terminal minimizes the creation of new traffic congestion through the use of new by-pass road and proposed road network by this UCR study (i.e., Tha Rua to Sara Buri and Sara Buri by-pass and Suphan Buri/Tha Rua highway). The alternative location of the terminal in Bang Pa-in and Phachi will be less favorable in this regard and it should be noted that Bang Pa-in is classified as the flood water retention area.

4) Project Time Frame and Costs

The PTT study envisages the pipeline operation in 1992 with 30 to 36 months construction period assuming the government approvals in 1989. The UCR study urges PTT and Department of Highways (DOH) to have close communication with reference to the ROW of the pipeline, since the implementation of Tha Rua/ESB road link utilizing existing Khlong 13 canal road is expected to take place in 1994. The project life of 20 years is assumed for the pipeline.

As for project capital cost, 2,03 billion baht (81.2 million dollars in 1989 price) are preliminarily estimated for the pipeline and the pump station by the PTT study, of which 52% is foreign potion and the rest is local potion. In addition the terminal facilities are estimated to cost 700 million baht.

With these cost estimation this project yields around 20% economic and financial rate of return (with inclusion of jet fuel, 28% of FIRR are derived). This strong feasibility of the project could also be revealed by differentials between trucking and pipeline in the overall unit transportation cost. The cost advantage of 0.03 to 0.06 baht per litter in favor of pipeline system is estimated to prevail in serving the northern and the northeastern regional petroleum product markets.

5) Salient issues for implementation

For realizing the project, it is necessary to have products exchange agreements among various oil companies in satisfying the total market. This agreement is said to be difficult in view of the product differentials among oil companies due to their different marketing strategies. This product exchange agreement has to be reached to realize expected benefits of the project.

4.1.2 Natural Gas Distribution System with Natural Gas Pipeline from Nam Phong

1) Background

Just recently in late April 1990, interim natural gas sales agreement was reached between PTT and ESSO. ESSO who acquired Nam Phong concession in Khon Kaen in 1975 discovered natural gas reserve in 1981. In 1984 a verification well was set up and until 1989 additional two wells were constructed to verify reserve. Thus at Nam Phong currently four wells exist, by which 75 MMSCFD of methane rich natural gas are available for consumption.

With this amount and the requirement of further reserve verification process, the so-called "Interim Sales Agreement" took place. PTT will join in gas field development by 20% sharehold participation through the ESSO/PTT Exploration and Development Corporation. Utilization scheme of natural gas during the Interim Sales makes EGAT to absorb the all of the available gas from the Nam Phong field. EGAT is now constructing a total capacity of 355 MW combined cycle power plant within 4km radius from the gas production center. This plant consumes the gas of 40-60 MMSCFD gas. This Interim Sales is subject to modification in three years during when more accurate estimate of reserve will be made.

Looking at future prospect of the Nam Phong gas field, there exists a possibility that the proven reserve would amount to over 1 TCF. Having this supply prospect and future direct fuel demand in the UCR, a gas pipeline connecting the Nam Phong field with the existing gas pipeline in Sara Buri is naturally considered. Prerequisites for this pipeline project are; i) Production capacity of the field over 250 MMSCFD to satisfy the economy of laying pipeline (1.0 TCF enables this production level), and ii) existence of the gas absorbing market.

Previously this pipeline project has gathered due attention within PTT, which led to the pipeline feasibility study by Bechtel in 1988/89. However, unfortunately this study is not available for us. It is informed from the PTT/personal that there exist two alternatives for the pipeline

from the Nam Phong field. One is to connect it directly with Bang Pakong where large expansion of power generation facilities is considered. The other is to connect it with the existing gas pipeline system at Sara Buri with possible reverse flow of the gas to Bangkok. In either case, the new pipeline is laid to go through Nakhon Ratchasima where industrialization is expected in long-term.

From the UCR development point of view, the region is expected to see tripling energy requirement in 2010 and it is recommended to set the pipeline route so as for it to be connected with the existing pipeline with its additional distribution network system. This project then opens up new comparative advantage of the UCR with the availability of pollution free, stable and easily controllable fuel source.

In these instance the following project and study are recommended.

2) Project Feature and Objective

(1) Natural gas pipeline connection from Nam Phong to the existing system
(2) Natural gas distribution system (city gas network) for Greater Sara Buri Industrial Core (GSIC).
(3) Feasibility study on the ii) above i.e., the city gas network in GSIC

a) Recommendation for the most efficient way of utilizing natural gas from Nam Phong
b) Delineation of distribution pipeline system to seize the above opportunity
c) Recommendation of project phasing

3) Scope of the Project and Study

(1) General

About 300 km long natural gas pipeline and distribution extension system from Nam Phong through Nakhon Ratchasima to Sara Buri is the main feature of this project. According to a current idea of PTT, objective of this pipeline is to serve mainly

for the demand in Bangkok with a very limited provision of gas for the UCR's use, which is about 4% of the 250 MMSCFD capacity.

As stated above, there exists a large room for the industry in the UCR to utilize natural gas as their fuel source. The constraints for this direction of natural utilization is the energy product pricing with product replenishment system.

