Sustainable energy alternatives to the 1,400 MW coal-fired power plant under construction in Prachuap Khiri Khan

A comparative energy, environmental, and economic cost-benefit analysis

Produced by

Thai-Danish Cooperation on Sustainable Energy
with
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Revised Version

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Preface

Thailand is facing immense social and environmental challenges. The earth, air, and waters are polluted by industry, transportation, and energy to a degree that threatens both health and livelihood of our people. At the same time, the majority of the Thai population may be considered to be poor, underemployed, and left without influence.

How may we secure a development, which is sustainable environmentally, socially and technically, without jeopardizing the demand for bringing economic development to the poor?

In this study, and other research studies initiated by "Thai-Danish Cooperation on Sustainable Energy", we have set out to analyze and discuss the economic, environmental and social rationality of sustainable energy. And we will suggest actions that will help implement a sustainable energy sector development for a better society.

"Thai-Danish Cooperation on Sustainable Energy" is a joint non-profit and non-governmental effort by Appropriate Technology Association (ATA) and the Danish Organization for Renewable Energy (OVE) to promote a sustainable energy sector development for Thailand. The people of Denmark through DANCED (Danish Cooperation for Environment and Development) finance all activities.

The original document as of July 12, 1999, was prepared by a team of economists and engineers from Aalborg University in Denmark, Kasetsart University in Bangkok, Thammasat University in Bangkok, and Thai-Danish Cooperation on Sustainable Energy.

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The current revised document now correctly calculates atmospheric CO2-emissions and furthermore includes the most current information about emission factors as outlined in the official Environmental Impact Assessment, which has only recently been obtained.

Nakhon Ratchasima, November 24, 1999

Assist. Prof. Chanchai Limpiyakorn
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Thai-Danish Cooperation on Sustainable Energy

Appropriate Technology Association

The Danish Organization for Renewable Energy

Danish Cooperation for Environment and Development

Executive summary

In this paper, a team of energy sector analysts, economists and engineers, have set out to analyze the rationality of a planned coal-fired power plant under construction at Prachuap Khiri Khan. A technical-economic cost-benefit analysis is performed; in which the coal-fired power plant project and a proposed technical alternative are assessed in relation to a wide range of specific and general official development objectives for Thailand and Thailand's energy sector.

The paper documents that the current plans for implementing a coal-fired power plant at Prachuap Khiri Khan is indeed not very rational and that alternatives exists which are more suitable for Thailand in terms of economic growth and stability, employment, decentralization, rural development, technology development, industry development, and environmental sustainability.

The paper recommends for EGAT to cancel the contract with Union Power on the implementation of a coal-fired power plant at Prachuap Khiri Khan and for the Thai government to stimulate decentralized power production.

1. Introduction

Power sector development projects are well known to be conflicting issues. On one hand we find an institutionalized setup consisting of EGAT, PTT, and a number of private power producers and industrial companies, setting the pace for the establishment of a power sector based on large-scale, separate production of heat and power based on fossil fuels. On the other hand we see a society badly affected by the economic crisis, unemployment, degradation of natural habitats, division of local societies, where the majority is left with little or no influence on the development of the energy sector.

In between stakeholders in civil society and market, we see a political system facing the difficult task of regulating the energy sector, in order to meet the social and economic objectives of Thailand most effectively.

Politicians and stakeholders who want to establish a rational basis for decision making, continuously needs to look into whether the current situation and development is rational, and if not so, whether alternatives exists, which will meet the social and economic targets more effectively.

1.1 Official social and economic objectives for Thailand and Thailand’s energy sector

In order to evaluate and assess the rationality of decisions taken in Thailand’s energy sector, it is essential to have a look at the official social and economic objectives for the development of the Thai society, as formulated by the Thai government.

In fact, in “Strategies for the Energy Development during the Eighth National Economic and Social Development Plan 1997-2001”, it is established that the National Energy Policy Office of Thailand (NEPO) is responsible to “develop policies, management and development plans and measures related to Thailand’s energy sector in accordance with the National Economic and Social Development Plan and government policies to be presented to the NEPC (National Energy Policy Council).”

In other words, NEPO is required to relate all plans and base all decisions on the wide range of official objectives found in the National Economic and Social Development Plan and other government policies.

The 8th National Economic and Social Development Plan (1997-2001) is considered to be a turning point in the way the plan recognizes the globalization process and the need for a continuous and long-range process of planning, decision-making, implementation, monitoring and evaluation. The plan is said to be a move towards a holistic people-centered development.

The social and economic objectives formulated in the plan is intended to be the basis of planning and decision-making throughout all economic sectors – issues includes economic policy, security of supply, employment, rural development, technological innovation, the environment a.o. On this basis, also energy plans and projects shall be assessed.

In Section 1.1.1 – Section 1.1.5 below, the main official objectives are referred to and discussed:

- Secure sufficient and efficient energy supply at a reasonable price
- Improve the balance of payment and stimulate employment
- Strengthen rural development; employment, decentralization, empowerment
- Support industrial and technological innovation
- Promote clean technologies and a clean environment

1.1.1 Secure sufficient and efficient energy supply at a reasonable price

In "Strategies for the Energy Development during the Eighth National Economic and Social Development Plan 1997-2001"[1], NEPO states:

"In order to develop the international competitiveness of the country, a sufficient supply of energy to meet the demand in various economic activities is essential since energy is a crucial fundamental production factor. The supply of energy must be at reasonable prices with sufficiently high quality consistent with consumer's requirements. At the same time, production activities must utilize energy in an efficient and economical manner."

1.1.2 Improve the balance of payment and stimulate employment

In the "Revision of the 8th Economic and Social Development Plan"[2], the National Economic and Social Development Board (NESDB) states that:

"In light of the revised macroeconomic target, which is lower than the growth rate during 7th Plan and the target previously set in the 8th Plan, the overall expenditure, both public and private, must be controlled to go in line with the country's economic and financial conditions."

And further…:

"The criteria for screening public investment projects will strictly consider the projects with low import content and stimulate employment, or has adequate foreign currency generation capacity to cover foreign currency cost".

The current situation [3] urges for NESDB to highlight these objectives.

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[1] NEPO 1997.
[2] RESD99, National Economic and Social Development Board (NESDB), April 1999.
[3] With the economic crisis, the external debt has increased to 86.7 billion USD in 1998, and the unemployment rate has increased from 1.4% in 1997 to 5.3% in 1998 and is now 1.8 million people. The government expects further increase in the unemployment rate for 1999.

1.1.3 Strengthen rural development; employment, decentralization, empowerment

The disparity between urban and rural areas has been considered a problem for Thailand's economic and social development and the official policy is to stimulate rural development.

In "The 8th Economic and Social Development Plan" (ESD98)[4], the government outlines the framework for "enhancing the development potential of the regions and rural areas, by redistributing income on a more equitable basis and decentralizing development activities to regional and rural areas; promoting popular participation in development through the empowerment of community organizations; supporting and expanding community learning networks; promoting the role of the private sector and non-governmental organizations (NGOs) in job creation; and managing development at all levels through cooperative partnership."

Furthermore, the government specifies the following objectives[5]:

- "To create employment opportunities for approximately eight million of rural poor, so that they can gain sufficient income and economic security."

- "To provide rural people working in the agricultural sector with a wider range of non-agricultural employment options", and

- "To distribute economic activity evenly and create development and employment opportunities appropriate to the potentials of different people and communities".

In fact, as the economic crisis hit, the World Bank[6] found the rural areas to be affected relatively worse.

Also in ESD98, the government specifies how to stimulate democratic empowerment for rural communities[7]:

- "To increase the roles of people's organizations and local administrative governments, so that they can work together to achieve regional and rural development which is responsive to the needs of people living in those areas" (p. 56).

- "To enhance the development potentials of people and communities in regional and rural areas, so that they can participate in the process of local development" (p. 56).

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[4] National Economic and Social Development Board (NESDB), 1998.
[5] Page 56-57.
[6] "At a regional level, the largest initial increase in the unemployment after the advent of the crisis occurred in the rural areas and the Northeast region, where the concentration of poverty is highest", and "The absolute increase in the rate of unemployment was the largest in the rural Northeast (3.5% unemployment in February 1997 and 8.2% in February 1998)". SOCIAL MONITOR, January 1999, The World Bank Thailand
[7] Page 56.

1.1.4 Support industrial and technological innovation

In the "5th National Research Policy and Agenda (1997-2001)", the National Research Board states that research to increase competitiveness of industrial sectors must be promoted. And the industrial sector should improve efficiency in use of resources and energy.

From the "Follow Up Plan 1998-2002", NESDB states that one of the most important goals for industrial development should be incubation and strengthening of small and medium supporting industries.

In the "Industrial Restructuring Plan 1998", the Ministry of Industry states that conditions should be established, which are upgrading technological capabilities and modernizing target industries as well as enhancing product development and design, and global marketing channels.

1.1.5 Promote clean technologies and a clean environment

In "The 8th Economic and Social Development Plan", the government also formulates objectives in relation to the environment[8]:

- "To utilize, preserve and rehabilitate the environment and natural resources in such a way that they can play a major role in economic and social development and contribute to better quality of life for the Thai people".

- "Natural Resources and Environmental Management, including directions of conserving and rehabilitating natural resources that will promote balance in the ecosystem; maintaining and upgrading environmental conditions to enhance quality of life and to provide an enduring resource base to support development; improving management systems for natural resources and the environment in order to ensure proper supervision, efficient utilization, and fair distribution of benefits to the community and society; and management guidelines for the prevention and relief of natural disasters".

1.1.6 Summary of social and economic objectives

As stated in the "Revision of the 8th Economic and Social Development Plan", both private and public projects shall be assessed in relation to the current social and economic objectives.

[8] Page 3-5.

In conclusion, all private and public energy sector projects shall therefore be assessed on their ability to provide:

a) sufficient energy supply
b) reasonable energy prices
c) high energy efficiency
d) high cost efficiency
e) low import content
f) new products for export
g) more and better employment
h) positive effects on public budgets
i) rural development
j) decentralization of the planning and decision making process
k) technological innovation
l) a healthy environment

1.2 Current policies and planning

Does ongoing energy sector projects and plans currently meet these objectives? In order to answer this question, we took a look at how energy institutions plan to meet the energy demand.

1.2.1 Official forecast for the development of electricity demand

In September 1998, the Thailand Load Forecast Subcommittee (TLFS) made an electricity demand forecast, which was divided into 3 cases of economic development: Moderate, Rapid and Low Economic Recovery (MER, RER and LER). The forecast does not specify end-use demands but states only the expected demand for central supply capacity and generation.

Figure 1 shows the forecast results in terms of installed capacity and generation. The Moderate Economic Recovery (MER) is EGAT's reference case in the current Power Development Plan.

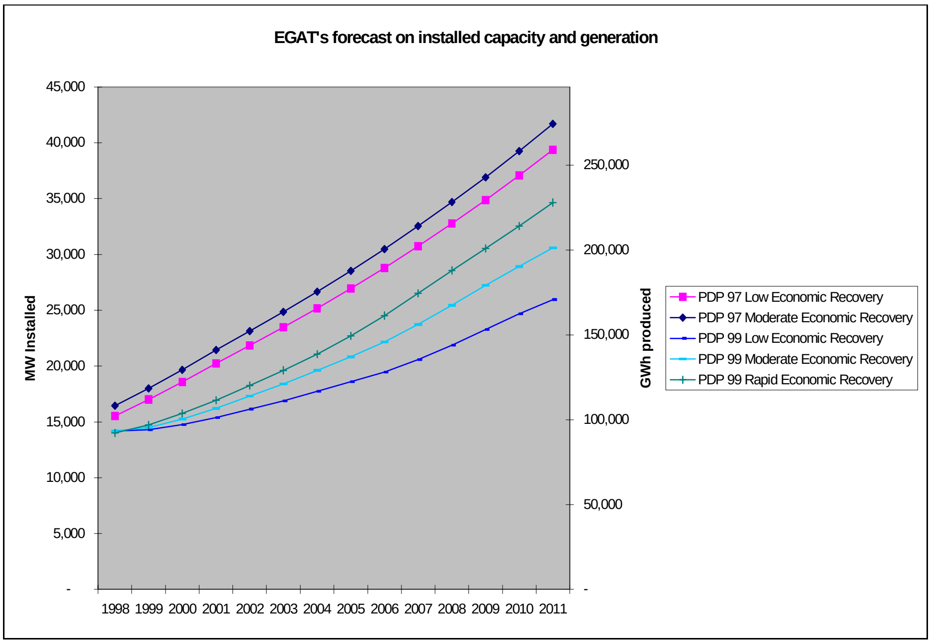

Figure 1: Power sector forecast on power generation capacity and electricity generation. A 25% reserve margin has been a planning criterion.

1.2.2 Official plans on how to meet the electricity demand

In the revised Power Development Plan from January 1999 (PDP99-01 Revised), which covers the period from 1999 to 2011, EGAT is considering six candidate options for power production towards 2011.

- conventional thermal (gas, oil, and coal-fired)
- combined cycle gas turbine
- diesel gas turbine (OCGT)
- pump storage

Ongoing (or postponed) contracted power projects are not considered as candidate plants but rather as compulsory plants.[9]

The decision making process in EGAT's power developments takes place using a least-costs model which basically optimizes the system to minimize investment and operation costs, regardless of other official development goals and relating social costs.

According to PDP99-01 Revised, the model bids EGAT to install 21.2 GW within 13 years; which will increase the installed capacity from 18.2 GW in 1997 to 39.4 GW in 2011. The planned generation by fuel is listed in Table 1.1.

