PDAAP128
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PROJECT PAPER ANNEXES

MICRO/MINI HYDROELECTRIC PROJECT

(A.I.D. Project No. 493-0324)

USAID/Thailand

September 1982

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ANNEXES

A. Log frame

B. Technical Analysis

C. Financial Analysis

D. Social Soundness Analysis

E. Economic Analysis

F. Sub-Project Site Selection Model

G. Methodological Note on Financial and Economic Analysis

H. Indicative TOR for Key Project Personnel

AID [illegible] (7-71)
SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

(INSTRUCTION: THIS IS AN OPTIONAL FORM WHICH CAN BE USED AS AN AID TO ORGANIZING DATA FOR THE PAR REPORT. IT NEED NOT BE RETAINED OR SUBMITTED.)

Life of Project:
From FY 82 to FY 86
Total U.S. Funding $8.1 Million
Date Prepared 1-30-82

Project Title & Number: Micro/Mini Hydroelectric Project (493-0324)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: (A-1)	Measures of Goal Achievement: (A-2)	(A-3)	Assumptions for achieving goal targets: (A-4)
1. Support RTG national development objectives.	1a. Project objective dovetail with those of RTG.	1a. National Plan and NESDB/NEA stated intentions in energy sector.	- Thailand will not become a major producer of fossil fuels.
2. Improve the national balance of payments situation.	1b. Foreign exchange and operating cost savings are achieved by Project installations, thereby loosening up these monies for other RTG development goals.	1b. Site operating agency (PEA, RFD, etc.) records.	- Small hydro generation will continue to cost less than fossil fuel generation in terms of foreign exchange and operating costs.
	2. Project installations reduce need for imported fuel, parts, etc. and simultaneously improve local export productivity within ZIP of each site.	2a. Same as 1b. above, and local production statistics.	

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AID 1020-29 (7-71)
SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 82 to FY 86
Total U.S. Funding $8.1 Million
Date Prepared: 1-30-82

Project Title & Number: Micro/Mini Hydroelectric Project (493-0324)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Project Purpose: (B-1) - To systematically develop options to reduce Thailand's dependence on fossil fuels for electrical energy generation through the development of economically attractive, indigenous micro/mini hydropower resources.	Conditions that will indicate purpose has been achieved: End of project status. (B-2) - An empirical body of knowledge of the potential for small hydro development in Thailand, in a form utilizable for future sectoral investment decisions. - Project installations generate electricity which either: replace existing diesel generation, feed an existing oil or gas thermal-powered grid, or develop new power in an area which would have required fossil fuel generation. - All Project installations are declared economically attractive.	(B-3) - Project records.	Assumptions for achieving purpose: (B-4) - The differential financial and economic costs of thermal vis-a-vis hydro conti... to favor hydroelectric generation optic... - That the project model accurately asses... the economic worth of each Project installation.

AID 1020-28 (7-71)
SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

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Project Title & Number: Micro/Mini Hydroelectric Project (493-0324)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Outputs: (C-1)	Magnitude of Outputs: (C-2)	(C-3)	Assumptions for achieving outputs: (C-4)
1. Creation of new "run-of-river" hydroelectric power generation systems providing electricity to local villages or to the national grid.	1a. Twelve (12) "run-of-river" generation/distribution systems with a total design capacity of approx. 4000 KW.	1a. Site examination; NEA, supervisory engineer and construction contractor records.	- RTG sector objectives, budgets and allocation of sector analysis responsibilities to NEA remain as now conceived.
	1b. Estimated 72 villages electrified through Project installations with total population of 60,000 people, of which 50% will receive electricity.	1b. NEA,PEA, and other operating agency records.	- Cooperation of operating agencies (PEA,RFD,etc.) is forthcoming.
2. Enchanced capacity of Thai institutions to develop the country's small hydroelectric potential.	2a. One integrated small hydro site selection model.	2a. Existence of NEA models.	- That appropriate, qualified technical assistance (both contract and NEA) be located and assigned to the Project in a timely fashion.
	2b. Two (2) NEA engineers with new specialized skills in small hydro development.	2b. Performance evaluation of engineers by NEA Deputy Director General.	
	2c. Improved Thai power plant manufacturing capacity.	2c. NEA assessment and manufacturing promotion consultant reports.	
	2d. Improved village-level capacity to utilize electricity generated in project.	2d. Consumer promotion consultant reports and NEA/PEA assessment.	

AID 1020-28 (7-71)
SUPPLEMENT 1

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
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Project Title & Number: Micro/Mini Hydroelectric Project (493-0324)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Inputs: (D-1) 1. Civil works construction 2. Technical Assistance 3. Equipment 4. Final Engineering & Supervision 5. Power Plant Procurement	Implementation Target (Type and Quantity) (D-2) 1. Est. twelve site construction contracts of total value $5.7 million. 2. Est. 167 person-months of contract services of total value $0.8 million. 3. Est. $20,000 of minor equipment to support POU staff. 4. Est. twelve site engineering design and supervision contracts of total value $0.6 million. 5. Est. twelve power plants of some 4000 kW aggregate capacity at value $1.8 million. (Above is exclusive of contingencies and inflation)	(D-3) - Procurement and contracting records. - Contractor progress reports and records. - Site inspections and construction inspection documentation - Audit	Assumptions for providing inputs: (D-4) - RTG and AID funding will be made available as planned.

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ANNEX B: TECHNICAL ANALYSIS

I. Basic Engineering Description

This project proposes to assist the RTG with developing perhaps as many as 12 micro/mini hydro electric power plants in rural areas. Of these 12, six sites have been identified, inspected, and preliminary design characteristics determined. These six sites are expected to be fairly representative of the cost and scope of all 12 sites to be funded.

It is anticipated that all sites will have a general layout as illustrated in Figure A1. They are "run-of-river" schemes with the following primary features:

- Diversion Structure which consists of a weir, intake, gate and a bulk trash rack. The weir's primary function is to control the water level at the intake to the headrace although it may also serve to impound a small volume of storage water. The diversion structure may be designed to divert a fraction or the totality of the river flow to the headrace.

- Headrace (or power canal). The headrace transfers the water from the diversion structure to the top of the penstock. It can be an open canal, unlined or lined with concrete, or a closed pipe channel depending upon the terrain.

- Forebay. The forebay is the structure at the inlet to the penstock and is designed to handle surges in water flow, to prevent sand and trash from entering the penstock, and to ensure that air is not intrained in the water flow through the turbine.

- Penstock. The penstock is the piping which transfers the water through the difference in head from the forebay to the power house.

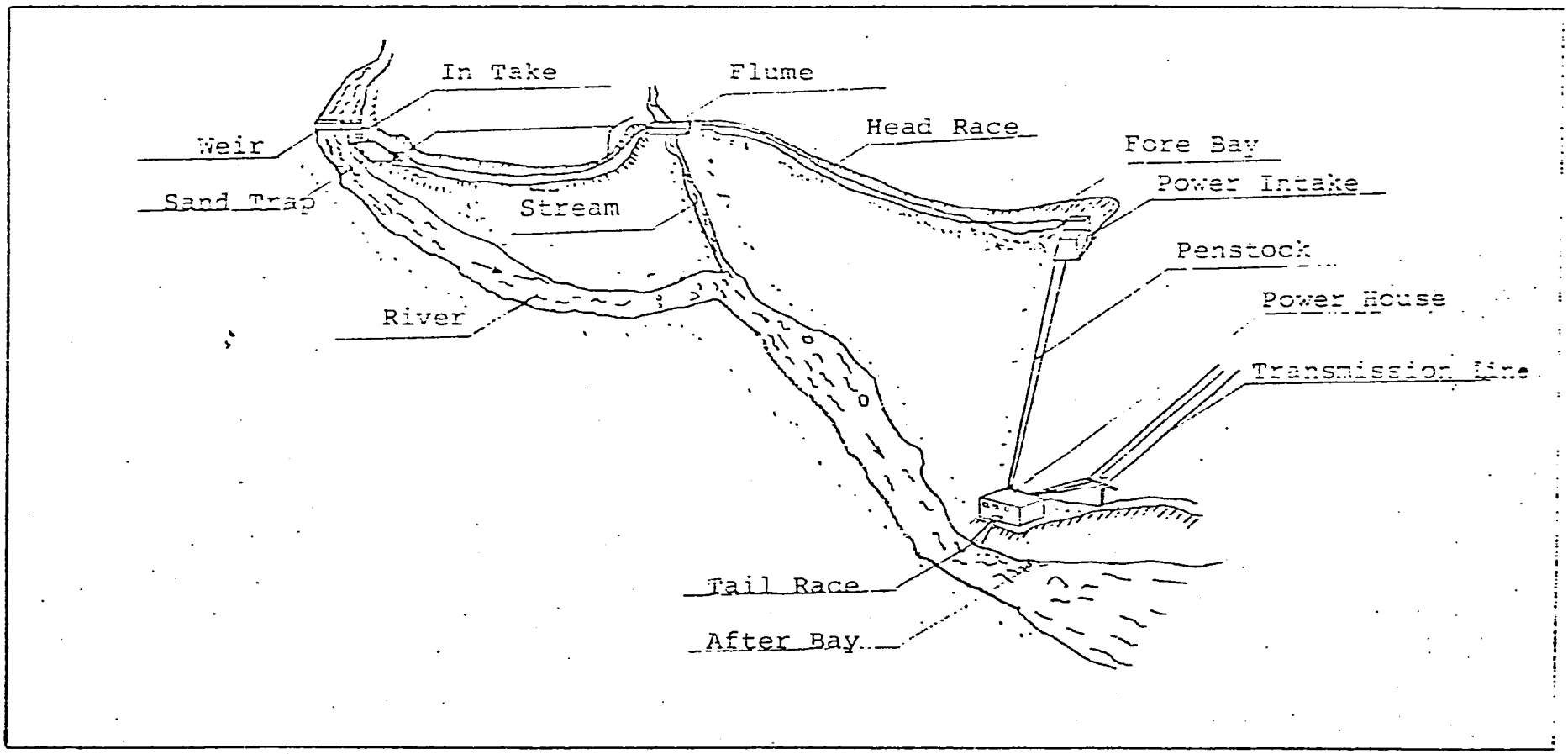
- Power House. The power house encloses the turbine, generator, switchgear, and control equipment.

- Power Plant. The power plant consists of the turbine, generator, control equipment, switchgear, and step-up transformer.

- Distribution. The electrical distribution consists of the lines and structures required to transmit the electrical power from the station transformer to the end users.

The potential power at a site is proportional to the quantity of flow (Q) times the effective head (H). In "run-of-river" schemes the head is constant and the flow varies from day-to-day, season-to-season, and year-to-year. The river flows, as a function of time can be graphically represented by the site flow duration curve. From this curve, three flows are important:

Figure A1 : Sketch of a Representative Project Hydroelectric Power Plant



- Maximum flow - for determining the size of the diversion structure and powerhouse setting.

- Minimum flow - for determining the minimum or firm power capacity of the site.

- Design flow - the flow through the power plant that optimizes the system's cost and benefits. All the civil, mechanical, and electrical components will be based upon this design parameter.

II. Site Selection Methodology

The approach utilized in the feasibility studies and pre-testing studies of the first six sites (first tranche) is noted below. The experience gathered from analysis of the first tranche sites has permitted the PP team, in collaboration with NEA, to develop a simpler, less expensive site selection model (see Annex F) which should reduce selection time while improving accuracy for the second tranche sites. (If successful, NEA has indicated an interest in adapting the model as a standardized requirement of their future site selection).

For the first tranche, selection of various probable locations for small scale hydro development were taken from several sources. These included inventories done by the NEA and Royal Thai Forestry Department, which included estimates of available head and probable minimum dry season flow at various locations throughout Thailand. Additional sites were selected from one to 50,000 scaled maps. All of these sites were also studied on 50,000 maps to give a projection of probable village locations within the area. Armed with this data, NEA and ARD engineers visited some 22 sites with a team of socio-economic specialists to pre-screen engineering and social feasibility. From the select group (including locations in North, East, South and West Thailand) the list was prioritized from an engineering, social and economic standpoint, and the highest ranked sites were selected for further on-site studies. Some sites were dropped from consideration because of lack of adequately detailed topographic and hydrographic information; others were passed over because electric demand or potential electricity demand gave little prospect of economic payout; and still others were postponed for reasons of expediency and/or difficulty of access within the specific time frame allotted for inspections.

Teams of surveyors were then sent to each site to acquire profile information on the length of water course between the probable intake works and tailrace. Topographic surveys were accomplished at the intake power house and tailrace locations. The head race canal works were surveyed and site slops were surveyed to give an indication as to the type of canal (versus pipe) which would best fit the local conditions. Environmental protection was carefully designed into the construction of this portion of the civil works. This data was put on site maps (attached for reference), and a relatively firm cost estimate was projected. These costs are not expected to materially vary except as inflation may affect works between this writing and actual contracting for construction.

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The hydrologic data presented a more difficult task for costing out the units. Low water flows were measured at each of the sites. These were compared with data from gauging stations at the nearest location to give a probable long term minimum flow. These projections are expected to give adequate assurance that electricity can be generated year round at minimum generation projections included in this report. The watersheds of all the proposed installations are relatively stable; and can be expected to be protected, since most of the areas are either on national park lands or downstream on national forest land.

Social and economic data was also gathered in the field for each of the first tranche sites. These details are located in Annex D and E.

It should be emphasized here that preliminary analysis and review of Thailand's rainfall and runoff records indicates that selection of turbine sizes by the usual procedure may not be in the best interests of NEA. This comes about because the periods of high stream flow, in most sites investigated, last from 3-4 months, whereas most US streams, having some upstream storage, maintain a design flow for much longer periods of time - say, 8-9 months, with critical low flows lasting only 3-4 months.

Under such circumstances, selection of turbine capacity at all sites except Mae Hat was based on the longer term period of low flow rather than the 15% exceedance criteria normally used in the US to establish turbine capacity. This results in a much higher overall plant factor than is normally experienced in the USA, even greater in most cases than the 40-50% range relatively common in the north-east sector of USA.

III. Site Description

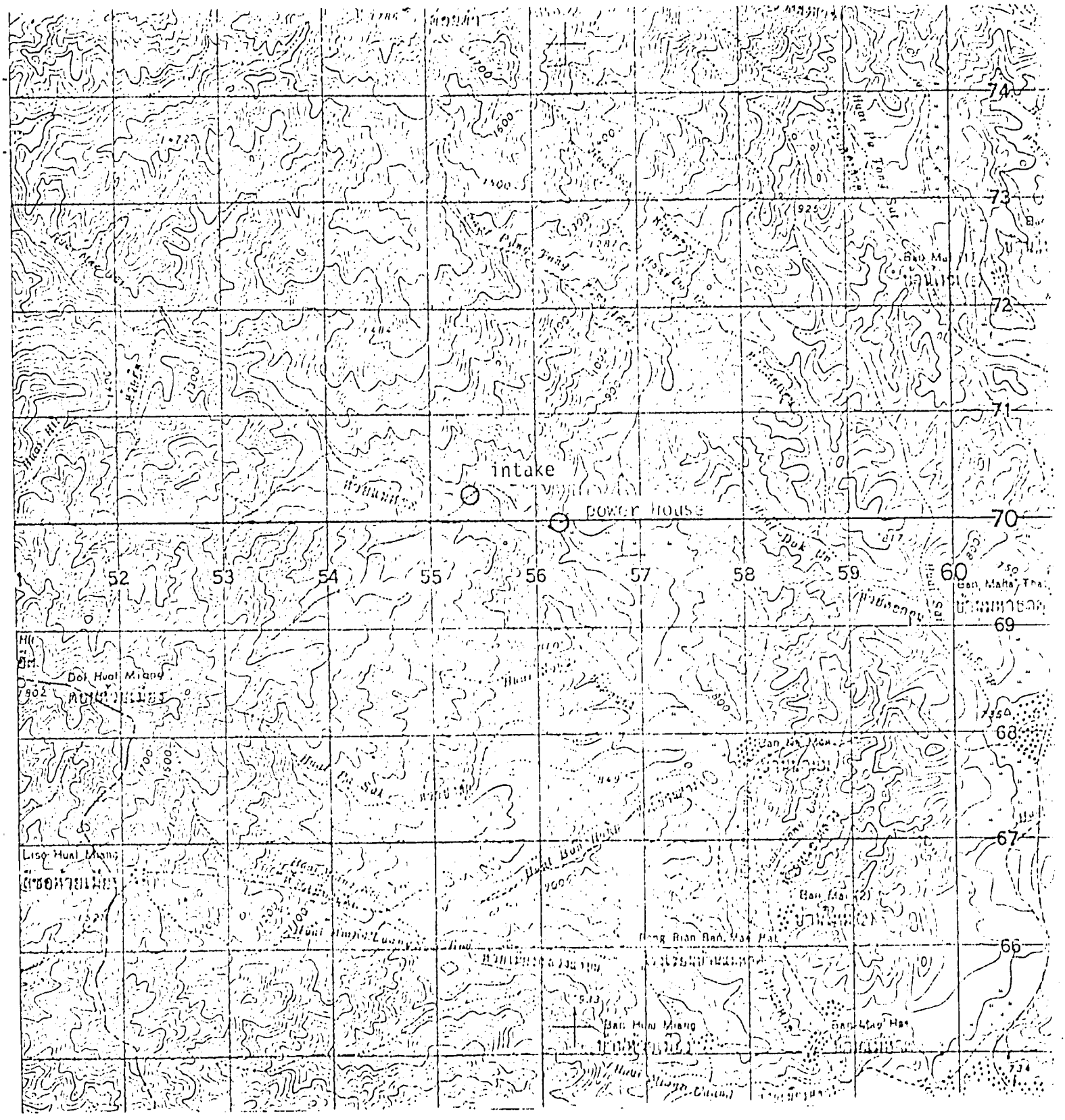
Project layouts for the six sites to be developed in the first phase of the program are shown on Figures A2 through A7 as follows:

Figure A2 - Mae Hat
Figure A3 - Mae Suk
Figure A4 - Mae Aep
Figure A5 - Mae Chon Luang
Figure A6 - Khlong Ta Riu
Figure A7 - Khlong Ra

