ECONOMY AND ENVIRONMENT PROGRAM FOR SOUTHEAST ASIA

Surrogate Pricing for Water: The Case of Micro Hydro-Electricity Cooperatives in Northern Thailand

Sitanon Jesdapipat and Siriporn Kiratikarnkul

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Sitanon Jesdapipat and Siriporn Kiratikarnkul*

December 1998

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FOREWORD

With the increasing pressure on Thailand's natural resources, the Thailand Environment Institute (TEI) is looking into the optimal allocation and conservation of a wide variety of natural resources for their sustainable use. TEI's multi-disciplinary structure addresses a diversity of environmental challenges that range from issues at the grassroots level to effective macro policy formulation. This enables TEI to look at cross-sectoral issues from a holistic perspective. The micro-hydro project reported here exemplifies such an endeavor.

The project was funded by the Economy and Environment Program for Southeast Asia (EEPSEA) to enable TEI's Natural Resources Management Program (NRM) to work with local researchers in Chiangmai, local government officials, local technical experts, and local stakeholders to assist micro-hydro project managers in deciding on the pricing scheme for electricity produced by hydro power projects. This research effort systematically evaluated options for energy production and use based on sound economic and ecological principles. On behalf of TEI, I wish to thank David Glover, EEPSEA Director, for his support; Dr. Stein Hansen, the international expert on the project, and the local officials, research team and villagers, for their cooperation. Since renewable resources and forest management are essential to Thailand's sustainable development, TEI will continue with this kind of research in order to facilitate sound decision- making, particularly at the local level.

Dr. Tongroj Onchan
President
Thailand Environment Institute

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ABSTRACT

Thailand has been able to provide 95 percent of its electricity demand through supply management, mainly by building large dams and utilizing electricity production systems based on imported fossil fuels. The remaining unserviced areas are mostly in remote rural areas. To have electricity, these areas can use local resources, which would make them self-sufficient and, at the same time, would lighten the burden on the public sector. One option is to use mini- and micro-hydros, which rely heavily on water supply from the forest, thus requiring effective conservation of forests. As deforestation becomes widespread, water supply becomes irregular and erratic, significantly threatening the operation of hydro projects. To effectively correct the situation, full-cost price needs to be calculated and implemented. This study calculated the full-cost prices for two energy project sites in Thailand. Options were explored to assist villagers on how to respond to price changes and explore new sources of supply.

The financial analysis revealed that none of the new investment options was viable for the small-scale 12-kilowatt Pangbong Project. The larger scale project, Mae-ton-luang, was estimated to be very financially attractive in all possible options. The results are based on the assumption that forest protection is integrated into the project costs. In estimating net benefits of the projects, it was noticed that indirect benefits far outweighed direct benefits, implying that an energy project like micro-hydros can be planned and implemented in an integrated manner. Its implementation will maximize both intended and unintended benefits for local communities.

Key words: mini- and micro-hydros; climate change; full-cost pricing; marginal cost pricing; demand-side management; supply-side management.

SURROGATE PRICING FOR WATER: THE CASE OF MICRO HYDRO-ELECTRICITY COOPERATIVES IN NORTHERN THAILAND

Sitanon Jesdapipat and Siriporn Kiratikarnkul

1.0 INTRODUCTION

Like most developing countries, Thailand has insufficient basic infrastructure such as roads, highways, and energy supply. Trying to overcome these deficiencies is the first step in the development process, and Thailand's National Economic and Social Development Plans, especially the First and the Second Plans, did just that[1].

Electricity, one of the most crucial factors of modern industrial production as well as a means of improved general livelihood, is one of the basic infrastructures for which Thailand has achieved substantial success to meet rising demand. Thailand was able to supply nearly 95 percent of the country with electricity in 1996. Other areas, consisting largely of remote, mostly mountainous areas, are yet to receive access to the national grid.

In the big picture, 85 percent of the electricity supply is derived from imported energy, the majority (44%) of which comes from natural gas. This situation implies a high dependency on imports, as the domestic supply of natural gas is on the verge of full exploitation (EGAT 1994: 14). Ensuring a stable future supply of electricity requires secure energy input, and the Thai-Myanmar natural gas deal is one example of such efforts.

Supply management at the height of environmental awareness is not easy - as has been repeatedly proven by public protests against major dam construction. Successful management implies full coverage of the service areas with reliable energy, and a change in the composition of energy sources to sustain Thailand's high growth rates of GNP and sustainable development. Thailand has done quite well for the first one. For the latter, other alternative sources of energy include renewable energy such as geothermal energy, which supplies 95 percent of the total alternative energy in Thailand (EGAT 1994: 27). There are also solar energy, mini and micro hydros, and biomass energy which are often identified as attractive energy sources for environmental reasons (e.g., in the context of climate change). While solar energy appears to be an attractive option, due to the high number of sunny days in the country, its high cost[2] prevents it from being competitive to hydro energy, if water is available at the same site. The latter appears attractive, especially the mini and the micro scales, because it is renewable and environmentally benign. Many countries have recognized the potential of small-scale hydropower. In late 1996, Indonesia, for example, decided to spend over one billion US dollars on mini-hydro projects with World Bank support. Over 90 percent of electricity produced in Norway come from

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[1] This is true even in latter period of development, namely late 1980s, when deficiency in infrastructure became a threat to sustaining growth and investment.

[2] Currently, imports of solar technology is subject to 161 percent tariff, hampering more popular adoption of such attractive technology (Jesdapipat 1996). At present it is not clear, however, whether a removal of such tariff would make this alternative competitive, as there are other technological difficulties associated with its application (e.g., domestically-produced substandard batteries for electricity storage).

hydro power. In contrast, only five percent of the total electricity production in Thailand is hydro-based. This is due mainly to the limited availability of sites for major dams as well as the public rejection of any new construction of large-scale hydropower facilities. Mini- and micro-hydro projects do not face these problems, making them very attractive. However, scale itself limits the service areas, and thus the per unit cost is often higher than the conventional national grid.

1.1 Research Problems

Northern Thailand is blessed with natural resources, especially forest and water resources. Most importantly, it has many of the country's important watersheds which nurture many major rivers. Yet, the region is one of the poorest among all regions in terms of per capita income. For instance, in 1993, the per capita income of the north was only 16.69 percent that of Bangkok. Yet, it housed 50.65 percent of the country's poor. Most of these poor reside in mountainous areas, relying mainly on agricultural production. Environmental damage in the highlands (e.g., soil erosion, deforestation) is a result of intensive activities carried out in these areas (TDRI 1994). Migration from highlands into cities began in the face of this environmental degradation that makes local resources no longer able to support the expanding population and its increased material demands. Pursuit of economic development has put the highlanders at the mercy of lowland cultures and markets, thus causing greater imbalances in their traditional social fabric and economies.

A similar dependency can also be seen in energy utilization. Most noticeably, rural communities that gain access to electricity rely on the energy supplied by the Provincial Electricity Authority (PEA), which purchases it from the Electricity Generation Authority of Thailand (EGAT), a monopolist. Villagers may now gain access to 24-hour electricity service generated from remote sources. While advantageous, they bear no witness to environmental consequences that might result from the project, unless these have direct impact on their lives. Such is the case of Mae Moh Power Plant in Lampang Province, northern Thailand, which pollutes air, harms human and animal health, and negatively affects crop growth.

During his visit in 1983 to remote villages in Doi Saket District of Chiangmai that had no electricity service, His Majesty the King advised officials to explore the possibility of mobilizing local water resources to generate electricity for local use. Hence, some isolated villages have discovered that they can be self-reliant in electricity supply. Furthermore, these projects have created awareness that the forest and water resources must be conserved if the electricity supply is to be sustained. For instance, kids have asked their fathers not to cut trees in the forest for fear that electricity supply would no longer be available and they would not be able to watch their favorite TV programs. Both children and adults have learned to establish the link between water supply from the forest and electricity (Jesdapipat 1994).

At present the mini hydro-electricity[3] cooperatives (MHECs) in Doi Saket District of Chiangmai are facing an uncertain future. Critically dependent on water supply from weirs constructed to collect water flowing from ravines and creeks in highlands, the generation of electricity has been periodic, depending on water supply which is

[3] According to the Department of Energy Development and Promotion (DEDP), which oversees small-scale hydro projects exclusively, micro hydros are projects which are less than 200 Kw, whereas mini hydros are projects with capacity between 200- 600 Kw.

insufficient for normal full operation throughout the year. This is due to the reduced and erratic supply of water caused by the rising cases of deforestation (Jesdapipat 1994). Deforestation is caused by illegal logging, increased demand for fuelwood for the tea industry in the area, and expansion of cultivation areas.[4] Man-made forest fires have also caused serious damage to forest resources. Despite all these limitations, electricity demand has increased as the amount of electrical appliances in households has risen, despite stagnant population growth in the areas. Essentially, this puts current electricity production capacity under serious threat.

A short-term solution has been implemented by cutting back hours of operation in order to limit electricity supply. No price adjustment was attempted to manage demand, as it is too sensitive an issue. These adjustments have caused many inconveniences to villagers, who look to other villages that now have access to the new PEA grid with much enthusiasm, if not envy. They increasingly look at the current system more as a burden than as convenience. If the situation continues, the potentially high operation and maintenance costs could make the system less attractive, compared to the conventional grid provided by PEA.

Many other measures could potentially be introduced to correct the situation as well as to fulfill demand, including, for instance:

- improving efficiency in water use or re-pricing the electricity (e.g., by pricing water and internalizing it into the electricity production system);
- reducing high loss in electricity supply (which requires, among others, good maintenance of the distribution systems);
- replacing deficient meters and light bulbs;
- enlarging water supply sources or creating more water bodies at higher latitudes in addition to the current one;
- introducing demand-side management (DSM) to villagers; and
- replacing sources of electricity supply (i.e., switching to PEA).

Choosing one or a combination of these options requires information on costs and benefits -- from both the private and social perspective. Investment requirements for these options range rather widely, and would have varying private and social net benefits. Most importantly, it is a decision that MHECs will have to make.

This research aimed to calculate full-cost price of electricity by taking into account the full-cost price of water. It also explored the financial viability of adjustments available to the project.