Table 1.1: The planned generation of electricity by fuel. Source: PDP99-01 Revised (p.69).

Fuel	Unit	1999	2001	2006	2011
Hydropower	GWh	3,925	3,925	5,388	5,972
Natural Gas	GWh	51,696	65,676	84,440	103,076
Fuel Oil	GWh	15,501	3,915	4,008	5,354
Diesel	GWh	484	542	-	-
Lignite	GWh	12,361	13,915	16,821	16,571
Imported Coal	GWh	-	-	14,764	33,848
Purchase	GWh	9,211	15,711	17,582	32,452

Consequently, Thailand's power system is planned to become more dependent on natural gas and imported coal. Purchasing from SPP and neighboring countries will be increased from 10% to 16% of total electricity generation. The electricity from hydropower and lignite will be slightly increased in terms of quantity, but slightly decreased, relatively. Production based on fuel oil and diesel is being significantly decreased.

[9] The methodology is highly criticized by PriceWaterhouseCooper in "Review of Electric Power tariffs", 1999.

In accordance with this plan, EGAT plans to implement the following projects:

- Install 4,070 MW thermal power based on natural gas and fuel oil,
- Install 2,175 MW combine cycle plants based on natural gas and diesel,
- Construct 2 pumping storage hydro power plants with a total capacity of 1,660 MW. Also, EGAT plans to increase the capacity of existing hydropower plants by 10 MW.
- Install 100 MW steam turbine in connection to an existing gas turbine plant at Surat Thani.

Furthermore, EGAT plans to purchase electricity from private producers:

- Purchase 10,444 MW from IPPs, of which 5,944 MW from 7 producers have already been contracted, and some of which are currently under construction. 4 of these producers will use natural gas; the others will use imported coal. The additional 4,500 MW is outlined as combined cycle power plants, but have not yet been specified in terms of fuel.
- Purchase 3,426 MW from hydropower projects in Laos and 300 MW from Malaysia.
- Purchase 1,535 MW from 20 firm SPPs based on natural gas (940MW), coal (420 MW), wood (180 MW) and rice straw (5 MW).

1.3 Is the energy sector currently fulfilling the official development objectives?

It is evident that EGAT's energy policy and planning methods are limited to financial aspects rather official social and economic objectives. Also, as neither supply alternatives nor demand side-management alternatives have been analyzed, it is not clear whether EGAT's plans are even relatively better at meeting the objective to provide "adequate energy at a reasonable price, while ensuring quality and security of supply."

EGAT does not consider issues in relation to reducing the foreign debt burden and domestic investment expansion, the social development goals, the reduction of income disparity, to create employment, and to promote decentralization of decision-making. The fundamental analyses required to assess whether the existing energy sector development is fulfilling the official social and economic objectives are currently not available.

The existing technology paradigm in Thailand's energy supply sector consists of a combination of large-scale fossil-fueled power plants and separate fossil-fueled heat production. The existing paradigm is characterized by being based on well-proven technologies supported by an extensive well-established infrastructure of foreign companies and governments, provided mainly as turn-key facilities with little local technology development, being highly capital intensive with relatively high import content, requiring relatively little local employment.

Furthermore, the paradigm is intolerant to sudden change. The future electricity demand is highly uncertain due to the uncertain economic situation. In 2011, the difference between the slow and fast economic recovery case in TLFS's forecasts is 10,000 MW, or almost 50% of the currently installed capacity. This situation turns investment in large-scale power plants with a long period of planning and construction into unnecessarily inflexible and risky business. The situation may become traumatic by the fact, that contracts obliges EGAT to pay IPPs and firm SPPs according to their installed capacity, which implies that EGAT, and with them the electricity consumers and Thai taxpayers, will carry the economic burden from inflexibility in planning and management.

It is likely that this old-fashioned paradigm does not hold the capacity to meet the social and economic objectives for the modern Thai society.

2. The power plant at Prachuap Khiri Khan

2.1 Background

Three decades ago, the Government of Thailand established the Electricity Generating Authority of Thailand (EGAT), which is a state-owned enterprise in charge of electricity generation and transmission. The purpose of this establishment was to secure sufficient energy to develop the nation.

EGAT supplies and sells electricity to two other state-owned enterprises, the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA). MEA controls electricity distribution in the greater Bangkok area while the rest of the country is covered by PEA.

EGAT has expanded Thailand’s power generating capacity from less than 500 MW three decades ago to a total installed capacity of more than 18,000 MW today. EGAT's capacity expansion has mainly been in large-scale power plants: Mae Moh Power Plant (2,625 MW), Wang Noi power station (2,024 MW), and Bang Pakong power station (3,675 MW). These large-scale power plants have been financed by international finance institutions such as World Bank, Japan's Overseas Economic Cooperation Fund, and bilateral aid agencies.

The constraint that these international finance institutions put on EGAT for qualifying for more future funding is that the rate of return on EGAT's investment must be at least 8%. Since EGAT is a monopoly, it can pass all costs to consumers, i.e. EGAT can tie its revenues to its investment costs plus any operation and maintenance costs as well as the required rate of return from finance institutions. Under these conditions, EGAT has had basically no problems in obtaining funding from the international finance institutions and has been given a good incentive for continuing their business of investing in large-scale, capital-intensive projects. Furthermore, the Thai government has never rejected EGAT’s plans for investments in capital-intensive projects, as EGAT cites technical considerations like reliability and economies of scale as a rationale for its investment policy. However, others may claim this development is rather based on EGAT’s institutional growth mechanism of business as usual.

However, during the past decade, the day-to-day problems associated with operating these power plants, e.g. technical failures, environmental and social concerns, uncertain fossil fuel prices etc., have forced EGAT to reexamine its strategic plans. As a result, EGAT together with NEPO and the World Bank have established instruments to improve EGAT’s efficiency as well as diminishing the governmental investment burden. One instrument has been to introduce a concept for the privatization of EGAT. Furthermore, a program for promoting Independent Power Producers (IPPs) and Small-scale Power Producers (SPPs) has been established.[10]

[10] The difference between IPPs and SPPs is that SPPs are those power producers who utilize either cogeneration or facilities using renewable energy as fuel, which sell electricity to EGAT of not more than 90 MW for each project. According to the report in "EGAT, Power

2.2 The Hin Krut Power Plant in Prachuap Khiri Khan

The Hin Krut power plant project in Prachuap Khiri Khan is in the process of becoming such IPP. The project is located at Kok Ta Horm village in Thongchai sub-district, Bangsapan province in Prachuap Khiri Khan province. The owner of the project is “Union Power Development Co., Ltd.”, a joint venture with 90% foreign capital (Figure 2).

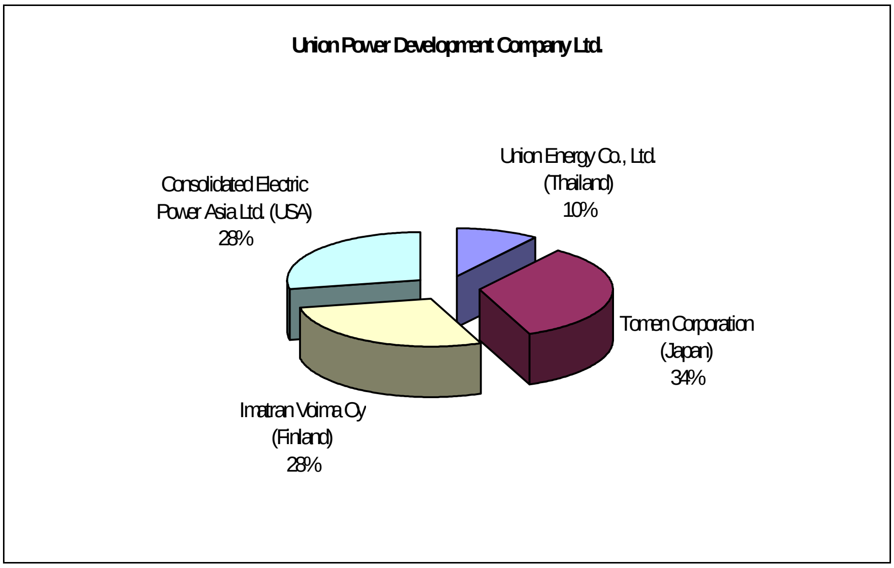

Figure 2: Shareholders in “Union Power Development Co., Ltd.”

The joint venture proposed its project in June 1995, received the initialized power purchase agreement (PPA) on December 27, 1996, and signed a 25-year IPP-contract with EGAT on June 30, 1997. At present, the project is only awaiting a construction license from the local Tambon Administrative Organization (TAO) in order to commence the actual construction of the power plant.

In the meantime, there have been growing concerns about the negative impacts of the project on the surrounding environment from locals and environmentalists. The coal-based power plant will not install scrubbers to reduce sulfur dioxide emissions and is expected to become a hazard to local people's health and livelihood.

As of August 1999, the opponents of the project have failed to convince the TAO about not to provide the required construction license. Union Power is now underway of finalizing the last step of the official procedure of approval, which is to obtain a concession to produce electricity from the Ministry of Interior.

Development Plan, 1998 to 2001, (as of August 1998)", seven IPPs have received Power Purchase Agreements (PPAs) from EGAT to sell a total capacity of 5,944 MW of electricity. And there are fifty-five SPPs with a total capacity of 2,445 MW of electricity to be sold to EGAT.

Though already contracted, EGAT may apparently cancel the project by paying a compensation for already invested cost of approximately USD 67 million (THB 2.5 billion).[11]

Some form of compensation will be in accordance with the existing regulation introducing the SPP and IPP programs. As the programs are designed to attract private investors, the PPAs guarantees a low-risk investment with constant returns. The IPP company is protected from any repercussions of investment risks by the “change-in-law” clause in PPA, which places the financial responsibility of any change in law, including environmental problems and baht floatation, on EGAT - and thereby on the Thai government, energy consumers and taxpayers.

2.3 Technical-economic characteristics

The coal-fired plant is planned to have an installed capacity of 1,400 MW from two 700 MW units. The first is planned to be ready for production in 2001 and the second in 2002. Fuel will be imported bituminous coal from Australia, Indonesia and South Africa and no desulphurisation units are to be installed. According to the information given by Union Power the plant will consume 3.85 million tons of bituminous coal per year producing 7,125 GWh/year at an efficiency of 44.77%.[12]

The construction costs for the turnkey-plant is USD 900 million. In addition hereto come financial costs, consulting costs etc. at a total of USD 300 million. Thus, the expected construction price is USD 1.2 billion (THB 45 billion). The operation and maintenance costs are USD 12 million per year (THB 450 million per year). Union Power refers to a coal price of USD 40 per ton, which is similar to the current cost of coal according to EGAT. Furthermore, EGAT expects the real price for coal to increase at 2.08% per year.

According to the contract, Union Power will receive two types of payment:

(a) fixed payment paid for the available power supply of the plant.

(b) reimbursement of variable costs associated with fuels consumption and operation and maintenance.

[11] Manager Weekly, May 3-9, 1999, Mr. Koichi Atsuta, Chairman of Union Power Development Company.
[12] Please refer to Annex A 5

The actual payment is kept secret from the public, but the PPA between EGAT and an SPP has been seen to hold a capacity payment of 422 Bath per kW per month.[13] EGAT will be obliged to pay this amount whether or not the power plant produces electricity. This favorable contract is intended to secure the investor an internal rate of return of the investment of 15%. In the analyses in Chapter 4, the capacity payment represents the economic costs of the project expect for the calculation of employment consequences. Please refer to the Annex A 1 and A 2 for further details on the technical-economic data.

[13] Dr. Piyasvasit, NEPO, Presentation on Energy Sector Privatization at the 1998 Thai Electricity and Gas Investment Briefing, July 1998.

3. Technical alternatives to the power plant at Prachuap Khiri Khan

3.1 Introduction

While assessing the real costs and benefits from a coal-fired power plant at Prachuap Khiri Khan an alternative has been produced for comparison. The Alternative, which is named “The Biomass, Energy Efficiency and Micro-Hydro Power Alternative” consist of 3 components:

1) Industrial co-generation based on biomass
2) Demand Side Management (DSM)
3) Micro Hydro Power (MHP)

The Alternative combines the utilization of indigenous fuels with Thai industrial and technological development intended to create employment, technological innovation, export opportunities and other benefits.

3.2 Industrial co-generation based on biomass

Introduction and development of industrial co-generation based on biomass combines two strategies: fuel-shifting to a renewable and indigenous resource and increasing energy efficiency through combined production of heat/steam and power.

For the fuel-shifting part, Thailand has considerable biomass resources, which have been only partly accounted for. Important resources include rice straw and sugar cane. Both rice straw and partly sugar cane is currently left in field and in many cases burned under open air. An estimated technical potential of 10,000 ktoe of rice straw and 7,000 ktoe sugar cane is available. However, part of these resources serves as fertilizer and may not be used for energy purposes. Including other biomass fuel potentials such as logging trash, rice husk, corncobs, coconut shells, Thailand has an estimated technical biomass potential of more than 20,000 ktoe, which is equal to more than half of current oil consumption[14].

For the efficiency part, energy consumption in the industrial sector is dominated by consumption of centrally produced electricity together with fuel consumption used for production of process heat. Industrial co-generation does exist, but is not being implemented on a larger scale.

The technical industrial CHP potential is estimated to be approx. 10,000 MW electrical power. However, several uncertainties applies, e.g. part of the 1997 industrial fuel consumption was not used for process heat. Utilizing the estimated technical potential fully would result in fuel savings of almost 8,000 ktoe - equivalent to more than 30% of total 1997-fuel consumption in power production.[15]

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[14] Ramboll 1998.
[15] Please refer to A 3 on page 49 for details on how this estimation was reached.