In addition, detailed analysis of the power potential at each proposed installation was calculated from hydrographic and site data and shown in the following tables:

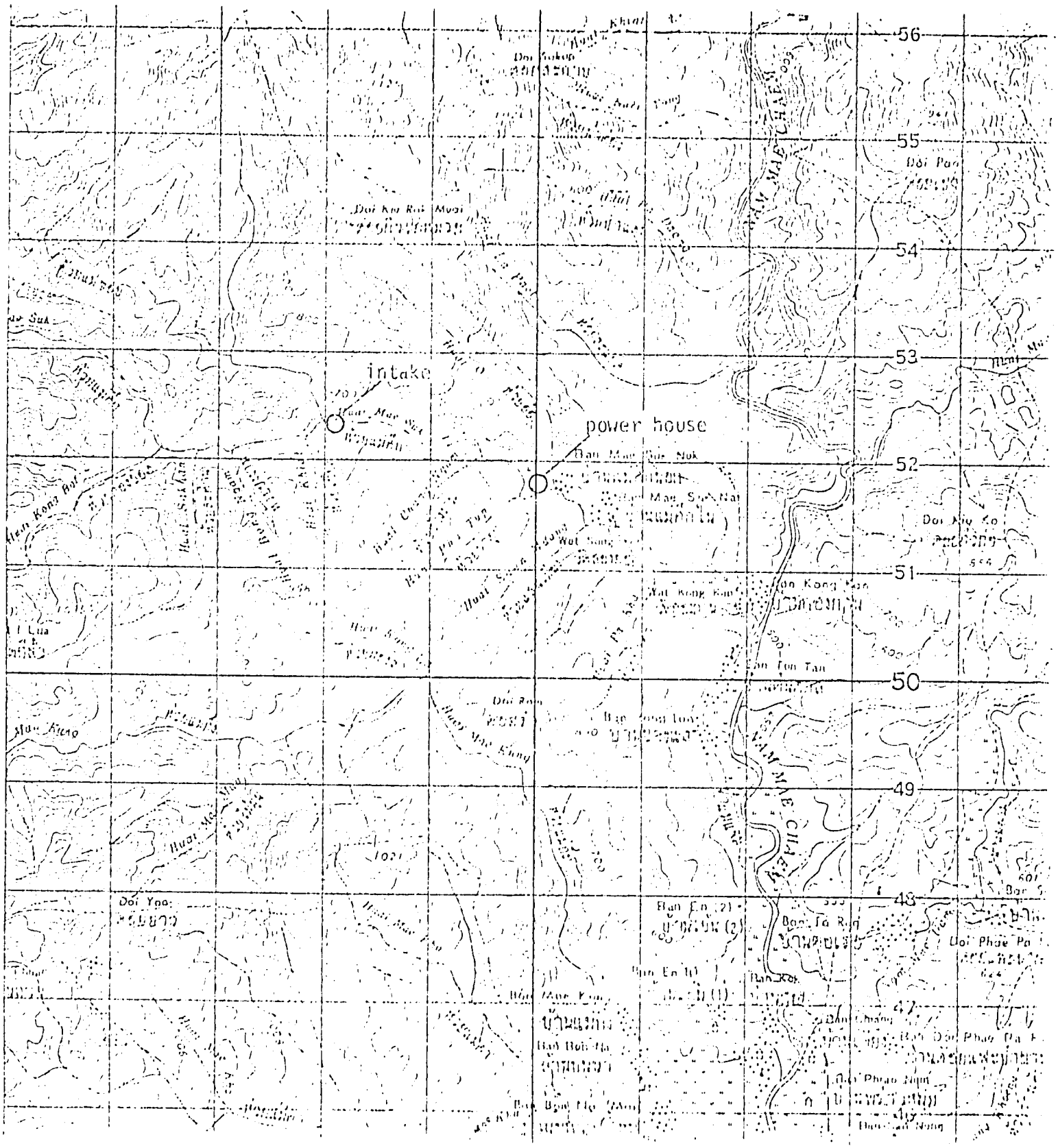
Table A1 - Mae Hat
Table A2 - Mae Suk
Table A3 - Mae Aep
Table A4 - Mae Chon Luang
Table A5 - Khlong Ta Riu
Table A6 - Khlong Ra

FIGURE A2 : MAE HAT SITE



Reference: Sheet 4748 III
1 : 15,000 Scale Map

FIGURE A3 : MAE SUK SITE



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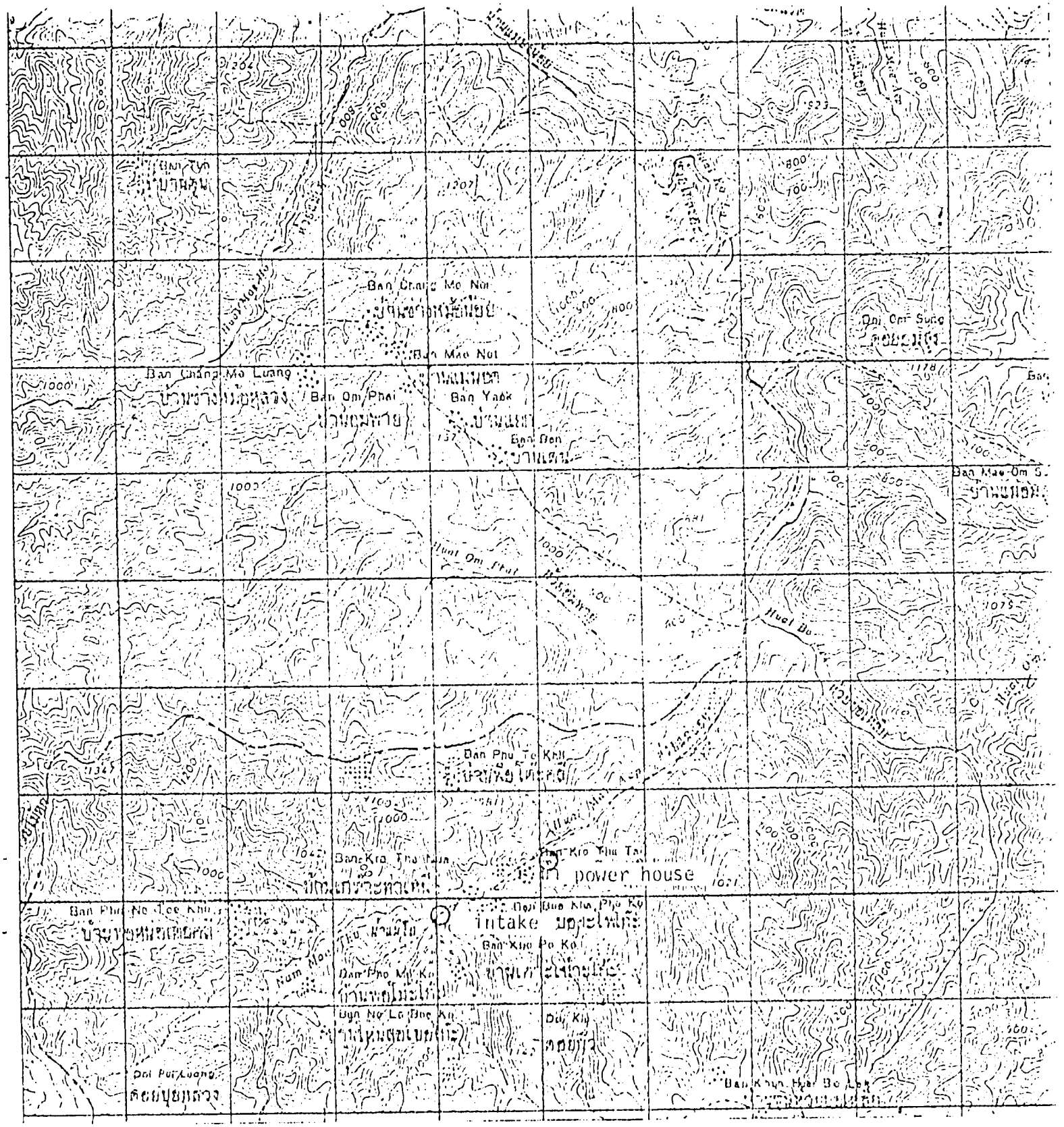
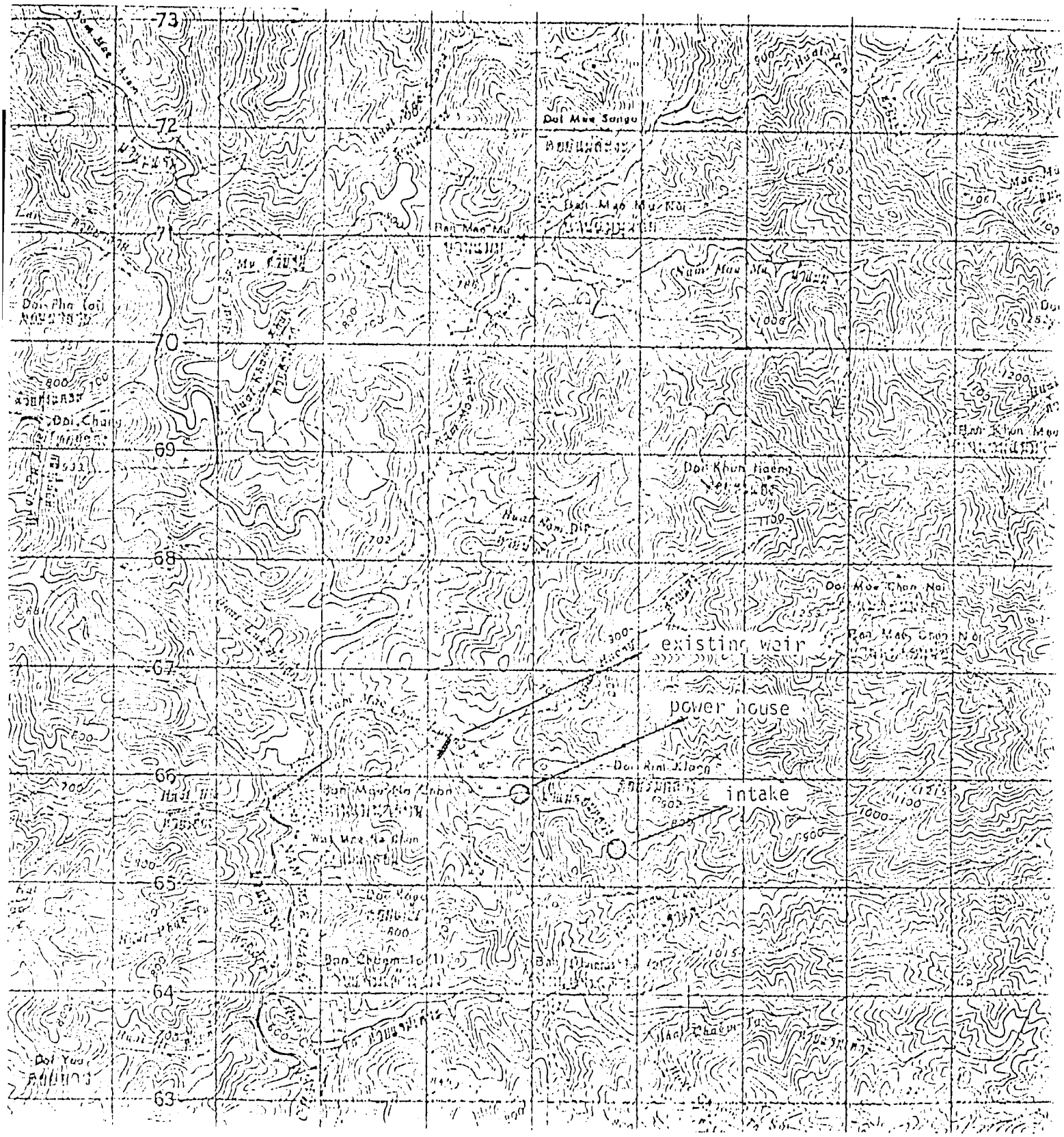
Reference:Sheet 4646 II
1 : 15,000 Scale Map

FIGURE A4 : MAE AEP SITE



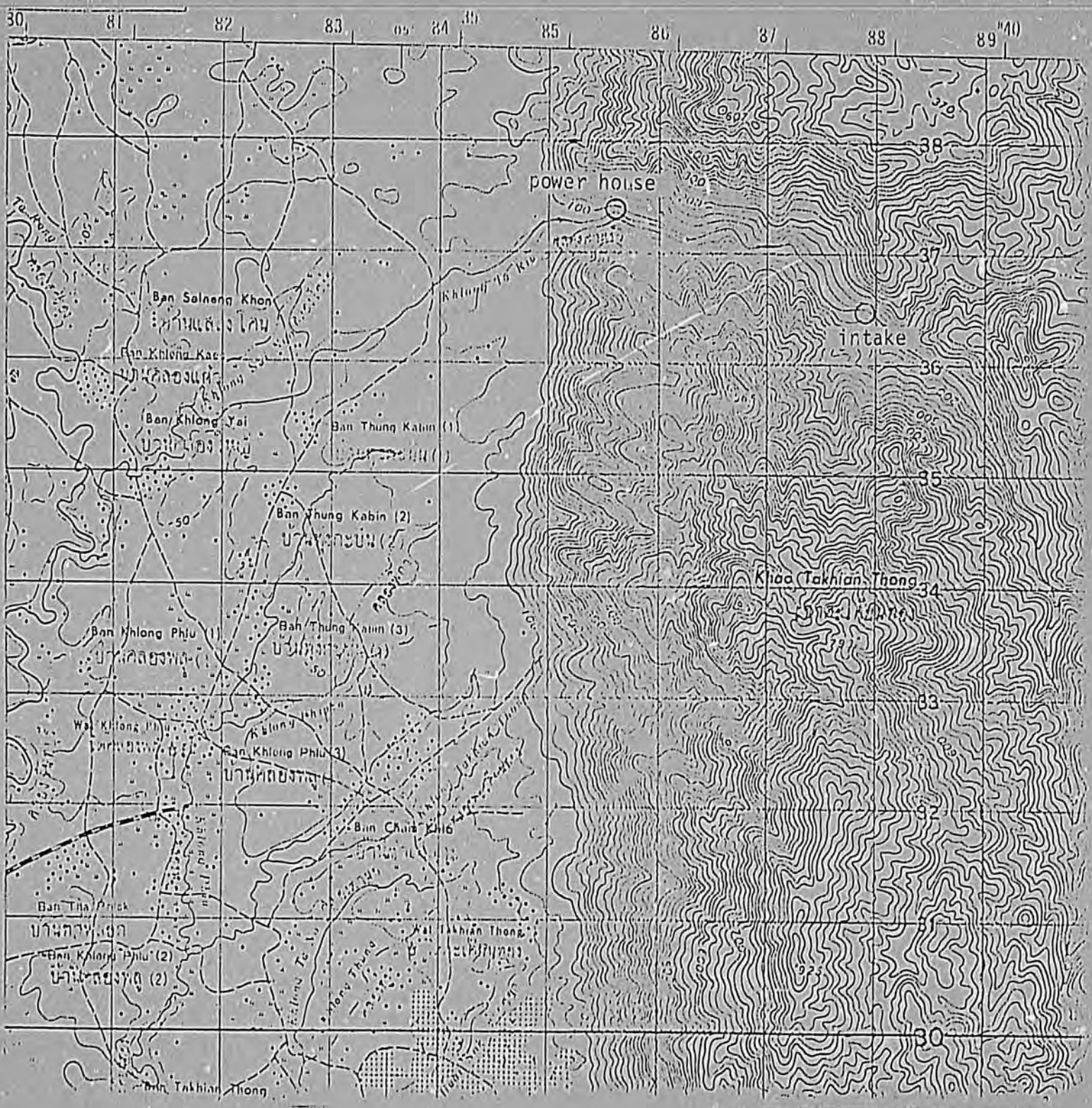
Reference: Sheet 4645 IV
1 : 15,000 Scale Map

FIGURE A5 : MAE CHON LUANG SITE



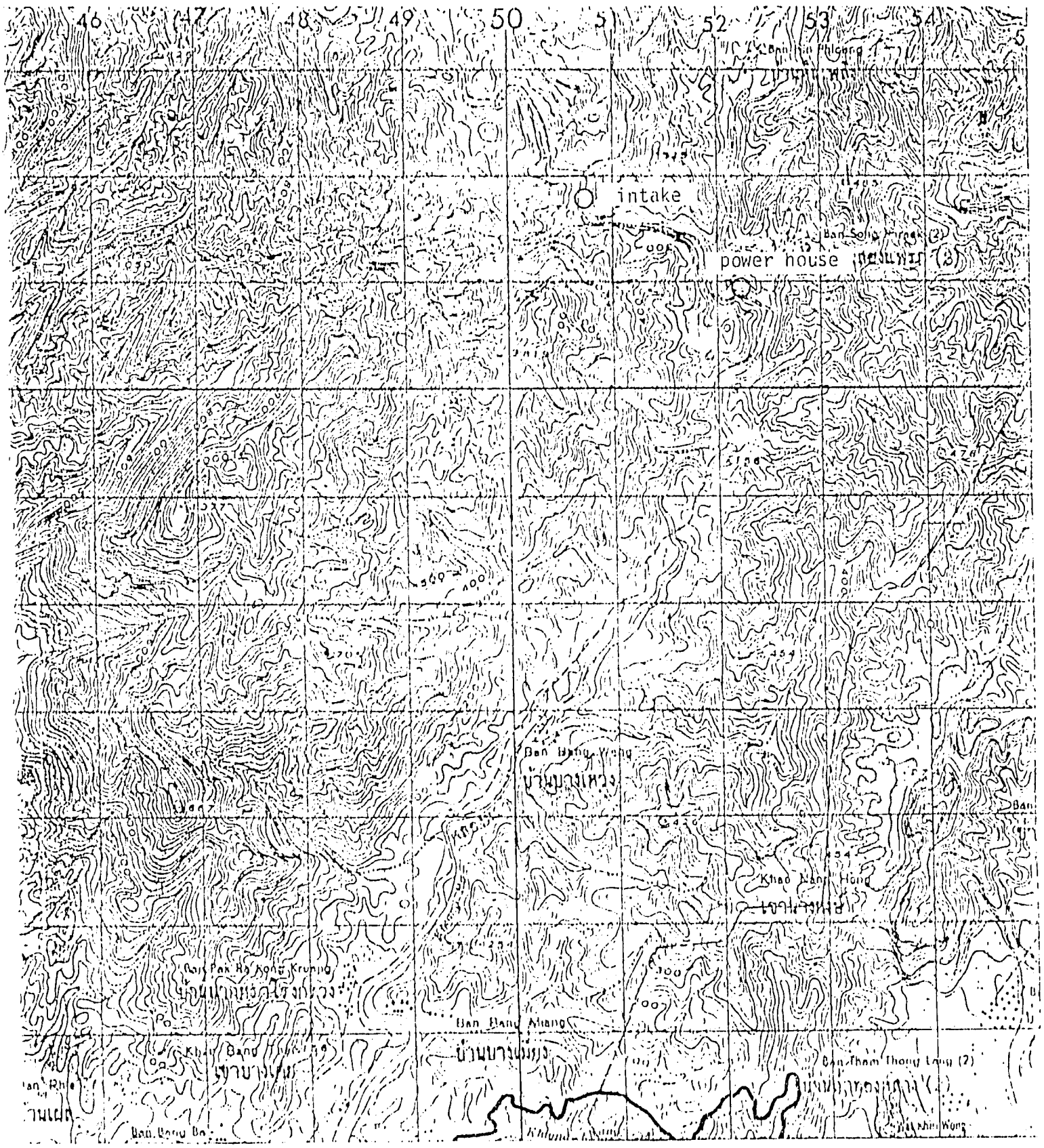
Reference: Sheet 4646 II
1 : 15,000 Scale Map