1.2 Research Objectives

The general objective of this study is to help decision making by exploring ways to price water and improve its efficient use through a surrogate pricing scheme (i.e., through electricity prices). It also identified ranges of options which are available to a micro-hydro project to fulfill its projected demand. The specific objectives are:

[4] Local villagers estimated that tea production requires a cut down of 20 trees per year per household or about 10 cubic meters of wood per household. (Estimated by the District Office of Doi Saket). For one village, about 2-4 thousand trees will be required per year. However, there has been an attempt to design a more efficient stove which required less fuel for the same amount of energy requirement. Other alternatives, such as group drying of tea leaves, are also being sought.

1. to calculate full-cost prices of water and electricity, using the marginal opportunity cost (MOC) and least-cost concepts;

2. to evaluate, for decision making, the various potential options that an MHEC has to address its problems; and

3. to suggest the best policy option for the management of water resources and electricity pricing reform.

1.3 Research Methods

1.3.1 Conceptual framework

There are two sets of parameters that determine prices of water (P_w) and electricity (P_e), respectively (Chart 1). *The first set* is the "production" and the consumption (by project) of water. The production of water (S_w) is carried out by two processes: direct rainfalls and continuous discharge from existing forest cover, assuming that tropical forest has this function of generating water[5] which flows into a weir. The weir is a facility for water storage and its construction may be counted as part of supplying water for the electricity project. The S_w has two types of usage: consumed by the MHEC (D_w) and for other activities, such as agriculture (D_o). The amount that is "consumed" by MHEC ($D_w < S_w$) represents no loss, however, because the water simply runs through the generator and goes out into the lower stream again. Such a disposal does not have any environmental impacts, compared to the without-project scenario. D_o may be significant in some project areas that are in the same altitude as the generator. S_w and the derived demand for water ($D_o + D_w$) determine prices of water (P_w). *The second set* of parameters determine prices of electricity (P_e). These are the supply of electricity by an MHEC (S_e) and the demand for electricity by households (D_e).

Theoretically speaking, the "right" supply price of a natural resource should be a full-cost price, to correctly reflect its opportunity cost, with the following components in it (Warford 1994):

Price of a resource = MOC = MUC + MPC + MEC,

where MOC = marginal opportunity cost;
MUC = marginal user cost, reflecting discounted cost of replacing current asset or resource or the net replenished cost;
MPC = marginal production cost; and
MEC = marginal externality cost representing negative environmental impact due to resource use.

[5] This is an inconclusive and controversial issue. See, for example, Hamilton and King (1983).

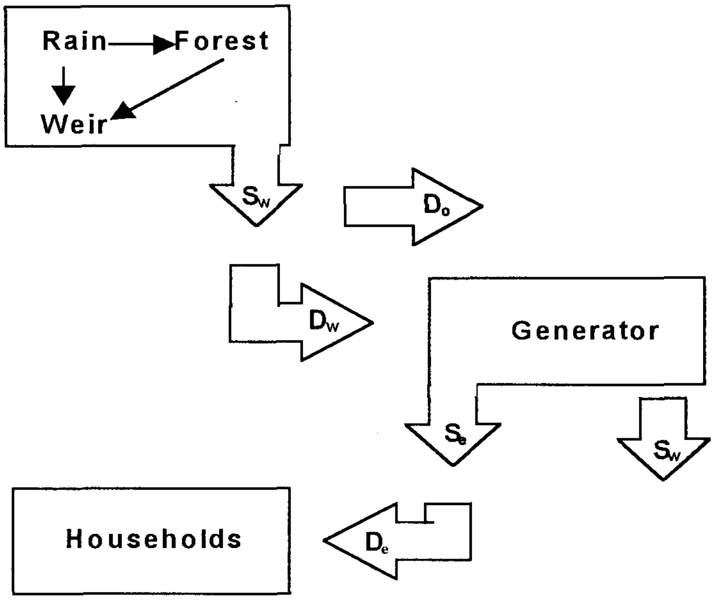

Chart 1. Water and Electricity Generation and Use

This concept has been applied widely (TDRI and HIID 1995; Prabowo; Suparmi; Prakoso 1995, for instance). Applied to the current situation, the concept of MOC is described as follows:

- ***The calculation of MOC of water***

1. MUC_W

MUC for water, MUC_W, should be zero because neither system of water generation or extraction (rain and forest water regulation or release) foregoes any future water supply. Assuming that most of the rainfall is kept and released regularly by forests, the major factor that affects water supply is the existence of forest cover in the area. Having good forest cover assures that water is a renewable resource, and implies that MUC_W is zero.

Effective forest protection to assure well-covered forests is a rather strong assumption in the case of Doi Saket District, because deforestation is believed wide-spread, as mentioned above. However, deforestation which threatens the natural water supply is "external" to the natural process of water production. It has nothing to do with such a natural extraction of water from the forest. Forest protection, therefore, adds an extra cost to assuring natural water supply, and should be accounted for in the MPC_W, not MUC_W.

2. MPC_W

The estimation of MPC_W in MOC is straight forward. It consists of forest policing costs to ascertain continuous supply of water (PC); opportunity costs of using the same amount of water for other types of usage (OP_w), such as irrigating crops that compete for water in the vicinity of the mini-hydro projects; and opportunity cost of using the storage site for other purposes (OP_1), e.g., agriculture or forest benefits.

$$MPC_w = PC + OP_w + OP_1$$

While the calculations of other costs are straightforward, the most complicated calculation is the cost of policing the forests. *Strictly defined, the effective rate of forest protection is the rate that maximizes and assures sustainable timber and non-timber benefits including water benefits.* There are two alternatives to calculate the effective rate of forest protection. *One* is to use a marginal cost of forest protection (MCFP). The difficulty with this approach for Thailand is that there *may not* be an effective rate of MCFP. Even if there is one, it is likely that the rates will vary according to many factors e.g. existing stock of forest resources, local cooperation and enforcement, and forest type. One may have to extrapolate, from various marginal costs of forest protection in Thailand, an effective marginal rate of forest protection. This may be done by collecting policing cost of all forests in the North (for dry and semi-dry forests) and extrapolating for such a figure. In reality, however, such costs do not exist. The official cost of forest protection is a flat rate of 5 baht/rai/year.

Another approach to MCFP calculation is using *the present value of net benefits* from forest protection, a case of "with" and "without" project analysis. Without forest protection, non-water benefits increase sharply in the beginning and drop after a relevant range, while water benefits decline rapidly, too. *The effective forest protection assures both positive net benefits and the sustainability of such benefits.* Conceptually, it is only rational to protect the forest as long as the benefits from protection are at least as high as the costs, and are higher than benefits to be derived from the protection scenario. Based on the definition of effective rate of forest protection given above, this covers all derived direct and indirect benefits. In the long run, to warrant continuous protection, the net benefits cannot be negative.[6] The main complication in this approach is how to account for all benefits, including timber and non-timber benefits.

3. MEC_w

In water extraction, MEC_w should be net externality costs of the system. The only possible costs of water production are siltation due to construction of the weir and methane emissions due to flooding of the forest cover at the weir site. The measurement of these costs requires technical skill and their associated costs can be difficult to estimate.[7] MEC_w will be assumed non-significant in this study.

♦ ***The calculation of MOC of electricity***

The calculation of MOC of electricity is simpler than MOC_w. In addition to the MOC_w, which because of scarcity is now an important part of the electricity production cost, MOC_e has to include the following marginal costs:

[6] It makes no economic sense to protect a forest if the net benefit is negative, assuming that all benefits have been taken into account and priced correctly.

[7] Trees in the portion of land are flooded and can be considered as an externality cost, but already accounted for in the production cost as opportunity cost of forest cover.

1. MUC_e

The extraction of electricity today by MHECs does not forego future supply, as long as there is sufficient water to generate the power. The electricity is produced from the flow resource. Its MUC_e should, therefore, be zero.

2. MPC_e

MPC_e can be calculated by simply summing up all marginal cost of labor (L) and capital (K) cash and in-kind, costs of pipeline and powerline construction (C), operation and maintenance costs (O&M), and opportunity costs of capital (r).

3. MEC_e

What about MEC_e? In the project, the generation of electricity using water from weirs may have minimal perceivable environmental costs. One such cost arises from construction of the weir, construction of pipelines necessary to bring water into the production system, and construction of power lines -- *not the use of water in the production itself.* The construction of a concrete weir is a minimal structural improvement on the natural catchment; its cost depends on how high is the wall and how large is the existing catchment. While opportunity cost of the land is already covered under MPC_w, there seems to be no environmental costs for construction of the weir, except those already accounted for by MPC_w (e.g., CH_4 emissions and siltation). Because few trees may have to be cut for pipelines and power lines, MEC_e may have a rather small value, measured by foregone *economic returns* from the lost acreage or trees felled.

Table 1.1 summarizes all the costs needed to calculate marginal opportunity costs of water and electricity. One should note that MOC_w is included into the calculation of MOC_e in order to take full account of resource costs. This conceptualized method will be modified and applied to calculate all marginal costs.

Table 1.1 Summary of water and electricity pricing

MOC	MUC	MPC	MEC	Other
MOC_w	*zero*	*MCFP; OP_w; OPI*	*Zero*	-
MOC_e	*zero*	*L; K; O&M; r; C*	*small*	*MOC_w*

Note: All costs are calculated on marginal basis. OP_w = opportunity cost of water; OPI = opportunity cost of land; L = labor; K = capital; O&M = operation and maintenance; r = rate of returns to capital; and C = cost of pipeline and powerline construction.

1.3.2 Project sites

There are seven MHECs in Doi Saket District alone. Two project sites were selected because they are accessible and representatives of the other districts. Pangbong and Mae-ton-luang, are located about 15 and 26 kilometers away from Doi Saket District Office. The former was established in 1987, and the latter in 1990, with initial membership of 58 and 172 persons, respectively.

1.3.3 Data requirements

Two types of data were required:

1. Primary data on water and electricity supply; on-going prices of electricity and demand (amount consumed, given the current fixed price); type of electricity production technologies; population; income; number of household electric appliances; coverage of services; and accounting cost of electricity production. These information were gathered from MHECs and all of the member households of the cooperatives.

2. Secondary data on MHECs business operation and related technical data. These data also included water flow records, revenue and expenses of cooperatives, and prices of alternative energy (i.e., gasoline, electricity price charged by PEA).