Currently, only a very small part of this potential is exploited. In the short-term, a potential of 3,000 MW can be implemented by replacing existing low pressure boilers with modern high pressure boilers in only those agro-food industries, which have an annual production output, which makes CHP feasible. An international analysis of this potential concluded that "… there is reason to believe that - with a suitable government policy - the boiler industry could take up the development and manufacturing of high pressure boilers."[16]

In the long-term, using rice straw and other biomass for energy purposes on an even larger scale is possible. As some of the technologies in question are only emerging on the market, Thailand may harvest great benefits from being involved in the development of e.g. gasification of biomass in combination with combined cycle. "If feasible, Thailand could go for a leading role in the development of this technology."[17]

The investment costs of biomass CHP plants in industries vary from 1,000 to 1,650 USD/kW electric output. Typically annual operation and maintenance costs for this technology are 5% of investment costs.

Please refer to Annex A 2 for a summary of technical-economic data, which have been used in the analyses.

3.3 Demand Side Management (DSM)

Demand Side Management (DSM) means planning and implementation of activities intended to control the consumption of electricity rather than investing in new production capacity. Activities include e.g. introduction of efficient end-user technologies, information campaigns, and industrial energy audits.

The average annualized costs of implementing DSM in Thailand has been estimated to be in the range of 0.37 B/kWh at a discount rate of 7% to 1.03 B/kWh at a discount rate of 10%, which is less than most production supply alternatives.

In the period from 1990 to 1998, EGAT is believed to have implemented DSM savings of 400 MW.[18] In a 1993 study by IIEC, the DSM potential for 2001 was estimated to be 2,200 MW peak, equal to 13,000 GWh/year at an average 6,000 hours/year. [19] A range of costs was reviewed and an annualized cost of 0.49 B/kWh at a discount rate of 8% was suggested.[20]

Please refer to Annex A 2 for a summary of technical-economic data, which have been used in the analyses.

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[16] Ramboll, 1998.
[17] Ramboll, 1998.
[18] Thailand: Promotion of electricity energy efficiency, IIEC, 1993
[19] DSM for Thailand's Electric Power System – Five-Year Master Plan, IIEC, 1991
[20] Assuming all investment takes place in the first year and that the average life time of measures is 25 years, this equals an initial investment of 28.0 million THB.

3.4 Micro Hydro Power (MHP)

From 25 river basins, Thailand has currently installed 2,909 MW of hydropower of which 2,870 MW is large-scale hydropower plants. Production from hydropower in 1997 was 7,340 GWh of which an estimated 1.2 GWh came from small-scale hydropower systems (mini- and micro-hydro).[21]

Estimations of the technical potential for hydropower ranges from 12,000 MW to 27,000 MW. Some considers 3,500 MW to be financially feasible.[22] The technical potential for mini-micro may be in the range of the difference between "financially feasible" (assumable large-scale projects only) and the technical potential of between 12,000 MW and 27,000 MW. This leads us to suggest a technical potential for mini- and micro-hydro power of 8,000 MW or more.

Large-scale hydro power project are currently not a likely alternative for Thailand due to its environmental and social impacts, e.g. deforesting and destruction of rural communities, while mini- and micro-hydropower does not represent similar negative effects. In fact, Thailand may possibly harvest great benefits from developing this technology. DEDP informs that existing mini- and micro-hydropower turbines are typically produced in China and that this technology is not yet well proven, a possible windows of opportunity for Thailand to take a leading role in developing this technology.

DEDP has current plans for implementing 100 MW (343 GWh/year) mini- and micro-hydro projects. Current production costs are relatively high, however lower than for solar cells. Nevertheless, a strong public support in the development of this technology would certainly stimulate technology development and lead to lower production costs, as has been the situation for wind turbines in Denmark (please refer to Chapter 5.[23]

Please refer to Annex A 2 for a summary of technical-economic data, which have been used in the analyses.

3.5 The Biomass, Energy Efficiency and Micro-Hydro Power Alternative

The proposed Alternative to the coal-fired power plant in Prachuap Khiri Khan has been carefully composed to consist of 1000 MW Industrial CHP based on biomass, 350 MW DSM, and 40 MW Micro-hydro power (Table 3.1).

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[21] The fact that the currently installed 39 MW of small-scale hydropower only produced 1.2 GWh in 1997 witness that existing systems have an very low capacity factor and that many of them probably do not work at all.
[22] "Sustainable Energy – Sustainable Society", Thai-Danish Cooperation on Sustainable Energy, May 1999.
[23] In the analysis, it is expected that the required investment costs and operation and maintenance costs for Micro-Hydro power will be halved by 2010.

Table 3.1: Composition of Alternative compared to the estimated technical potential.

	Alternative	Estimated Thai potential
Industrial CHP	1,000 MW	10,000 MW
- biomass resources	2,200 ktoe/year	20,000 ktoe/year
DSM	350 MW	2,200 MW
Micro Hydro power	40 MW	8,000 MW

The composition of the Alternative has been guided by the following principles:

- The Alternative is generally composed as to meet the official social and economic objectives for Thailand as discussed in Chapter 1, i.e. it should be cost-effective, reliable, stimulate employment, rely on indigenous resources etc. The micro-hydro power element of the Alternative is not likely to show up as financially feasible in the short-term; it is however included due to its positive impacts on technology development, employment a.o.

- Each element of the Alternative takes up only a minor part of the estimated technical potential for that element, which means that this type of Alternative is generally applicable to future coal-fired projects in Thailand.

- In the period from 2001 till 2010, the coal-fired power plant is expected to replace electricity produced on oil-fired steam turbines with an efficiency of 33%. Over the 10-year construction period, the Alternative is consequently supplemented by electricity produced by oil-fired steam turbines with an efficiency of 33%. All costs of the supplemental electricity production are included in the Alternative.

- The Alternative and the coal-fired power plant produces (or saves) identical amounts of electricity – both in total and year by year.

- While the coal-fired power plant will be constructed over a period of no more than 2 years, the Alternative takes advantage of the surplus capacity in power production expected to be available until 2010 distributing the construction over 10-year period from 2000 to 2010. This will also give industries time to develop and market even better biomass CHP and micro-hydro power technologies.

4. Comparative analyses

4.1 Methodology

In the analysis, the procurement and the operation and maintenance of the planned coal-fired power plant at Prachuap Khiri Khan (the Reference) is compared to the procurement and the operation and maintenance of the Alternative as described in Chapter 3.

The Reference and the Alternative are compared on their energy, environmental and economic characteristics over a period of 25 years. Economic costs are calculated in a cost-benefit analysis using factor prices, i.e. investment costs and O&M costs excluding VAT and other taxes.

The analysis compares the Reference and the Alternative by each of the criteria below:

- Final energy consumption
- Atmospheric emissions of CO_2, SO_2, and NO_X
- Economic costs
- Consequences for the balance of payment (share of import)
- Public finances
- Rural economy
- Employment

4.2 General conditions

Please refer to Annex A 1 and A 2 for details on conditions and assumption as well as specific technical-economic technology data used in the analyses; discount rate, exchange rate, emission factors, fuel prices, investment costs, lifetime a.o.

The following highlights or additional comments apply:

- The economic investment costs for the coal-fired power plant at Prachuap Khiri Khan is represented by the capacity payment that EGAT has agreed to pay Union Power as an IPP, in stead of implementing the power plant project themselves. However, for the employment calculation, the actual investment costs according to Union Power are used.

- A real discount rate of 7% has been chosen after careful consideration of market rates and time factors in public and private investment. A low discount rate will favor relatively capital intensive projects such as hydropower and industrial co-generation, for which the up-front costs are relatively high, compared to future costs. Conversely, a relatively high discount rate will favor relatively low capital cost projects such as combined-cycle gas turbines. EGAT uses a real discount rate of 10% in their analyses, which also falls into the generally accepted range for countries like Thailand.

- The longer period of implementation means that some CHP-plants will have a lifetime beyond the plan period analyzed. However, the scrap value has been set to zero for all system elements.

- Yearly production hours for the coal-fired power plant at Prachuap Khiri Khan are expected by Union Power to be just over 5,000 hours/year. In the analysis, a realistic figure of 6,000 hours/year has been used, which gives the coal-fired power plant considerable benefits in terms of increased electricity production. Industrial CHP-plants and DSM are characterized by similar production/consumption hours.

4.3 Energy and environmental consequences

Final energy consumption and atmospheric emissions of carbondioxide (CO2), sulpurdioxide (SO2), and nitrogenoxides (NOX) has been analyzed for the coal-fired power plant at Prachuap Khiri Khan and the Alternative.

Figure 3 shows the final energy consumption of Prachuap Khiri Khan over a period of 25 years. The final energy consumption in the form of bituminous coal is found to be 67.5 PJ/year [24], totaling 1,689 PJ over the period.

Figure 4 and Figure 5 shows the final energy consumption of the proposed Alternative. As the Alternative is introduced over a period of 10 years, the final energy consumption develops from 85.9 PJ/year in 2001 to 1.3 PJ/year from 2010 onwards in accordance with the increasing system efficiency. Final energy consumption totals 450 PJ over the period.

Figure 6 shows the atmospheric emissions of CO_2, SO_2 and NO_X for the coal-fired power plant at Prachuap Khiri Khan and the proposed Alternative. For the coal-fired power plant at Prachuap Khiri Khan, the emissions of SO_2 totals 625 thousand tons over the period or 25.0 thousand tons per year, while emissions of NO_X totals 321 thousand tons or 12.8 thousand tons per year. Emissions of CO_2 from Prachuap Khiri Khan totals 160 million tons over the period or 6.4 million tons per year.

The Alternative results in negative atmospheric emissions as coal and oil used in industrial boilers is substituted with biomass used in industrial co-generation plants.

The implementation of the Alternative rather than the coal-fired power plant at Prachuap Khiri Khan consequently:

- reduces final energy consumption by 73% over a period of 25 years
- reduces emissions of CO_2 by 262 million tons over a period of 25 years
- reduces emissions of SO_2 by 1,026 thousand tons over a period of 25 years
- reduces emissions of NO_X by 712 thousand tons over a period of 25 years

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[24] Except for years 2001 and year 2026 as 700 MW is ready for 2001 and another 700 MW only comes under full operation in 2002. The 700 MW installed in 2001 is taken out of operation by the end of 2025 after 25 years of service. The same situation Applies for the proposed alternative.

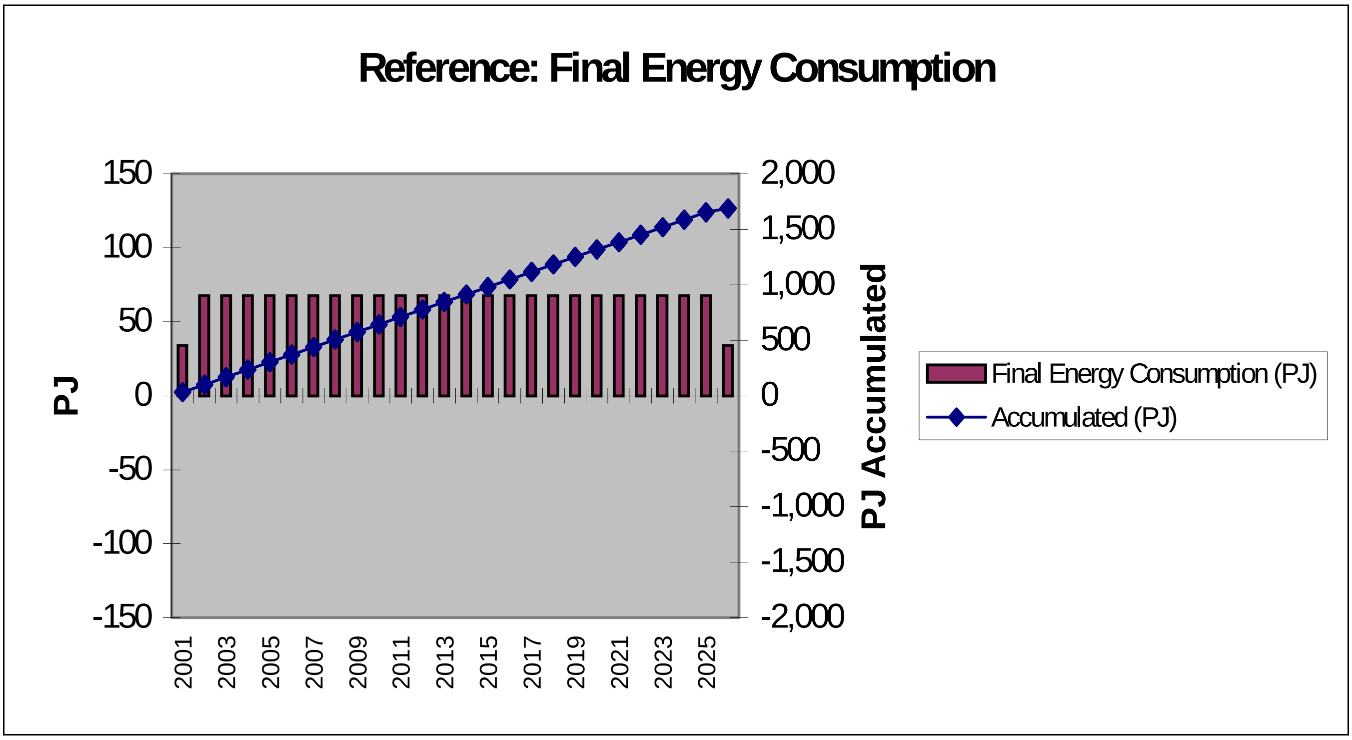

Figure 3: Final energy consumption for the coal-fired power plant at Prachuap Khiri Khan.