Pricing is the main feature of energy policy measures. It is quite conceivable that the economic benefits from the total economy point of view could bring more favorable effects, if financial energy prices are set attractive to the users who can generate multiplier effects for the total of economy but neither to the energy producers nor to a particular segment of the consumer industry.

As for the natural gas absorptive capacity in the UCR, it is estimated to be 60.6 MMSCFD in 1996, 83.1 MMSCFD in 2001 and 125.5 MMSCFD in 2010 by assuming that just little over 40% of petroleum products demand are converted to natural gas use. In addition, if all of the fuel required for cement industry were to be converted to natural gas, the gas absorption capacity in UCR jumps to 170 MMSCFD in 1996, 211 MMSCFD in 2001 and 285 MMSCFD in 2010.

In addition to industrial fuel use of natural gas, a possibility of city gas in the UCR especially Sara Buri/Ayutthaya area should gather due attention. Looking at the future Liquid Propane Gas (LPG) market in the nation, this city gas will work complementary to it. Energy use in the residential and commercial sectors will be large enough in this country within this decade and the country should be able to have both supply systems. Then it is important to examine the pros and cons of the both systems with special reference to the total energy requirement to replenish, cost of distribution and efficiency of transportation.

Currently LPG is widely used not only by residential and service sectors, but also by manufacturing sector. In 1988, LPG use in the residential and service sector accounted for 77% of the total LPG consumption. The LPG consumption showed a remarkable growth rate of 15.5% per annum during the 1982 to 1988 period, though, in the last three years, the growth rate declined to 8% per annum. In the UCR, LPG use is being accelerated at a rate of 11.4% per annum during the last three years. It is increasingly used in service and resident sectors in addition to manufacturing sector.

In meeting these rapid LPG demand growth, Thailand imports 20% of total LPG consumption. With the average growth rate of 8% per annum, based on the current plan of LPG supply capacity expansion by new refineries and the second natural gas separation plant, it is foreseen that the supply and demand gap will be widen in LPG market in the next 7 years. A strong argument to support introduction of the city gas system lies here.

The second argument to favor city gas at this moment is the price differential between LPG and city gas. Current pricing for natural gas is set on the basis of fuel oil equivalent in terms of thermal value. By applying this to the comparative prices of LPG to natural gas, there exists a differential of 0.5 baht per 1,000 kcal, showing that natural gas is a lot cheaper (In 1988 price for LPG is 0.82 baht/1,000 kcal and 0.31 baht/1000 kcal for fuel oil). With this price advantage, even with further price reduction of natural gas the city gas system will present favorable economic and financial rate of return.

In introduction of the city gas, a strategy is recommended provide gas for specific targets such as new industrial estates and their neighboring towns. Our study proposes several industrial estates with stress on GSIC development.

As specifically for residential use of the city gas, it is estimated 3.2 MMSCFD demand will be in Sara Buri/Ayutthaya area. For this

estimation 2,800 mega cal/dwelling unit/year and 60% of urban households connection are assumed. For energy requirement per dwelling unit per year, "Energy and Nuclear Power Planning Study for Thailand" assumes 1,400 Mcal for cooking and water heating in the 1990's. On the other hand, in Japan's experience, those cooking and water heating energy consumption increased from 1,700 Mcal/year in 1964 to 5,800 Mcal/year in 1981. Along economic development, the behavior of using energy is expected to change in favor of the use for cooking and water. Thus, houschold unit consumption of 2,800 Mcal is adopted here. In these instances, it is recommended to study the following items to identify a specific natural gas distribution network.

(2) Major items to be studied

a) Projection of the demand for direct use,
b) Estimates of the economic value of natural gas for different uses
c) Alternative utilization schemes
d) Delineation of the utilization system
e) Cost estimates for utilization configuration
f) Recommendation for pricing and accelerated use of natural gas

4) Implementation of the Project and the Study

The implementing agency will be PTT. For the study, 26 man-month would be required. The study should start as earliest as possible, and the main pipeline and distribution network are recommended to commission in the last phase of 7th Five-Year Development Plan i.e., 1995/96.

4.2 Power System Expansion

4.2.1 Background

Recently, the UCR with 95% of the village electrified experienced a rapid growth of electricity consumption at a rate of 10% per annum by spill over

effects from Bangkok economic activities. This high growth rate is also expected during the 7th Five-Year Plan. Therefore, how to meet these growing demand is the main issue for the power sector followed by another issues of achieving 100% village electrification and upgrading supply services.

Having been well aware of these situation, EGAT and PEA have already laid out the supply expansion plan to remedy the current situation and to cope with the expected demand growth.

The UCR without any major power generation resources should necessarily be viewed for it's power supply system in the perspective of total national power supply. Therefore, the UCR alone can not effectively come up with its own major power system expansion and improvement.

Since electricity consumption in the UCR is expected to grow by 5 to 6 times by the year 2010, due attention should be paid to the continuous system expansion and improvement.

The followings are the major projects for power supply expansion in the UCR (see Diagram 4.2).

4.2.2 Projects of Electricity Generating Authority of Thailand (EGAT)

1) Strengthening power supply for Ayutthaya and Bang Pa-In Area (EGAT classification Subproject No.2)

(1) Objective

Objective of this project is to supply bulk power to industrial estates in Ayutthaya and Bang Pa-In areas which will require power supply in the range of 250-300 MW. The project will also increase reliability of the existing Ayutthaya and Bang Pa-In Substations.