FIGURE A6 : KHLONG TA KIO SITE



Reference: Sheet 5434 IV
1 : 15,000 Scale Map

FIGURE A7 : KHLONG RA SITE



Reference: Sheet 4726 III
1 : 15,000 Scale Map

Table A1:

POWER AND ENGERY CALCULATIONS

Project No: 1 Project Title: Mae Hat

District: Chiang Dao Province: Chiang Mai

Item No:	Description	Amount	
1	Turbine discharges:		
	Maximum	1520	liters/sec
	Minimum	460	liters/sec
	Design flow, average	620	liters/sec
2	Head:		
	Gross head	109	meters
	Losses	9	meters
	Design head	100	meters
3	Plant Capacity:		
	Installed capacity	440	KW
4	Energy:		
	Average annual energy	1.40×10^6	KWH
	Plant factor	36.3	%
5	Dependable Capacity:		
	Flow, dependable	460	liters/sec
	Head, at dependable flow	100	meters
	Capacity, dependable	325	KW

Table A2:

POWER AND ENGERY CALCULATIONS

Project No: 2 Project Title: Mae Suk

District: Mae Chaem Province: Chiang Mai

Item No:	Description	Amount	
1	Turbine discharges:		
	Maximum	1050	liters/sec
	Minimum	370	liters/sec
	Design flow, average	460	liters/sec
2	Head:		
	Gross head	67	meters
	Losses	5	meters
	Design head	62	meters
3	Plant Capacity:		
	Installed capacity	305	KW
4	Energy:		
	Average annual energy	1.15×10^6	KWH
	Plant factor	43.1	%
5	Dependable Capacity:		
	Flow, dependable	370	liters/sec
	Head, at dependable flow	62	meters
	Capacity, dependable	240	KW

Table A3:

POWER AND ENERGY CALCULATIONS

Project No: 3 Project Title: Mae Aep

District: Hot Province: Chiang Mai

Item No:	Description	Amount	
1	Turbine discharges:		
	Maximum	300	liters/sec
	Minimum	100	liters/sec
	Design flow, average	170	liters/sec
2	Head:		
	Gross head	79	meters
	Losses	4	meters
	Design head	75	meters
3	Plant Capacity:		
	Installed capacity	100	KW
4	Energy:		
	Average annual energy	0.50×10^6	KWH
	Plant factor	56.6	%
5	Dependable Capacity:		
	Flow, dependable	100	liters/sec
	Head, at dependable flow	75	meters
	Capacity, dependable	60	KW

Table A4:

POWER AND ENGERY CALCULATIONS

Project No: 4 Project Title: Mae Chon Luang

District: Mae Chaem Province: Chiang Mai

Item No:	Description	Amount	
1	Turbine discharges:		
	Maximum	300	liters/sec
	Minimum	160	liters/sec
	Design flow, average	230	liters/sec
2	Head:		
	Gross head	77	meters
	Losses	2	meters
	Design head	75	meters
3	Plant Capacity:		
	Installed capacity	100	KW
4	Energy:		
	Average annual energy	0.53×10^6	KWH
	Plant factor	60	%
5	Dependable Capacity:		
	Flow, dependable	160	liters/sec
	Head, at dependable flow	75	meters
	Capacity, dependable	60	KW

Table A5:

POWER AND ENERGY CALCULATIONS

Project No: 5 Project Title: Khlong Ta Riu

District: Makam Province: Chanthaburi

Item No:	Description	Amount	
1	Turbine discharges:		
	Maximum	1000	liters/sec
	Minimum	350	liters/sec
	Design flow, average	455	liters/sec
2	Head:		
	Gross head	55	meters
	Losses	5	meters
	Design head	50	meters
3	Plant Capacity:		
	Installed capacity	145	KW
4	Energy:		
	Average annual energy	0.57×10^6	KWH
	Plant factor	45.1	%
5	Dependable Capacity:		
	Flow, dependable	350	liters/sec
	Head, at dependable flow	50	meters
	Capacity, dependable	115	KW

Table A6:

POWER AND ENGERY CALCULATIONS

Project No: 6 Project Title: Khlong Ra

District: Thap Put Province: Thangnga

Item No:	Description	Amount	
1	Turbine discharges:		
	Maximum	1150	liters/sec
	Minimum	400	liters/sec
	Design flow, average	560	liters/sec
2	Head:		
	Gross head	132	meters
	Losses	7	meters
	Design head	125	meters
3	Plant Capacity:		
	Installed capacity	355	KW
4	Energy:		
	Average annual energy	1.50×10^6	KWH
	Plant factor	48.3	%
5	Dependable Capacity:		
	Flow, dependable	400	liters/sec
	Head, at dependable flow	125	meters
	Capacity, dependable	250	KW

Table A7:

PROJECT DATA SHEET

Project No: 1

Project Title: Mae Hat

District: Chiang Dao

Province: Chiang Mai

General:

Type of plant	Run-of-river
Drainage area	77 km^2

Head data:

Type of diversion	Over flow weir - 5 m high
Elevation at diversion	415 meters
Elevation at tailrace	306 meters
Design head, after losses	99 meters

Waterways:

Intake	Concrete w/gated control & trash rack
Open channel (if required)	1100 meters trapezoidal concrete lined
Pipeline (if required)	-
Forebay	Concrete w/screen & by pass
Penstock	150 cm Ø, 350 meters, steel
Tailrace	80 meters open channel

Power Plant:

Turbines	1-500 hp-horiz Francis
Generators	1-750 kw 220/380 volts
Governor	Mechanical
Powerhouse	5 x 10 meters - concrete block
Total installed capacity	440 kw
Total annual energy	1.40×10^6 kwh
Plant factor	36.3%

Electrical:

Transformers	1-3Ø, 1500 kva, 22 kv
Switchgear	metal clad
Transmission lines	30 Km primary
Distribution lines	8 Km scondary

Special Items:

Access road to site	Needs improvement
Project roads	1½ Km steep sidehill
Special work (if any)	none

Table A8:

PROJECT DATA SHEET

Project No: 2

Project Title: Mae Suk

District: Mae Chaem

Province: Chiang Mai

General:

Type of plant	Run-of-river-daily ponding
Drainage area	85 Km^2

Head data:

Type of diversion	Small dam-center overflow, 8 meters
Elevation at diversion	179 meters
Elevation at tailrace	95 meters
Design head, after losses	62 meters

Waterways:

Intake	Concrete, gated control & trashrack
Open channel (if required)	-
Pipeline (if required)	1.15 m Ø, 2.25 Kms, buried steel
Forebay	Concrete, W/gate, screen & by pass
Penstock	115 cm Ø, 375 meters, steel
Tailrace	20 meters open channel

Power Plant:

Turbines	1-400 hp cross-flow
Generators	1-350 Kw 220/380 volts
Governor	mechanical
Powerhouse	4 x 8 meters concrete block
Total installed capacity	305 Kw
Total annual energy	1.15×10^6 Kwh
Plant factor	43.1%

Electrical:

Transformers	1-3Ø, 1000 Kva 22 Kv
Switchgear	metal clad
Transmission lines	8.5 Km primary
Distribution lines	1.0 Km secondar

Special Items:

Access road to site	Available - needs improvement
Project roads	Existing - repairs necessary
Special work (if any)	Irrigation demand upstrem

Table A9:

PROJECT DATA SHEET

Project No: 3

Project Title: Mae Aep

District: Hot

Province: Chiang Mai

General:

Type of plant	Run-of-river
Drainage area	26 Km^2

Head data:

Type of diversion	Overflow weir, 2 meters
Elevation at diversion	742 meters
Elevation at tailrace	658 meter
Design head, after losses	75 meters

Waterways:

Intake	Concrete gated cnetral w/trashrack
Open channel (if required)	Trapezoidal 2½ Km, concrete lined
Pipeline (if required)	-
Forebay	Concrete, screen, gate & by pass
Penstock	50 cm Ø, 180 meters steel
Tailrace	20 meters open channel

Power Plant:

Turbines	1-140 hp Cross flow
Generators	1-100 KW 220/380 volts
Governor	Mechaniacal
Powerhouse	3 x 7.5 meters - concrete block
Total installed capacity	100 Kw
Total annual energy	0.50 x 10^6 kwh
Plant factor	56.6%

Electrical:

Transformers	1-3Ø, 250 Kva 22 Kv
Switchgear	Metalclad
Transmission lines	2 Km primary
Distribution lines	3 Km secondary

Special Items:

Access road to site	Existing - fair condition
Project roads	2 Kms - average work
Special work (if any)	none

Table A10:

PROJECT DATA SHEET

Project No: 4 Project Title: Mae Chon Luang

District: Mae Chaem Province: Chiang Mai

General:

Type of plant	Run-of-river
Drainage area	19 Km^2

Head data:

Type of diversion	Overflow weir - 2 meters high
Elevation at diversion	730 meters
Elevation at tailrace	657 meters
Design head, after losses	75 meters

Waterways:

Intake	Concrete, gates, 8c trashrack
Open channel (if required)	2.2 Km. trapezoidal, concrete-lined
Pipeline (if required)	
Forebay	Concrete, bypass screen and gate
Penstock	30 cm Ø, 250 meters steel
Tailrace	10 meters open channel

Power Plant:

Turbines	to be determined
Generators	220/380 volts
Governor	Mechanical
Powerhouse	4 x 6 meters concrete block
Total installed capacity	100 Kw
Total annual energy	0.53×10^6 KWH
Plant factor	60

Electrical:

Transformers	1-3Ø 100 KVA 22 Kv
Switchgear	Metalclad
Transmission lines	2 Kms primary
Distribution lines	1 Kms secondary

Special Items:

Access road to site	Farm-needs extension
Project roads	2 Km - average work
Special work (if any)	none

Table A11:

PROJECT DATA SHEET

Project No: 5

Project Title: Khlong Ta Riu

District: Makam

Province: Chanthaburi

General:

Type of plant	Run-of-river w/storage
Drainage area	70 Km^2

Head data:

Type of diversion	Small dam center overflow - 3 m high
Elevation at diversion	135 meters
Elevation at tailrace	80 meters
Design head, after losses	50 meters

Waterways:

Intake	Concrete, trashrack, gated control
Open channel (if required)	2.5 Km. trapezoidal, concrete-lined
Pipeline (if required)	-
Forebay	Concrete, bypass screen and gate
Penstock	80 cm Ø, 250 meters steel
Tailrace	20 meters open channel

Power Plant:

Turbines	1-250 hp - Cross flow
Generators	1-210 Kw 220/380 volts
Governor	Mechanical
Powerhouse	4 x 8 meters, concrete block
Total installed capacity	145 Kw
Total annual energy	0.57 x 10^6 Kwh
Plant factor	45.1%

Electrical:

Transformers	1-3Ø 400 Kva 22 Kv
Switchgear	Metalclad
Transmission lines	7.0 Kms primary
Distribution lines	6.0 Kms secondary

Special Items:

Access road to site	All-weather-needs extension
Project roads	3.0 Kms - steel, rock slopes
Special work (if any)	None

Table A12:

PROJECT DATA SHEET

Project No: 6 Project Title: Khlong Ra

District: Thap Put Province: Phangnga

General:

Type of plant	Run-of-river
Drainage area	90 Km^2

Head data:

Type of diversion	Overflow weir-5 meters high
Elevation at diversion	305 meters
Elevation at tailrace	178 meters
Design head, after losses	125 meters

Waterways:

Intake	Concrete, w/gates, trashrack
Open channel (if required)	-
Pipeline (if required)	1.0 m Ø, 2 Kms long - buried steel
Forebay	Concrete, screen and bypass
Penstock	1.0 meters Ø, 200 meters steel
Tailrace	20 meters open channel

Power Plant:

Turbines	1-450 hp - Impulse, horiz
Generators	1 x 600 Kw 220/380 Volts
Governor	Mechanical
Powerhouse	5 x 10 meters, concrete block
Total installed capacity	355 Kw
Total annual energy	1.50×10^6 Kwh
Plant factor	48.8

Electrical:

Transformers	1-3Ø, 1500 Kva 33 Kv
Switchgear	Metalclad
Transmission lines	5.0 Kms primary
Distribution lines	2.0 Kms secondary

Special Items:

Access road to site	Existing - OK, all-weather
Project roads	2.0 Kms - rocky canyon
Special work (if any)	None

Table A13: Salient Physical Characteristics of Tranche One Sites

ITEM	1 MAE HAT	2 MAE SUK	3 MAE AEP	4 MAE CHON LUANG	5 KHLONG TA RIU	6 KHLONG RA
Catchment Area	72 KM^2	85 KM^2	26 KM^2	21 KM^2	38 KM^2	23 KM^2
Design Flow	0.62 CMS	0.46 CMS	0.17 CMS	0.23 CMS	0.46 CMS	0.56 CMS
Headrace	Concrete Pipe 1700 M	Concrete Pipe 2300 M	Canal 2800 M	Canal 1300 M	Concrete Pipe 3000 M	Concrete Pipe 1700 M
Penstock	380 M	350 M	250 M	250 M	300 M	280 M
Transmission Line	22 KM	9 KM	7 KM	9.5 KM	11 KM	6 KM
Installed Capacity	440 KW	305 KW	100 KW	100 KW	145 KW	355 KW
Effective Head	100 M	62 M	75 M	75 M	50 M	125 M

Source: Singh Mohar: "Planning of Mini/Micro Hydropower Projects in Thailand" NEA, June 1981.

Table A14: Project Cost Recapitulation ($US , June 1981 Prices)

	ITEM	MAE HAT	MAE SUK	MAE AEP	MAE CHON LUANG	KHLONG TA RIU	KHLONG RA
					(Stage 1) 50 KW		
1	Headwork	36,150	36,150	24,100	24,100	26,500	26,500
2	Headrace	85,000	195,500	60,500	31,100	165,000	116,850
3	Forebay	15,000	15,000	10,000	10,000	10,000	10,000
4	Penstock	99,750	91,900	28,750	28,750	52,500	73,500
5	Power House	15,000	15,000	12,000	12,000	12,000	15,000
6	Power Plant	178,900	149,050	49,700	24,850	75,000	194,150
7	Trans/Distrib.	220,000	90,000	38,500	19,250	66,000	60,500
8	Road	40,000	20,000	10,000	20,000	10,000	10,000
9	Sub-Total	689,800	612,600	233,550	170,050	417,000	506,500
10	Contingencies (15%)	103,450	91,900	35,030	25,500	62,550	75,950
11	Eng & Adm (10%)	69,000	61,250	23,350	17,000	41,700	50,650
12	Total Cost	862,250	765,750	291,930	212,550	521,250	633,100
					(Stage 2) 50 KW		
	Plant Capacity	440 KW	305 KW	100 KW		145 KW	355 KW
	Cost/KW (US $)	1,960	2,511	2,920		3,595	1,784
13	Power Plant				24,850		
14	Distribution				33,000		
15	Contingency, Eng & Adm				14,500		
	Total Cost				284,900		
	Cost/KW (US $)				2,849		

Source: Singh Mohar: "Planning of Mini/Micro Hydropower Projects in Thailand" NEA, June 1981.

Overall project data sheets were then prepared to show the physical characteristics at each site, and the amount of electric power, both in KW of installed capacity and KWH of electric energy to be developed. This data is summarized on separate project data sheets as follows:

Table A7 - Mae Hat
Table A8 - Mae Suk
Table A9 - Mae Aep
Table A10 - Mae Chon Luang
Table A11 - Khlong Ta Riu
Table A12 - Khlong Ra

The salient features of all six sites are recapitulated, for references, in Table A13.

Using the site layouts from the topographic map data, the Power and Energy calculations, and the Project data sheets for reference, estimates of Cost were prepared for each site, and are recapitulated in Table A14.

IV. Power Plant Analysis

A. Background: Generation of electric power and energy in the United States dates back to the days of the so-called Industrial Revolution of the mid-1800's. Water wheels, though extensively used for various mill projects, were relatively slow speed, undershot or overshot and used to lift water, drive grinding wheels or other machinery for processing raw materials to usable products. Soon after development of commercial electric generators, numerous innovators coupled water wheels to generators for development of power as a more convenient and economic way to transmit power to machinery remote from the generator. In a short time, as technological research and practical experience accumulated, more sophisticated water wheels were developed, and were known as water turbines. In this general category, the net head available to the turbine runner dictates the type of turbine suitable for a particular installation, and the rate of flow expected through the turbine determines its capacity. When the two basic characteristics are combined in multiplication, with a factor, power is developed.