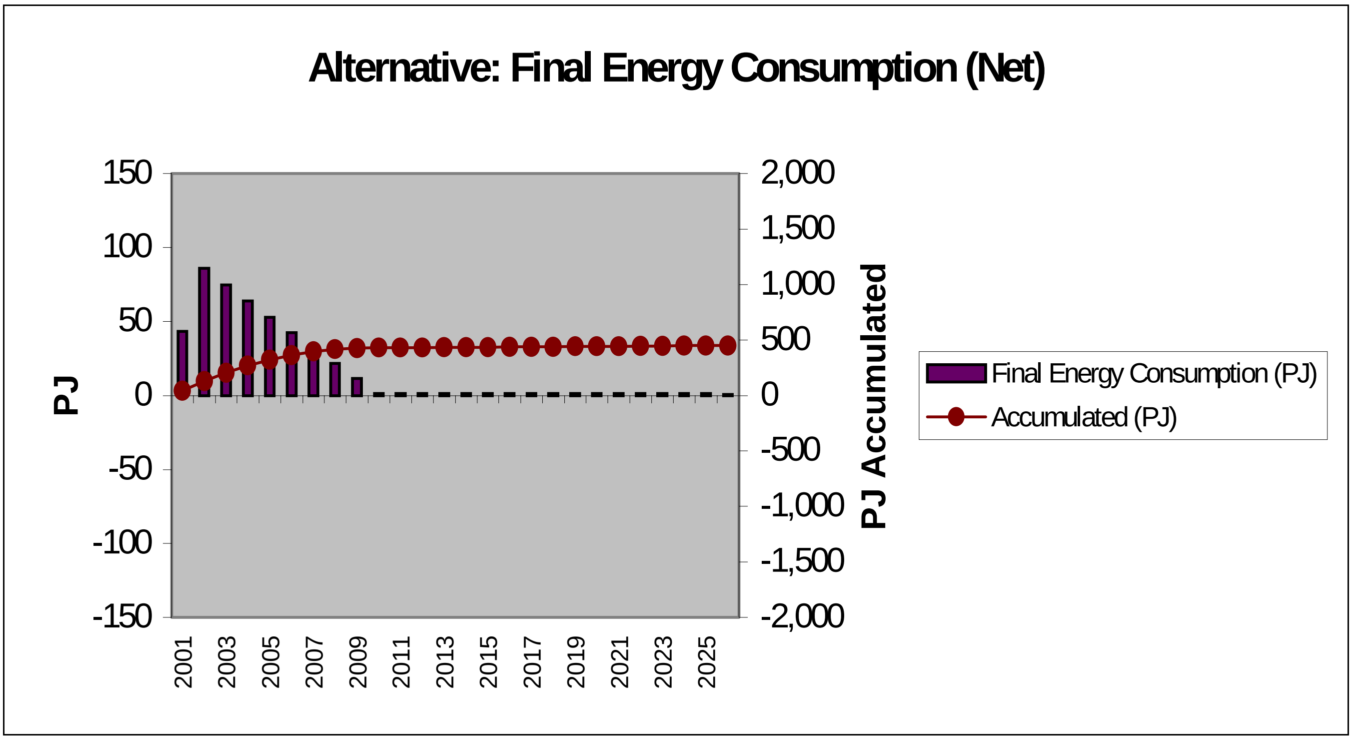

Figure 4: Final net energy consumption for the Alternative.

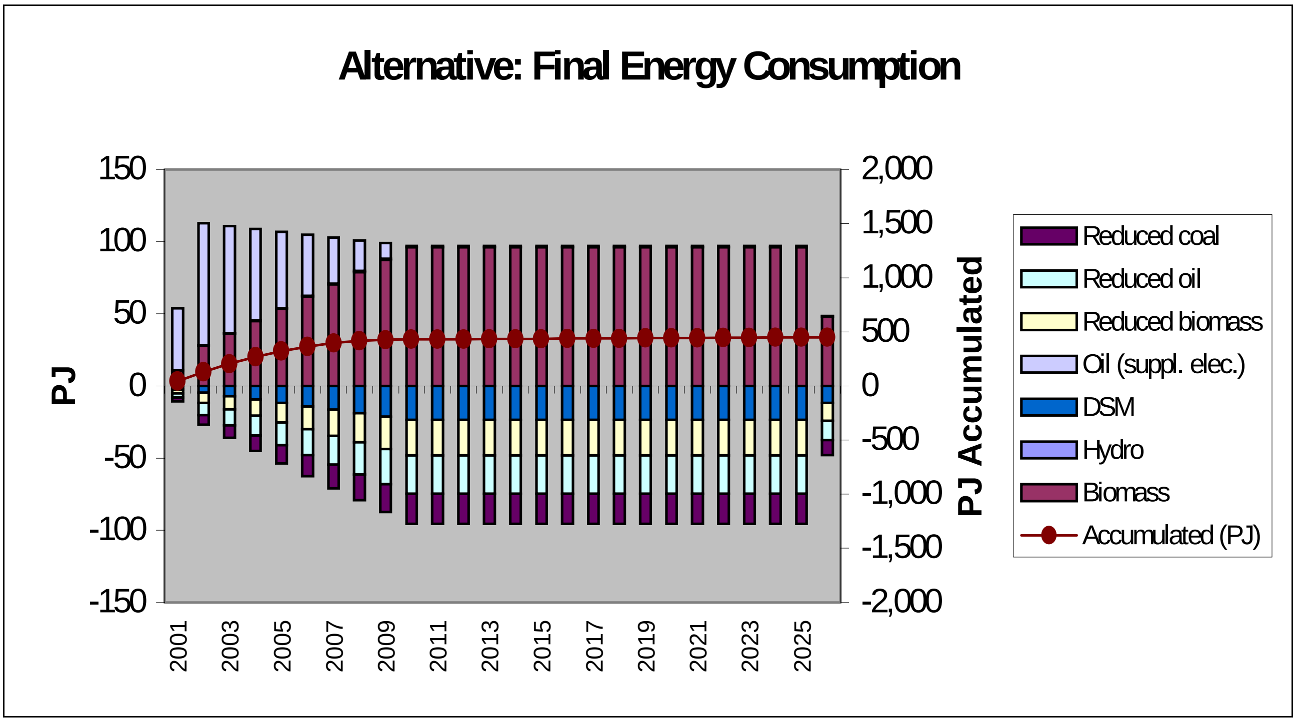

Figure 5: Final energy consumption for the Alternative.

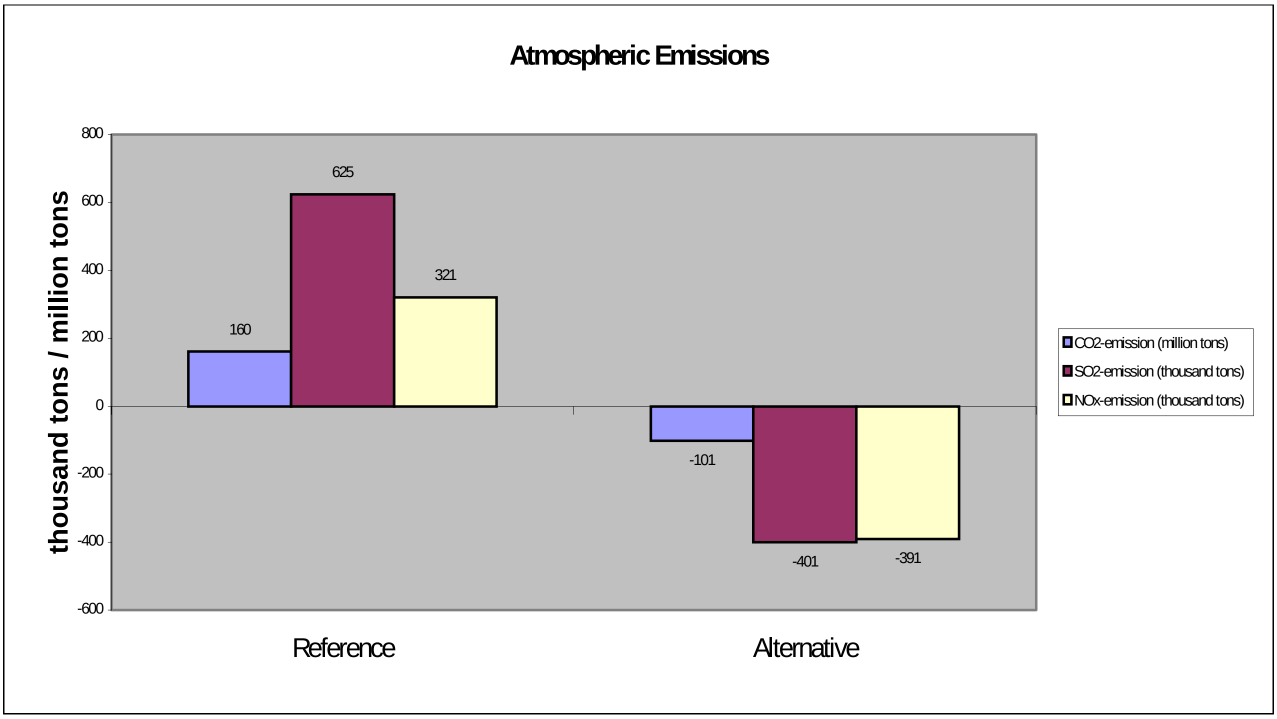

Figure 6: Comparison of total atmospheric emissions of CO_2, SO_2, and NO_X over a period of 25 years.

4.4 Economic production costs and consequences for the balance of payment

The net present value of economic costs and consequences for the balance of payment (economic cost of import) has been analyzed for the coal-fired power plant at Prachuap Khiri Khan and the Alternative.

Figure 7 shows that the net present value of economic costs is practically similar for the coal-fired power plant at Prachuap Khiri Khan and the Alternative, totaling THB 152-154 billion using a discount rate of 7% per year equivalent to 1.60-1.62 THB/kWh electricity produced.

The division between capital costs, O&M costs and fuel costs influences the contribution to e.g. employment and the rural economy. Figure 7 shows that while the production costs at the coal-fired power plant at Prachuap Khiri Khan is made up of 53% capital costs, 44% fuel costs and only 3% O&M costs, the Alternative is made up of 39% capital costs, 40% fuels costs and 21% O&M costs.

Figure 8 shows to which level economic production costs are spent on imported goods and services and thereby negatively influences Thailand's balance of payment. The coal-fired power plant at Prachuap Khiri Khan costs THB 117 billion in foreign currency, while the economic costs of import for the Alternative is THB 39 billion.

Figure 9 and Figure 10 shows the cash flow of economic costs in real 1999 prices for the coal-fired power plant at Prachuap Khiri Khan and the Alternative.

Furthermore, the analysis shows that the coal-fired power plant at Prachuap Khiri Khan contributes with THB 35 billion to Thailand's GDP, while the Alternative contributes with THB 115 billion.

The implementation of the Alternative rather than the coal-fired power plant at Prachuap Khiri Khan consequently:

- implies practically identical economic costs of 1.60-1.62 THB per kWh electricity produced over a period of 25 years,
- induces lower capital and fuel cost, but higher O&M costs, which indicates an advantageous contribution to employment and the rural economy,
- saves foreign currency worth THB 78 billion (USD 2.1 billion), thereby reducing the negative impact on Thailand's balance of payment by 67%,
- contributes to Thailand's GDP with an additional THB 80 billion.

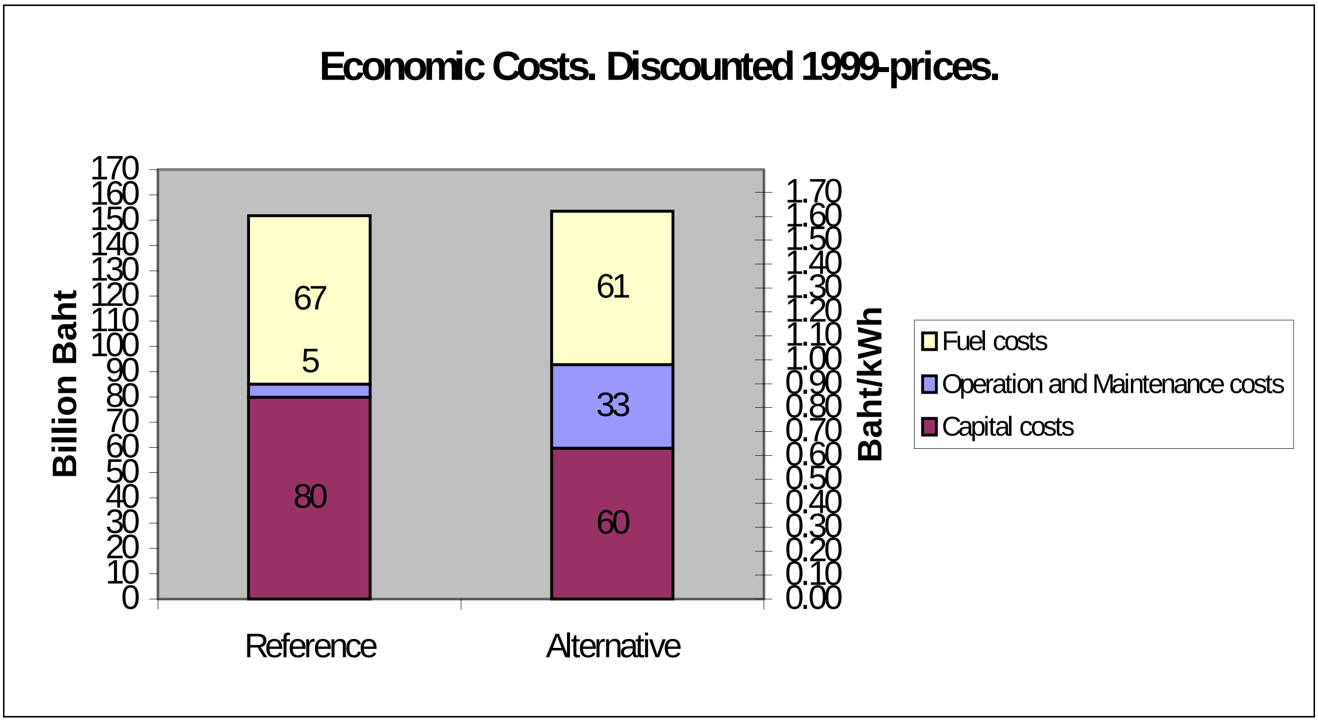

Figure 7: Comparison of economic production costs.