(2) Scope

Project feature/scope is as follows;

- Termination of the 230 kv Ang Thong 1 - Rangsit lines to Bang Pa-In 2, by construction of twin double cirduit steel towers, using 1272 MCM ACSR conductor, a distance of approximately 1 km.
- Construction of 115 kv Bang Pa-In 1 - Bang Pa-In 2 double circuit line, using 2x795 MCM ACSR conductor per phase, a distance of approximately 3 km.
- Construction of 230/115 kv Bang Pa-In 2 Substation and installation of two 230/115 kv tie transformers, each rated ONAN/ONAF/OFAF 120/160/200 MVA and two 20 MVA 115 kv shunt capacitor banks.
- Expansion of 115 kv Bang Pa-In 1 Substation for two incoming lines from Bang Pa-In 2.
- Addition of communication system.

(3) Cost

The amount of estimated cost is 535 million baht of which foreign currency portion occupies 280 million baht.

(4) Commissioning

December 1992

2) Power Supply for Ayutthaya and Bang Pa-In area.
(EGAT Classification Subproject 3)

(1) Objective

Objective of this project is to increase power supply capacity for industrial demands in Thalan and Saraburi areas. This project will increase reliability of power supply, improve voltage drop conditions, and reduce system losses.

(2) Scope

Project components are as follows

- Construction of 230 kv Tha Tako - Thalan 3 double circuit transmision line, using 2x1272 MCM ACSR conductor per phase, a distance of approximately 130 km.
- Termination of one circuit of 230 kv Ang Thong 2 - Saraburi 2 line at Thalan 3 Substation by construction of a double circuit steel tower line, using 1272 MCM ACSR conductor per phase, a distance of approximately 1 km.
- Construction of 230 kv Thalan 3 Substation for two 230 kv incoming lines from Tha Tako, one 230 kv incoming line from Ang Thong 2, one 230 kv outgoing line to Saraburi 2 and for three 230 kv tie transformers rated ONAN/ONAF/OFAF 120/160/200 MVA, and construction of 115 kv Substation for the termination of the existing 115 kv Thalan 1 - Saraburi 2 lines, and for three tie transformers. Provision will be made for 115 kv lines expansion to Saraburi 4 Substation in the near future.
- Expansion of 230 kv Tha Tako Substation for two outgoing line to Thalan 3 Substation.
- Installation of shunt capacitor banks at various substations amounting to 178.9 MVAr as follows :

Substation	Voltage (kv)	Rating (MVAr)
Saraburi 2	230	1x60
	115	3x20
Saraburi 4	115	1x20
Thalan 1	115	1x20
Saraburi 1	22	4x3.15
Nakhon Nayok	22	2x3.15

(3) Costs

The estimated costs are reportedly 1,950 million baht of which 965.0 million baht will be for foreign portion.