In general, hydraulic turbines have two classifications: either impulse or reaction. The reaction type of turbine is the most widely used class of turbine, but is not as efficient as an impulse turbine at high heads, generally over about 60-70 meters. And this is especially true in the small-sized units usually available for mini/micro hydro installations.

Reaction turbines are classed as Francis (mixed flow), or Propeller (axial flow). Propeller turbines are available with both fixed blades and variable pitch blades (Kaplan). Both classes, Francis as well as Propeller, can be mounted either horizontally or vertically; propeller units can be slant mounted

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Figure A8: Typical Turbine Installations

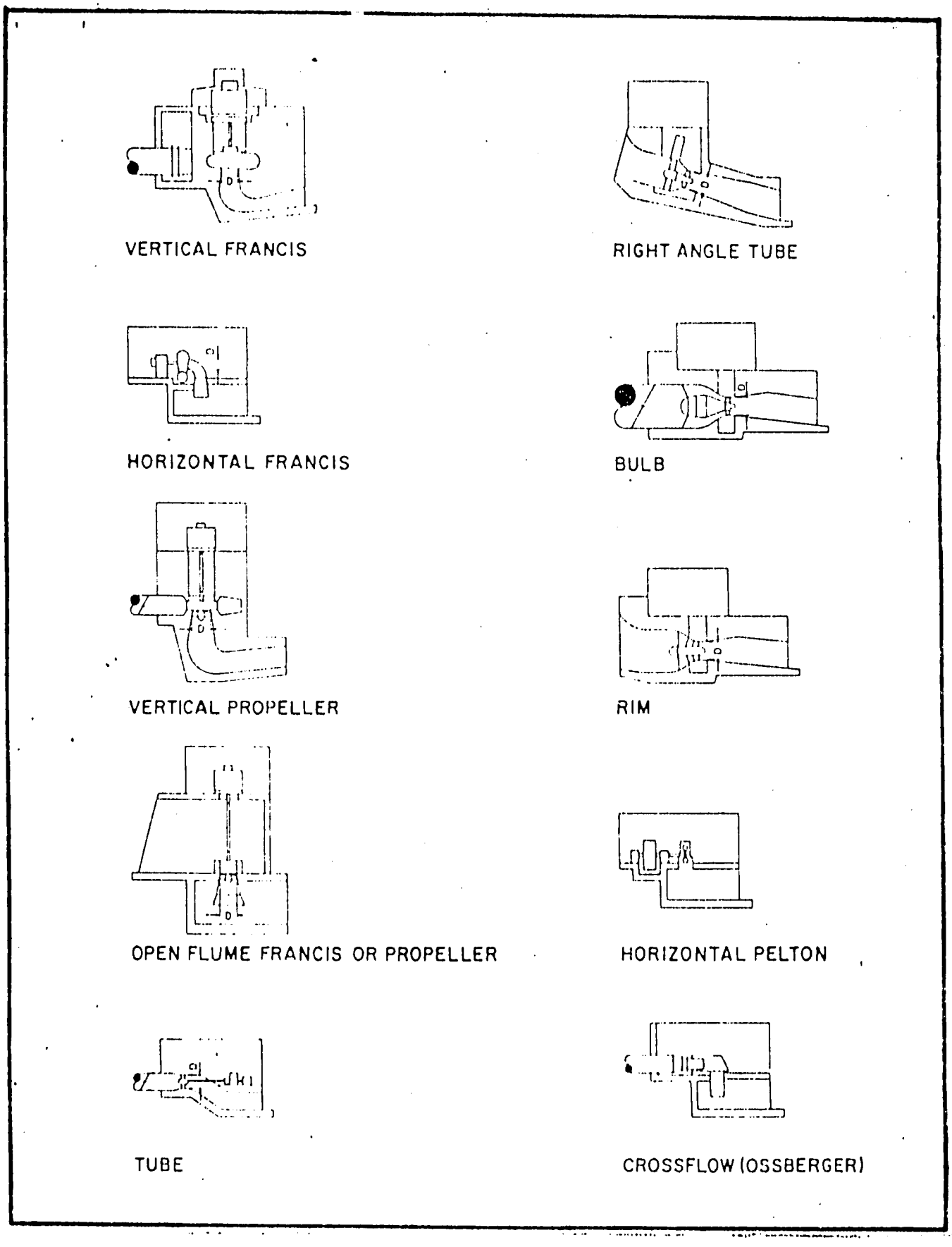
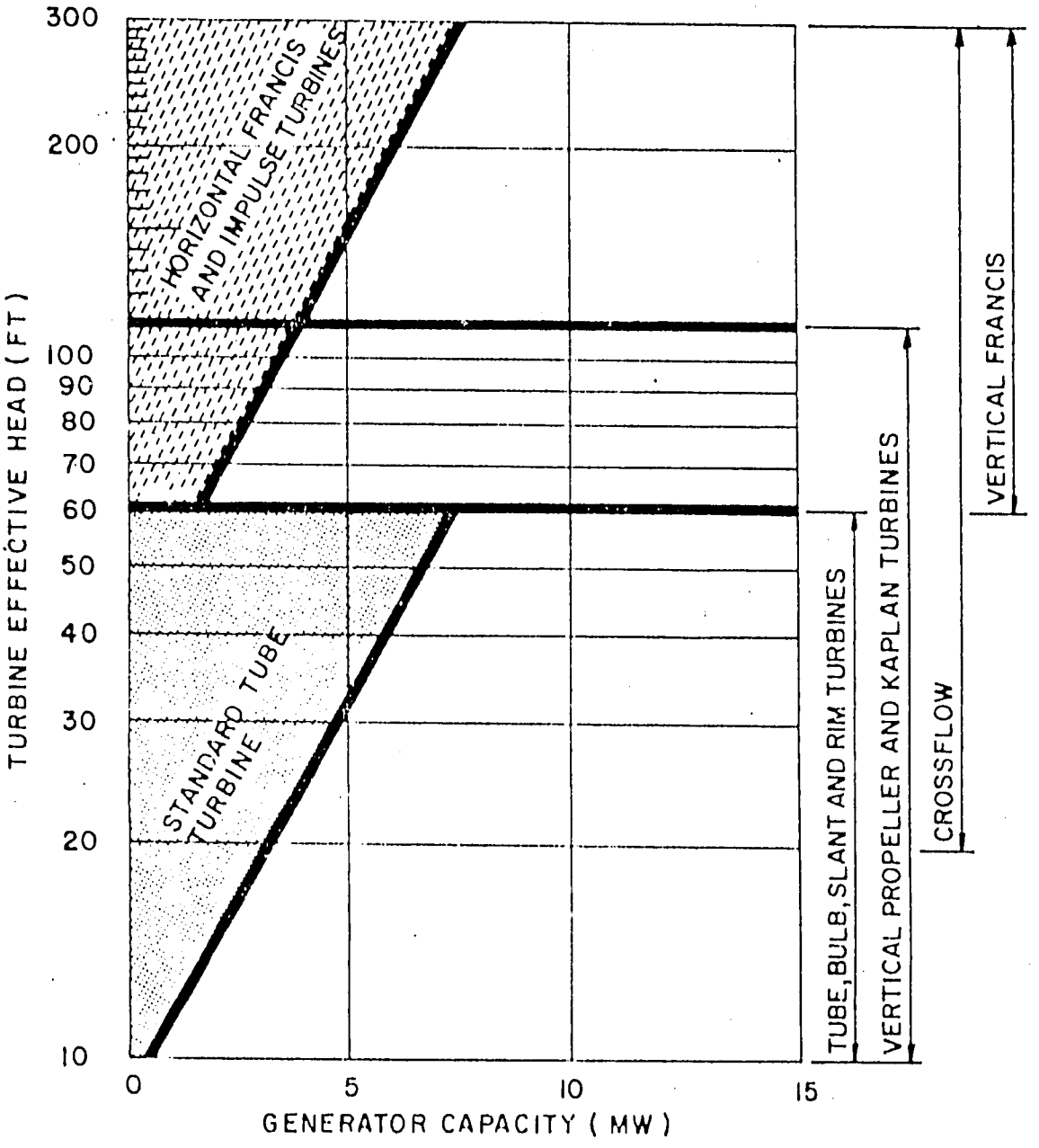


Figure A9: Usual Turbine Operation Ranges



also, and are divided further into Bulk, Tube or Rim subclasses, none of which are efficient or are used in high head installations over 20-30 meters. Vertical Francis units in large capacities have been installed in heads over 60-70 meters, but small sized vertical Francis units have found acceptance only at low heads, usually under 15-20 meters.

In addition to the generalities cited above, there are two proprietary turbines in common use on small scale hydro plants; they are the Ossberger, or Cross Flow turbine, and the Straflo, or Rim turbine. The Straflo turbine (a manufacturer's modification on a tube turbine), is limited to low head installations, whereas the Ossberger unit is suitable and reasonably efficient at high heads, especially under relatively constant heads. Figure A8 herewith illustrates in cross-section the various types and classes of turbine in typical installations. Figure A9 reflects a generalized interpretation of the usual turbine operating ranges. It demonstrates that, in accordance with normal practice, installations with normal operating heads over about 30 meters and under about 5 MW capacity are limited to use of horizontal Francis, impulse or cross-flow turbines.

Thailand is presently manufacturing their own cross-flow turbines at a much lower cost than they can import foreign turbines. However, the application range for cross-flow turbines is not well known. Notice that Figure 3 does not include cross-flow turbines. The history of cross-flow turbines has many success stories of installations that have operated for decades, and disaster stories of units that were developed and destroyed within months.

NEA has installed and operated their cross-flow turbines successfully. One of the purposes of this project should be, therefore, to expand the number of Thai turbines installed, and compare their operation against imported turbines.

As a result of reconnaissance in the field, and discussions with NEA representatives, who are advocating heads above 30 meters at all proposed sites, it is apparent that for mini/micro installations under 1 MW (the upper limit of capacity by definition), only impulse or cross-flow turbines are recommended, though in special circumstances, a horizontal Francis unit may warrant consideration.

B. Manufacturing Capabilities

1. U.S. Source. Part of the purpose of AID's program for furnishing technical and financial assistance to the RTG selected agency to install small-scale hydro units is to demonstrate the apparent superior efficiency of US-manufactured equipment. If successful, this would warrant further purchase by agencies of RTG from US supplies.

However, as a result of low petroleum product prices in the USA and the impetus for generation of electric energy by nuclear-fueled plants, the turbine manufacturing industry after World War II declined both in number of manufacturers and number of units manufactured.

From 1950 through the early sixties, there were only three recognized water turbine manufacturers in the USA.

1. S. Morgan Smith, makers of high quality and the most efficient turbines.

2. Allis Chalmers, widely accepted maker, and a close competitor to S. Morgan Smith.

3. James Leffel and Co., recognized as a long time participant in the field, but more or less stodgy in approach, and conservative in research or innovation.

Recently, however, as oil prices have skyrocketed and intensive searches were instituted for alternate sources of generating electric energy, the turbine manufacturing industry has undergone major changes.

First, Allis Chalmers bought out S. Morgan Smith, not only to eliminate a competitor, but to capitalize on the technical expertise and capability of S. Morgan Smith and the upsurge in markets of big hydro installations, mostly foreign and mainly in South America.

Second, during 1980, Tempalla of Sweden, in joint venture with Bofors, also a Swedish conglomerate, purchased James Leffel and Co. in order to gain access to the American market, and a tremendous stock of old patterns, molds and engineering data, compiled by Leffel over the past 100 years.

Third, many small manufacturers have started up in business in the United States, fabricating units on a custom order basis in the mini/micro field. Some of these, but not all, certainly, include:

1. Bell Hydropower, Cooperstown, New York - small cross-flow turbines.
2. Independent Power Developers, Sandpoint, Idaho - small impulse and propeller turbines.
3. Small Hydro-electric Systems, Custer, Washington - small impulse turbines.
4. Siemens-Allis, Atlanta, Georgia - bulb turbines only.

The first four are, or at least were, quite small, with limited capitalization and rely on firm orders before initiating any work. The fifth is an attempt by the German firms of Siemens, in association with Allis (a generator manufacturer) to work in the small scale hydro program in the US, in the 5-15 MW range - all low-head units.

To summarize briefly, present capability for manufacture of small scale hydro units seems to fall into two distinct categories:

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(a) By US standards, small hydro covers the range from about 1 to 15 MW in capacity, with large rates of flow under low heads, requiring Tube, Bulb, Rim or vertical Francis turbines.

(b) Mini-scale hydro is limited to relatively high head units having very low flows in the 5 to 50 KW range of capacity mostly using impulse turbines.

It must be considered significant that for the present, no manufacturer in the US is currently producing a cross-flow turbine. Most Ossberger, or cross-flow units in the US are manufactured by F.W.E. Stapenhorst, Inc., of PE Claire, Quebec, Canada.

The relative unavailability of high-head low capacity turbines as contemplated for Thailand is emphasized by the fact that Allis Chalmers, in attempting to be competitive in this field, advocates the use of standard centrifugal pumps for such purposes. The incentive for such advocacy stems from the proven circumstance that there are many pump manufacturers in the USA, competition is stiff, and hence machinery prices are low. Admittedly, efficiencies are low, but can be improved by use of stay ring inserts, stay vanes to provide a means of adjusting turbine output, addition of flow control devices to minimize turbulence. Needless to say, such modifications, including use of a turbine runner instead of a standard pump impeller, add measurably to cost. Since prototype installations are few, and have not proven entirely satisfactory, use of centrifugal pumps after modification is not considered acceptable in Thailand.

2. Thailand Source. In order to ascertain capabilities of manufacture by local Thai companies, turbine and generator manufacturers in Thailand were surveyed. In addition, site visits were made to two small mini/micro sites where NEA has installed hydro generation facilities: the first a 12.5 KW unit with a locally designed and built cross-flow turbine, belt driven speed increaser, and a Chinese (PRC) generator, operating under the low head of 5.6m; a water ballast regulating governor is used. The second, a proposed two-unit plant, has only one unit currently installed, (50 KW capacity), with a locally-produced cross-flow turbine driving an Italian generator through an oil-immersed chain-driver speed increaser and a German-made governor.

Specifically, visits were made to the shop of a turbine and penstock fabricator in Chiang Mai, who fabricated equipment for both present installations, to other machine shops in the Bangkok area, and to a generator builder in Bangkok working to British standard specifications from German designs. As a result of these inspections it is apparent that capabilities for local manufacture of most components of small-scale micro/mini hydro-electric installations in the high head range (over 30 meters) and capacities under 100 kva do exist in Thailand, and should be utilized in NEA's program. Both cross-flow and impulse turbines can be fabricated here in the small horsepower range, though actual

installation of an impulse turbine on a prototype basis has not yet been accomplished. Though NEA has chosen to utilize foreign made generators because of extremely low price, AID's consultants satisfied themselves that the Bangkok manufacturer builds a superior generator with operating characteristics and repairability features parallel to US standards.

b) Speed increasers - In the case of low capacity impulse or cross-flow turbines, it is usually necessary to increase the speed of the turbine to 50 cycle synchronous speed, with belt driven (either V-belt or flat belt), chain drive, gear drive or eccentric friction drives being used to achieve this purpose. As discussed above, belt driven and oil-immersed chain drives have been used by NEA in present installations. NEA has proposed the use of automobile or truck transmissions to increase turbine speed to generator requirements on the larger sized units, whether in isolated areas or in those locations where connection to either the national grid or the PEA local grid is contemplated. In the consultants' judgment, use of auto or truck transmissions for increasing speed constitutes a weak link in the chain of hydro-electric machinery, inasmuch as continuous operation on a 24-hour basis imposes unaccustomed loads and unanticipated design and engineering parameters on auto and truck transmissions, which are subject to intermittent rather than continuous operating loads. For example, 8,760 hours per year, continuously, even at an average speed of 50 km/hr, would be equivalent to more than 400,000 km/yr - which is extremely unrealistic. It is prudent, then, for Thai industry to initiate design and engineering production of speed-increasing gears, such as Falk or Milwaukee of US origin. Facilities for such production appear to be available in Thailand, and fabrication should impose no problem, once firm orders are placed.

c) Governors - Analysis by AID's consultants has indicated that wholly local made, 100% mechanical, governors are adequate to meet present NEA requirements, and with adequate consideration during design for frequency and voltage regulation, as well as droop, will suffice for later interconnection to the National (EGAT) or PEA grids, though some modification may be necessary at the time of interconnection, to meet more stringent requirements of these authorities.

Under these assumptions, local manufacture of governors is possible, and should be encouraged for adaptation to the AID-sponsored micro/mini hydro program.

d) Transformers - Local facilities for fabrication of transformers in all necessary sizes, either single or three phase, already exist, and no unusual problems are apparent in adopting local facilities for manufacture of transformers in the range of sizes expected for use in NEA's small hydro program.

c. Conclusions on The Sector - In summary, then, with some care in design and careful fabrication of sensitive parts and equipment, it is believed safe to assume that all components of small scale, high head, low capacity hydro-electric units can be manufactured locally in Thailand, with the proviso that such fabrication and/or manufacture of turbines be limited to cross-flow and impulse turbines - in view of the fact that: a) the heads contemplated by NEA are high, and b) no reaction-type turbine, either Francis or Propeller type, has yet been designed or built in Thailand. Potential installation of either Francis or Propeller type turbines in Thailand in the umbrella of NEA's program for small-scale hydro is believed to be extremely limited, and may never occur.

It is suggested that the USAID project promote the following activities in relation to power plant development and procurement:

-- A thorough overview of Thai power plant manufacturing potential be untaken for NEA by a qualified Thai or U.S. specialist. That overview should include specific suggestions for reasonable encouragement of local development, to be funded by, or at least coordinated under, the project.

-- Competition for procurement of all project-funded power plants should be opened to both U.S. and Thai (and eventually Code 941) sources, with an understanding that RTG and AID intent is to both favor indigenous productive capabilities (probably smaller size cross-flow systems) and encourage U.S.-manufacturer interest in the Thai market (probably larger size Francis or Pelton systems). This competition should be viewed as beneficial for both countries, affording useful comparisons of local and imported technology and potentially stimulating sectoral cooperation (e.g., joint-venture agreements), which could reduce costs and facilitate a rapid transfer of technological knowledge to Thailand through the private sector.