It was foreseen that the most difficult part would be acquiring data on the marginal cost of forest protection. This was extrapolated, using average incremental costs in forest protection, from a series of actual expenses. Current practices in forest protection in Thailand pay the protection costs out of official coffer and extra expenses from each site. The "best" national parks believed to be effectively protected are Khao Yai National Park and Khao Sok National Park in the Northeast and the South, respectively. Because of the differences in the forest types between the north and elsewhere, these sites were used only as reference costs, while expert judgment was applied in selecting the appropriate figure.

1.3.4 Methods of analysis

At present, most of MHECs' electricity generation is under-capacity. Calculated cost would be adjusted according to full capacity and effective forest protection. This is necessary for the estimation of supply of water and electricity.

Methods of analysis used are as follows:

1. Calculation of water price. This was done by matching the MOC_w with the projected demand for water in full-capacity electricity production. The optimal price of water can be used to explore alternative inputs for an ideal system of electricity production. For example, if the price of water is higher than the price of fossil fuel, one may suggest the use of the latter in the next system of production. However, such a conclusion should take into account other benefits of water conservation that come with the current system (e.g., environmental impact).

2. Calculation of electricity price. After arriving at the marginal opportunity cost of electricity production[8], associated supply (full capacity) was matched with the projected demand for electricity to calculate optimal price of electricity. The projected demand and the optimal price were used to determine least-cost option for providing supply. Such an alternative could be the supply by PEA, for example.

[8] Hartwick and Olewiler (1986: 147- 153) suggest three methods for measurement of natural resource scarcity: the real unit costs approach; the real price of extracted resource approach; and the resource rents approach, argued to be the most appropriate one-- despite certain weaknesses. The method employed in this study differs from all of these.

3. Estimation of net benefits of projects under different scenarios and options using benefit/cost ratios and NPVs. Information in this stage included water and electricity prices, and all relevant costs in each option. Three scenarios were established: abandoning the system; business-as-usual (BAU); and system improvement. Within the system improvement scenario, other options were identified and related costs and benefits calculated.

2.0 PROJECT BACKGROUND

Production of electricity from hydro is a simple process in which water is channelled to propel the turbine, creating a magnetic field of electricity. Theoretically speaking, the amount of electricity generated depends on the effective head (or steep of the water body or source) and the discharge into the electricity production system. In reality, the amount of power generated depends on efficiency of the propeller and the generator, usually ranging from 0.70 to 0.95.

The concept of hydro power is simple, but establishing a system requires both engineering and economic knowledge from which a carefully tailored design of the system is produced to assure highest efficiency of the system. In Thailand, the Department of Energy Development and Promotion (DEDP) is entrusted to construct mini- (200- 6,000 kW) and micro-scale (less than 200 kW) projects. Overall, mini- and micro-hydro fit well with the National Economic and Social Development Plan (NESDP), especially starting with the Fifth Plan which for the first time called for development which is less dependent on energy imports. Today, about 25 mini-scale projects and 53 micro-scale projects have been built (DEDP 1996). The former are constructed and run exclusively by DEDP itself, or by other agencies to which DEDP transfers the rights of management. These projects operate exclusively on a commercial basis. DEDP sells the electricity generated from the project site back into the normal PEA grid at prices negotiated between the two agencies. These prices are normally the same standard prices PEA pays EGAT, the country's monopoly producer. The micro-scale projects are constructed in cooperation with local communities willing to match government funding (each party shares about half of the total cost) and to take over the operation after the construction is completed. Either a user's group or a service cooperative called a micro-hydro electricity cooperative (MHEC), is established to function on behalf of the whole community. Net revenue is kept with the project. After the transfer, DEDP only services the technical component, while the Department of Cooperative Promotion (DCP) advises MHECs on business management.

At the same time, other criteria are usually applied to locating and constructing a system. These include, among others, lack of services from PEA grid, and appropriateness of geographical set-up. Remoteness, thus lacking access to a PEA grid, is usually the major characteristic of these project sites. Besides direct benefits of the project, one could expect the project to provide a more equitable sharing of public infrastructure to these remote villages.

2.1 Project Briefs

♦ Mae-ton-luang Project

The system here has the capacity of 35 kW. It was built in 1983 at a cost of 2.6 million baht from the government budget, matched by another 1.5 million baht in-kind from villagers. The MHEC started operation in October 1984 servicing an initial 190 households. By 1997, seven more households were added to its clientele. Of the 197 households, 113 are in the study areas. The size of catchment area is approximately 16km^2 and draws water from the natural ravines, Mae-iuang and Mae-ton. The project site is 40 km away from the District Office, and is reached by travel over mountain roads.

Major facilities of the system include:

1. 2.2 x 19 - meter concrete weir.
2. 1.28 - km fibreglass tubes system to draw water;
3. 150 - meter penstock that increases water pressure before running it through the turbine;
4. locally-designed CRSS Flow turbine;
5. locally-produced Brushiess generator;
6. mechanical hydraulic speed governor;
7. 3,500-voltage, 5.5km powerline and associated equipment, including a transformer (380 volts to 3,500 volts) at the production site, and a transformer (3,500 volts to 380 volts) before connecting into households.

The production facilities are housed in a small hut built by villagers. The 4x5m concrete floor is strong enough to support the heavy machines. One person is paid by the project to take care of the facilities. The management team supervises overall operation including maintenance of the water ways and the distribution systems.

Socio-economic profile

Out of 197 households, 113 were randomly chosen for interview for socio-economic data. It was found that tea planting is the main occupation of villagers. Most of the households are in the low income bracket, earning less than the national average. They earn much less than their peers in Pangbong, having only 5,063 baht in cash income, compared to 8,195 baht in Pangbong. This is due to more limited opportunities for earning extra income. For example, in Pangbong, residents produce crops for the Royal Project, which often introduces exotic temperate crops that fetch better prices compared to the common crops. However, with more acreage for tea plantation, an average family earns higher income per household than households in Pangbong. The annual average income is about 40,000 baht per household.

The Mae-ton-luang MHEC

Mae-ton-luang MHEC was formed on April 25, 1985 and started operation on July 1st of the same year with 133 initial members. The initial capital was 8,300 baht, which has increased to only 8,850 baht in 1996. Indeed, the slow growth is a result of problems that have been plaguing the organization. As a single-purpose service cooperative, it relies only on the sale of electricity generated from its weir. The low population growth has not been good for its operation which has a wider area of service than the Pangbong MHEC (thus making its overhead higher). Mae-ton-luang MHEC's operation covers seven villages, all of which were covered in this study.

With a larger population and a larger economy compared to Pangbong, members of Mae-ton-luang MHEC have purchased more electrical appliances, showing a significant change in life-style triggered by access to electricity and wealth. Most of the demand for electricity is for lighting, which is on for 4-5 hours per day. Like Pangbong MHEC, but to a lesser extent, there is a gap between registered units of electricity used and actual production, which has been in relatively stable supply. Financially, Mae-ton-luang MHEC is in better business shape than Pangbong MHEC. This is mainly due to larger demand.

- **Pang-bong Project**

Pangbong MHEC was constructed in early 1981 and started operation in April 1983 with full capacity (12 kW). It is considered to be rather small. The government budget for the project was 869,200 baht, matched by 594,070 baht in-kind from the villagers. Located in a mountainous area 35 kilometres from the District Office, it started servicing 41 households in 1983. By 1997, the number of households served rose to 55 in four villages in the periphery of its operation: Pangbong; Kewtam, Pangsoong, and Huaymakiang. The size of catchment area is only 6 km^2.

Major facilities of the system include:

1. 2.5 x 13 - meters concrete weir;
2. 0.9 - km fibreglass tubes system to draw water;
3. 160 - meter penstock that increases water pressure before running it through the turbine;
4. Locally-designed Pelton Flow turbine;
5. Locally-produced Brushless generator;
6. Electronic Load Controller to control speed;
7. 3,500-volt, 2.5 kilometre powerline, and associated equipment, such as transformers.

Socio-economic profile

The villagers' main occupation is tea planting from which they earn much less cash income than Thailand's average per capita, using the 1994 figure. On the average, the plantation is considered small, averaging about one hectare per household. Income is also earned from forest product gathering, agriculture in cooperation with the Royal Project which shares half of the average income from non-tea sources and hired labour. With annual per capita income averaging 18,000 baht, the majority of people in the project earn much less per capita income than the national average of 60,631 baht in 1994 (BOT 1997: 110). It is very likely that this characteristic of poverty will persist as villagers have little opportunity to diversify in terms of current livelihood opportunities, from which they earn a limited but stable income. Compared with those in the Mae-ton-luang project, they are economically poorer.

The Pangbong MHEC

The cooperative registered on April 25, 1985 as a service cooperative. As of 1995, its share capital was 13,300 baht, priced at 50 baht per share. Its operating capital in 1995 was 10,612 baht but its operation has been relatively unsuccessful. Internal conflict at the management level seems to be higher than at Mae-ton-luang. As will be discussed later, this becomes a critical constraint for any attempt to introduce change into the current system. In fact, it is one of the destabilizing factors for sustainability and success of the project.

The "success" of Pangbong MHEC could have been enhanced by a recent increase in electrical appliances such as televisions, refrigerators, rice cookers and irons, which in turn increase the demand for electricity. Light bulbs have also increased in recent years, averaging about four per household. However, the documented unit of use has been inaccurately registered compared with the actual production which has been quite stable over the same period of time due to unreliable substandard meters that villagers bought from the market themselves. The average units of electricity use in the project in the past three years have been stable, unusual considering that electrical appliances have increased over the years. Obviously, this is one of the reason which explains why Pangbong MHEC has been turning a better profit. What has made it worse is the fact that over the years, the nominal price of electricity it charges its members has been unreasonable, especially in more recent years when its operation experienced a water shortage. Although a major imposition of flat price came into force in 1995, Pangbong MHEC's financial situation has not improved. The flat price has neither truly reflected scarcity nor effective demand. On the contrary, charging the flat price prevents Pangbong MHEC from extracting more consumer surplus (via marginal cost pricing) which could be high as a result of the expected increase in demand mentioned earlier.