(4) Commissioning

December 1992

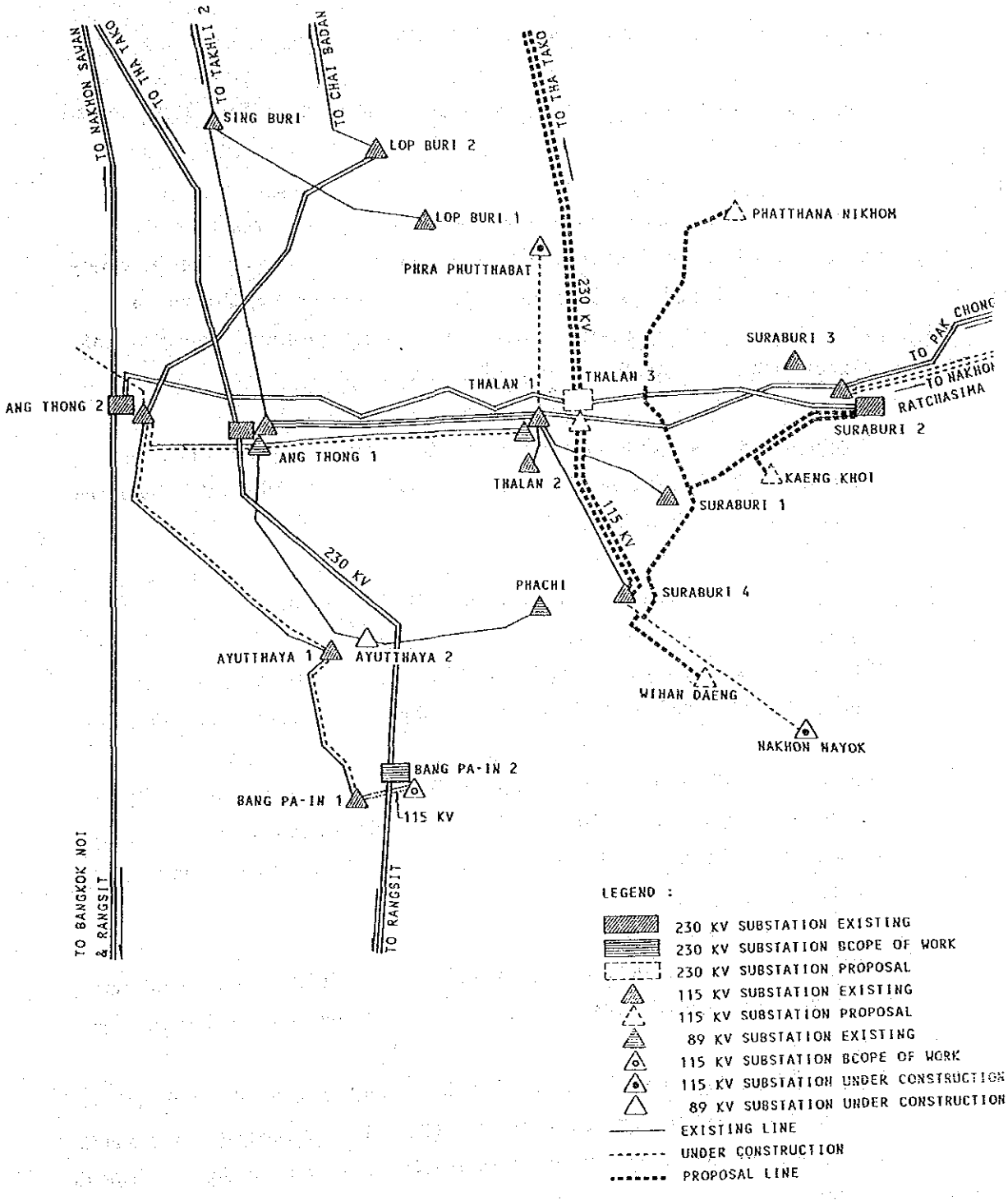

Fig. 4.2 Planned Power System in the UCR

4.2.3 Projects of Provincial Electricity Authority (PEA)

1) Power Supply to Planned Industrial Estates

Seven industrial estates planned in Ayutthaya and 3 in Sara Buri are all taken care of by PEA.

Each estate has a same supply capacity of 80 MVA as shown on the following table. All together 680 MW power is required. The necessary components of these projects to supply this volume are already in progress in accordance with EGAT. With these projects, industries can expect stable and quality supply of power.

Financing of substation in each estate is arranged by the estate developer. Then PEA repays those in terms of electricity sales over the period (not less than 3 years).

2) Village Electrification Project Phase 3 (VEP3)

As have been observed in the Table 1.8 Status of Electrification, Lop Buri, Sara Buri and Chai Nat need additional efforts for electrification.

Village Electrification Project Phase 3 (VEP) will provide electricity to the villages left over by 1992. Then 100% electrification rate would be envisaged in the UCR. However, household hook up rate is considered to be 80%.

VEP is a national project for the period 1990 to 1992 with national target of 2,000 unelectrified villages and 17,735 extension jobs in 70 provinces.

The total cost for VEP3 is estimated at 3,560 million baht of which 1,250 million baht are foreign currency portion. This estimated investments are subject to the Budget Bureau's approval. The UCR portion is difficult to obtain.

3) Transmission System and Substation Development Project : First Stage

This project aims at increasing service quality of PEA to meet the growing power demand resulting from decentralization of industrial base. Ang Thong, Sara Buri, Ayutthaya, and a part of Lop Buri will be benefitted from this project (see the schematic map of Power Expansion) Objectives of this project are the followings:

(1) Objectives

- To meet increasing electricity requirements, especially of middle and large scale industries.
- To increase system efficiency and reliability.
- To solve and minimize problems of operations, maintenance and system losses.

(2) Scope/components of the project

The scope of this project includes substations and transmission lines in the U-shaped area consisting of 18 provinces surrounding Bangkok, and its physical components are as follows;

- 18 new 115-22 kv Substations with total installed capacity of 880 MVA.
- 478.5 cct-km. of new 115 kv transmission lines (12 transmission lines), with conductor size of 2x400 mm2 AAC per phase.

(3) Cost

The total estimated costs run about 5.0 billion baht of which 2.3 billion are for foreign portion. The UCR's portion is difficult to identify.

(4) Implementation period

From 1991 to 1996.

4.2.4 Recommendations on Salient Issues in Implementing Power Supply Expansion

It has been a practice among EGAT and PEA that EGAT takes care of construction and maintenance of transmission and substations and PEA is in charge of distribution system of 22 kv or 33 kv right after the EGAT substations with switch facilities connected to the substations.

In the future, a new demarcation is recommended to be set between EGAT and PEA so that EGAT takes care of the transmission and substations associated with 500 kv and 230 kv system and PEA takes over the secondary transmission system of 115 kv with distribution facilities.

Current practice is merely to separate activities and assets of EGAT and PEA without the point of view of power supply technicalities. It is quite posssible to have switch facilities with substation facilities within the same substation area. By having these two together, personal for maintenance can be reduced and better operation is promised by being able to seize power supply side and demand side at a glance. Technically and economically, it is recommended to charge the current practice as stated above. Especially, construction of substations for power distribution requires prompt reaction to the market behavior. To meet rapidly increasing demand, both quantitatively and qualitatively, there is a large room for new substations to be constructed near the large demand center. It is PEA to be fully responsible for this matter touch current set up of PEA will not fit this responsibility. Moreover current power supply practice of long distance distribution line can not simply meet the power demand level. This long distance distribution line is frequently subject to the voltage fluctuation and accidents.