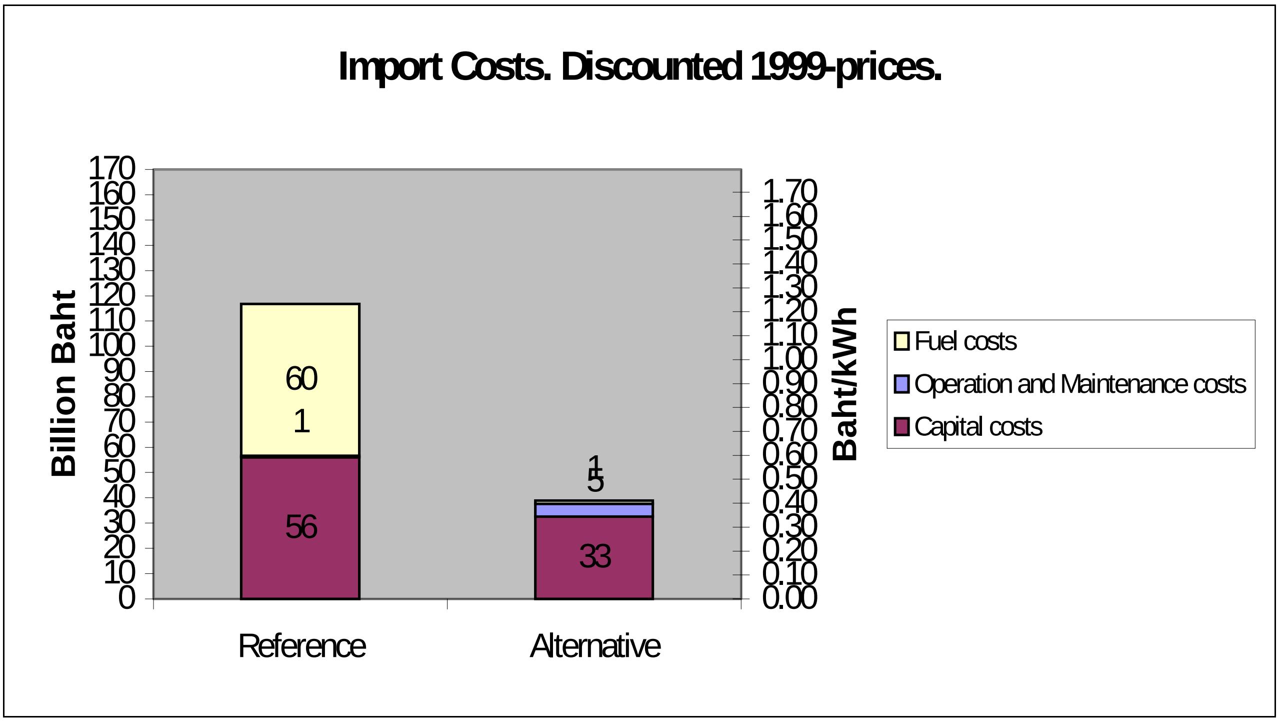

Figure 8: Comparison of economic production costs to be paid in foreign currency.

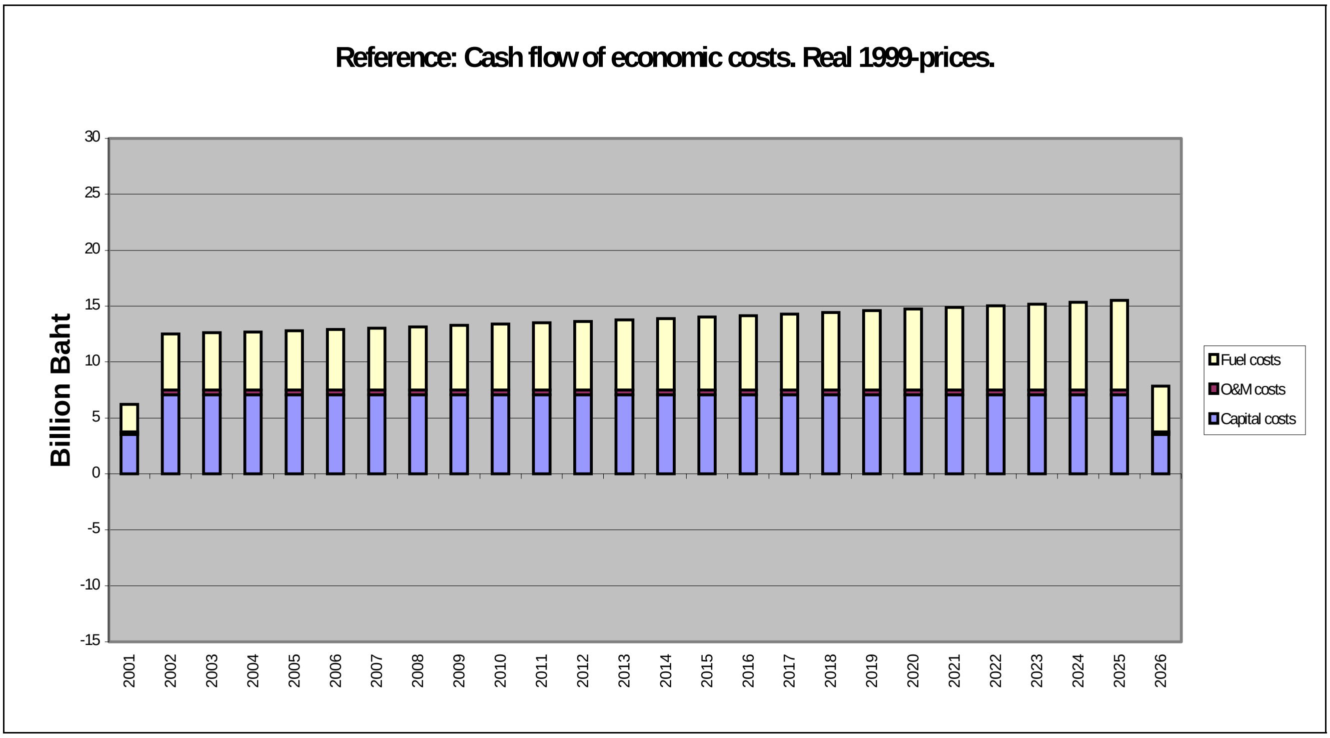

Figure 9: Cash flow of economic costs for the coal-fired power plant at Prachuap Khiri Khan.

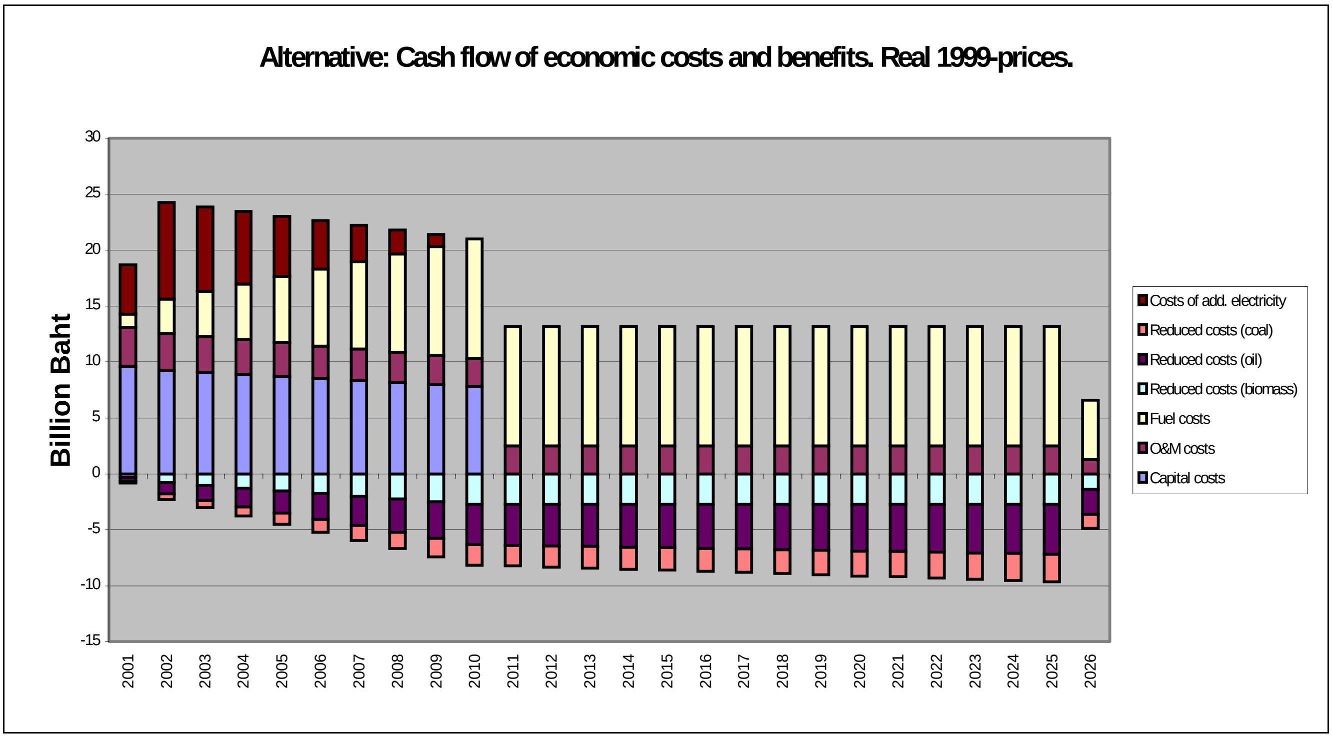

Figure 10: Cash flow of economic costs and benefits for the Alternative.

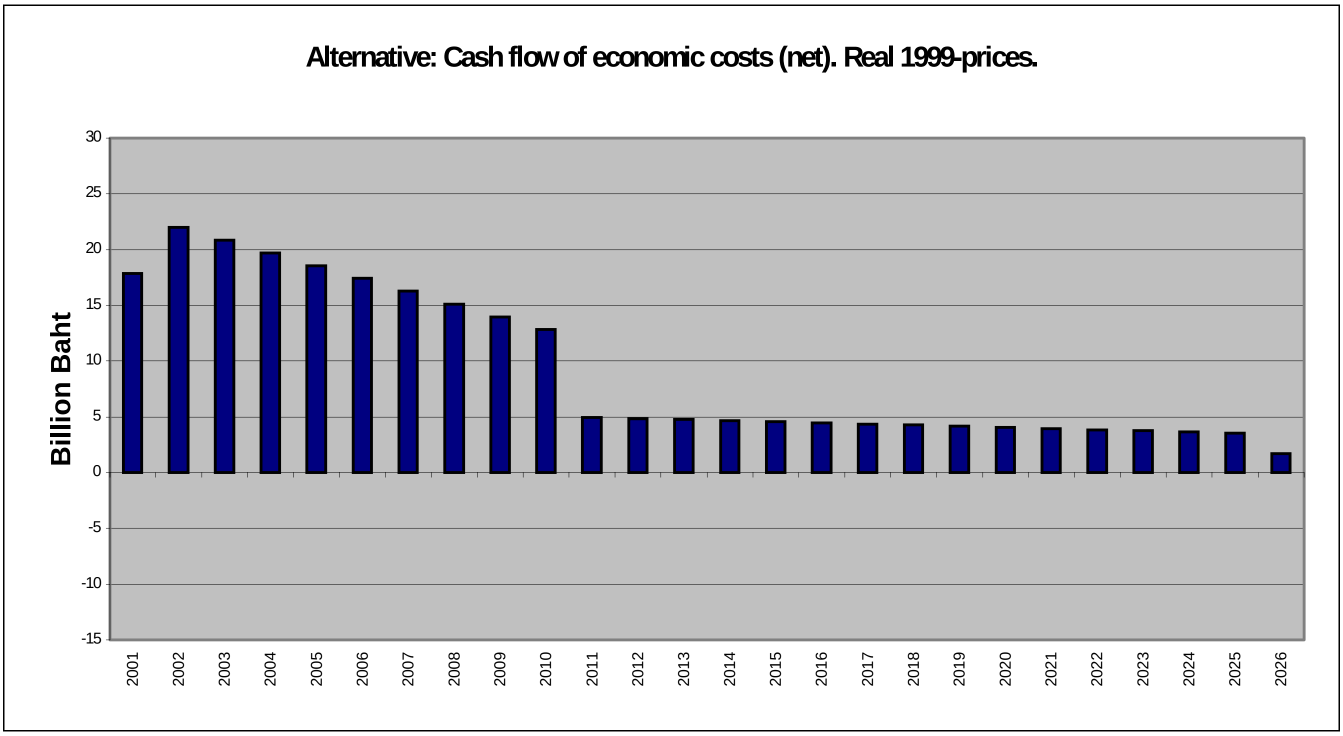

Figure 11: Cash flow of economic costs (net) for the Alternative.