2.2 Theoretical Considerations

In the absence of other systems, an MHEC monopolizes the production of electricity in the area studied. Assuming profit maximization, MHEC's cost structure and existing aggregate demand, optimum quantity, and price can be determined. The size of the excess profit of this monopoly depends on its cost structure. If cost of deforestation is internalized (or the marginal cost of forest protection is internalized), rents will be reduced.

Monopoly profit could also be negative, should either price be distorted or should consumers be unwilling to pay expected full-price, which will consequently result in lower output. This is the situation in some of the MHECs. In other words, pecuniary external diseconomy and consumers' refusal to pay the full-price have caused lower production than the profit maximizing level. Consequently, monopoly profit is reduced.

In the study area, the entry of the new PEA grid is a threat to this local monopoly if the PEA grid provides comparable quantity and better service (e.g., more reliable, more stable). Given the same aggregate demand, the firm with the higher marginal cost would be driven out of the new duopolistic competition, should the market price fall below its average variable cost. In this duopoly model, the lower marginal cost PEA may indeed drive MHEC out of business, if subsidy is not provided to a higher-cost MHEC or if PEA charges relatively low prices by not having an internalized environmental cost (i.e., new price the PEA establishes is unreasonably lower than full-cost price). However, depending on price, the MHEC may continue to maximize profit despite the successful PEA entry, which would now share some of the existing demand. If for other reasons (e.g., inability of members to switch due to inaccessibility to the new grid), MHEC may have to continue servicing the remaining members – a situation which exists in some of the nearby MHECs. The per unit cost of existing MHEC will undoubtedly be higher than the grid system (Figure 2-1).

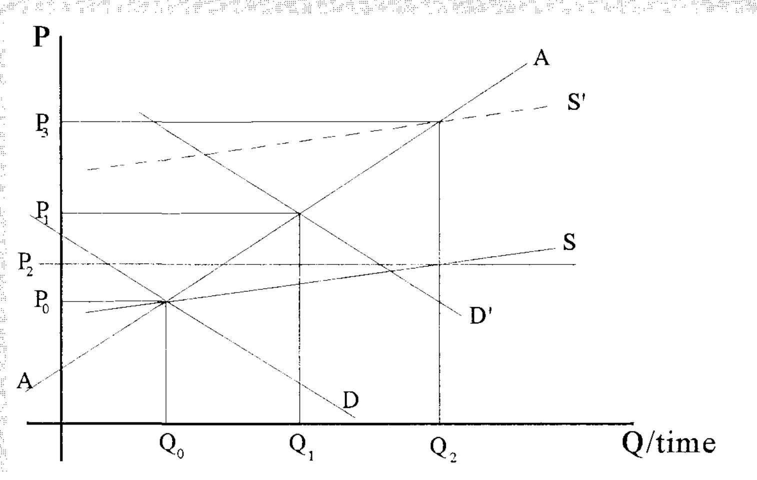

Figure 2-1: Price and quantity under two supply systems

At full capacity MHEC supplies up to Q_0 unit of output and charges its customers at P_0. Beyond this, say up to Q_2, the PEA grid is assumed to provide with lower marginal cost. Should the marginal cost AA of MHEC stay above that of PEA, every unit provided by the latter will always be cheaper, if it is priced by marginal cost. It may not be so if PEA price is not full-cost. Assuming that MHEC price is already full-cost, MHEC will always benefit from producer surplus, which is higher than that of PEA at any output level lower than Q_2. If MHEC price is not full-cost, it will tend to gain more producer surplus for every additional unit it produces. PEA grid could drive MHEC out of business, and provide all of the output itself.

Each MHEC has three options in response to change in supply of electricity, especially with the provision of a new PEA grid in the areas.

1. Option one is to maintain[9] the system and/or take a step further to upgrade the existing system for self-sufficiency. The major question here relates to quality and marginal cost. In terms of quality, MHEC would have to maintain the system and provide services comparable with those of PEA so that members would be just as happy to stay with them if they were to switch to the new PEA grid. This option will require additional investment to restore or upgrade the system so that consumer will not feel worse off. This may mean better and reliable services or an acceptable price regime, or both. This additional investment will shift the marginal cost as high up as the provision of full-cost services, which include forest protection and internalization of other externalities. The net cost will be compared with the

[9] This is the Business-as-usual (BAU) scenario.

full-cost of electricity from the PEA source.[10] Additional investment is required to maintain a PEA-compatible MHEC system and inevitably it has to be full-cost pricing to assure sustainability of the system. If the new price is lower than that charged by PEA full-cost price, then it is socially preferable.

2. Option two is to salvage the existing system and switch to the PEA altogether. No additional investment is required, but there might be a social cost as a result of increased deforestation and opportunity cost, or foregone benefit from using the existing system. From the societal point of view, the only relevant costs are the cost of deforestation, opportunity cost, and the additional cost of switching to the new grid. No additional investment cost is incurred, but potentially the society is to bear additional cost of deforestation, system opportunity cost, and switching cost. Whether it is socially preferable or not, depends on resulting net benefits.

3. Option three is the combined option. Under this scheme, production of MHEC continues, with additional investment to enable the system to commercialize its output to PEA, and MHEC member's switch to the new PEA grid. Under this scheme, cross subsidy is possible so those users of the PEA grid subsidize MHEC members. An internal subsidy can also be introduced using sales from the traditional system to subsidize PEA price paid by MHEC members. Consumers are given subsidy to consuming supply coming from PEA, while keeping the current MHEC system running. Net price to consumers is potentially lower, while the society gains from sustained forest management.

In the next chapter, results from two MHEC projects will be presented. Full-prices will be computed and financial and economic viability of each of these options will be calculated.

3.0 RESEARCH RESULTS

This chapter presents the analyses of financial and economic viability of the various adaptation options that MHECs have with the threat of PEA operation in the area.

3.1 Calculation of PEA Full-cost Price

While EGAT is Thailand's production monopoly, PEA is a regional monopoly that buys electricity from EGAT and resells it directly to consumers. In this study, its price was used as the threshold reference price against which MHEC full-cost price was compared. It is not clear to what extent the environmental cost has been included into price formulation of the PEA. According to EGAT information, it sells at per unit price of 0.80 baht to PEA, the price which factors in other costs (mainly costs associated with grid expansion, carbon off-setting costs such as reforestation cost) and operating and maintenance costs into EGAT's calculation of *average, not marginal* price. Altogether, these costs are considered expenses in project development. Consumers are therefore charged an average price by PEA, the price which to a certain extent has already internalized the environmental cost. However, in EGAT's

[10] Another possibility is to derive an incremental cost by comparing this marginal cost with the BAU or the without project scenario, which is not very realistic in this situation.

own interpretation, when environmental cost is considered, only pollution cost is taken into account (EEP 1995). An example is the inclusion of costs of scrubbers into electricity prices at its Mae Moh Power Plants in Lampang, Northern Thailand.

One may therefore conclude that PEA price is at least a "semi-full-cost" price as it sells to consumers at 1.25 baht per unit.[11] This is a nation-wide average price, not marginal.[12] Assuming that the price margin has already internalized associated environmental cost, at least at the production if not the distribution stage, this "marginal-cost" price can be compared to MHEC's full-cost price.

3.2 MHEC Full-cost Price for Electricity

This study employs two concepts to calculate full-cost prices -- MOC and AIC – both of which are detailed below.

3.2.1 Calculation of full-cost price using the MOC concept

The key concept is to find marginal opportunity cost of water (MOC_W) and internalize it into the price of electricity to derive the marginal opportunity cost of electricity (MOC_e) as summarized in Table 1.1. To calculate the former, marginal cost of forest protection must first be calculated based on the marginal cost of effective forest protection, or based on net benefits of forest protection.

a) Calculation of marginal cost of forest protection

Calculation of marginal cost of effective forest protection is one of the most difficult tasks in the project. First, no forest near the studied area can be used as a model, nor is the forest in study sites effectively protected. Second, estimates of costs vary widely.

There are two major sources of figures for effective forest protection. The crude *average* (which in this case is also marginal) figure of 5 baht/rai/year has been used by the Royal Forest Department (RFD) in its annual budgeting. Forestry units often have to raise their own extra funding in various ways including fees and charges. Most, however, may not bother to do so because any output of their forest management can easily be excused by the low input. Such is a popular claim when ineffective protection of forest is mentioned. This 5 baht figure is far from being perfect as forest protection of RFD has not been effective. In the study areas, the local administration has set an annual budget for forest protection in addition to the government budget already mentioned. Taking this extra source of budget into account, the new figure calculated is 5.5 baht/rai/ year. In reality, it is felt that the effective cost should at least double this official estimate.

The second source provides maximum marginal cost of effective forest protection, while the first provides the minimum. Estimates of *average* expense at a Royal Project in the same watershed -- Huay Hong Krai Rural Development Study Center -- in Doi Saket District may be an ideal estimate since its standing forest seems

[11] Of course, mark-up, profit margin, administrative and other marketing costs should be included in this price also. No one at PEA can tell, however, whether other externality costs have been dully included into this price or not.

[12] This is the pricing policy demanded by the government in order to assure equity in energy consumption.

to be well-protected. However, the project has many functions and it is very resource-intensive. Thus, its cost may be exceptional and it is extremely difficult to estimate the "true" figure for forest protection. Available figures may be over-estimated because the generous funding for the project comes from numerous sources, sometimes in-kind, and indirect (e.g., funding for income generation so that people will not encroach on the existing forest).[13]

A "true" marginal cost should be of the same forest type, as costs may vary accordingly. For the semi-dry forest in the Doi Saket District, minimum value of marginal cost for effective protection, hence, should be in the range of official estimate and the generous estimate. The mid-range figure of 10 baht/rai/year is used in the analysis. This is the figure used throughout the report and the results of calculation are presented as "forest protection cost" in relevant tables.

b) Calculation of net benefits of forest protection

The concept is straightforward: the forest is worth protecting if it is worth something. The "something" is how much the forest is actually worth. Effective forest protection efforts yield several gross benefits, which can be grouped as follows. Not all of them are estimated in this study, however.[14]

1. Direct benefits

These benefits consist of both timber and non-timber benefits. The timber benefits are fuelwood (estimated and valued at 200 baht per cubic meter, the on-going price at the District) and wood for house construction (estimated as 3 percent of the current amount used in the household), which are "allowed" by the village under its own rules.