4.3 Rice Husk Utilization (Power generation/production carbonized husk)toward Achievement of Natural Resource Recycling System

4.3.1 Background

How to cope with the ever increasing electric power demand is the initial starting point of this project. Now power supply system network has been established throughout the country through the efforts of state owned utility

companies of EGAT, PEA and Metropolitan Electricity Authority (MEA). The existing power supply structure supported by these institutions have been the best to efficiently and stably meet the power demand necessary for the development so far.

Nevertheless power demand is anticipated to grow constantly along with further economic growth of this country. During the 6th National Plan period, the power sector investment climbed up to 100 billion baht and is expected to double that amount during for the 7th Plan period. This aggregate investment requirement would surpass government capability. Meanwhile, private sector involvement in national development process has been increasingly important with its financial and human resource capability. In addition, the technilogies in energy sector to attain higher energy efficiency and more effective use of energy resources are getting widely available.

In these instances, it is time to purse efficient and effective utilization of locally endowed resources for power supply expansion. This consideration compelled the government to discuss and to amend the private sector power purchase regulation in 1989. Furthermore, it is felt important to establish a diversified power supply system by utilizing available resources effectively so as to bring synergistic outcomes in meeting ever increasing power demand.

Looking at the UCR, rice husk is awaiting for utilization. Currently 2.1 million tons of paddy are produced in the UCR. With results of intensification and diversification programs of our agriculture sector plan, it is expected that 2.3 million tons of paddy are harvested in the UCR in 2010. This volume will annually provide about 460,000 tons of rice husks, which is equivalent to 147,000 tons of crude in terms of thermal value. This available biomomass resource, if utilized 100%, would meet 1% of total petroleum product consumption in the UCR and if converted to electricity, it would meet 7% of total electricity consumption of 140 GWH in the UCR.

In the UCR, it is aimed to attain a balance between agriculture and industry and harmonization of its natural conditions with development. Toward this goal, recyclic utilization of natural resource will be one of the main strategies in developing productive sectors, where agricultural products residues are utilized for further processing in down stream industry as well as utilized as a decentralized power generation energy source. This strategy will add

comparative advantage of the UCR in terms of self power supply capability at possibly lower costs for the UCR's resource oriented industries, i.e., diversified food industries.

As for utilization of residues from rice mill, not only the rice husks but also rice brawn is promissing material. The oil from rice brawn is gathering due attention for its ability to dissolve coresterole and this oil is traded at the price level three times as high as those of regular vegitable oil. With the paddy production of 2.3 million tons, about 33,000 tons of rice brawn oil is possibly produced in the UCR. The above electricity from rice husks will harness these down stream industrial activities.

Simultaneously with power generation by rice husks, it is possible to obtain carbonized rice husks (CRH) by not burning out the husks completely. This production of CRH will further add opportunities to strengthen the resource recycling utilization scheme. CRH effectively works as soil reformer and the soil for seed-beds in agriculture and in industrial area. It works as heat insulation material, deodorizer/purifier, and materials for bricks. Currently in Japan about 130,000 tons of CRH is produced annually with 60% for agricultural use and 40% for industrial use. Its effectiveness has been recognized especially in agricultural application such as replenishing silica, softening soil, increasing water retention and reforming acid soil. These applications will be required to remedy deteriorated soil in the upland of the UCR.

As for the power generation from rice husk, the actual implementation has been observed through the sales of such, power generation equipment. However it is limited to only the generation of power. Jarung Engineering Co.,Ltd. has sold 30 sets of such equipment with 90 kw generation capacity in average. With the use of this power generation system, 720,000 baht savings per year has been reported[1] .

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1 "A Seminar on Regulations on Privately Paper for Generated Power Purchase"
National Energy Policy Office. Mar. 1989

4.3.2 Project Objectives/Feature

To produce power by utilizing the rice husks or to produce power and carbonized rice husks for soil reformer, the project feature comprises of

- Rice husk storage facility
- Carbonizer
- Carbonized husk extinguisher
- Carbonized husk storage facility
- Waste heat boiler
- Turbine Generator.

4.3.3 Scope of the Project

1) A case project

Projects for rice husk utilization can be divided into two types. One is 100% power generation and the other is to produce power as well as carbonized rice husks (CRH) for soil reformer.

Typical cases of these two options are shown on the table below assuming i) rice husk input of 24,000 ton per year and ii) operation 8,000 hours per year.

	Option A (Power and CRH)	Option B (Power only)
Boiler type	Waste heat boiler	Waste tube boiler
Boiler capacity	6,600 kg/h	10,500 kg/h
Turbine Generator	600 kw	1,550 kw
Husk carbonizer	3 Ton/h	-
CRH Production	4,800 Ton/year	-
Power production	450 kw	900 kw
Energy production	3.6 Gwh/year	7.2 Gwh/year
Power Cost Saving	6.1 million B/year	12.2 million B/year
CRH benefit*	5.6 million B/year	12.2 million B/year

Source : Results of hearing trone manufacturers in Japan.