4.5 Employment effects

The employment effects have been analyzed for the coal-fired power plant at Prachuap Khiri Khan and the Alternative.

Figure 12 shows that the coal-fired power plant at Prachuap Khiri Khan creates 0.2 million man-years over a period of 25 years, i.e. an average of 6,941 man-years per year.

Figure 13 shows that the Alternative creates 1.8 million man-years over a period of 25 years, i.e. an average of 70,857 man-years every year in the period.

The implementation of the Alternative rather than the coal-fired power plant at Prachuap Khiri Khan consequently:

- creates an additional 1.6 million man-years over a period of 25 years, i.e. when the coal-fired power plant at Prachuap Khiri Khan creates 1 man-year, the Alternative creates 10.2 man-years.

- creates an additional 63,917 man-years every year over the period.

4.6 Consequences for the rural economy

The consequences for the rural economy[25] have been analyzed for the coal-fired power plant at Prachuap Khiri Khan and the Alternative.

Figure 14 shows that the net present value of the economic activities which will be contributing to the rural economy created by a coal-fired power plant at Prachuap Khiri Khan totals THB 5 billion, while the Alternative contributes to the rural economy with THB 93 billion.

The implementation of the Alternative rather than the coal-fired power plant at Prachuap Khiri Khan consequently:

- contributes to the rural economy with an additional THB 88 billion, i.e. for every billion the coal-fired power plant at Prachuap Khiri Khan contributes to the rural economy, the Alternative contributes with THB 18.5 billion.

4.7 Consequences for public finances

The consequences for public finances[26] have been analyzed for the coal-fired power plant at Prachuap Khiri Khan and the Alternative.

Figure 15 shows that the net present value of the public revenue created by a coal-fired power plant at Prachuap Khiri Khan totals THB 7 billion, while the Alternative creates public revenue of THB 22 billion.

The implementation of the Alternative rather than the coal-fired power plant at Prachuap Khiri Khan consequently:

- contributes to the public revenue with an additional THB 15 billion, i.e. for every billion the coal-fired power plant at Prachuap Khiri Khan contributes to public revenue, the Alternative contributes with 3.3 billion.

[25] Economic activity which stems from biomass production and O&M activities.
[26] Primarily from personal income taxes.

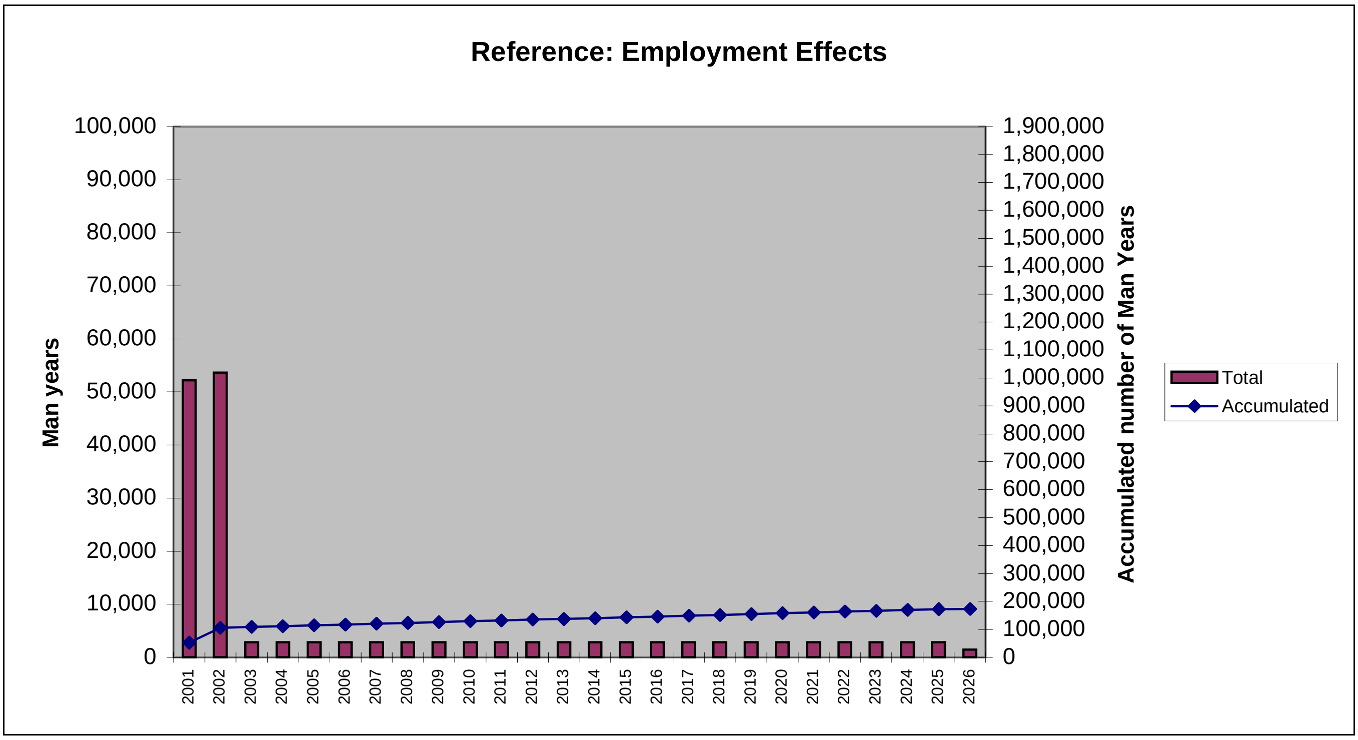

Figure 12: Employment effects in the coal-fired power plant at Prachuap Khiri Khan.

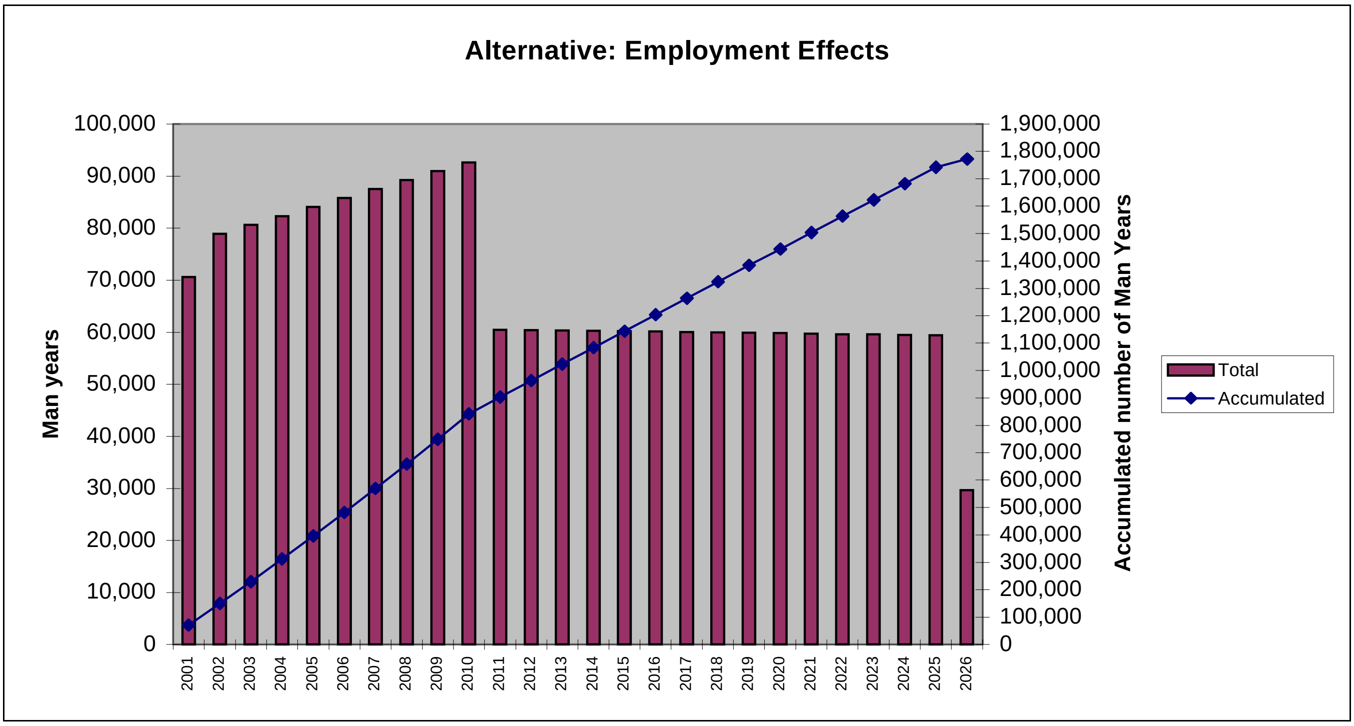

Figure 13: Employment effects in the Alternative.

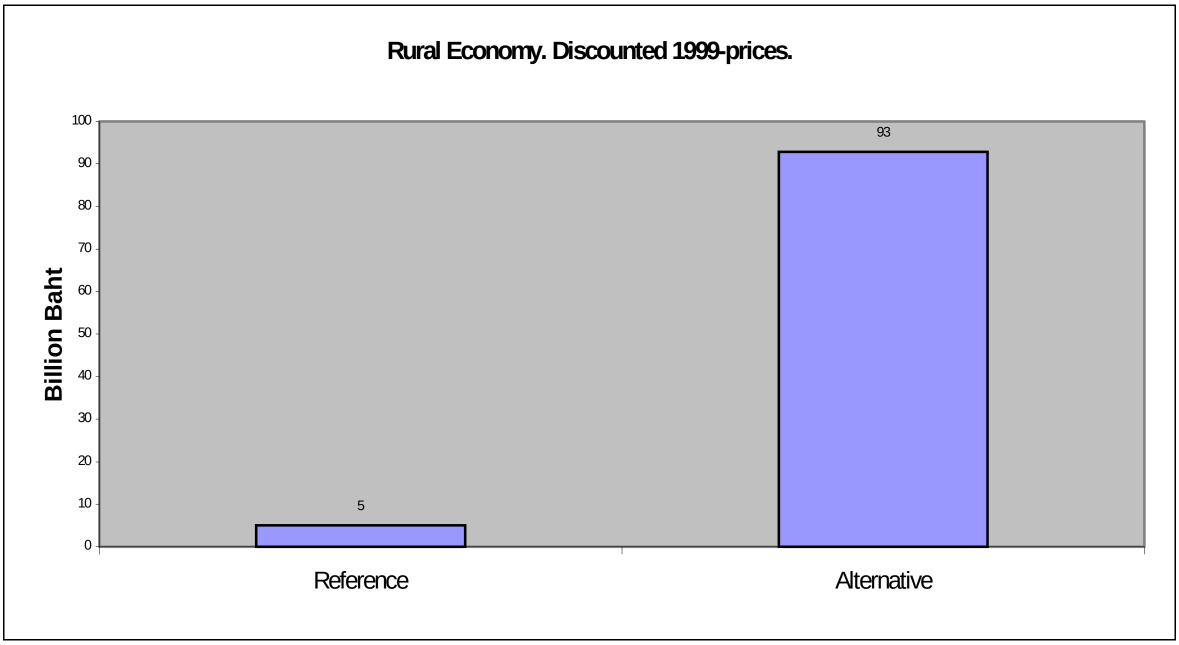

Figure 14: Comparison of economic costs associated with the rural economy.

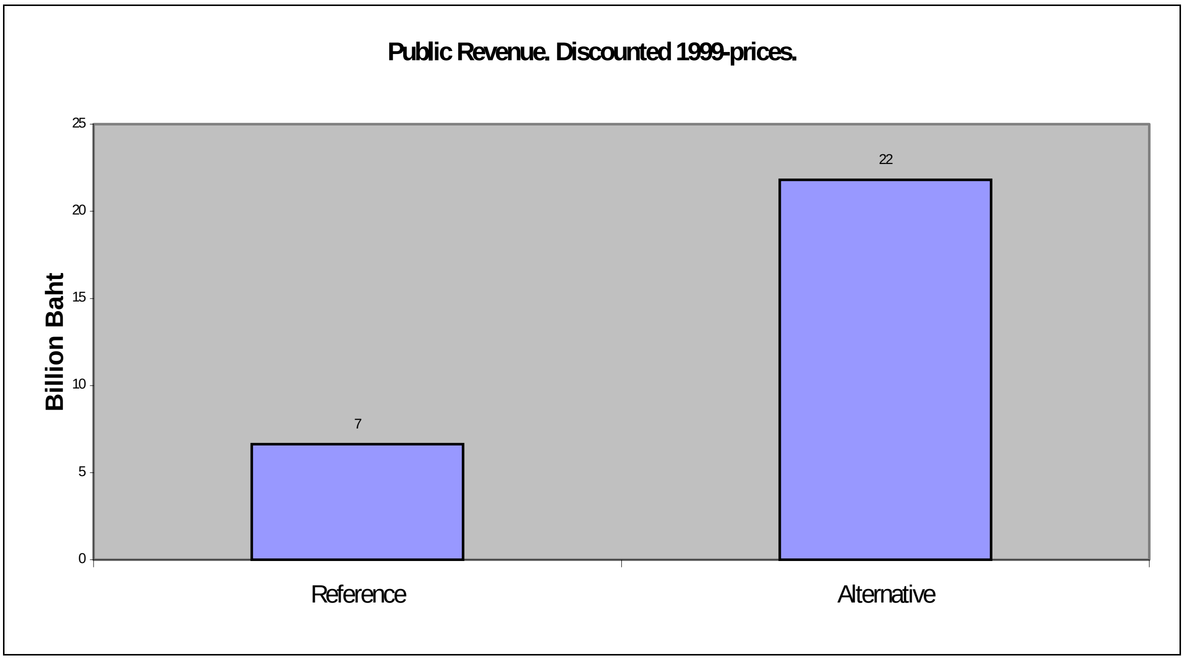

Figure 15: Comparison of contribution to public revenue.