Non-timber benefits refer to anything taken out of forest, including those that were not currently taken out at the time of survey. They are both for sale and home consumption (called consumption benefits), and are estimated based on going price either in the village or in nearby villages. These items include: bamboo shoots, different kinds of mushroom, orchid[15] and ornamental plants, honey, and wildlife.

2. Indirect benefits

Indirect benefits include, *inter alia,* watershed conservation benefits, value of biodiversity, and water regulation. This component of benefit was not estimated in this study.

3. Option values

Biodiversity and tourism stand out in option values of forest conservation. Tourism is low in the area and biodiversity is extremely difficult to estimate. This component of benefit is not covered in this current estimate of forest benefits, however.

[13] It should also be mentioned that theoretically, one could construct a marginal cost function for effective forest protection by simply regressing existing forest cover on cost of forest protection, which in the case of Thailand would result in a negatively sloped marginal cost schedule. The negatively sloped supply curve is not meaningful for our purpose. At best it shows that forest protection is underfunded.

[14] What was covered is already sizable.

[15] There is one indigenous orchid species that is native to the area. This has not yet been well-researched.

4. Existence values of forests is not estimated in this project.

5. Bequest values

Two major values may be prominent in forest bequest value: biological diversity resources and accumulated avoided emission. (Jesdapipat 1997). This benefit component is not covered, however.

Gross direct benefits[16] are netted of costs to produce net benefit, which are discounted at 10% discount rate over a 15-year period. Calculating an NPV (Net Present Value) from forest in Mae-ton-luang project yields:

$$= \sum_{i=1}^{15} \text{PV of benefits} - \sum_{i=1}^{15} \text{PV of forest protection cost}$$

= 20,105,355-10,717,527

= 9,387,828 (*10% interest rate, forest protection cost = 10 baht/rai/year, for 15 years).

Average NPV of forest protection $= \dfrac{9{,}387{,}828}{140{,}907}$ = 66.62 bath/rai/year

This estimate is based on the stream of costs and benefits from forest protection. It shows that the forest is worth protecting. This figure is the estimated net direct benefit should the forest in Mae-ton-luang be protected effectively. The direct benefits do not include water benefit. Therefore, it is not possible to calculate the marginal opportunity cost of water based on this figure. Moreover, because data is lacking on how much water is generated by one rai of forest in the area, it is extremely difficult to make such an estimate.

For Pangbong, the present value of net benefits are negative:

$$= \sum_{i=1}^{15} \text{PV of benefits} - \sum_{i=1}^{15} \text{PV of forest protection cost}$$

= 6,871,870 - 10,717,534

= -3,845,664

Calculating this on the per area basis, one arrives at -2.73 baht/rai/year, showing that the forest at Pangbong is not worth protecting. This figure may not be a realistic marginal opportunity cost of water for the project as the negative figure is meaningless as a price.

3.2.2 Calculation of full-cost price of electricity using Average Incremental Cost (AIC)

There is a need to calculate marginal investment cost in the two projects. The marginal investment cost consists of three major components.

[16] To be conservative, only direct benefits are considered.

1. The first component relates to system improvement, namely, new investment in components and parts including systems transformation gadgets which will enable the system to commercialize its electricity output;

2. The second component is the distribution facilities, such as new power lines systems; and

3. The third component of marginal investment is the operation and maintenance costs.

Together with the forest protection cost, the full marginal cost of electricity would include these three components.

In many instances, including the current one, it is not possible to calculate the direct marginal opportunity cost. Major reasons are capital indivisibility, or the "lumpiness" of capital and other inputs, and the indivisibility of output. The average incremental cost, AIC, according to Warford (1994), could be used to approximate the marginal opportunity cost. AIC can be calculated as follows.

$$\text{AIC} = \sum_{t=1}^{T} (I_t + R_t - R_0)/(1+r)^t \;/\; \sum_{t=1}^{T} (Q_t - Q_0)/(1+r)^t$$

where

I	=	incremental investment cost between year 0 and year t;
R_t and R_0	=	respective maintenance and operation cost in year t and year 0;
r	=	discount rate; and
Q	=	volume

In actual calculation, AIC could differ according to the variables above. The following tables show values of AIC which vary with options discussed in Chapter 2.

It can be seen from Tables 3.1 to 3.3 that the current management regime has the lowest AIC followed by the combined option. Self-sufficiency option has the largest price tag. Compared to the price of electricity EGAT sells to PEA, the 0.88 and 0.79 in Table 3.2 and Table 3.3 reflect the "true" marginal opportunity cost of electricity. In other words, the EGAT price is already full-cost price. These are lower than AIC of Pangbong project as demonstrated in Tables 3.4 to 3.6. These results are reasonable considering the small scale of the Pangbong project, which should face higher marginal cost, compared to the larger one. However, AIC cannot be calculated for another option: abandoning of the project.

Table 3.1 AIC of Business-as-usual scenario (BAU), no forest protection, Mae-ton-luang

Discount rate	$\sum_{t=1}^{T} (I_t+R_t-R_0)/(1+r)^t$	$\sum_{t=1}^{T} (Q_t-Q_0)/(1+r)^t$	AIC
10%	10,793,753	21,213,366	0.51 baht/KW
12%	9,639,597	19,739,686	0.49 baht/KW
15%	8,244,104	17,921,930	0.46 baht/KW

Note: The assumption here is that Mae-ton-luang MHEC will continue to conduct its business into the next 15 years with only necessary marginal maintenance and operating costs.

Table 3.2 AIC of Improvement for self-sufficiency scenario, with forest protection, Mae-ton-luang

Discount rate	$\sum_{t=1}^{T} (I_t+R_t-R_0)/(1+r)^t$	$\sum_{t=1}^{T} (Q_t-Q_0)/(1+r)^t$	AIC
10%	1,052,114	1,196,672	0.88 baht/KW
15%	761,170	861,198	0.88 baht/KW

Note: It is assumed that Mae-ton-luang MHEC makes necessary additional investment to provide its members with enough electricity supply into the next 15 years.

Table 3.3 Combined option, with forest protection, Mae-ton-luang

Discount rate	$\sum_{t=1}^{T} (I_t+R_t-R_0)/(1+r)^t$	$\sum_{t=1}^{T} (Q_t-Q_0)/(1+r)^t$	AIC
10%	17,264,967	21,899,451	0.79 baht/KW
12%	15,661,889	20,337,039	0.77 baht/KW
15%	13,689,879	18,499,059	0.74 baht/KW

Note: Under this option, Mae-ton-luang would act as both buyer and seller of the electricity by continuing to produce electricity for sale into the PEA grid and its members switch to new PEA grid.

Table 3.4 AIC of Business-as-usual scenario, Pangbong, with no forest protection

Discount rate	$\sum_{t=1}^{T} (I_t+R_t-R_0)/(1+r)^t$	$\sum_{t=1}^{T} (Q_t-Q_0)/(1+r)^t$	AIC
10%	10,231,138	6,881,804	1.49 baht/KW
15%	7,910,615	5,846,395	1.35 baht/KW
20%	6,361,729	5,122,962	1.24 baht/KW

Note: Pangbong MHEC continues to operate, with only necessary expenses for maintenance and operating cost.

Table 3.5 AIC of Efficiency improvement for self-sufficiency scenario, with forest protection, Pangbong

Discount rate	$\sum_{t=1}^{T} (I_t+R_t-R_0)/(1+r)^t$	$\sum_{t=1}^{T} (Q_t-Q_0)/(1+r)^t$	AIC
10%	11,088,865	6,881,804	1.61 baht/KW
15%	8,745,946	5,846,395	1.50 baht/KW
20%	7,117,010	5,122,962	1.39 baht/KW

Note: The Pangbong MHEC continues to produce for self-sufficiency.

Table 3.6 AIC of Combined option, with forest protection, Pangbong

Discount rate	$\sum_{t=1}^{T} (I_t+R_t-R_0)/(1+r)^t$	$\sum_{t=1}^{T} (Q_t-Q_0)/(1+r)^t$	AIC
10%	11,271,795	6,881,804	1.64 baht/KW
15%	9,346,808	5,846,395	1.60 baht/KW
20%	7,695,668	5,122,962	1.50 baht/KW

Note: Pangbong MHEC buys and sells electricity at the same time.

The 2 baht/unit price charged by MHEC is already high, indicating that it pays to charge the on-going price even after upgrading the system. This is later confirmed by the economic analysis of the project.

3.3 Strategic Responses

As already outlined in Chapter 2, an MHEC has various ways of responding to the potential entry of PEA. Analyses of these responses will be discussed in detail below.

* Scenario I: Abandoning MHEC

For MHECs, abandoning MHEC is an option in itself. Under this scenario, the respective MHEC exits from the market and lets PEA take over. In effect, PEA becomes a new monopoly, being able to fully set price. Quantity demand will vary according to an upward shift in the aggregate demand. This is due to the response to shift in new supply, which is also more stable and reliable than the former supply source.

The MHECs do not incur any direct financial cost if they decide to abandon the current systems. Direct benefits from the hydro project goes to zero, while the society bears the cost of abandonment. *Inter alia,* potentially the social cost includes, at the margin, the abandonment cost or the opportunity cost, increased marginal cost of potential increased deforestation, and marginal cost of switching to the new grid.

Total indirect benefits include direct marginal benefits arising from increased consumption and production as a result of better access to new electricity supply source and other new associated benefits such as amenity and convenience (A&C).

It should be noticed that this option or scenario is a second best option of the combined option to be discussed below. In reality, however, for both Mae-ton-luang and Pangbong MHECs, this opt-out option is almost meaningless because it is not possible within five years. It is especially true for Pangbong which is rather remote and has a large number of households which may not be able to switch to the new grid. To simulate probable financial viability, results from the without project option are presented in Tables 3.7 and 3.8 for Mae-ton-luang. It has a greater chance of switching because about 80 percent of the co-op members expressed their intention to do so if the new grid is available and if the general meeting of MHEC decides to do so.

The results indicate that this option is obviously not viable even when only the opportunity cost of electricity production is considered. The cost could be higher if, for instance, the foregone benefits from forests are counted as costs.