* In Japan CRH is priced as 70 yen/kg. for indicative calculation, the economic benefit type margin is set as 1/10 of the current price of Japan

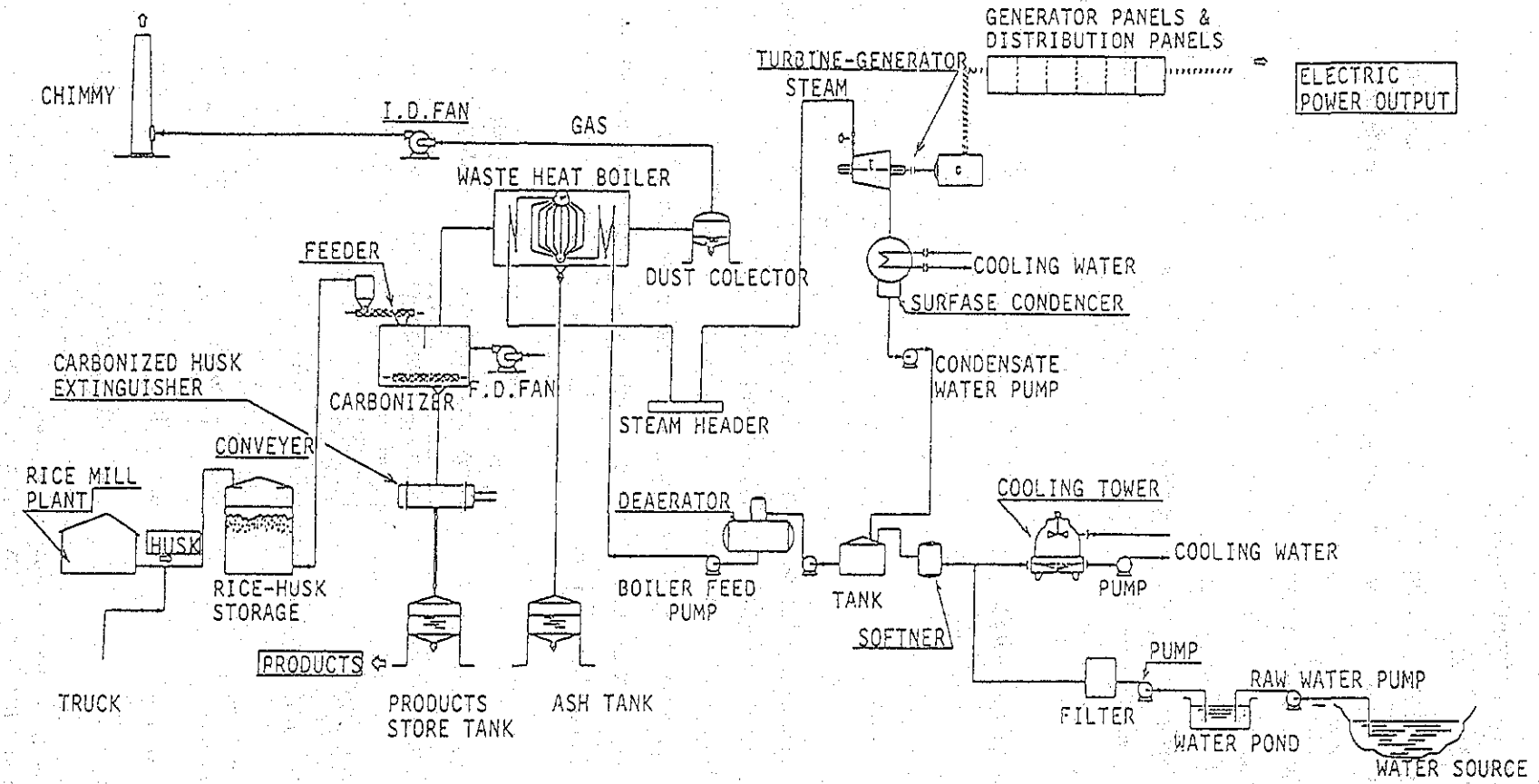

Fig. 4.3 Typical Schematic Flow

For the Option B of power generation system, the steam could be utilized in neighboring plants after going through the steam turbine for generation. The schematic flow diagram for Option A is shown on Diagram 4.3.

2) Implementation of the Project

Private sector participation is considered. Implementation period is from 1992 to 1996. The best project location will be within the proposed agro-processing zone. However, through out the UCR this project is applicable to the whole area of the UCR except the upland area.

4.3.4 Salient Issues for Implementation

In implementing this project, seasonality of rice husk procurement and logistic costs should be paid careful attention. Another aspect which needs attention is project executor. Private sector is considered for execution and operation of this rice husk utilization and a suitable executer would be rice mill factory or agricultural cooperative. Currently there are 1,469 rice mills according to the 1986 Ministry of Industry (MOI) data. However, with the proposed intensification of paddy production in relation to rice husk utilization, relocation or merging of rice mills would be required. Though already initiated, amendment of the power sector regulation is urgently required to realize actualize this project, where the power produced from rice husks could be sold to neighboring customers through the PEA distribution system.

In considering these, it is recommended to carry out a location-specific feasibility study with due attention to the rice husk collection system and marketing prospects for the carbonized rice husks. For this study an executing body could be the business incubator organization as proposed by the our study.