V. Demand Analysis

A. Project Demand Forecasting

The methodology used in preparing the estimate of customers was from the Census records of the Province and District to determine the population in the service area. A population growth rate of 3% was utilized to determine the estimated population at year 5 and 10.

The number of dwellings in each area was available with the above data and each area varied in the members/dwelling. This same factor was used to determine dwellings for year 5 and 10.

The number of customers for years 1, 5 and 10 was estimated to be 50% at Year 1, 65% at Year 5, and 90% at Year 10 of the corresponding number of dwellings.

The number of small and medium business customers was estimated by reviewing the results of on site village interviews and consideration of the economic status of the area. Within the classification of small business it would contain stores, restaurants, dressmaking establishments, and rice mills. In the classification of medium business such things as cottage industry, small irrigation pumps, large rice mills, sawmills and tapioca crushing equipment. The following were the initial and projections for the classifications:

Project	Business Customers			
	Small		Medium	
#1 Mae Hat	24	1	5	10
#2 Mae Suk	32	1	2	3
#3 Mae Aep	28	2	3	4
#4 Mae Chon Luang				
#5 Khlong Ta Riu	32	1	1	2
#6 Khlong Ra	20	1	2	2

The KWH/month consumption of the proposed customers was assumed to be 16 KWH/mo. for 5 of the 6 sites and 24/KWH/mo. for Mae Hat project. The basis for the higher assumption in the Mae Hat area was the higher costs of petroleum products due to transportation charges and the prosperity of the isolated valley. Three scenarios were prepared utilizing a 5%, 7.5% and 10% growth in KWH consumption. The following is an analysis of the PEA electric system's growth in KWH for the (1970-79) period.

Table A15:

Analysis of Load Growth by Consumer - PEA

		PEA 1970	1975	1979
Residential		470,584	768,160	1,542,303
Growth	%		10.30%	12.60%
Monthly Growth	KWH	42.7	59.4	63.6
	%		6.82%	4.53%
Small Business		5,228	8,455	22,166
Growth	%		10.09%	17.41%
Monthly Growth	KWH	2,115	3,072	2,989
	%		7.75%	3.92%
General Business		216	497	954
Growth	%		18.14%	17.94%
Monthly Growth	KWH	47,261	49,799	56,796
	%		1.01%	1.47%
Medium Business		12	67	106
Growth	%		41.05%	27.39%
Monthly Growth	KWH	290,028	235,572	283,019
	%		(4.07%)	(0.27%)

2/

Analysis of KWH Growth

The residential consumer on the MEA system has had a growth rate of 4.25% (1970-79) using 224 KWH/mo. in 1979, compared to the same classification on the PEA system the growth rate is 4.53% (1970-79) using 63.6 KWH/mo. This is a reasonable result taking into the difference of the levels of consumption as the MEA user is 3.5 times more. A proposed growth rate for the small isolated units will be 5.0%, with two additional scenarios at 7.5% and 10%.

The Small Business consumer on the MEA system had a growth rate of 5.90% (1970-79) using 804 KWH/Mo. compared to some classification on the PEA a growth rate of 3.92% using 2,989 KWH/Mo. The difference in level indicates a classification of combined rates in the two systems. A proposed growth rate for Small Business is assumed to be 5.00%, with consideration given to the same scenarios at 7.5% and 10%.

The estimated demand of each project area was determined by utilizing the so-called "A" and "B" factors from REA Bulletin 45-2. These factors were derived by plotting KHW/mo./KW versus consumers for actual field measurements and the following eequations derived:

Factor A

$$\text{Factor "A"} = C\ (1-0.4C + 0.4\ (C^2 + 40)^{\frac{1}{2}})$$

where C = number of consumers

Factor B

$$\text{Factor "B"} = 0.005925\ (\text{KWH/mo/consumer})^{0.885}$$

Demand = Factor "A" x Factor "B" in KW

In determing the value of factor "B" the avg/kwh/month was calculated by utilizing the total kwh sold/month and dividing this figure by estimated users for the project for the corresponding year. The formula takes into consideration the system lossess.

The annual load factor was determined by utilzing the estimated demand for each site by year.

A recapitulation of individual site demand is presented in Tables A16 through A23, for reference. Population base data was drawn from the Social Analysis undertaken by the PP Team.

Table A16: SUMMARY OF VILLAGE POPULATION AND ESTIMATED NUMBER OF USERS

Project	District	Province	Villages	Population 1981	Population 1985	Population 1990	Est. Dwellings 1981	Est. Dwellings 1985	Est. Dwellings 1990	Est. Users 1981	Est. Users 1985	Est. Users 1990
#1 Mae Hat	Chiang Dao	Chiang Mai	6	5398	6075	7043	1503	1692	1961	752	1099	1765
#2 Mae Suk	Mae Chaem	Chiang Mai	8	5351	6023	6982	702	790	916	351	513	824
#3 Mae Rep	Hot	Chiang Mai	7	4069	4580	5309	772	869	1007	386	564	906
#4 Mae Chon Luang	Mae Chaem	Chiang Mai										
#5 Khlong Ta Riu	Makhum	Chanthaburi	16	5703	6419	7441	883	994	1152	442	645	1037
#6 Khlong Ra	Thap Put	Phangnga	8	5125	5768	6687	867	976	1131	434	634	1018

Table A 17:

Estimated kwh Requirements and Sales

Mae Hat

Site #1

Proposed Rural Village System	Year Ending 1	5	10
Residential Customers	727	1,066	1,719
Avg kwh/mo.	24	29	37
kwh/month	17,448	30,914	63,603
Small Business Customers	24	31	43
Avg kwh/mo	240	292	372
kwh/month	5,760	9,052	15,996
Medium Business Customers	1	2	3
Avg kwh/mo	2,400	2,917	3,723
Kwh/month	2,400	5,834	11,169
Total kwh sold/month	25,608	45,800	90,768
% Line Loss	15.0	14.0	12.0
kwh of Line Loss	3,841	6,412	10,892
Total kwh Required/month	29,449	52,212	101,660
Annual kwh Requirements	353,388	626,544	1,219,920
Estimated Demand (kw)	102	178	343
Annual Load Factor %	39.6	40.2	40.6

Table A18:

Estimated kwh Requirements and Sales

Mae Suk

Site #2

Proposed Rural Village System	Year Ending 1	5	10
Residential Customers	317	474	778
Avg kwh/mo	16	19	25
kwh/month	5,072	9,006	19,450
Small Business Customers	32	36	42
Avg kwh/mo	160	194	248
kwh/month	5,120	6,984	10,416
Medium Business Customers	2	3	4
Avg kwh/mo	1,600	1,945	2,482
kwh/month	3,200	5,835	9,928
Total kwh sold/month	13,392	21,825	39,794
% Line Loss	15.0	14.0	12.0
kwh of Line Loss	2,009	3,056	4,775
Total kwh Required/month	15,401	24,881	44,569
Annual kwh Requirements	184,812	298,572	534,828
Estimated Demand (kw)	53.4	85.3	152.4
Annual Load Factor %	39.5	39.9	40.1

Table A19:

Estimated KWH Requirements and Sales

Mae Aep

Site #3

Proposed Rural Village System	Year Ending 1	5	10
Residential Customers	357	531	867
Avg kwh/mo	16	19	25
Kwh/month	5,712	10,089	21,675
Small Business Customers	28	32	38
Avg kwh/mo.	160	194	248
kwh/month	4,480	6,208	9,424
Medium Business Customers	1	1	1
Avg kwh/mo	1,600	1,945	2,482
kwh/month	1,600	1,945	2,482
Total Kwh Sold/month	11,792	18,242	33,581
% Line Loss	15.0	14.0	12.0
KWH of Line Loss	1,769	2,554	4,030
Total KWH Required/month	13,561	20,796	37,611
Annual KWH Requirements	162,732	249,552	451,332
Estimated Demand (KW)	48.1	73.5	132.5
Annual Load Factor %	38.6	38.8	38.9

Table A21:

Estimated KWH Requirements and Sales

Khlong Ta Riu

Site #5

Proposed Rural Village System	Year Ending 1	5	10
Residential Customers	409	608	993
Avg KWH/mo	16	19	25
KWH/month	6,544	11,552	24,825
Small Business Customers	32	36	42
Avg kwh/mo	160	194	248
KWH/month	5,120	6,984	10,416
Medium Business Customers	1	1	2
Avg kwh/mo	1,600	1,945	2,482
Kwh/month	1,600	1,945	4,964
Total kwh sold/month	13,264	20,481	40,205
% Line Loss	15.0	14.0	12.0
Kwh of Line Loss	1,990	2,867	4,825
Total KWH Required/month	15,254	23,348	45,030
Annual KWH Requirements	183,048	280,176	540,360
Estimated Demand (KW)	54.1	82.5	157.6
Annual Load Factor %	38.6	38.8	39.1

Table A22:

Estimated KWH Requirements and Sales

Khlong Ra

Site #6

Proposed Rural Village System	Year Ending 1	5	10
Residential Customers	413	609	990
Avg kwh/mo	16	19	25
Kwh/month	6,608	11,571	24,750
Small Business Customers	20	23	26
Avg kwh/mo	160	194	248
Kwh/month	3,200	4,462	6,448
Medium Business Customers	1	2	2
Avg kwh/mo	1,600	1,945	2,482
Kwh/month	1,600	3,890	4,964
Total kwh Sold/month	11,408	19,923	36,162
% Line Loss	15.0	14.0	12.0
Kwh of Line Loss	1,711	2,789	4,339
Total kwh Required/month	13,119	22,712	40,501
Annual KWH Requirements	157,428	272,544	486,012
Estimated Demand (KW)	47.3	80.4	143.2
Annual Load Factor %	38.0	38.7	38.7

Table A23:

Combined Consumer Requirements

Sites 1 thru 6

Site #	Name	Customers Years 1	5	10	KWH Required Years 1	5	10
1	Mae Hat	752	1,099	1,765	353,388	626,544	1,219,920
2	Mae Suk	351	513	824	184,812	298,572	534,828
3	Mae Aep	386	564	906	162,732	249,552	451,332
4	Mae Chon Luang						
5	Khlong Ta Riu	442	645	1,037	183,048	280,176	540,360
6	Khlong Ra	434	634	1,018	157,428	272,544	486,012
TOTAL							

Combined KW Requirements

Years

1	5	10
345	563	1,053

3/

B. Sales to the Grid

An interconnection agreement will be required between PEA and NEA to account for both the surplus energy from the hydro systems and the so-called emergency or back-up capacity and energy to be furnished the three projects that are contemplated to be interconnected to the PEA system.

A concept that might be used is the so-called "split the difference" method. This means that there is a difference in each party's average cost/KWH and it would be advantageous for one or the other to receive surplus energy. As an example, if PEA's average cost of producing energy for the area by small diesel was 3 baht/KWH and the NEA hydro costs were 2 baht/KWH, PEA would pay NEA 2.5 baht/KWH and each party would benefit by the transaction. However, where PEA system is interconnected to the grid and pays the standard EGAT rate, it would be more difficult to practise this concept. If the goal of reducing the country's dependency on imported petroleum products is to be realized and the complexity of operating an interconnected system, and the experience of both PEA and RFD, the overall benefit to the ultimate consumer would be better served by this proposed arrangement.

The following two sites are contemplated to be interconnected to the PEA system:

Project	Name
#2	Mae Suk
#6	Khlong Ra

PEA or EGAT could not provide specific costs for this type of interconnection, but during discussion with EGAT personnel, comparable costs were agreed upon. The costs of a non-synchronizing interconnect installation including a recloser, protection, disconnects, relaying and metering would be estimated to $10,000. This cost will be added to the electric system costs on the above two projects.

In view of the limited period of NEA's proposed operation of the systems, it might be worth considering the need for that investment for a relatively short time. Another method of determining the amount of energy provided through the point of interconnection would be to utilize the station production meter less KWH sold and arrive at an agreed upon transfer each month.

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C. Tariff Structures for Sites Not Hooked to Grid

The present MEA and PEA rates utilize the concept of inverted rates. The more that is used, the higher the steps become. However, on a small isolated hydro system with surplus capacity this concept could be counter-productive. Therefore, in view of the country's goal to encourage renewable energy generation and to avoid excessive surplus capacity on small isolated hydro systems, the middle of the road traiff proposal, such as the one noted below, would seem highly desirable.

(Residential Customer only)

- 3.00 Baht per Month Customer Charge (Minimum)
- 3.00 Baht per KWH for all KWH's

Thailand's tariff rates for electricity sales are established for the entire Kingdom by a special tariffs committee. Any modification to these standard rates would require the special permission of this committee, and, potentially, that of the Cabinet.

It is suggested, therefore, that Project analysts examine carefully this aspect of demand promotion, and, if deemed appropriate, make a documented appeal for special tariff considerations at one of the Project sites.

D. Actual Electric Generating Costs in Thailand

According to specialized personnel at EGAT, the monthly load factor of their entire system varies from approximately a low of 65% during December to a high of 75% during the months of April through June. In other words, the monthly load factor varies only 10% during the year. The annual load has increased from 63% in 1972 to 71% in 1980. This significant increase can be attributed to mandate on curtailment of elctric use during 1980.

EGAT indicates their energy costs to be 1.00 baht from the base load thermo units. Hydro was assigned a zero value for energy, while gas turbine 2.25 baht, diesel from 1 MW unit 2.0 - 2.3 baht and our anticipating 0.75 to 1.12 baht from the combined cycle gas turbine units with the introduction of LPG.

In analysing a typical daily load curve, it appears the peak period is from 6:00 to 10:00 pm at costs of 2.0 to 2.5 baht while the other 20 hours are approximately 1.0 baht making an average energy cost of 1.25B/KWH. In comparing the costs of small hydro one must realize that these are energy costs only and one must consider that capital costs need be added to come up with the so-called real costs.

The cost of small isolated diesel units on the PEA system appear to be in excess of 3B/KWH taking into fuel costs only.

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Therefore, with the estimates of continued petroleum increases, a substitution of hyro that can be assessed a total unit cost of 3B/KWH seems reasonable.

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ANNEX C: FINANCIAL ANALYSIS

This Annex is devoted to the provision of a detailed budget description fo the Project as well as a review of the recurrent costs obligations that it will generate. These two aspects of the Project are presented hereafter under separate headings.

I. Project Financial Plan

In accordance with standard AID procedures, a complete financial plan of expenditures has been presented in Table C1. Final accounting includes a generalized 10% allowance for physical contingencies as well as a 15%/yr. rate for inflation, compounded annually over the life of the Project. All costs have been calculated in current 1982 U.S. dollars at an exchange rate of US.$1.00 = 23 baht.

The detailed description of the individual financial plan entries is noted hereafter.

Item A: Final Engineering

It is intended that all final engineering of the Project sites will be done on a contract basis with a local Thai consulting firm. Final engineering here is defined as including both the drawing up of finalized plans, specifications and bid documents, as well as supervisory engineering services for actual site construction. Costs for this item have been calculated, based on past NEA experience, at 11% of the total cost of Tranche I site development (excludes power plant procurement). The percentage used on Tranche II sites was reduced to 8% to account for the heavy incidence of inflation in the year after engineering design. This cost item could be reduced somewhat, if, upon completion of final engineering, NEA feels it is capable of taking on part or all of the supervisory engineering responsibilities, thereby excluding the necessity to utilize a consultant. It is tentatively expected that USAID and RTG will share these expenses on a 50:50 basis.

Item B: Construction Costs

Finalized construction costs will, of course, only be possible following completion of final engineering plans (later in 1982 for the first tranche sites). The construction costs reflected in the Project Financial Plan are those submitted by NEA as being representative of the current cost of such structures in Thailand. These costs have been reviewed by O/EST and have deemed adequate for the purposes of project budgeting (+ 20%). It should be noted that the construction contract and power plant procurement portions of the individual site estimates have been separated for purposes of Project planning. It is currently

Table [illegible]: Project Financial Plan (US$ 000; 1982 Baht $)

ITEM	1982 AID EX	1982 AID LC	1982 RTG	1983 AID EX	1983 AID LC	1983 RTG	1984 AID EX	1984 AID LC
A. Final Engineering								
1) Sites 1-6		135	135					
2) Sites 7-12					180	180		
B. Construction								
1) Site #1: Mae Hat								
- Construction contract		147	147		147	147		
- Power plant (est. U.S.)	206							
2) Site #2: Mae Suk								
- Construction contract		134	134		134	134		
- Power plant		170						
3) Site #3: Mae Aep								
- Construction contract		53	53		53	53		
- Power plant		57						
4) Site #4: Mae Chon Luang								
- Construction contract		42	42		42	42		
- Power plant		29						
5) Site #5: Khlong Ta Riu								
- Construction contract		99	99		99	99		
- Power plant		85						
6) Site #6: Khlong Ra								
- Construction contract		90	90		90	90		
- Power plant (Est. U.S.)	223							
7) Sites 7-12 (estimate)								
- Cosntruction contract								1,939
- Power plants								1,073
C. Project Staff								
1) NEA Project Manager			4			5		
2) NEA Field Engineer			3			5		
3) Senior Engineer/Coordinator	67	23		90	30		90	30
4) Construction Manager		20			30			30
5) Soc-Econ Analyst(s)	22	16			15			8
6) Manufact. Promotion Specialist(s)	22	8			16			
7) Consumer Promotion Specialist(s)	22	8					22	13
8) NEA Geologist/Hydrologist			8			13		
9) Forecasting Specialist	22	8						
10) NEA Computer Specialist			8					
11) Secretary		1			2			2
12) NEA Accountant			1			2		
13) NEA Drivers			2			5		
D. Equipment								
1) Minor Support Equipment	20							
2) NEA Vehicles			41					
E. Seminar Support		5						
F. Special AID Evaluation (Grant)							69	
Sub-Total	604	1,130	767	90	838	775	181	3,095
+ Physical Contingencies (10%) + Inflation (15%/yr.)		-	-		1.15	1.15		1.32
TOTAL	664	1,243	844	114	1,060	980	263	4,494

1985 AID FX	1985 AID LC	1985 RTG	1986 AID FX	1986 AID LC	1986 RTG	TOTAL AID FX	TOTAL AID LC	TOTAL RTG
		5		1				
		5		1				
90	30							
	18							
	8							
	8							
	2		1					
		2		1				
		5		1				
90	66	17	-	1	4			
1.52	1.52		1.75	1.75				
150	110	28	-	2	8	1,191	6,909	4,700

GRAND TOTA[L] = $12,800,00[0]

anticipated that NEA will undertake independent power plant procurement for each of the sites and that the construction contract will cover civil works, transmission and major distribution lines only. Costing of future site construction (item B.7.) was undertaken on the assumption that average site size for future projects will probably be in the 400 KW range. Costs of second tranche sites were based on first tranche estimates and were escalated out accordingly to include inflation prior to and during construction. It was anticipated that, due to improved loal manufacturing capacity, all power plants could be purchased in Thailand (local cost only). It has been anticipated that the civil works construction contract will be funded by USAID and the RTG on a 50:50 basis. All power plants procurement will be funded by USAID.