Table 3.7 Cost of switching to use power generated from PEA, Mae-ton-luang (baht)

Year	(1) Expense for new meters	(2) Opportunity cost of Mini Hydro	Total	PV (r=10%) cost
1997	1,020,500	258,780	1,279,280	1,162,993
1998	-	258,780	258,780	213,778
1999	-	258,780	258,780	194,421
2000	-	258,780	258,780	176,747
2001	-	258,780	258,780	160,677
2002	-	258,780	258,780	146,081
2003	-	258,780	258,780	132,806
2004	-	258,780	258,780	120,721
2005	-	258,780	258,780	109,749
2006	-	258,780	258,780	99,760
2007	-	258,780	258,780	90,650
2008	-	258,780	258,780	82,447
2009	-	258,780	258,780	74,969
2010	-	258,780	258,780	68,137
2011	-	258,780	258,780	61,962
Total	1,020,500	3,881,700	4,902,200	2,895,888

1. Expense for new meters (1,020,500), averaged from PEA users paying for a 5-Ampare meter and associated equipment at 6,500 Baht per household.
2. Evaluated from the current output potential.

Table 3.8 Financial Project Analysis of Mae-ton-luang, 1997- 2011 (considered only direct B/C)

Discount rate	PV stream of benefit (baht)	PV stream of Cost (baht)	B/C Ratio	NPV (baht)
10%	1,196,672	1,107,488	1.08	89,184
15%	861,198	801,231	1.07	59,967

* Scenario II: Improving the MHEC

♦ Option 1: Improvement for self-sufficiency

Improving the system to sustain self-sufficiency requires less additional investment than improving the system to commercialize production. For example, such a move will not require the additional three pieces of equipment necessary for transforming and adapting the low currency produced by MHEC into the high voltage PEA grid. This saves about 1.0 million baht on the spot. Improving the system for self-sufficiency demands alteration, additional investment and improvements such as forest protection, new powerline systems, and other necessary maintenance measures.

This could be an unsustainable option for the project due mainly to external diseconomy. Table 3.9 and Table 3.10 below summarize the stream of benefits of the current systems for Mae-ton-luang and Pangbong, respectively. They include both direct and indirect benefits of projects.

Table 3.9 Benefit of Mae-ton-luang project, efficiency improvement, 1997-2011, direct and indirect benefits included (baht)

Year	Revenue From Electric current	Benefit to woody fuel	Benefit to wood for construction	Benefit from other forest product	Consumption Benefit from forest	Total
1997	90,931	500,096	10,045,902	401,519	275,638	11,315,086
1998	98,388	500,096	301,377	401,519	275,638	1,577,018
1999	106,455	500,096	301,377	401,519	275,638	1,585,085
2000	115,185	500,096	301,377	401,519	275,638	1,593,815
2001	124,630	500,096	301,377	401,519	275,638	1,603,260
2002	134,850	500,096	301,377	401,519	275,638	1,613,480
2003	145,907	500,096	301,377	401,519	275,638	1,624,537
2004	157,872	500,096	301,377	401,519	275,638	1,636,502
2005	170,817	500,096	301,377	401,519	275,638	1,649,447
2006	184,824	500,096	301,377	401,519	275,638	1,663,454
2007	199,980	500,096	301,377	401,519	275,638	1,678,610
2008	216,378	500,096	301,377	401,519	275,638	1,698,002
2009	234,121	500,096	301,377	401,519	275,638	1,712,751
2010	253,319	500,096	301,377	401,519	275,638	1,731,949
2011	274,091	500,096	301,377	401,519	275,638	1,752,721
Total	2,507,748	7,501,440	14,265,180	6,022,785	4,134,570	34,431,723

Table 3.10 Stream of benefits of Pangbong Project, 1997-2011 (baht)

Year	Revenue from electric current	Benefit of woody fuel	Benefit of wood for construction	Cash benefit from forest	Consumption benefit from forest	Total
1997	69,120	122,638	3,322,476	132,275	125,123	3,771,632
1998	69,120	122,638	66,450	132,275	125,123	515,606
1999	69,120	122,638	66,450	132,275	125,123	515,606
2000	69,120	122,638	66,450	132,275	125,123	515,606
2001	69,120	122,638	66,450	132,275	125,123	515,606
2002	69,120	122,638	66,450	132,275	125,123	515,606
2003	69,120	122,638	66,450	132,275	125,123	515,606
2004	69,120	122,638	66,450	132,275	125,123	515,606
2005	69,120	122,638	66,450	132,275	125,123	515,606
2006	69,120	122,638	66,450	132,275	125,123	515,606
2007	69,120	122,638	66,450	132,275	125,123	515,606
2008	69,120	122,638	66,450	132,275	125,123	515,606
2009	69,120	122,638	66,450	132,275	125,123	515,606
2010	69,120	122,638	66,450	132,275	125,123	515,606
2011	69,120	122,638	66,450	132,275	125,123	515,606
Total	1,036,800	1,839,570	4,252,776	1,984,125	1,876,845	10,990,116

Note: Value of electricity = power generated X production hour X days of operating per year X 0.8 X 1 Baht / unit.

The stream of cost, which is minimal include only maintenance and operating costs. Forest protection cost is considered additional investment which will internalize into the project the externality due to deforestation. Results are shown in Table 3.11 for Mae-ton-luang and Table 3.12 for Pangbong.

Table 3.11 Direct and indirect-costs of Mae-ton-luang Project, self-sufficiency scenario, 1997-2011 (baht)

Year	(1) Maintenance cost Transmission line system	(2) Operating Cost	(3) Cost of forest protection	Total
1997	25,770	68,774	1,409,070	1,503,614
1998	27,058	75,651	1,409,070	1,511,779
1999	28,410	83,216	1,409,070	1,520,696
2000	29,831	91,538	1,409,070	1,530,439
2001	31,323	100,692	1,409,070	1,541,085
2002	32,889	110,761	1,409,070	1,552,720
2003	34,534	121,837	1,409,070	1,565,441
2004	36,260	134,021	1,409,070	1,579,351
2005	38,073	147,423	1,409,070	1,594,566
2006	39,976	162,165	1,409,070	1,611,211
2007	41,976	178,382	1,409,070	1,629,427
2008	44,076	196,220	1,409,070	1,649,365
2009	46,278	215,842	1,409,070	1,671,190
2010	48,592	237,426	1,409,070	1,695,088
2011	51,021	261,169	1,409,070	1,721,280
Total	556,065	2,185,117	21,136,050	23,877,232

Note: 1. Averaged 10% of the total fixed cost (2,577,150 Baht), assumed to grow 5% per year.
2. Averaged from expense of 1993 to 1996 = 68,774 Baht, and annual expenses increase at 10%. (From 1993-1996 annual expense increased at 10%).
3. It is evaluated at forest protection cost of 10 Baht per rai per year. The watershed area is 140,907 rai.

Table 3.12 Direct and indirect Cost, Pangbong project, self-sufficiency scenario (baht)

Year	Equipment	Transmission line system improvement	Maintenance cost	Operation cost per year	Forest protection cost	Total
1997	765,000	215,000	292,000	38,160	1,409,070	2,719,230
1998	-	-	-	38,160	1,409,070	1,447,230
1999	-	-	-	38,160	1,409,070	1,447,230
2000	-	-	-	38,160	1,409,070	1,447,230
2001	-	-	-	38,160	1,409,070	1,447,230
2002	-	-	-	38,160	1,409,070	1,447,230
2003	-	-	-	38,160	1,409,070	1,447,230
2004	-	-	-	38,160	1,409,070	1,447,230
2005	-	-	-	38,160	1,409,070	1,447,230
2006	-	-	-	38,160	1,409,070	1,447,230
2007	-	215,000	-	38,160	1,409,070	1,447,230
2008	-	-	-	38,160	1,409,070	1,447,230
2009	-	-	-	38,160	1,409,070	1,447,230
2010	-	-	-	38,160	1,409,070	1,447,230
2011	-	-	-	38,160	1,409,070	1,447,230
Total	765,000	430,000	292,000	572,400	21,136,050	23,195,450

Note: 1. Maintenance cost, averaged at 25 % of fixed cost (869,200+594,070), life time 15 years.
2. Forest protection cost is averaged 10 Baht per rai.

Given these streams of costs and benefits, the financial viability is evaluated and presented in Table 3.13 for Mae-ton-luang and Table 3.14 for Pangbong. It can be seen that only Mae-ton-luang is financially viable for self-sufficiency option. Pangbong project has very little potential to survive in the next 10 to 15 years.

Table 3.13 Financial Project Analysis of Mae-ton-luang, self-sufficiency scenario

Discount rate	PV stream of benefit (baht)	PV stream of Cost (baht)	B/C Ratio	NPV (baht)
10%	21,213,366	11,913,635	1.78	9,299,731
12%	19,739,686	10,639,732	1.86	9,099,954
15%	17,921,930	9,099,452	1.97	8,822,478

Table 3.14 Financial Project Analysis of Pangbong, self-sufficiency scenario

Interest rate	PV stream of Benefits (baht)	PV stream of Cost (baht)	B/C ratio	NPV (baht)
10%	6,881,804	12,239,365	0.56	-5,357,561
15%	5,846,395	9,653,363	0.61	-3,806,968
20%	5,122,962	7,855,420	0.65	-2,732,458

- **Option 2: Combined option**

This option requires improvement in the current system to enable an MHEC to sell its electricity output to PEA. The expected output will therefore be larger than the self-sufficiency scenario. The MHEC also buys from PEA at PEA price.

Table 3.15 shows the costs of various item used later in the financial analyses of various options. Tables 3.16 to 3.17 show the costs and benefits calculations, respectively used in the financial analysis of the combined option.

Table 3.15 Calculations of costs, Mae-ton-luang

Item	Cost (baht)	Maintenance cost and operation (Baht/year)
1. Equipment	1,076,000	1 @ 3% = 32,280
2. Transmission line system	350,000	2 @ 5% = 17,500
3. Repairing cost of previous equipment	300,000	3 @ 3% = 9,000
4. Operating cost		4 @ 10% = 172,600
Total	1,726,000	231,380

Note: 1, 2, 3 = Averaged maintenance cost per year.
4 = Operation cost per year.