APPENDIX 1. PROJECTION OF NATIONAL AND REGIONAL ENERGY CONSUMPTION

APPENDIX 1. Projection of National and Regional Energy Consumption

Table A-1 Electricity Consumption Projection

UNIT: GWH

	1988/96	*1996/2001*	*1988/2001*	*1988/2010*
NATION	*10.10%*	*6.89%*	*8.85%*	*8.04%*
GREATER BKK	*9.19%*	*7.58%*	*8.57%*	*8.16%*
UCR	*10.62%*	*9.21%*	*10.07%*	*9.63%*
UCR	*10.15%*	*6.64%*	*8.79%*	*8.10%*

		1988 *5)	1996	2001	2010	*G.Impact 2010/1988*
NATION	1)	28,861	62,297	86,928	158,350	5.5
GREATER BKK	2)	13,947	28,175	40,603	78,380	5.6
UCR	3)	1,904	4,269	6,632	14,403	7.6
UCR	4)	1,904	4,127	5,692	10,571	5.6
EGAT GEN.REQT		31,997	69,065	96,373	175,554	

REGIONAL SHARE

NATION	100.00%	100.00%	100.00%	100.00%
GREATER BKK	48.32%	45.23%	46.71%	49.50%
UCR	6.60%	6.85%	7.63%	9.10%
UCR	6.60%	6.62%	6.55%	6.68%

UNIT : KWH/1000BHATS

Electoricity Intensity					*INTENSITY G. RATE FOR 1988/2010*
NATION	58.3	71.9	76.3	82.3	*1.58%*
GREATER BKK	57.0	60.7	63.1	70.9	*0.99%*
UCR	92.0	122.0	146.5	185.2	*3.23%*
UCR	92.0	119.2	122.9	133.8	*1.72%*
Electoricity Elasticity					
NATION	*1.40*	*1.22*	*1.34*	*1.26*	
GREATER BKK	*1.10*	*1.12*	*1.11*	*1.15*	
UCR	*1.56*	*1.75*	*1.62*	*1.55*	
UCR	*1.53*	*1.11*	*1.37*	*1.29*	

NOTES: 1) Based on the reviewed Load Forcast July 1988.
2) 1996's figure is from MEA forecast. The rests are Team estimates
3) PEA forecast up to 2001. 2010's by extarpolation
4) Team estimates
5) All figures in 1988 are actual

Table A-2 Petroleum Products Consumption Projection

	1988/96	1996/2001	1988/2001	1988/2010
NATION	8.73%	4.85%	7.22%	6.10%
GREATER BKK	9.10%	5.49%	7.70%	6.73%
UCR	6.85%	6.90%	6.87%	6.89%
UCR	8.13%	5.63%	7.16%	6.20%

UNIT: 10^6 LITRES		1988 *5)	1996	2001	2010	G. Impact 2010/1988
NATION	1)	15,417	30,117	38,162	56,690	**3.7**
GREATER BKK	2)	8,562	17,190	22,447	35,906	**4.2**
UCR	3)	816	1,386	1,935	3,535	**4.3**
UCR	4)	816	1,524	2,004	3,066	**3.8**
EGAT GEN. REQT		31,997	69,065	96,373	62,849	
			REGIONAL SHARE			
NATION		**100.00%**	**100.00%**	**100.00%**	**100.00%**	
GREATER BKK		**55.54%**	**57.08%**	**58.82%**	**63.34%**	
UCR		**5.29%**	**4.60%**	**5.07%**	**6.24%**	
UCR		**5.29%**	**5.06%**	**5.25%**	**5.41%**	

P.Products Intensity			UNIT : LITRES/1000BHATS		INTENSITY G. RATE FOR 1988/2010
NATION	31.1	34.8	33.5	29.5	-0.25%
GREATER BKK	35.0	37.0	34.9	32.5	-0.34%
UCR	39.4	39.6	42.8	45.4	0.65%
UCR	39.4	44.0	43.3	38.8	-0.07%

P.Products Elasticity				
NATION	1.21	0.86	1.09	0.96
GREATER BKK	1.09	0.81	1.00	0.95
UCR	1.01	1.31	1.11	1.11
UCR	1.22	0.94	1.12	0.99

NOTES: 1) Figures 1) through 3) from 1996 to 2001 are from NESDB/NEPO projection. Figurs for 2010 are by Team estimates.

4) Team estimates
5) All figures in 1988 are actual from NEA

Table A-3 Direct Fuel Consumption Projection

NATION	1988/96	1996/2001	1988/2001	1988/2010
DIRECT FUEL	8.69%	3.90%	6.82%	5.83%
TOTAL FINAL ENE	8.91%	3.78%	6.91%	6.09%
UCR				
DIRECT FUEL	6.31%	5.69%	6.07%	5.67%
TOTAL FINAL ENE	6.78%	5.82%	6.41%	5.62%

UNIT: '000TOE

	1988	1996	2001	2010	G. Impact 2010/1988
NATION					
DIRECT FUEL	13,615	26,516	32,113	47,372	3.5
TOTAL FINAL ENE	16,586	32,824	39,520	60,865	3.7
UCR					
DIRECT FUEL	1,306	2,130	2,809	4,390	3.4
TOTAL FINAL ENE	1,468	2,483	3,295	4,891	3.3