Item C: Project Staff

Staff utilized for the Project will be located in the Project Operations Unit (POU) and will include both NEA line pesonnel and Project-funded contract personnel. Table C2 indicates the PP estimate for personnel requirements over time. Although this estimate should prove reasonably accurate for key Project personnel (NEA Engineers, Senior Engineer, Construction Manager, Socio-economic Planner) it should be noted that the need for, and timing of, other part-time specialists is highly speculative. Project management should be allowed maximum flexibility in contracting for these categories of personnel.

A full-time contract secretary has been assigned to the POU and will be located in Bangkok. All other POU support personnel (drivers, accountant, supplemental secretarial assistance) will be supplied by NEA.

Total expatriate personnel costs (salary, housing, etc.) have been calculated at $10,000/month. Thai contract personnel have been costed (all expenses) at $2500/mo. (Construction Manager, Socio-economic Planner, short-term specialists). NEA staff salaries have been calculated at global current NEA rates (Baht 9000/month for engineer/short-term specialists and Baht 3000/month for support personnel, including all expenses (per diem, travel, etc.).

Item D: Equipment for Technical Assistance

A lump sum of $20,000 has been allocated for minor equipment directly supportive of POU analytical activities (programmable calculator, simple soil kit, simple hydrology and surveying instruments). Allowance for computer time (estimated maximum $5,000) has also been included under this item. NEA will procure three vehicles with RTG funds for full-time use by POU. Two four-wheel drive pick-ups will be purchased for up-country travel and one station wagon will be purchased for use in Bangkok and occasional triaps to the field. The two pick-up trucks were estimated to cost $13,000 each and the station wagon $15,000.

Table C2: Project Personnel Requirements
(In man months per calendar year)

Description	1982	1983	1984	1985	1986	Total	Expect Source
1. NEA Engineer	9	12	12	12	2	47	NEA
2. NEA Engineer	6	12	12	12	2	44	NEA
3. Senior Engineer	9	12	12	12	-	45	Contract
4. Construction Manager	8	12	12	7	-	39	Contract
5. Socio-economic Analyst(s)	6	6	3	3	-	18	Contract (mos. U.S. and 15 mos. Thai Source)
6. Manufacturing Promotion	3	6	-	-	-	9	Contract (3 mos. U.S. and 6 mos. Thai Source)
7. Consumer Promotion	3	0	8	3	-	14	Contract (6 mos. U.S. and 8 mos. Thai Source)
8. NEA Geologist/Hydrologist	3	5	-	-	-	8	NEA
9. Forecasting Specialist	3	-	-	-	-	3	Contract (U.S. Source)
10. NEA Computer Specialist	3	-	-	-	-	3	NEA
11. Secretary	9	12	12	12	2	47	Contract
12. NEA Accountant	6	12	12	12	2	44	NEA
13. NEA Drivers (3)	6	12	12	12	2	44 (132)	NEA

Item E: Seminar Support

A lump sum of $5,000 has been allocated for two seminars to be sponsored by POU (See p. 19 of Project Paper) to further widespread understanding among public and private interest groups of the small hydro sector in Thailand

Item F: Special AID Evaluation

Some $69,000 (approximately $100,000 after contingencies and inflation) will be utilized, as required, to finance special USAID needs during the course of its mid-stream evaluation (see page 45 of Project Paper). This constitutes the only Grant-funded item under the Project.

II. Recurrent Costs

Although a public sector project, each of the hydroelectric sites should generate sufficient revenue from electricity sales to consumers to cover all recurrent costs (overhead, regular and periodic maintenance) over the useful life of each site.

The site selection model (Annex F) utilized by the Project for second tranche sites will build in additional safeguards in this respect through its financial analysis which stipulates the necessity for an 8% financial rate of return. This rate of return on capital investment should ensure auto-financing of each site, not only for basic operating costs but also for future site expansion (e.g., new transmission, second phase generator, etc.).

ANNEX D: SOCIAL ANALYSIS *

1. Project Social Profile

A. Demography and Income:

Local demographic and revenue trends are exceedingly important in hydro-electric site selection as they are the point of departure in determining demand forecasts. Due to lack of time and resources, demand forecasting of the first tranche sites (#1-6) was based essentially on official data as corroborated by short field trips to the villages located in the individual sites' zones of influence. The accuracy and localization of this data will be greatly enhanced for sites 7-12 through the utilization of the field survey prescribed in the site selection model contained in Annex F.

The first six sites proved reasonably easy to characterize. Though population density in the various site zones of influence were low, there were still enough beneficiaries within the radius of 15 kilometres to make the program worthwhile. At least 500 households with more than 2,000 population will be benefited from each electric site (see Table D-1). There are differences in social and cultural organization among the various selected communities of each particular region, but all are well integrated into the wider national economy and society through the systems of education, transportation and communications. Ethnically, they are also different, especially the four selected communities in Chiang Mai, but most still identify themselves as Buddhist Thai when faced with outsiders.

Furthermore, ecological differences make for differences in occupation and hence differences in income distribution. Most of the communites in Chiang Mai , where most of the population belong to various ethnic groups, are poor and remote so that contact with outside is rather limited. Their main income is derived from wet and dry rice cultivation, opium growing (among the H'mong, Lisu and Lahu), trade and working as wage labourers for the Forest Department stationed in the areas. More than half of the population have income below the World Bank's poverty line (฿2,300/year). In the South and the East (Phang Nga and Chantaburi) villagers earn higher income from mining, but there is little opportunity to grow rice, the main staple. More often, most have to buy rice for more than six months a year. The economy is highly commercialized and is more subject to the outside markets.

B. Rural Energy Consumption Patterns

Though most communities have no experience with the using of the small hydro-electric generators, they are certainly familiar with electricity for home use. There are, particularly in the North, some villages which have already had household electricity generated from

*For greater detail on the results of PP field studies, see Preecha, Kuwinpant, "Small Scale Hydro-electric site survey: A Preliminary Study" May, 1981, not included in this PP.

Table D1:

SUMMARY OF SOCIAL AND ECONOMIC

CONDITIONS OF COMMUNITIES

Project	District	Province	Villages	Population	Potential Resources	Economic State
#1 Mae Hat	Chiang Dao	Chiang Mai	6	5,398 Tai Yai, Northern Thai	- rice mills - estimated 10 pick-up buses - 12 village shops	prosperous: - main income from trade - soon becoming sub-district
#2 Mae Suk	Mae Chaem	Chiang Mai	8	5,351 Karen, Northern Thai	- rice mills - pick-up buses - village stores	intermediate: - easily reache - plenty of wat for agricultu
#3 Mae Aep	Hot	Chiang Mai	7	4,069 Chinese Ho, Thai Yai, H'mong, Karen	- rice mills - 5 village stores - pick-up cars - projects on development supported by Forest Department	intermediate: - easily reache - Forestry Cent

Project	District	Province	Villages	Population	Potential Resources	Economic State
#4 Mae Chon Luang	Mae Chaem	Chiang Mai				
#5 Klong Ta Riu	Makham	Chanthaburi	16	5,703 Thai and in-migrants from the North-East and near by provinces	- wet rice - tapioca plantation - irrigation - electricity will be useful for pumping and thus second cropping can be practised	- the poorest ar of the distric - road is being constructed - Volunteer Sold Unit - 5-6 own elect generators and TV sets - hired pumps
# 6 Khlong Ra	Thap Put	Phangna	8	5,125 Buddhist Thai in-migrants from the North-East	- mining - few rice farmers - rubber plantation - electricity is available for large mines - very close to the town and buses are available	- most commercia mines are owne by townspeopl - almost all hou holds own moto cycles - buying rice fo consumption - TV sets avail

small private diesel engines. The poor, however, have less opportunity to enjoy the benefit of electricity. Close to the tin mining, villagers in the South are also tempted with electricity, but little chance to utilize it.

Villagers rely mainly on kerosene lamps for household lighting and wood (charcoal) for cooking. The cost of wood is nothing but the surrounding trees. Kerosene is purchased from either the towns or village stores at the price of 10 baht for one bottle. The average household use is 4-5 bottles a month, depending on the number of household members and some special occasions such as house blessing and the like. On some ceremonies at the wat (temple), a small electrical generator is hired either from the town or tambon centers. Thus, many villages, though remote and not yet hooked up to the grid, are fairly familiar with electricity and its uses.

C. Assessment of the Impact of Electrification

To be familiar with electricity is not to say that the villagers all realize about what and how to make productive uses of it. In addition to lighting, most just do not know what they can apply for to make the most use of it in terms of economic development. Nevertheless, potential resources are there and only some guidance needed.

As part of the country, electrification is crucial to integrate these villages into the economy and society. With electricity, knowledge about the outside world increases through the employment of radio and television, not mentioning lighting, refrigerator and other household uses. The actual use of television is not for one particular household, but is also enjoyed by other nearby households who cannot afford to have their own and the house soon becomes a center for villagers.

Electrification also helps reduce the cost of kerosene and extends working hours, particularly for housewives to weave and for children to study. Such conveniences are the main reasons for the need of electricity. In addition, electrification also benefits schools, health centers and the wat for public purposes which will be enjoyed by all villagers. Such institutes have already existed in all communities under survey.

As far as the Forest Department is concerned, at Mae Aep site (Chiang Hot District, Chiang Mai Province), electricity mainly serves the forestry center. Several projects such as distribution and experimentation of substitute crops for opium and industry of some local products - flowers and fruits - have already been introduced. It is hoped that electricity will attract more hill people to settle around the center and also help accelerate economic growth in the area. However, careful study and attention must be given to the existing social and cultural forms of the local dwellers to prevent any destruction of social life.

In the South, electricity will mainly be consumed by many mining stations hopefully to increase their capacity. As the mines are growing, more labor employment is anticipated. Even individual miners can also increase and enlarge their own operations. However, caution must be given to potential conflicts between villagers and owners for most of the land has been granted concession to large mines.

Furthermore, all villages have several stores and rice mills functioning as centers whereby any information is likely to be heard. Extension of working hours means the increase of sales and the amount of products. Normally, owners are prosperous and are able to afford television and other facilities, and often act as innovators introducing some new activities and methods concerning agriculture. Hypothetically, the more the number of village stores increase, the more chance that electricity will be used productively and successfully. The poor thus indirectly enjoy the benefit and participate in the phase of development.

Finally, though electricity is needed, there are many who cannot afford to pay up the the real cost of electricity. Fifty baht a month as compared to the use of kerosene is the average price which most are willing and able to pay. This, however, is a matter of further discussion among all concerns. Each particular community may require specific arrangements according to social, economic and cultural conditions of each area.

II. Institutional Analysis

A. Basic Strategy:

An electric utility is a unique business as it requires a large initial investment with a relatively low rate of return, normally only one electric service entity in any given locality which in turn makes the utility a monopoly. The operation of a utility is a complex business requiring competent management and trained employees. The PP team suggests, therefore, that first tranche sites (#1-6) be turned over to PEA for management upon completion of power plant construction. As the Project will only finance construction up to the center of the user village, metering, hook-up and arrangements for billing and collection will be the responsibility of PEA for the first six sites. NEA should therefore coordinate its activities carefully with PEA prior to commencing construction so that downstream users will already be integrated into the power system when it is ready to be electrified.*

For the second tranche sites (#7-12), however, advance planning should permit greater flexibility in experimenting with other management options, including RFD, RID, EGAT and most importantly, private ownership or cooperatives. Because it is a fairly complex question, utilization of the cooperative option is discussed more fully below, although the PP Team esteems that it would be premature to attempt such a system at this point in time.

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*NEA reserves the right to operate the power plant for a period of one year to ensure proper technical functioning of the system, as well as to permit a smooth transition to ~~total PEA~~ management ~~[illegible]~~ the appropriate authority ~~[illegible]~~.

B. The Cooperative Option:

In Thailand, the Cooperative movement has a long history dating back to 1916. The First Cooperative Societies Act was promulgated in 1928. Later, in 1968, the Cooperative Societies Act B.E. 2511 (1968) was approved and the earlier act was repealed. The 1968 Act provided for the following six types of cooperatives.

1. Agricultural Coops
2. Fishery Coops
3. Land Settlement Coops
4. Consumer Coops
5. Service Coops
6. Thrift and Credit Coops

The Cooperatives in Thailand are vertically organized at three levels: primary coops at the local level, secondary coops at provincial level and the so-called apex coops at the national level. This structure is very similar to levels of cooperatives in the United States and provides a vehicle for growth of six types of coops in Thailand.

Cooperatives Societies Act B.E. 2511 (1968) provides that the Director-General or its equivalent Registrar of Cooperative Societies will register all cooperatives and notify in the the Government Gazette as to the type of coop in what locality and occupation of the prospective members that will be accepted for registration. In addition, the Act sets forth requirements of membership, accounting records required, and provision of dissolution.

The Act also provides for two types of cooperative: a limited and unlimited cooperative. In a limited coop, the liability of a member is the amount remaining unpaid on the shares held, while an unlimited coop the liability of all members is joint for the coop's obligations. In addition, the Act permits 3 or more coops to operate a so-called Federation, similar to the regional cooperatives in the United States. At the national level or so-called Apex Coop, the Cooperative League of Thailand's duties and obligations are also included in the enabling legislation.

The technical division of the Cooperatives Promotion Department provides a complete and detailed model Bylaw for an Agricultural Cooperative Limited. The Board shall consist of at least seven, but not more than fifteen directors. The bylaws are very complete and detailed, providing the guidelines and requirements of all cooperatives.

The Technical Division of the Cooperatives Promotion Department indicate that an electric cooperative could presently be organized under th existing enabling legislation under Agricultural type Cooperative.

A few electric cooperatives were organized and operated, however, today none exist. The Department of Cooperatives Promotion indicate they were located in urban areas, operating isolated diesel units as a power source. When PEA lines became adjacent to the Coop area, the cost differential was favorable for transfer of ownership to PEA. It was hoped that an on-site visit would indicate construction standards, personnel requirements and directors' attitudes for one coop still listed as an electric coop. The Coop's name was Pothleum Rural Electric Coop with a membership of 425, an adequate P&L and balance statement and now is a water supply activity having sold the electric facilities to PEA yet retaining a rural electric name.

It appears that an electric cooperative could be formed without the normal time-consuming requirements of legislative effort to create enabling legislation. This means that a coop could be created to provide a vehicle for local member labor utilization during the construction period. It would provde a means to reward those who provided labor and possibly some material for their value in the form of shares, the limitation being that no member can hold more than 10% of the total shares of the cooperative. A recommendation would be to utilize this Self-Help concept.

Aside from the financial gain, the employment of members in the community to help with the construction of a project enhances the cooperative principle. The person who has helped to construct their own project has a greater interest in both the social and economic success of the project than otherwise. Experience has shown that employment of the members whereby they may earn some extra money has made it possible to connect more initial consumers to the line than otherwise possible.

The Department of Cooperative Promotion indicated their desire to help organize an electric cooperative under the Agricultural classification. They have the staff, Provincial and District Offices throughout Thailand, plus an on-going mobile demonstration unit to aid the members in the application of electricity. The Department of Coop Promotion also requires that each coop be annually audited by its auditors. In reviewing the required P&L Statement, the Balance Sheet and additional substantiating data such as the Source and Disposition of Funds indicated a thorough review of each coop's financial condition.

C. Conclusions and Suggestions:

As a reasonably large-scale infrastructure development project, it is probably not unusual that the bulk of Project funds and analysis have been focused on the supply side (physical infrastructure) of a power system which is designed to service the demand of a large group of downstream users. It is suggested that a number of demand-related issues could and should usefully be treated by Project specialists in the course of implementation, especially in the promotion of

productive uses of electricity, but also in encouraging greater participation in the functioning of the system. The future site selection model presented in Annex F will provide considerable data for the generation and evaluation of such concepts.

Specifically, from a social soundness standpoint, it is suggested that the following tasks be carried out by Project specialists:

1. Socio-economic research and its follow-up of information in all electricity-site communities. Certain things can then be said about the success and problems concerning the overall project.

2. Promotion of productive uses and rural development. Villagers must be encouraged to make productive use of electricity. Certain types of help are needed. With a thorough knowledge, several development projects could be innovated. It is expected that liason with relevant government services would make this possible, especially those concerned with agriculture.

3. Promotion of rural participation and decision-making. This involves discussion with village leaders and villagers to insure participation from the beginning to create a sense of ownership. Villagers must be well informed and encouraged to participate. With a good understanding of village social organization, the best way can be determined.

4. Formal sources of credit for local industries. These are needed to help local entrepreneurs and villagers with good local "industrial" projects which are worth credit investment. BAAC and commercial banks and donors could become involved.

5. Training of selected employees to run cooperatives, and training in various aspects of productive use of electricity. Certain skills and resources existing in local communities should be identified. Workshops could also be arranged for exchange of knowledge among participants from the different communities.

6. Establishment of at least one electricity cooperative with appropriate methods and accepted forms. This needs to be discussed with villagers on a frequent basis.

To accomplish the above tasks, given institutional and timing constraints, it is suggested that Project staff may wish to use a local institution which has most of the needed expertise. Several likely institutions are available in Thai universities. If utilized, a contract should be signed out prior to construction so that village participation can be derived from the beginning. This would probably be most pertinent for second tranche site development. The contracted institution must be able to point out each year progress and problems of the overall project and recommend what shall have to be done in successive years. The first year of the contract is the most critical

one, involving the bulk of conceptual development.