Table 3.16 Cost stream, Mae-ton-luang, combined option, with forest protection, 1997-2001 (baht)

Year	cost of power electric purchase	cost of operation	Equipment	Transmission line improvement	Maintenance cost	Operation cost	Forest protection cost	Opportunity cost	Total	PV of Cost r=10%	PV of Cost R=12%	PV of Cost r=15%
1997	92,444	1,020,500	1,076,000	350,000	172,380	172,380	1,409,070	258,780	4,679,174	4,253,837	4,178,034	4,069,010
1998	94,293	-	-	-	-	172,380	1,409,070	258,780	1,934,523	1,598,110	1,542,202	1,462,693
1999	96,179	-	-	-	-	172,380	1,409,070	258,780	1,936,409	1,454,824	1,378,336	1,273,189
2000	98,102	-	-	-	-	172,380	1,409,070	258,780	1,938,332	1,323,881	1,231,810	1,108,338
2001	100,064	-	-	-	-	172,380	1,409,070	258,780	1,940,294	1,204,729	1,100,923	964,714
2002	102,066	-	-	-	-	172,380	1,409,070	258,780	1,942,296	1,096,426	983,967	839,655
2003	104,107	-	-	-	-	172,380	1,409,070	258,780	1,944,337	997,833	879,424	730,876
2004	106,189	-	-	-	-	172,380	1,409,070	258,780	1,946,419	908,005	786,159	636,284
2005	108,313	-	-	-	-	172,380	1,409,070	258,780	1,948,543	826,377	702,645	553,971
2006	110,479	-	-	-	-	172,380	1,409,070	258,780	1,950,709	751,998	628,128	482,215
2007	112,688	-	-	350,000	300,000	172,380	1,409,070	258,780	2,602,918	912,322	748,339	559,367
2008	114,942	-	-	-	-	172,380	1,409,070	258,780	1,955,172	622,918	501,893	365,422
2009	117,241	-	-	-	-	172,380	1,409,070	258,780	1,957,471	567,079	448,652	318,089
2010	119,586	-	-	-	-	172,380	1,409,070	258,780	1,959,816	516,020	400,978	276,922
2011	121,978	-	-	-	-	172,380	1,409,070	258,780	1,962,208	469,753	358,495	241,155
Total	1,598,671	1,020,500	1,076,000	700,000	600,000	2,585,700	21,136,050	3,881,700	32,598,621	17,504,112	15,869,985	13,881,900

Table 3.17 Benefit of Mae-ton-luang Project, 1997-2012 (baht)

Year	Value from Electric current	Benefit from Woody Fuel	Benefit from wood for construction (1)	Benefit from other forest products	Consumption Benefit from forest (2)	Total
1997	235,200	500,096	10,045,902	401,519	275,638	11,458,355
1998	235,200	500,096		401,519	275,638	1,713,830
1999	235,200	500,096		401,519	275,638	1,713,830
2000	235,200	500,096		401,519	275,638	1,713,830
2001	235,200	500,096		401,519	275,638	1,713,830
2002	235,200	500,096		401,519	275,638	1,713,830
2003	235,200	500,096		401,519	275,638	1,713,830
2004	235,200	500,096		401,519	275,638	1,713,830
2005	235,200	500,096		401,519	275,638	1,713,830
2006	235,200	500,096		401,519	275,638	1,713,830
2007	235,200	500,096		401,519	275,638	1,713,830
2008	235,200	500,096		401,519	275,638	1,713,830
2009	235,200	500,096		401,519	275,638	1,713,830
2010	235,200	500,096		401,519	275,638	1,713,830
2011	235,200	500,096		401,519	275,638	1,713,830
2012	235,200	500,096		401,519	275,638	1,713,830
Total	3,528,000	7,501,440	10,045,902	6,022,785	4,134,570	35,451,975

Note (1) 3% of current value of wood used in current construction and maintenance.
(2) Estimated.

Table 3.18 shows that the combined option are viable for Mae-ton-luang project, while Table 3.20 points to the opposite for Pangbong. The next section put these analyses in the perspective of the society.

3.4 Economic Analysis of Options

The above analyses concluded that it was financially viable for the Mae-ton-luang project, but not the Pangbong project. In order to further analyze project viability from society's perspective, the following coefficients were used to adjust the stream of costs. They were updated by Termkunanon (1991) from original coefficients that have been used for years in Thailand.

- Standard Conversion Factor = 0.906;
- Intermediate goods for consumption = 0.95;
- Fuel products = 0.93;
- Construction = 0.89; and
- Capital goods = 0.961.

Results of the two options: self-sufficiency and combined options from society's perspective are presented in the following tables for the respective two projects.

Table 3.18 Financial Project Analysis, Mae-ton-luang, combined option, 1997-2011

Discount rate	PV stream of benefit (baht)	PV stream of Cost (baht)	B/C Ratio	NPV (baht)
10%	21,899,451	17,504,112	1.25	4,395,339
12%	20,377,039	15,869,985	1.28	4,507,054
15%	18,499,059	13,881,900	1.33	4,617,159

Table 3.19 Stream of cost, Pangbong Project, 1997-2011, combined option (baht)

Year	(1) Cost of buying electric	Cost of operation	Improved Equipment	(2) Transmission line system improvement	Maintenance cost	Operation cost per year	Forest Protection cost	Total
1997	49,500	357,500	765,000	215,000	292,000	38,160	1,409070	3,126,230
1998	50,985	-	-	-	-	38,160	1,409070	1,498,215
1999	52,515	-	-	-	-	38,160	1,409070	1,499,745
2000	54,090	-	-	-	-	38,160	1,409070	1,501,320
2001	55,713	-	-	-	-	38,160	1,409070	1,502,943
2002	57,384	-	-	-	-	38,160	1,409070	1,504,614
2003	59,106	-	-	-	-	38,160	1,409070	1,506,336
2004	60,879	-	-	-	-	38,160	1,409070	1,508,109
2005	62,705	-	-	-	-	38,160	1,409070	1,509,935
2006	64,586	-	-	-	-	38,160	1,409070	1,511,816
2007	66,524	-	-	215,000	-	38,160	1,409070	1,728,754
2008	68,520	-	-	-	-	38,160	1,409070	1,515,750
2009	70,576	-	-	-	-	38,160	1,409070	1,517,806
2010	72,693	-	-	-	-	38,160	1,409070	1,519,923
2011	74,874	-	-	-	-	38,160	1,409070	1,522,104
Total	920,650	357,500	765,000	430,000	292,000	572,400	21,136,050	24,473,600

Note: 1. Average cost of power electric per household = 75 baht /Month and incremental rate of use at 3%.
2. Cost of operation included internal wiring and meter, average 6,500 baht/household.

Table 3.20 Financial Project Analysis of Pangbong

Discount rate	PV stream of Cost (baht)	PV stream of Benefit (baht)	B/C Ratio	NPV (baht)
10%	6,881,804	13,007,316	0.53	-6,125,512
15%	5,846,395	10,259,122	0.57	-4,412,727
20%	5,122,962	8,415,212	0.61	-3,292,250

- **Mae-ton-luang project**

Table 3.21 Case 1: Improvement for self-sufficiency

Discount Rate	PV stream of Cost (baht)	PV stream of Benefit (baht)	B/C ratio	NPV (baht)
10%	1,052,114	1,196,672	1.137	144,558
15%	761,170	861,198	1.131	100,028

Table 3.22 Case 2: Combined option

Discount rate	PV stream of Cost (baht)	PV stream of Benefit (baht)	B/C Ratio	NPV (baht)
10%	17,264,967	21,899,451	1.268	4,634,484
12%	15,661,889	20,377,039	1.301	4,715,150
15%	13,689,878	18,499,059	1.351	4,809,181

The analyses show that from the society's perspective, self-sufficiency is preferable although the combined option seem to be better than the self-sufficiency one.

- **Pangbong project**

Table 3.23 Case 1: Improvement for self-sufficiency

Discount rate	PV stream of Cost (baht)	PV stream of Benefit (baht)	B/C Ratio	NPV (baht)
10%	6,881,804	11,088,865	0.62	-4,207,061
15%	5,846,395	8,748,946	0.67	-2,899,551
20%	5,122,962	7,117,010	0.72	-1,994,048

Table 3.24 Case 2: Combined option

Discount rate	PV stream of Cost (baht)	PV stream of Benefit (baht)	B/C Ratio	NPV (baht)
10%	6,881,804	11,271,795	0.611	-4,389,991
12%	5,846,395	9,346,808	0.626	-3,000,413
15%	5,122,962	7,695,668	0.666	-2,572,706

The Pangbong project continues to be unfavorable from the society's perspective. Hence, compared to the Mae-ton-luang project, Pangbong should be scrapped.

4.0 CONCLUSION AND POLICY DISCUSSIONS

This study aimed to estimate full-cost prices of water and electricity of two micro-hydro projects in Doi Saket District of Chiangmai Province in Northern Thailand. This objective has been justified by the fact that water used in electricity by the two projects has been running scarce—thus, water is no longer a free resource for electricity production, and the electricity price should consequently reflect that scarcity in its marginal opportunity cost. Later, the objective expanded to assist in decision making on the fate of the two micro-hydro projects. Three options were identified: the business as usual option, which in effect assumes that the projects will be continued in the manner as they have always been ran; the self-sufficiency option, which assumes moderate improvement in production of electricity and distribution; and the combined option, which assumes that projects will be improved for sale of their electricity into the national grid, while users will switch to the new national grid which is more reliable—and cheaper on the average.

The primary objective was not satisfactorily fulfilled. The calculation of the marginal opportunity cost of water was not very successful because it is extremely difficult to divide both the costs and the benefits of forest protection[17]. The marginal cost and benefit units vary by type of forest and location. No figure is available for forests in the project areas. Even *average* figures for forest protection cost vary. The *average* cost of effective forest protection, which is used as a proxy,[18] varies widely in Thailand, depending not only on the annual official allocation of budget for forest protection, but also on additional expenses that the local administration or the local RFD units would contribute. The "best" estimate used in this report relies on expert judgement, which suggested doubling the official rate to 10 baht per rai per year. This *average* figure was compared to the net benefits of effective forest protection per rai. The concept of net benefits was used to evaluate the value of forest, which, if effectively protected, will yield a cluster of benefits, including water. However, benefits of water alone were not calculated under this approach.