NATION	REGIONAL SHARE			
DIRECT FUEL	100.00%	100.00%	100.00%	100.00%
TOTAL FINAL ENE	100.00%	100.00%	100.00%	100.00%
UCR				
DIRECT FUEL	9.59%	8.03%	8.75%	9.27%
TOTAL FINAL ENE	8.85%	7.56%	8.34%	8.04%

Direct Fuel Intensity UNIT : LITRES/'000BHATS

NATION					INTENSITY G. RATE FOR 1988/2010
DIRECT FUEL	27.5	30.6	28.2	24.6	-0.50%
TOTAL FINAL ENE	33.5	37.9	34.7	31.6	-0.26%
UCR					
DIRECT FUEL	63.1	61.5	60.6	55.6	-0.58%
TOTAL FINAL ENE	71.0	71.7	71.1	61.9	-0.62%

Direct Fuel Elasticity

NATION				
DIRECT FUEL	1.20	0.69	1.03	0.92
TOTAL FINAL ENE	1.23	0.67	1.04	0.96
UCR				
DIRECT FUEL	0.95	0.95	0.95	0.90
TOTAL FINAL ENE	1.02	0.97	1.00	0.90

NOTES : 1) Team estimates
All figures in 1988 are actual

Table A-4 Final Commercial Energy Consumption Projection

UNIT: '000 TOE

			1988	1996	2001	2010
	TOTAL NATION					
1	DIRECT FOSSAIL FUEL	(=2+3)	14,127	27,516	32,113	47,372
2	P. PRODUCTS		13,259	25,901	31,140	46,259
3	OTHERS	(=i+ii+iii)	868	1,615	1,371	1,855
i)	LIGNITE					
ii)	IM. COAL					
iii)	N.GAS					
4	ELECTORICITY		2,459	5,308	7,407	13,493
5	TOTAL FINAL ENE	(=1+4)	**16,586**	**32,824**	**39,520**	**60,865**
	UCR					
1	DIRECT FOSSAIL FUEL	(=2+3)	1,306	2,131	2,810	3,990
2	P. PRODUCTS		674	1,133	1,638	2,535
3	OTHERS	(=i+ii+iii)	632	998	1,171	1,455
i)	LIGNITE					
ii)	IM. COAL					
iii)	N.GAS					
4	ELECTORICITY	(=1+4)	162	352	485	901
5	TOTAL FINAL ENE		**1,468**	**2,483**	**3,295**	**4,891**

APPENDIX 2. LIST OF STUDY REPORTS AND PAPERS

APPENDIX 2. LIST OF STUDY REPORTS AND PAPERS

1. REPORTS

Design for the Study

Inception Report

Inception Report: Amendment

Progress Report

Interim Report
- Executive Summary
- Master Plan Report
- Technical Reports
  - Vol. 1 Spatial Framework for Development
  - Vol. 2 Environmental Management
  - Vol. 3 Land Use and Agricultural Development
  - Vol. 4 Industrial Development
  - Vol. 5 Distribution
  - Vol. 6 Water Resources Management
  - Vol. 7 Transportation
  - Vol. 8 Economic Environment
  - Vol. 9 Local Government Finance
  - Vol. 10 Energy
  - Vol. 11 Landsat Analysis

Draft Final Report
- Executive Summary
- Master Plan Report
- Sector Reports
  - Vol. 1 Spatial Framework and Network for Development
  - Vol. 2 Urban Management
  - Vol. 3 Environmental Management
  - Vol. 4 Water Resource Management, Agricultural Development and Land Use Management
  - Vol. 5 Industrial Development
  - Vol. 6 Distribution and Marketing
  - Vol. 7 Energy
  - Vol. 8 Social Development in Rural Economies
  - Vol. 9 International and National Economic Environment
  - Vol. 10 Human Resource Development
  - Vol. 11 Landsat Analysis

Final Report
- Executive Summary
- Master Plan Report
- Sector Reports
  - Vol. 1 Spatial Framework and Network for Development
  - Vol. 2 Urban Management
  - Vol. 3 Environmental Management

Vol. 4 Water Resource Management, Agricultural Development and Land Use Management
Vol. 5 Industrial Development
Vol. 6 Distribution and Marketing
Vol. 7 Energy
Vol. 8 Social Development in Rural Economies
Vol. 9 International and National Economic Environment
Vol. 10 Human Resource Development
Vol. 11 Landsat Analysis

2. PAPERS

Papers for Seminar, Sara Buri, November 2-3, 1989

1. Development Framework, Strategies, and Production
2. Urban, Land Use and Infrastructure Development
3. Critical Issues for Development Management

Papers for Seminar, Pattaya, July 28-29, 1990

1. Agriculture and Water Resources: Policies and Programs
2. Industry and Energy: Policies and Programs
3. Urbanization and Infrastructure Facilities: Policies and Programs
4. Development Administration and Environmental Management: Policies and Programs

APPENDIX 3. STAFF INPUT

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CUSRI: Chulalong Korn University Social Research Institute
ECFA: Engineering Consulting Firm Association
IDCJ: International Development Center of Japan
PCI: Pacific Consultants International
SOMC: Shinko Overseas Management Consultant

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