Operationally, the conclusions of this social research should be ultimately integrated into the site selection model to ensure that key social considerations are addressed in a systematic and balanced manner.

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Annex E : Economic Analysis

1. Introduction to Economic Analysis

Considerable amount of time and field effort went into the development of the economic analysis methodology in this project paper. As will be noted in the following pages, economic analyses on a cost-benefit basis were performed for the first six project sites to be constructed under the project. On the basis of the experience of these first six site investigations, however, a simple, justifiable site selection model which includes least-cost economic analysis and comparative cost benefit financial analysis was developed. That model is included in Annex F and should be utilized for the future selection of all new project sites done under the project. This annex will, therefore, present only the economic methodology and results of the economic analyses for the first six project sites.

2. Justification for First Six Sites

Economic analyses were performed for six high-head project sites. The IRR's range from a low of 11% to a high of 46%. The primary reason for the very high return is that it was assumed, as is expected, that all surplus energy generated will be fed into the grid wherever possible substituting for energy produced by diesel or thermal powered generators. Even if no energy is transmitted to the grid, however, the IRR is still over 12% overall. Generally, according to the methodology utilized among the six sites, the "indirect benefits" per kilowatt hour of electricity used for agricultural use are much higher (roughly 4 times greater than those generated by residential social facilities or commercial industrial uses in areas similar to those of the project). As will be noted later in the finalized project selection model developed under this project, because of problems of measurement, the "indirect benefit" calculation has been abandoned for future project use. The potential for agricultural use in the six areas is rather low, mainly as a consequence of the terrain associated with these high head systems. The project does intend to install some low head systems eventually, however, and these areas are likely to have more agricultural land that could profitably be irrigated by pumping. Sites 3 and 7 have relatively high IRR's. At least in part this is explained by a comparatively high utilization of capacity - for only two years after coming on stream will dependable power be adequate to meet peak demands. For the purpose of this economic analysis, it was presumed that any deficit in power would be met by other (extra-project) sources. This is far from certain, however, and of course very costly. In any case, the large deficits between peak demand and dependable capacity will result in some rather severe community problems. The deficits could be reduced by a more restricted distribution

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system at the cost of a lower utilization of the plants output potential and service to a number of households. The load factors i.e. average relative to peak power, are low for all sites, about 40%.

The project should try to be innovative in keeping construction costs down. It was in this context that the investment costs were estimated and consequently, maybe on the optimistic side. Because of this, the sensitivity analyses assumed an extraordinary large (33% increase) in these costs. As Table E1 shows, the IRR was not very sensitive to this change. It impacted on the IRR approximately the same at an assumed 25% decrease in demand (consumption) for energy. This is also a rather large change, so used because the projected level of consumption assumes a special effort to promote the use of electrical energy especially for "productive uses". Estimates of indirect benefits are subject to rather large error. A decrease of 1/3 was assumed in these benefits for a sensitivity analysis. The impact on the IRR was approximately the same as for the assumed increase in capital costs and decrease in energy consumption. The assumption that the project would suffer all three of these adverse changes, judged to be a very unlikely occurence, reduced the IRR only about half.

Conservative assumptions of plant efficiencies were used for the economic analysis - 72% for the two plants which will install US manufactured turbines and generator, and 60% for locally manufactured. An increase in efficiency from 60% to, say, 80%, (a 33% increase) would be accompanied by the same relative increase in capacity. This would be of no value for sites (not connected to the grid) which will have adequate power to meet local requirements and for which there is no external market for the surplus. For sites with inadequate stream flow, however, the cost of manufacturing more efficient equipment should be investigated and this cost measured against the benefits of the increased energy.

Another area meriting investigation is the storage of water during low power use for use during periods of peak demand. This would require the construction of a dam instead of a weir and would cost more. This cost could be compared with the extra benefits resulting from the higher power.

And finally, an effort should be made to devise a scheme which prices peak power time energy substantially higher than at other times.

3. Benefit Cost Methodology

a.) Benefits

1. Non-quantifiable benefits.

Many of the benefits stemming from rural electrification are not amenable to quantification. For example, through mass media, electricity introduces extension services in formal education, child care, good hygienic practices and family planning methods. That it reduces urbanization costs is also likely, for with electricity generated improvements in rural lifestyle and greater work opportunities in villages, urban influx is probably slowed. No attempt is made to quantify such anticipated benefits although they may indeed be substantial.

2. Quantifiable benefits.

Quantifiable benefits are comprised of both direct and indirect. The PP analysis for these six sub-sites has drawn heavily from World Bank studies in Thailand to establish the relative magnitude of the latter compared to the former. This is of course a critical assumption. Essentially, the indirect benefits (relative to direct) as estimated by the Bank[1] were used in this paper. Some adjustments were made. These adjustments were based on surveys of the project sites and changes in relative prices (costs) since the World Bank studies.

a) Direct benefits:

Power tariffs are an approximate[2] measure of what we refer to as direct benefits.

b) Indirect benefits: These benefits include increased agricultural, commercial, industrial, residential and communal (social) output and savings in fuel costs.

Electricity assists agriculture in a number of ways. For example, irrigation pumps operate more cheaply by electric motors than by diesel engines. Mechanical energy becomes essential to multiple cropping and improved land yields. Electricity relieves labor shortages during peak agricultural seasons. Labor shortages during busy seasons have a high economic cost. Since the availability of busy season labor is essential to increased farm output households are more

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1 Thailand: Appraisal of the Accelerated Rural Electrification Project - World Bank Report No.1467A-TH, February 1, 1978

2 Footnote: Approximately because, depending on elasticity, an increase in rates might cause total expenditures for electricity to rise (indicating more benefits) although consumption might fall. Also certain assumptions are made about the marginal utilities of income among different income classes, which assumptions may not be impurichy valid nor do they measure consumers surplus.

to incur off-peak season unemployment than they would be otherwise. In addition, because of busy season labor shortages, innovations and crop area extension that require labor during peak season are hampered. Also, families directly affected by such shortages may opt for expanding their size, an uneconomical way of meeting critical energy needs.

Electricity in work shops saves fuel costs. It increases labor productivity by substituting horse power for manual, the former being much cheaper than the latter. Also, domestic industries that make electrical appliances and fixtures gain because of an increase in demand for their products. Electricity also introduces refrigerators and ice to village shops, consequently, rural people will have access to many perishable products, to medicines that require refrigeration, cold drinks, etc. Village shops also gain by using power for pumping water and lighting.

Residential customers benefit by substituting electricity for kerosene through a) savings in fuel costs and b) by using nights productively on such things as studies, farm tool repairs, mending shoes and clothes, sewing, spinning, weaving and producing other homemade goods.

Communal (social) benefits are mostly non-quantifiable. Estimates can be made, however, of some such benefits, e.g. of piped water and of greater use of facilities such as schools and health centers.

b) Costs

Project costs are essentially those costs provided to the economist by NEA and the Project Paper engineer. No allowance has been made for any economic shadow pricing and taxes have been judged to be such a small element of the overall project costs that they have not been considered in the economic costing either. Finally, as the costs will be utilized in a discounted analysis, no allowance was made for inflation in estimation of economic costs of the project. *

4. Distribution of Benefits

This project is likely to yield few direct benefits to the poorest households. However, through employment generation, the indirect benefits to the lowest income classes may be substantial, for NEA views this project as fundamentally a rural development project and stresses the promotion of productive "uses" - agricultural, industrial, commercial, residential and communal - which can be made of the

* N.B.: Economic analysis for the sites 1-6 was undertaken in 1981, using mid-year 1981 prices. This will differ from Project costs used elsewhere, which reflect early 1982 prices.

5/

project's energy. Consequently, the project includes a component for the express purpose of promoting such energy use in order to increase output, income and demand for labor in the project areas. An example of such promotion might be the provision of electricity at a very low price for pumping irrigation water during off-peak periods.

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Table E1: Basic EIRR and Sensitivity Analysis

Plant Site	Basic EIRR	Sensitivity Analysis					
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
1. Mae Hat	12.4	14.8	14.5	12.3	14.3	11.8	10.0
2. Mae Suk	10.4	8.4	9.2	6.3	7.6	6.0	4.6
3. Mae Aep	10.5	12.2	12.1	9.6	12.5	9.7	7.5
4. Mae Chon Luang	22.4	14.6	18.5	14.7	14.9	14.8	11.6
5. Khlong Ta Rui	13.0	10.2	10.0	7.6	10.3	7.7	5.9
6. Khlong Ra	16.6	17.8	18.5	14.9	17.9	14.8	11.6

Note

Case 1: Capital costs raise by 1/3.
Case 2: Demand falls by 25% for each year.
Case 3: Combination of 1 and 2.
Case 4: Indirect Benefits fall by 33.33%.
Case 5. Combination of 2 and 4.
Case 6: Combination of 1 and 5.

Table E2: Capital Cost by Plant Site ($US)
(Price mid-CY1981)

Item	1 Mae Hat	2 Mae Suk	3 Mae Aep	4 SITE Mae Chan Luang	5 Khlong Ta Rui	6 Khlong Ra	Total
1. Headworks	36150	36150	34100	34100	26500	26500	193500
2. Headrace	85000	109500	60500	31100	165000	116850	568150
3. Forebay	15000	17500	10000	10000	10000	10000	72500
4. Penstock	99450	91900	28400	28750	52500	73500	374500
5. Powerhouse	15000	15000	12000	12000	12000	15000	81000
6. Powerplant	178900	140050	40700	24850	75000	154150	613650
7. Trans/Distrib.	120000	90000	88500	13250	66000	60500	438250
8. Road	10000	20000	10000	20000	10000	10000	80000
9. Sub-Total (Direct)	589800	612600	283550	170000	417000	506500	2609450
10. Eng & Adm (10%)	68900	61200	28300	17000	41700	50650	268245
11. Contingency (15%)	103400	91800	42500	25500	62550	75975	402325
12. Total ($US)	662250	765750	291940	212500	521250	633125	3086815
13. Total (฿1000)	18107	16021	6131	4464	10946	13296	69024

Methodological Note:

Civil Construction:
a. Items: (1), (2), (3), (4), (5), (8) & 80% of (7)
b. Distribution: 50% of cost expected to be incurred in year 1 & 50% in year 2.

Equipment:
a. Item (6) plus 20% of item (7)
b. Distribution: Cost of imported equipment for power plant (Item 6) for sites 1 & 6 will be incurred in year 2 and 1/3 of remaining equipment will also be incurred in year 2; 2/3 of cost of domestically produced equipment will be incurred in year 1 and 1/3 in year 2.

Engineering, Administration & Construction Mgmt.
a. Estimated at 10% of direct capital costs (item 9)
b. Distribution: 8/11 of cost expected to be incurred in year 1 and 3/11 in year 2.

Contingencies
a. 15% of direct capital costs (item 9)

Table E3: Recurrent Costs

1. Repair & Maintenance: 2% of Investment Cost (item 13)
2. Personnel/Support
   a. One plant custodian per plant at ฿24,000/year each
   b. Local professional staff at ฿500,000/year each for project; Cost covers supporting services.
      - Year 1: 4 at ฿500,000 ea = ฿2.0 Million
      - Years 2&3: 2 at ฿500,000 ea = ฿1.0 Million
      - Years 4-10: 1 at ฿500,000 = ฿0.5 Million
   c. Expatriate
      - Cooperatives Expert: 3 mos., Yr. 1; 4 Mos., Yr. 2; 2 Mos., Yr. 3 and 1 Mo., Yr. 4 at $85000/Mo.
      - Mechanical Engineer: 12 Mos., Yr. 1; 6 Mos., Yr. 2 at $8350/Mo.

Table E4: Recurrent Cost Schedule (฿1000)

	Project Site						
	1	2	3	4	5	6	Total
a. Repair & Maintenance							
Project Year							
2	145	180	63	79	121	92	657
3-50	362	322	123	79	219	266	1350
b. Personnel/Support							
(1) Custodian							
2-50	24	24	24	24	24	24	144
(2) Professional	211	211	167	167	100	346	1000
(a) Local a/							
1	550	450	153	96	221	542	2000
2-3	295	221	96	32	111	271	1000
4-10	139	115	37	19	5	136	500
(b) Expatriate b/							
1	960	480	161	50	389	570	2640
2	798	241	50	40	321	255	1766
3	254	-	-	-	103	-	357
4	128		-	-	51	-	179
c. Total Current							
1	1510	940	314	156	605	1112	4640
2	1245	694	245	151	599	672	3567
3	915	575	223	151	459	561	2881
4	651	461	125	132	349	426	2203
5-10	523	461	125	132	349	426	2024
11-50	386	316	149	113	243	270	1524

a/ Allocation based on proportion that each plant's capacity is of all capacity: respectively for sites 1, 2, 3, 4, 5 & 6.

b/ Cooperatives consultant cost allocated to sites 1 & 5 only. Allocation based on plants' capacities. Remain of consultant time allocated same as a/ above.

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Table E5: Energy Consumption Estimates
(KWH per connected household per year)

	Project Year			
	2a/	6	11	16
A. NEA/USAID				
1. Residential & Social Facilities	300	267	352	377
2. All Users	360	453	607	[illegible]
B. World Bank (2) b/				
1. Residential Only	146-264	168-277	206-362	240-405
2. Residential & Social Facilities	156-267	183-285	230-370	241-467
3. All Users	365-433	551-459	450-594	573-673

a/ Annual basis
b/ First figure refers to NE; 2nd figure to elsewhere

Table E6: USAID Population/Household Estimates Project Area

Site #	Population a/ 2	6	11	16	Households a/ 2	6	11	16
1	5560	[illegible]	7254	8207	1548	1743	2020	2285
2	5512	6204	7191	8136	723	814	943	1067
3	4191	4717	5465	6187	775	815	1037	1173
4	4953	5575	6463	7312	800	900	1044	1181
5	5894	6612	[illegible]	8671	909	1024	1187	1343
6	5277	5941	6888	7793	873	1005	1165	1318
Total	31,367	35,206	40,727	46,306	5669	6351	7316	8368
Users								
1	[illegible]	1132	[illegible]	2077				
2	368	[illegible]	547	960				
3	398	501	933	1056				
4	401	[illegible]	740	1063				
5	[illegible]	664	1068	1207				
6	4149	[illegible]	1047	1186				
Total	2837	4144	6657	7531				
% of HH's (%)	50	65	90	90				

a/ Population growth assumed to be 3% annually, years 1-11 and 2.5% years 11-16. Most recent W.B. data show rural population growing at 2.56% annually.

Table E7: Power and Energy Estimates

Item	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
1. Turbine Discharge (lps)						
a. Max						
b. Min	460	660	135	135	385	[illegible]
c. Design (Average)	620	830	230	500	400	[illegible]
2. Effective Head (M)	100	[illegible]	75	73	50	[illegible]
3. Plant Efficiency (%)	70	60	60	60	60	[illegible]
4. Plant Capacity (KW)						
a. Installed	[illegible]					
b. Average	[illegible]	305	100	145	[illegible]	[illegible]
c. Dependable	385	240	60	60	115	[illegible]
5. Energy						
a. Average Annual (MWH) a/	3316	2645	867	1257	3077	[illegible]
b. Plant Factor (%)						
6. Dependable Capacity						
a. Flow (lps)	460	660	135	135	385	[illegible]
b. Head (M)	100	[illegible]	75	73	50	[illegible]
c. Capacity (KW)	385	240	60	60	115	[illegible]

a/ Assumes 1% down-time.

Table E8 :

Site # 1 Mae Hat

A. Plant *

1. Turbine discharge (lps)
   a. Minimum 440
   b. Average (Design) 530
2. Effective head (M) 100
3. Plant Efficiency (%) 73
4. Plant Capacity (KW)
   a. Dependable 335
   b. Average (Design) 440

*Data for 2 units

B. Capital Cost (US$)

Item	Total	Year 1	Year 2
1. Headworks	36,150	18,075	18,075
2. Headrace	85,000	42,500	42,500
3. Forebay	15,000	7,500	7,500
4. Penstock	99,750	49,875	49,875
5. Powerhouse	15,000	7,500	7,500
6. Power Plant	98,450	—	98,450
7. Trans/Distrib.	220,000	117,333	102,667
8. Road	40,000	20,000	20,000
9. Sub-total	609,350	262,783	346,567
10. Eng, Adm (10% of Item 9)	60,935	44,316	16,619
11. Contingency (15% of Item 9)	91,405	39,450	51,955
12. Total			
a. US$	761,690	346,519	415,171
b. ฿ 1000 (฿21/$)	15,995	7,277	8,719

C. Recurrent Costs (฿1000:฿21/US$)

Project Year	Repair & Maintenance a/	Plant Custodian	Consultants	Total
1	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	24	[illegible]	[illegible]
3	[illegible]	24	[illegible]	[illegible]
4	[illegible]	24	[illegible]	[illegible]
5-10	[illegible]	24	[illegible]	[illegible]
11-50	[illegible]	24	[illegible]	[illegible]

a/ 2% of Investment cost

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D. Energy Demand Projection (KWH per Mo.)

Project Year	Residential & Social Facils.	Commercial Industrial	Agri-cultural	Total	Supplied by Project a/	Annual Project Benefits b/ (฿Million)
1						
2	19,[illegible]	6,[illegible]	[illegible]	[illegible]	[illegible]	0.12 c/
3	20,632	[illegible]	[illegible]	[illegible]	[illegible]	1.78
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	13,761	[illegible]	[illegible]	[illegible]	[illegible]
6	34,112	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	39,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	61,056	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	76,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16-50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a/ See E below

b/ Direct & indirect benefits. Direct benefits (KWH consumed at ฿1.5/KWH) comprise 0.368 of total benefits attributable to the Residential & Social facilities category. The comparable figures for the Commercial/Industrial and Agricultural categories are 0.374 and 0.105 (See Thailand:Appraisal of the Accelerated Rural Electrification Project, World Bank, February 1, 1978, Annex 11, P. 4.

c/ 8 Mos.