It was found that for Mae-ton-luang project, the present value of net benefit (NPV) was positive, whereas for Pangbong Project, the NPV was negative. The positive net benefit of 67 baht per rai per year for Mae-ton-luang project may not be sufficient to gauge the true marginal opportunity cost of water, due to indivisibility of both output and inputs in forest protection—and the lack of data on the amount of water generated by forests.[19] The figure shows that *average* net benefits of 67 baht from this forest will be assured, but that figure may not directly reflect the worth of water. Effective forest protection may not yield constant amount of water; neither is it possible to gauge the direct relationship between forest protection and water supply. The 67 baht per rai seems to indicate, however, that the government has underestimated the value of forest in the study area as it has been willing to invest only 5.5 baht to protect a rai of forest. Neither is the negative NPV realistic for valuing the

[17] It was assumed that effective forest protection yields water. Indeed, this is based more on general belief than rigorous scientific proof—which is not easy to obtain for a number of uncontrollable factors.

[18] Effective forest protection brings about a host of direct and indirect benefits, and water is one of those benefits. It is viewed as a joint product of forest benefits, which may have high "commercial" value in the case of micro-hydro projects. Water benefit in this case is direct benefit which may be evaluated by the net benefit of electricity production, (i.e., net benefit minus profit margin).

[19] This is a bold assumption, that effective forest protection generates water benefit, no scientific concensus has been reached and to test this hypothesis is extremely difficult due to many uncontrollable factofs.

worth of the forest or water-- such is the case of Pangbong project site. However, it may be dangerous to conclude that one should therefore denude the forest area because it is not worth protecting. It may suggest the opposite: the negative incremental cost should be subsidized in order to keep the forest intact (i.e., to arrive at effective forest protection level).

The average incremental cost (AIC) approach was applied to come up with one more set of full-price figures for the two projects. This approach measures net *incremental* costs in the case where marginal units cannot be systematically measured. It was found that the AIC calculated was close to the price already charged by EGAT to PEA, at a flat rate of 88 stangs per unit[20], when the latter buys electricity from the former. PEA then charges its customers a higher price --presumably adding on other average costs and profit margins. Hence, the fact that the PEA price is higher than the EGAT price reflects such additional average costs, marketing margin and PEA profit margins. Bangkok consumers will be charged a "fuller" price when they buy from MEA operating in Metropolitan Bangkok than from PEA, as PEA price is cross-subsidized by MEA through EGAT.

Beginning July 1st, 1997,[21] rates charged to MEA and PEA are as follows:

1. Basic monthly rates ("wholesale price") (baht/unit)

Capacity (kW)	Mon-Sat 9 am –10 pm	Mon-Sat 9 am –10 pm	Sunday, all day
230	1.5349	0.6671	0.6062
115	1.5697	0.6697	0.6088
69	1.6292	0.6769	0.6153
33	1.7720	0.6857	0.6232
22	1.7751	0.6864	0.6238

2. Monthly subsidy rate (baht/unit)

negative subsidy to MEA	-0.2577
positive subsidy to PEA	+0.1205

These rates are subject to additional conditions: (1) basic rates will be adjusted accordingly to external costs, such as prices of imported fuels and (2) rates are exclusive of value added tax (VAT), to be borne by buyers.

Source: Economic Policy Division, EGAT

With 88 stangs per unit as full-cost price, MHECs should have been making a wholesome benefit because its retail price was 2 baht per unit. Environmental costs are more than fully covered, including the full-cost price of water, which remains difficult to pin down. The Pangbong MHEC operates at a loss for other reasons, not that electricity price does not fully take into account the environmental costs, or full resource costs.

There remains some other important issues that should be discussed further. They relate to the vital assumption about the relationship between forest protection and existence of mini- or micro-hydro projects; and policy and measures to promote energy from renewable resources. Lastly, on-field observation has made researchers ponder the issue of sustainable living and sustainable development.

[20] One baht = 100 stang.

[21] Before this time, a flat rate was charged. EGAT maintains that its production cost is not full-cost, non-marginal, but average. The current rate is about 80 percent of its "full" cost—which is not full in the sense of full-cost pricing as, for example, user costs are not accounted for.

4.1 Questions on Deforestation

It is hypothesized in this study that dissolving an MHEC system may induce more deforestation in the existing forests because villagers no longer see the significance of forest protection (which is assumed to supply and regulate water for the electricity production system). To test this hypothesis, the study gathered data from two villages, Huaymore and Pang-un, in Doi Saket District, which had already phased out their micro-hydro operations. These projects bore many similarities to the two projects studied for this paper. Forty-five respondents were randomly chosen from among village residents and former MHEC management, for the interview. Findings revealed that the demand for wood (fuel and house construction) continued on the same trend after scrapping the projects, implying that no more deforestation activities than usual had been triggered by abandoning the projects. Moreover, reforestation for fuel wood also continued to fulfill such demand. More specifically, over half (52.5%) of the respondents believed that water supply in ravines had been observed to decrease as a result of deforestation within and outside the catchment areas. Another 38.5 percent thought that water supply remained the same even after the project ended. Surprisingly, 27.5 percent thought that water supply increased.

Of course, these opinions may not be a truly valid test of the hypothesis, as opinions can be right or wrong, and yet may or may not be a true reflection of increased deforestation. One thing seems true, though: water remains vital in the villagers' daily life for other use, although it is no longer important for electricity generation. How much of that significance has been translated into conservation actions actually realized is not clear, and has not been tested here.

Although the survey indicated that the study areas—Pangbong and Mae-ton-luang-- were not free of deforestation, efforts have been made from the government to increase efficiency of fuelwood used in the tea industry. At one time, collective processing was suggested in order to economize fuelwood use, but irregular timing of tea leaf collection made the suggestion impractical. Efficient stoves were invented and gradually introduced to villagers. The latter has had some multiplier effect in creating more job opportunities. Some villagers started commercial production of such stoves. The communities themselves realized that the various types of wood demand have put pressure on local forest resources, and have thus come up with their own rules and regulations to control -- not to prohibit -- the exploitation of forest resources. These measures do not seem to be sufficient, as reforestation is still needed to ensure adequate supply of fuelwood. Worries have been expressed regarding continued trend of deforestation, regardless of project existence—or without it.

It is not yet known what impacts the new Community Forest Bill, which is currently in Parliament, will have upon forest conservation of these communities. It is possible that the legitimacy of forest conservation, which has been a symbiotic one, may change for the better. The current level of dependency that villagers have on the forest resources has been sustained without the law, so there should be no reason why they cannot sustain it with a new legal support and legitimacy, unless the law itself inhibits, not fosters, conservation efforts. This, too, is possible if the new law tries to make forest conservation a bureaucratic effort.

4.2 Full-cost Pricing and Policy Reform

Implementation of a full-cost price regime is not difficult if it is done early on when the project is initiated. In the case discussed here, one can see that MHECs have already charged full-cost prices and consumers have been silent about it. Any increase after a price is established will be difficult as much resistance will be inflicted. But price change is not all impossible. In the case of some MHECs, the unit price has been replaced by a lump sum payment scheme (e.g., 50 bath per household, per month). With no demand differentiation, this may be disadvantageous for MHECs because the potential transfer of consumer surplus, by price differentiation, to cooperatives will not be possible.[22]

Results from this study seem to indicate a number of areas for a policy reform which will raise the profile of mini- and micro-hydro projects. Above all is a call for authorities to normalize existing policy dilemmas between PEA and MHECs so that small-scale hydro projects can be sustained. Its sustainability depends on a number of measures that can be initiated.

That is, if government policy is to promote this source of energy, electricity prices should be subsidized to poor villagers. For example, the government can buy it off with avoided emissions of greenhouse gases that would have been generated by conventional power plants. The pricing scheme may have to change to be more supportive of electricity produced by renewable resources, especially the ones that also bring other benefits, not limited to energy supply only. In the case of micro-hydro, for example, a bundle of indirect benefits have been derived from the project. These benefits bring more value added to the project, thereby making the project itself more attractive than the conventional electricity production. Environmental protection may not be viewed in isolation project by project; thus, projects of this nature are extremely attractive.

Problems requiring prompt decision of the management of studied MHECs still loom. Members of the management are impatient about the burden of maintaining the system. Most of them want to switch to the grid because it would lighten this burden. That will not happen easily as they have to meet certain requirements to switch to the grid, and as leaders of the communities, they have to be concerned about those who are not ready to switch. This means that some members will have to continue using the existing systems.

The financial viability is another major concern, despite the fact that users of MHECs are already paying full-prices. Increasing the price further would be a sensitive matter. In the short-term, villagers have been advised by the research team to change the meters in order to gain more business returns from better equipment. This too could be from government agencies although a development fund already exists. In the long-term, micro-hydro projects like these may still be attractive as intrinsic value tends to increase. That too have to be taken into account in formulating public policy.

[22] One may argue that MHEC members and users are the same group of people, so it does not make a difference as benefits will be reimbursed to individuals any how. It would make great difference if the project is a private enterprise operating independent of individual members who are not "owners" of the project.

4.3 Sustainable Living and Sustainable Development

Lastly, it should be mentioned that the provision of electricity to rural areas could be a two-bladed sword: it modernizes the way of life of people, but if not carefully planned and implemented, the access to electricity could lead to excessive consumption of goods, such as electrical appliances, placing people in debt in rural communities with low income. Such is the case in most rural communities in Thailand. Recent unofficial surveys of DEDP (personal communication) revealed that electrical appliances have increased over 60 percent during the past decade, as a result of electricity provision to rural areas of Thailand. Debt in this case is problematic because of the low potential and capacity to pay back the loan—although villagers have the absolute right to decide for themselves whether or not to be in debt. This problem suggests that rural development have to be approached in an integrated manner, taking into account all possible aspects so that development efforts will not end up making rural communities worse off. If achieved, sustainable development will be truly assured.

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APPENDIX A

Abbreviations Used

EGAT	Electricity Generation Authority of Thailand
PEA	Provincial Electricity Authority
DEDP	Department of Energy Development and Promotion
KW	Kilowatt
km	Kilometer
DCP	Department of Cooperative Promotion
hh	household

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