5. Conclusion

As discussed in Chapter 1, the official social and economic policy of Thailand gives high priority to projects, which provide:

a) sufficient energy supply
b) reasonable energy prices
c) high energy efficiency
d) high cost efficiency
e) low import content
f) new products for export
g) more and better employment
h) positive effects on public budgets
i) rural development
j) decentralization of the planning and decision making process
k) technological innovation
l) a healthy environment

Two energy projects have been analyzed and compared with respect to these objectives; the planned coal-fired power plant at Prachuap Khiri Khan (Reference) and a “The Biomass, Energy Efficiency and Micro-Hydro Power Alternative” (Alternative).

5.1 What does the analyses show?

The analysis shows that the proposed Alternative in all aspects analyzed is either better or practically similar to the Reference. The Alternative is noticeably better in terms of economic import costs, contribution to Thailand’s GDP, creation of employment, contribution to public revenue, contribution to rural economy, contribution to technology development, and environment, whereas the Alternative is practically similar to the Reference in terms of economic costs of production.

The “Biomass, Energy Efficiency and Micro-Hydro Power Alternative” is consequently the better project for Thailand. While the planned coal-fired power plant at Prachuap Khiri Khan only complies with the objective of reasonable production costs, the Alternative meets a wide range of official economic and social objectives as formulated by Thailand’s government in the 8th 5-year development plan a.o.

The main economic results are summarized in Table 5.1.

Table 5.1: Summary of main economic results. Economic figures and employment figures discounted at 7% per year.

Main economic results	Reference	Alternative	Difference
Economic Costs (Billion Baht)	152	154	1.8
Economic Import Costs (Billion Baht)	117	39	-78
GDP contribution (Billion Baht)	35	115	80
Income revenue contribution (billion baht)	7	22	15
Rural economy contribution (billion baht)	5	93	88

Main employment results	Reference	Alternative	Difference
Employment (discounted million man years)	0.2	0.9	0.7
Employment (discounted man years/year)	7,009	34,984	27,975
Rural economy employment (discounted million man years)	0.04	0.71	0.67
Rural employment (discounted man years/year)	1,527	28,311	26,784

In more detail, the results from the comparative analysis tells us, that…:

- The Alternative and the Reference implies practically identical economic costs of 1.60-1.62 THB per kWh electricity produced over a period of 25 years.[27] However, the Reference is characterized by relatively lower economic production costs in the first 10 years, whereas the Alternative is found to have relative lower production costs later on. This indicates that the implementation of the Alternative may require subsidies to get started.

- The Alternative will save foreign currency worth THB 78 billion (USD 2.1 billion), thereby reducing the negative impact on Thailand's balance of payment by 67%. This is not surprising, as the Alternative substitute 25 years of coal import with the consumption of indigenous biomass.

- The Alternative will contribute with an additional THB 80 billion to Thailand's GDP.

- The Alternative will create an additional 27,975 man-years per year over a period of 25 years (discounted), mainly because biomass fuel is produced in Thailand, while coal is imported.

- The Alternative will contribute to public revenue with an additional THB 15 billion, due to public income from increased tax base combined with public savings due to lower social expenditures as unemployment is decreased.

With specific regard to the consequences for the rural areas in Thailand, the comparative analysis tells us, that…:

- The Alternative will contribute with an additional THB 88 billion to the rural economy, as biomass fuel is produced in rural areas, whereas coal, and the increase in value, is produced in other countries. The Alternative thereby contributes relatively more to solving the problem of income inequality in Thailand

- The Alternative will create an additional 26,784 man-years per year in rural areas over a period of 25 years (discounted), mainly because biomass fuel is produced in rural Thailand, while coal is imported.

With regard to the environmental consequences, the comparative analysis tells us, that…:

- The Alternative will reduce final energy consumption by 72% over a period of 25 years,

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[27] If there had been no environmental problems linked to CO2-emissions, and if there had been no specific problems for Thailand in terms of foreign debt, unemployment and rural economic development, one could say, that the two energy projects have similar economic production costs

- The Alternative will reduce emissions of CO_2 by 262 million tons, SO_2 by 1,026 thousand tons, and NO_X by 712 thousand tons over a period of 25 years,

The analysis does generally not deal with issues of grid-connection, dispatching of plants, and more. However, experiences from Denmark leave little doubt, that these purely technical issues are solved without difficulty. Furthermore, the decentralization of energy production involves important technical-economic benefits also not dealt with in this comparative analysis; e.g. reduced transmission and distribution losses in the electricity grid.

Neither does the analysis more specifically deal with the fact, that Thailand's power supply capacity is much higher than the electricity demand. At present, according to EGAT, there is no need for additional production capacity at all.[28] Even without the coal-fired power plant at Prachuap Khiri Khan or the Alternative, the reserve margin will be still higher than 25%, which is EGAT's minimum standard.[29] In fact, the reserve margin (including the coal-fired power plant at Prachuap Khiri Khan) is expected to be between 43% and 52% until 2005, even under moderate economic recovery.

As a final point, the Alternative's important contribution to local and national technology development shall again be emphasized: The Alternative is likely to trigger and stimulate the development of Thailand's suffering biomass and energy technology industry and agriculture. This is the case for both micro-hydro power technology and industrial CHP technology. As the Reference is mainly based on imported technology, the spin-off to industrial and technological innovation processes will be insignificant.

On the other hand, the Alternative requires technology development in Thailand, which will result in the strengthening of knowledge, technical and organizational expertise required to organize decentralized power production and the production and distribution of biomass. If successfully implemented, this will initiate an innovation process, which will result in Thailand acquiring the true ownership to the technologies (technically, organizationally and in terms of knowledge) and thereby introducing prospectives for Thailand to become a technology leader and world market exporter.

This is a hardly quantifiable but very real benefit, which in fact is a very strong argument for promoting the Alternative. In comparison, the Danish wind power industry has undergone such development over a period of less than 20 years. In 1997, the turnover in the Danish wind power industry amounted to more than THB 25 billion of which 2/3 was export. At the same time, the industry employed 12,000 persons full-time. Thailand's energy sector may possibly face a similar window of opportunity these years with respect to industrial co-generation based on biomass and small-scale hydropower.

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[28] EGAT's PDP 99-01 revised.

[29] Actually, in "Review of Electric Power Tariffs", February 1999, PricewaterhouseCoopers, EGAT is criticized for targeting 25% as a minimum reserve margin, which is considered too high.

5.2 How should Thailand react to these conclusions?

5.2.1 EGAT should not hesitate to cancel the contract with Union Power!

EGAT should cancel the contract with Union Power on the coal-fired power plant at Prachuap Khiri Khan. This can apparently be done without going to court, if EGAT agrees to pay a compensation of USD 67 million.[30]. This corresponds to 3% of the net present value of the costs of USD 2.2 billion (THB 80 billion) that EGAT is contractually obligated to hold whether or not EGAT will take the electricity produced.

5.2.2 EGAT should be obliged to buy electricity from biomass based power plants at a price reflecting the long-term marginal costs of EGAT

EGAT should be obliged to buy electricity from biomass based power plants at a price reflecting the long-term marginal costs of EGAT. Based on the successful experiences from implementing wind power in Germany, Spain and Denmark, as well as the implementation of decentralized cogeneration in Denmark, it is very important to establish transparent, un-bureaucratic and stable price conditions, when new techniques are introduced and implemented. Especially when such new technologies are to be introduced by dispersed and financially weak investors.

Already, EGAT has offered Union Power very favorably settling prices for electricity, which leads to the conclusion that EGAT and the Thai government should provide the conditions listed below for small-scale power producers:

1. EGAT is willing to pay 422 Baht per installed kW/month from coal-based SPPs and a similar payment is suggested to apply for the small-scale producers in question (industrial CHP and small-scale hydro power).

2. As decentralized producers typically delivers electricity close to the consumers, less investments are required in the transmission grid and transmission losses are reduced. As this should benefit the decentralized producers, in compensation, EGAT shall pay all costs required to connect the decentralized power producer to the nearest transformer station. In a few cases, to be clearly specified, EGAT shall be allowed to refuse the connection of a decentralized producer if connection costs are too high.

3. EGAT's energy payment, i.e. the kWh-price, should follow the rules of the contract between EGAT and Union Power; i.e. the energy payment shall be linked to the world market coal price.

4. Biomass power producers shall be obliged to pay biomass producers the equivalent of the price of coal linked to the world market coal price, i.e. the price for biomass should currently be set to 67.9 Baht/GJ.

5. As the Alternative contributes with THB 22 Billion in public revenue, the Thai government shall introduce a subsidy scheme providing biomass producers an

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[30] Manager weekly newspaper, 3-9 May 1999

additional maximum of THB 30 per GJ, adjusted yearly if the world market price of coal increases.

6. All conditions shall be fixed by law for a period of at least 10 years in order to give producers, organizations, and farmers security for their investments.

To stimulate the implementation of the “Biomass, Energy Efficiency and Micro-Hydro Power Alternative” and as the Alternative contributes with THB 22 Billion in public revenue, the introduction of additional regulative measures are recommended:

1. The Thai government shall provide THB 5 billion to R&D and manufacturing of biomass-based industrial co-generation technologies.

2. The Thai government shall provide THB 1 billion to R&D and manufacturing of small-scale hydropower.

3. EGAT shall introduce a subsidy scheme, which will provide electricity consumers in industry and service a price payment for implementing DSM equal to EGAT’s avoided long-term marginal costs for saved capacity and energy.

4. The Thai government shall require for all energy projects planned by energy utilities to be assessed in terms of consequences on the balance of payment, employment, rural economy etc.

The economic situation and the objectives for the country’s development call for Thailand to break with the ruling technological paradigm. It is too expensive, it is not environmentally friendly and it does probably not fulfil important official social and economic objectives. In fact, a closely regulated and monitored energy sector development may be used as an instrument for developing Thailand into a modern and sustainable society with a build-in capacity to adjust to a world in change.

A 1. Technical-economic assumptions and notes

Figure 16 holds the key technical-economic data and assumptions used in the analyses. The following notes apply:

1) In general, data on the coal-fired power plant at Prachuap Khiri Khan have been derived directly from EGAT's and Union Power's own documents and analyses.

2) EGAT's fuel costs and real escalation rates are according to EGAT's own data (PriceWaterhouseCoopers, 1999).

3) Emission factors for SO_2 and NO_X are based on information from the Environmental Impact Assessment report from June 1999 (Ref. 14) in which SO_2 emissions are estimated to be 1.1 kg/s and NO_X emissions 0.6 kg/s.

4) It is assumed that there is unemployment in Thailand, and that people employed in a project would alternatively be unemployed. So any extra employment in energy projects will decrease the unemployment by the same amount of people. In 1998 there were at least 1.8 million unemployed persons in Thailand.

5) The economic investment costs for the coal-fired power plant at Prachuap Khiri Khan is represented by the capacity payment that EGAT has agreed to pay Union Power as an IPP, in stead of implementing the power plant project themselves. However, for the employment calculation, the actual investment costs according to Union Power are used.

6) Average salary calculated as average salary in the construction phase according to information obtained from Union Power, 1999. An average composition of the workforce has been assumed. 58% of the salaries are paid to 89% of the workforce, which is supposed to have a salary of 60,000 Baht/year. The average salary is used, when the employment effects are calculated.

7) Contribution to public revenue from the creation of employment is assumed to be 19%[31], without taking into consideration that the coal-fired power plant at Prachuap Khiri Khan may have more favorable tax conditions than the Alternative. The consideration below apply:

   a) Average personal income tax calculated to be 2.25%

   b) Value added tax (VAT) is at present 7%. Though this is rather low for a period of 25 years and while income is only increasing "social welfare" payments of 10,000 Baht to a salary of 60,000 Baht, it is assumed that consumer tax will be 7% of the total sum of salaries.

   c) Social welfare payments to unemployed is assumed to be 10,000 Baht/year per person, i.e. 9.75% of the total sum of salaries will be reductions in the social welfare payments.

[31] For comparison, in 1998, total governmental income was 15% of GDP.

Key assumptions

General and specific assumptions used in the analyses

General	*Unit*	*Value*
Discount rate	%	7
Average salary	Baht/year	91,800
Salary share of GDP	%	70%
Revenue factor	%	19%
Exchange rate	THB/USD	37.00

Emission factors	*Unit*	*PKK*	*Coal*	*Biomass*	*Oil*
CO2	kg/GJ	95	95	-	74
SO2	kg/GJ	0.370	0.400	0.130	0.141
Nox	kg/GJ	0.190	0.400	0.200	0.075

Efficiencies	*Unit*	*2001*
Central electricity production	%	33%

Industrial boilers	*Unit*	*Biomass*	*Oil*	*Coal*	*Sum*
Fuel shares in existing industrial boilers	%	34%	37%	29%	100%

Fuel prices	*Unit*	*Price*	*Esc. (%)*	*Import (%)*
Coal	Bath/MWh	254	2.08	90
Biomass	Bath/MWh	400	0	20
Oil	Bath/MWh	424	1.42	90

Reference (Coal-fired power plant)	*Unit*	*2001*	*2010*	*Import (%)*
Total capacity	MW	1,400		
Specific construction costs	Mill. Bath/MW	31.71		70
Operation and Maintenance	Mill. Bath/MW/year	0.32		15
Yearly production hours	hours/year	6,000		
Electric output efficiency	%	44.77		
Use construction costs as econ. inv.	TRUE/FALSE	FALSE		
Investment/Capacity payment	Baht/kW/year	5,064		

Alternative - Micro-Hydro	*Unit*	*2001*	*2010*	*Import (%)*
Total capacity	MW	40		
Specific construction costs	Mill. Bath/MW	900	450	34
Operation and Maintenance	Mill. Bath/MW/year	50	25	15
Yearly production hours	hours/year	6,000		
Electricity production	GWh/year	240		

Alternative - DSM	*Unit*	*2001*	*2010*	*Import (%)*
Saved capacity	MW	360		
Specific construction costs	Mill. Bath/MW	28	28	70
Yearly production hours	hours/year	6,000		
Electricity savings	GWh/year	2,160		

Alternative - Industrial CHP	*Unit*	*2001*	*2010*	*Import (%)*
Total capacity	MW	1,000		
Specific construction costs	Mill. Bath/MW	50	50	50
Operation and Maintenance	Mill. Bath/MW/year	1.5	1.5	15
Yearly production hours	hours/year	6,000		
CHP electric output	%	20	25	
CHP thermal output	%	60		
Boilers thermal output	%	80		
Electricity production	GWh/year	6,000		

Figure 16: Overview of key technical-economic assumptions.

A 2. Technology data sheets

The technology data sheets below hold details about the technical-economic background of the technologies involved in the analyses:

1. 1,400 MW coal-fired power plant at Prachuap Khiri Khan

2. 2.5 MW co-generation plant based on rice-husk

3. Micro-Hydro Power (grid connected)

4. Average Demand-Side-Management (DSM) - Service and Industry sectors

These technologies are considered to be representative as typical (or average) solutions in terms of technical-economic characteristics. For example, not all biomass-based industrial co-generation in the Alternative will be in the form of 2.5 MW co-generation plant based on rice-husk, however in general, the technical-economic characteristics of this particular technique is assumed to apply.

ELECTRICITY PRODUCTION TECHNOLOGY CASE: 1,400 MW coal-fired power plant at Prachuap Khiri Khan

ENERGY/TECHNOLOGY	Unit	Value
Fuel	-	Bituminous coal
Installed capacity (net)	MW	1,400
Yearly production hours (net)	hours/year	6,000
Thermal efficiency (net)	%	44.77
Life time	Years	25

INVESTMENT/O&M	Unit	Value
Construction costs	Million USD	1,200
EGAT Capacity payment	THB/kW/month	422
Operation and maintenance costs	Mill. USD/year	12
Import share of Construction costs	%	70%
Import share of O&M costs	%	15%

SUBSIDY – IF ANY	Unit	Value
Subsidy on Construction costs	THB	-

ELECTRICITY PRODUCTION TECHNOLOGY CASE: 2.5 MW co-generation plant based on rice-husk

ENERGY/TECHNOLOGY	Unit	1999	2010
Fuel	-	Rice-husk	-
Installed capacity (net)	MW	2.5	-
Production hours (net)	hours/year	6,000	-
Thermal efficiency (net)	%	20	25
Overall efficiency (net)	%	80	-
Life time	Years	25	-

INVESTMENT/O&M	Unit	Value
Construction costs	Mill. THB	125
Operation and maintenance costs	Mill. THB/year	3.75
Import share of Construction costs	%	50%
Import share of O&M costs	%	15%

SUBSIDY – IF ANY	Unit	Value
Subsidy on Construction costs	THB	-

ELECTRICITY PRODUCTION TECHNOLOGY CASE: Micro-Hydro Power (grid connected)

ENERGY/TECHNOLOGY	Unit	Value
Fuel	-	Hydro
Installed capacity (net)	W	50
Production hours (net)	hours/year	7,500
Life time	Years	25

INVESTMENT/O&M	Unit	2001	2010
Construction costs	THB	45,000	22,500
Operation and maintenance costs	THB/year	2,500	1,250
Import share of Construction costs	%	34%	
Import share of O&M costs	%	15%	

SUBSIDY – IF ANY	Unit	Value
Subsidy on Construction costs	THB	-

References:

Lil'Otto Hydro Electric Turbine, 1999: Technical-economic data taken from an example for a stand-alone system removing the components related to the battery storage. The system has been chosen for the availability of exact data and because of it's high cost. Using this system to represent typical technical-economic conditions, we have chosen a very conservative estimation of costs, which should apply for any small-scale hydro-power system from 50 W and up into the lower MW-range. The particular technique believed not to be appropriate for grid-connected power generation.

ENERGY CONSERVATION CASE: Average Demand-Side-Management (DSM) – Service and Industry sectors

ENERGY/TECHNOLOGY	Unit	Value
Peak capacity saved	MW	1
Average hours of peak demand	hours/year	6,000
Life time	Years	25

INVESTMENT/O&M	Unit	Value
Installation costs	Mill. THB	28.0
Operation and maintenance costs	THB/year	0
Import share of Installation costs	%	70%

SUBSIDY – IF ANY	Unit	Value
Subsidy on Installation costs	THB	-

References

1. DSM for Thailand's Electric Power System – Five-Year Master Plan, IIEC, 1991.
Thailand: Promotion of electricity energy efficiency, IIEC, 1993

A 3. Potential industrial CHP capacity and fuel savings

Conversion factors	**Value**	**Unit**
Conversion (toe -> J)	42.62	TJ/ktoe
Conversion (J -> Wh)	277.78	MWh/TJ
Conversion (toe -> Wh)	84.46	ktoe/TWh

Industrial fuel consumption in 1997	**Value**	**Unit**
Coal/lignite	3,970	ktoe
Natural gas	5,161	ktoe
Petroleum products	4,654	ktoe
Total fuel consumption	13,785	ktoe

Technical characteristics	**Value**	**Unit**
Existing boiler efficiency	80%	
CHP heat efficiency	60%	
CHP el efficiency	22.5%	
CHP Annual production hours	5,000	hours
Central electricity efficiency	33%	

Calculation of capacity potential	**Value**	**Unit**
Total heat demand in 1997	11,028	ktoe
CHP fuel consumption	18,380	ktoe
CHP electricity production	4,136	ktoe
CHP electrical power capacity	9,792	MW

Calculation of fuel savings	**Value**	**Unit**
CHP electricity production	4,136	ktoe
Fuel consumption in central electricity production	12,532	ktoe
Existing fuel consumption (heat + electricity)	26,317	ktoe
CHP fuel consumption	18,380	ktoe
Fuel savings	7,937	ktoe

A 4. Main results

Main results

Economic figures discounted at 7% per year

Economic Costs (Billion Baht)	Reference	Alternative	Difference
Capital costs	80	60	-20
Operation and Maintenance costs	5	33	28
Fuel costs	67	61	-6
Economic Costs (Billion Baht)	152	154	1.8

Economic Costs (Baht/kWh)	Reference	Alternative	Difference
Capital costs	0.84	0.63	-0.21
Operation and Maintenance costs	0.05	0.35	0.30
Fuel costs	0.71	0.64	-0.06
Economic Costs (Baht/kWh)	1.60	1.62	0.02

Economic Import Costs (Billion Baht)	Reference	Alternative	Difference
Capital costs	56	33	-23
Operation and Maintenance costs	1	5	4
Fuel costs	60	1	-59
Economic Import Costs (Billion Baht)	117	39	-78

Economic Import Costs (Baht/kWh)	Reference	Alternative	Difference
Capital costs	0.59	0.34	-0.25
Operation and Maintenance costs	0.01	0.05	0.04
Fuel costs	0.64	0.01	-0.62
Economic Import Costs (Baht/kWh)	1.23	0.41	-0.82

GDP contribution (Billion Baht)	Reference	Alternative	Difference
Capital costs	24	27	3
Operation and Maintenance costs	4	28	24
Fuel costs	7	60	53
GDP contribution (Billion Baht)	35	115	80

GDP (Baht/kWh)	Reference	Alternative	Difference
Capital costs	0.25	0.29	0.03
Operation and Maintenance costs	0.04	0.30	0.25
Fuel costs	0.07	0.63	0.56
GDP (Baht/kWh)	0.37	1.21	0.84

Other	Reference	Alternative	Difference
Employment (absolute million man years)	0.5	1.8	1.3
Employment (discounted million man years)	0.3	0.9	0.6
Income revenue contribution (billion baht)	7	22	15
Rural economy contribution (billion baht)	5	93	88
Rural economy employment (discounted million man years)	0.04	0.71	0.67
Total electricity production (TWh)	210	210	0
Final Energy Consumption (PJ)	1,689	450	-1,239
CO_2-emission (million tons)	160	-101	-262
SO_2-emission (thousand tons)	625	-401	-1,026
NO_x-emission (thousand tons)	321	-391	-712

Figure 17: Main results using EGAT's capacity payment as economic investment cost.

Main results

Economic figures discounted at 7% per year

Economic Costs (Billion Baht)	Reference	Alternative	Difference
Capital costs	40	60	20
Operation and Maintenance costs	5	33	28
Fuel costs	67	61	-6
Economic Costs (Billion Baht)	112	154	41.6

Economic Costs (Baht/kWh)	Reference	Alternative	Difference
Capital costs	0.42	0.63	0.21
Operation and Maintenance costs	0.05	0.35	0.30
Fuel costs	0.71	0.64	-0.06
Economic Costs (Baht/kWh)	1.18	1.62	0.44

Economic Import Costs (Billion Baht)	Reference	Alternative	Difference
Capital costs	28	33	5
Operation and Maintenance costs	1	5	4
Fuel costs	60	1	-59
Economic Import Costs (Billion Baht)	89	39	-50

Economic Import Costs (Baht/kWh)	Reference	Alternative	Difference
Capital costs	0.30	0.34	0.05
Operation and Maintenance costs	0.01	0.05	0.04
Fuel costs	0.64	0.01	-0.62
Economic Import Costs (Baht/kWh)	0.94	0.41	-0.53

GDP contribution (Billion Baht)	Reference	Alternative	Difference
Capital costs	12	27	15
Operation and Maintenance costs	4	28	24
Fuel costs	7	60	53
GDP contribution (Billion Baht)	23	115	92

GDP (Baht/kWh)	Reference	Alternative	Difference
Capital costs	0.13	0.29	0.16
Operation and Maintenance costs	0.04	0.30	0.25
Fuel costs	0.07	0.63	0.56
GDP (Baht/kWh)	0.24	1.21	0.97

Other	Reference	Alternative	Difference
Employment (absolute million man years)	0.2	1.8	1.6
Employment (discounted million man years)	0.2	0.9	0.7
Income revenue contribution (billion baht)	4	22	17
Rural economy contribution (billion baht)	5	93	88
Rural economy employment (discounted million man years)	0.04	0.71	0.67
Total electricity production (TWh)	210	210	0
Final Energy Consumption (PJ)	1,689	450	-1,239
CO2-emission (million tons)	160	-101	-262
SO2-emission (thousand tons)	625	-401	-1,026
NOx-emission (thousand tons)	321	-391	-712

Figure 18: Main results using Union Power's construction costs as economic investment cost.

A 5. Information from Union Power

บริษัท ยูเนี่ยนเพาเวอร์ดีเวลลอปเมนท์ จำกัด

UNION POWER DEVELOPMENT CO.,LTD.

1828 Sukhumvit Road, Phrakanong Bangkok Thailand Tel. (662) 311-5111 Fax : (662) 332-3882

8 มิถุนายน 2542

เรียน: คุณศุภกิจ นันทะวรการ (ห้องสัมมนาเมียนมาร์)

เรื่อง: ข้อมูลโรงไฟฟ้า "หินกรูด" บ้านโคกตาหอม

Tel/Fax. 561 5037, 561 4880, (01) 942 4319

1. <u>คำถาม</u> Energy Efficiency ของโรงไฟฟ้า (หรือ ผลิตไฟฟ้า kWh ใช้ถ่านหินเท่าไร)

   <u>คำตอบ</u>

Thermal Efficiency	44.77%
Heat Rate	8,042 kJ/kWh
Coal Calorific Value	6,300 kcal/kg หรือ 26,377 kJ/kg

ดังนั้น ถ้าผลิตไฟฟ้า 1 kWh จะใช้ถ่านหิน 0.30 kg.

2. <u>คำถาม</u> Construction cost ของโรงไฟฟ้า

   <u>คำตอบ</u> EPC (Engineering, Procurement and Construction) = US$ 900 million ห5

   1200

3. <u>คำถาม</u> Operation and Maintenance Cost ของโรงไฟฟ้า

   <u>คำตอบ</u> O&M Cost = US$ 12 million/year

4. <u>คำถาม</u> Fuel Cost or Coal Cost (ราคาถ่านหิน และ ปริมาณการใช้ต่อปี)

   <u>คำตอบ</u> ~ Coal Cost อิงกับ Japanese Bench Mark ซึ่งในปี 1996 จะ = US$ 40.00/ton

   ~ Coal Consumption = 3.85 million tons/year

5. <u>คำถาม</u> ปริมาณการผลิตไฟฟ้าต่อปี

   <u>คำตอบ</u> ใช้ Available factor 83% และ Load factor 70% จะผลิตไฟฟ้าได้ = 7.125 GWh/year หรือ 7,125 million kWh/year

ขอแสดงความนับถือ

นายธัญญา ศีลธร

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