E. Peak Demand & Surplus Dependable Capacity

Project Year	Peak a/ Demand (KW)	Surplus Dependable Capacity b/ (KW)	Additional Energy Required by Year c/ (MWH)	
1				
2	102	[illegible]	—	
3	126	[illegible]	—	
4	[illegible]	[illegible]	[illegible]	
5	[illegible]	[illegible]	—	
6	[illegible]	[illegible]	[illegible]	
7	[illegible]	[illegible]	[illegible]	
8	[illegible]	[illegible]	[illegible]	
9	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]
16-50	[illegible]	[illegible]	[illegible]	[illegible]

a/ Based on assumed distribution of consumption plus line loss

b/ Dependable capacity equals 325 KW

c/ Assumes peak demand power required averages 3.5 hrs. daily.

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F. Incremental Costs and Benefits: IERR

(₱ Million)

Project Year	Incremental Costs			Incremental Benefits	
	Capital	Current	Total	Total	Net
1	[illegible]	[illegible]	[illegible]	—	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16-50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

IERR: 17.4%

G. Sensitivity Analysis

		IERR
1.	Capital Costs Rise by 1/3	[illegible]
2.	Demand falls by 25% for each year	[illegible]
3.	Combination of 1 & 2	[illegible]
4.	Indirect Benefits fall by 1/3	[illegible]
5.	Combination of 2 & 4	[illegible]
6.	Combination of 1 & 5	[illegible]

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Table (E9) :

Site # 2 Mae Sak

A. Plant

1. Turbine discharge (lps)
   a. Minimum 670
   b. Average (Design) 830

2. Effective head (M) 64

3. Plant Efficiency (%) 60

4. Plant Capacity (KW)
   a. Dependable 245
   b. Average (Design) 305

B. Capital Cost (US$)

Item	Total	Year 1	Year 2
1. Headworks	36,150	18,075	18,075
2. Headrace	145,500	72,750	72,750
3. Forebay	15,000	7,500	7,500
4. Penstock	91,500	45,750	45,750
5. Powerhouse	15,000	7,500	7,500
6. Power Plant a/	75,000	37,500	37,500
7. Trans/Distrib.	70,000	35,000	35,000
8. Road	20,000	10,000	10,000
9. Sub-total	520,150	[illegible]	[illegible]
10. Eng, Adm (10% of Item 9)	52,500	27,157	14,650
11. Contingency (15% of Item 9)	78,725	[illegible]	[illegible]
12. Total			
a. US$	693,151	346,575	346,575
b. ฿ 1000 (฿21/$)	14,127	[illegible]	[illegible]

a/ Assumes one unit installed.

C. Recurrent Costs (฿1000:฿21/US$)

Project Year	Repair & Maintenance a/	Plant Custodian	Consultants	Total
1	—	—	166	166
2	154	24	433	611
3	283	24	211	518
4-10	283	24	106	413
11-50	283	24	—	307

a/ 2% of investment cost

D. Energy Demand Projection (KWH per Mo.)

Project Year	Residential & Social Facils.	Commercial Industrial	Agri-cultural	Total	Supplied by Project a/	Annual Project Benefits b/ (MMillion)
1	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]		[illegible] b/
3	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
16-50	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

a/ Direct & Indirect. See footnote b/, D. Site #1
b/ 8 Mos.

E. Peak Demand & Surplus Dependable Capacity

Project Year	Peak a/ Demand (KW)	Surplus Dependable Capacity b/ (KW)	Additional Energy Required by Year c/ (MWH)
2	[illegible]	[illegible]	
3	[illegible]	[illegible]	
4	[illegible]	[illegible]	
5	[illegible]	[illegible]	
6	[illegible]	[illegible]	
7	[illegible]	[illegible]	
8	[illegible]	[illegible]	
9	[illegible]	[illegible]	
10	[illegible]	[illegible]	
11	[illegible]	[illegible]	
12	[illegible]	[illegible]	
13	[illegible]	[illegible]	
14	[illegible]	[illegible]	
15	[illegible]	[illegible]	
16-50	[illegible]	[illegible]	

a/ Based on assumed distribution of consumption & line loss.
b/ Dependable capacity equals 245 KW

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F. Incremental Costs and Benefits: IERR

($ million)

Project Year	Incremental Costs			Incremental Benefits	
	Capital	Current	Total	Total	Net
1	7.70	0.19	8.57	—	-8.57
2	6.44	0.41	[illegible]	[illegible]	-6.[illegible]
3	—	[illegible]	[illegible]	[illegible]	[illegible]
4	—	[illegible]	[illegible]	[illegible]	[illegible]
5	—	[illegible]	[illegible]	[illegible]	[illegible]
6	—	[illegible]	[illegible]	[illegible]	[illegible]
7	—	[illegible]	[illegible]	[illegible]	[illegible]
8	—	[illegible]	[illegible]	[illegible]	[illegible]
9	—	[illegible]	[illegible]	[illegible]	[illegible]
10	—	[illegible]	[illegible]	[illegible]	[illegible]
11	—	[illegible]	[illegible]	[illegible]	[illegible]
12	—	[illegible]	[illegible]	[illegible]	[illegible]
13	—	[illegible]	[illegible]	[illegible]	[illegible]
14		[illegible]	[illegible]	[illegible]	[illegible]
15	—	[illegible]	[illegible]	[illegible]	[illegible]
16-50	—	[illegible]	[illegible]	[illegible]	[illegible]

IERR: ~~[illegible]~~ 10.7

G. Sensitivity Analysis

	IERR
1. Capital Costs Rise by 1/3	[illegible]
2. Demand falls by 25% for each year	[illegible]
3. Combination of 1 & 2	[illegible]
4. Indirect Benefits fall by 1/3	[illegible]
5. Combination of 2 & 4	[illegible]
6. Combination of 1 & 5	[illegible]

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Table E10 :

Site # 3 Mae Aep

A. Plant

1. Turbine discharge (lps)
   a. Minimum [illegible]
   b. Average (Design) [illegible]

2. Effective head (M) [illegible]

3. Plant Efficiency (%) [illegible]

4. Plant Capacity (KW)
   a. Dependable [illegible]
   b. Average (Design) [illegible]

B. Capital Cost (US$)

Item	Total	Year 1	Year 2
1. Headworks	[illegible]	[illegible]	[illegible]
2. Headrace	[illegible]	[illegible]	[illegible]
3. Forebay	[illegible]	[illegible]	[illegible]
4. Penstock	[illegible]	[illegible]	[illegible]
5. Powerhouse	[illegible]	[illegible]	[illegible]
6. Power Plant	[illegible]	[illegible]	[illegible]
7. Trans/Distrib.	[illegible]	[illegible]	[illegible]
8. Road	[illegible]	[illegible]	[illegible]
9. Sub-total	[illegible]	[illegible]	[illegible]
10. Eng, Adm (10% of Item 9)	[illegible]	[illegible]	6,320
11. Contingency (15% of Item 9)	[illegible]	[illegible]	[illegible]
12. Total			
a. US$	[illegible]	[illegible]	[illegible]
b. ฿ 1000 (฿21/$)	[illegible]	[illegible]	[illegible]

C. Recurrent Costs (฿1000:฿21/US$)

Project Year	Repair & Maintenance a/	Plant Custodian	Consultants	Total
1	[illegible]	[illegible]	[illegible]	[illegible]
2	70	[illegible]	[illegible]	236
3	122	[illegible]	[illegible]	216
4-10	123	[illegible]	[illegible]	[illegible]
11-50	123	[illegible]	—	[illegible]

a/ 0.02 of investment costs

D. Energy Demand Projection (EWH per Mo.)

Project Year	Residential & Social Facils.	Commercial Industrial	Agri-cultural	Total	Supplied by Project a/	Annual Project Benefits b/ (ØMillion)
1	—	--	--	--	--	---
2	5712	5549	531	11,792	11,792	2.42
3	6452	6121	607	13,480	13,480	.23
4	7151	6736	693	15,410	14,904	.51
5	7934	7414	792	16,140	16,320	.50
6	11,251	8027	906	20,186	18,007	.91
7	12,911	9235	1040	23,183	19,450	1.05
8	15,155	10,556	1211	26,920	21,384	1.16
9	17,664	12,262	1401	31,330	23,581	1.27
10	20,513	13,777	1611	35,900	25,951	1.40
11	24,004	15,735	1872	41,611	29,140	1.54
12	28,324	17,994	2122	48,440	31,354	1.70
13	33,450	20,012	2436	55,898	33,030	1.88
14	38,[illegible]	22,214	2832	63,810	34,201	1.55
15	30,[illegible]	25,401	3420	69,010	34,955	1.40
16-50	[illegible]	30,[illegible]	3800	[illegible]	37,155	1.40

a/ Assumes peak demand averages 3.5 hrs/day and a "secondary peak" at 50% of peak demand which averages the equivalent of another 3 hrs/day.

E. Peak Demand & Surplus Dependable Capacity

Project Year	Peak a/ Demand (KW)	Surplus Dependable Capacity b/ (KW)	Additional Energy Required by Year c/ (MWH)
1	--		
2	70	12	
3	[illegible]	4	
4	64	-4	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	125	[illegible]	[illegible]
10	144	-107	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	-107	[illegible]
13	[illegible]	115	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]
16-50	180	-107	[illegible]

b/ Dependable capacity equals 60 KW

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F. Incremental Costs and Benefits: IERR

(K Million)

Project Year	Incremental Costs: Capital	Current	Total	Incremental Benefits: Total	Net
1	3.25	0.38	3.63	—	-3.63
2	2.79	0.24	3.03	0.42	-2.61
3	—	0.22	0.22	0.73	0.51
4	—	0.18	0.18	0.81	0.63
5	—	0.18	0.18	0.88	0.70
6	—	0.18	0.18	0.97	0.79
7	—	0.18	0.18	1.05	0.87
8	—	0.18	0.18	1.16	0.98
9	—	0.18	0.18	1.27	1.09
10	—	0.18	0.18	1.40	1.22
11	—	0.15	0.15	1.58	1.43
12	—	0.15	0.15	1.70	1.55
13	—	0.15	0.15	1.78	1.63
14	—	0.15	0.15	1.85	1.70
15	—	0.15	0.15	1.90	1.75
16-50	—	0.15	0.15	1.90	1.75

IERR 15.5

G. Sensitivity Analysis

		IERR
1. Capital Costs Rise by 1/3	=	12.2
2. Demand falls by 25% for each year	=	12.1
3. Combination of 1 & 2	=	9.6
4. Indirect Benefits fall by 1/3		12.5
5. Combination of 2 & 4		9.7
6. Combination of 1 & 5		9.5

Table 4.11

Site II 4 Mae Chon Luang

A. Plant

1. Turbine discharge (lps)
   a. Minimum 160
   b. Average (Design) 230

2. Effective head (M) 73

3. Plant Efficiency (%) 60

4. Plant Capacity (KW)
   a. Dependable 70
   b. Average (Design) 100

B. Capital Cost (US$)

Item	Total	Year 1	Year 2	Year 4
1. Headworks	24,100	12,050	12,050	—
2. Headrace	31,100	15,550	15,550	—
3. Forebay	10,000	5,000	5,000	—
4. Penstock	28,750	14,375	14,375	—
5. Powerhouse	12,000	6,000	6,000	—
6. Power Plant	49,700	16,566	8,283	24,850
7. Trans/Distrib.	52,250	18,267	8,983	33,000
8. Road	20,000	10,000	10,000	—
9. Sub-total	227,900	89,809	80,241	57,850
10. Eng, Adm (10% of Item 9)	22,790	12,367	4,638	5,785
11. Contingency (15% of Item 9)	34,185	13,471	12,036	8,678
12. Total				
a. US$	284,875	115,647	96,915	72,313
b. ฿ 1000 (฿21/$)	5,982	2,429	2,035	1,519

C. Recurrent Costs (฿1000:฿21/US$)

Project Year	Repair & Maintenance a/	Plant Custodian	Consultants	Total
1	—	—	283	283
2	49	24	142	215
3	89	24	69	182
4	89	24	35	148
5-10	120	24	35	179
11-50	120	24	—	144

a/ 0.02 of Investment Cost

D. Energy Demand Projection (KWH per Mo.)

Project Year	Residential & Social Facils.	Commercial Industrial	Agri-cultural	Total	Supplied by Project a/	Annual Project Benefits b/ (฿Million)
1	—	—	—	—	—	—
2	7717	5401	126	14250	All	0.54
3	9,004	6322	1121	17,247	All	0.90
4	11,671	7226	1216	20,213	20,137	1.14
5	13,577	8152	1511	23,240	21,014	1.19
6	15,414	9067	1705	26,236	22,044	1.30
7	18,713	11,259	2277	32,261	26,520	1.50
8	21,561	13,461	2440	37,302	29,937	1.70
9	25,173	15,622	2583	43,378	33,472	1.94
10	29,201	17,585	3271	50,367	35,159	1.99
11	33,707	20,027	3666	56,400	37,545	2.14
12	34,003	21,131	3862	59,505	39,430	2.23
13	36,297	23,272	4070	63,610	41,014	2.32
14	38,097	25,350	4271	67,715	42,741	2.42
15	39,199	27,451	4473	70,020	44,335	2.51
16-50	41,665	29,565	4795	71,925	45,919	2.60

a/ Assumes peak demand for 3.5 hours/day and a "secondary peak" at 50% of peak for equivalent of 3 hrs. daily.

E. Peak Demand & Surplus Dependable Capacity

Project Year	Peak a/ Demand (KW)	Surplus Dependable Capacity b/ (KW)	Additional Energy Required by Year c/ (MWH)
2	57	13	
3	68	2	
4	80	-10	
5	91	-21	
6	102	-32	
7	121	-51	
8	146	-76	
9	169	-99	
10	191	-121	
11	213	-143	
12	223	-153	
13	233	-163	
14	242	-172	
15	252	-182	
16-50	262	-192	

a/ Dependable capacity = 70KW

F. Incremental Costs and Benefits: IERR

($ Million)

Project Year	Incremental Costs			Incremental Benefits	
	Capital	Current	Total	Total	Net
1	2.43	0.28	2.71	—	-2.71
2	2.04	0.22	2.26	0.54	-1.72
3	—	0.10	0.10	0.70	0.60
4	1.52	0.15	1.67	1.14	-0.53
5	—	0.10	0.10	1.19	1.01
6	—	0.10	0.10	1.30	1.12
7	—	0.10	0.10	1.50	1.32
8	—	0.10	0.10	1.70	1.52
9	—	0.10	0.10	1.84	1.66
10	—	0.10	0.10	1.99	1.81
11	—	0.14	0.14	2.14	2.00
12	—	0.14	0.14	2.23	2.09
13	—	0.14	0.14	2.32	2.18
14	—	0.14	0.14	2.42	2.28
15	—	0.14	0.14	2.51	2.37
16-50	—	0.14	0.14	2.60	2.46

IERR

G. Sensitivity Analysis

	IERR
1. Capital Costs Rise by 1/3	17.8
2. Demand falls by 25% for each year	18.5
3. Combination of 1 & 2	14.7
4. Indirect Benefits fall by 1/3	17.9
5. Combination of 2 & 4	14.8
6. Combination of 1 & 5	11.6

Table E.12.

Site # 4 Khlong Ta Tin

A. Plant

1. Turbine discharge (lps)
   a. Minimum 385
   b. Average (Design) 500

2. Effective head (M) 50

3. Plant Efficiency (%) 60

4. Plant Capacity (KW)
   a. Dependable 115
   b. Average (Design) 145

B. Capital Cost (US$)

Item	Total	Year 1	Year 2	Year 10
1. Headworks	26,500	13,250	13,250	—
2. Headrace	165,000	52,500	112,500	—
3. Forebay	10,000	5,000	5,000	—
4. Penstock	52,500	26,250	26,250	
5. Powerhouse	12,000	6,000	6,000	—
6. Power Plant	77,500	25,000	12,500	40,00
7. Trans/Distrib.	66,000	35,200	30,800	—
8. Road	10,000	5,000	5,000	—
9. Sub-total	419,500	198,200	181,300	40,00
10. Eng, Adm (10% of Item 9)	41,950	29,070	10,910	1,95
11. Contingency (15% of Item 9)	62,925	29,730	27,195	6,00
12. Total				
a. US$	524,375	257,020	219,405	47,95
b. ฿ 1000 (฿21/$)	11,012	5,397	4,608	100

C. Recurrent Costs (฿1000:฿21/US$)

Project Year	Repair & Maintenance[a/]	Plant Custodian	Consultants	Total
1	—	—	544	544
2	108	24	384	516
3	200	24	189	413
4	200	24	95	319
5-10	200	24	50	274
11-50	220	24	—	244

D. Energy Demand Projection (KWH per Mo.)

Project Year	Residential & Social Facilities	Commercial Industrial	Agri-cultural	Total	Supplied by Project a/	Annual Project Benefits (MW
1	—	—	—	—	—	—
2	6544	5990	730	13,264	13,264	.49
3	7734	6588	834	15,156	15,156	.54
4	9141	7224	952	17,317	17,317	.96
5	10,803	7876	1088	19,787	19,787	1.09
6	12,768	8578	1243	22,609	22,609	1.25
7	14,855	10,138	1456	26,479	26,479	1.47
8	17,322	11,952	1706	31,010	29,413	1.63
9	20,229	14,092	1997	36,318	33,485	1.80
10	23,522	16,612	2339	42,533	36,571	2.02
11	27,492	19,581	2740	49,813	41,722	2.31
12	29,691	21,147	2957	53,795	44,749	2.48
13	31,473	22,416	3137	57,026	47,019	2.60
14	33,046	23,527	3294	59,877	49,018	2.71
15	34,368	24,479	3425	62,272	50,455	2.79
16-50	35,056	24,968	3494	63,518	50,743	2.81

E. Peak Demand & Surplus Dependable Capacity

Project Year	Peak a/ Demand (KW)	Surplus Dependable Capacity b/ (KW)	Additional Annual Energy Requirements to Meet Peak Dmd. (MWH)
2	54	61	—
3	63	52	—
4	72	43	—
5	81	34	—
6	90	25	—
7	110	5	—
8	130	-15	19.2
9	151	-36	46.0
10	171	-56	72
11	191	-76	97
12	200	-85	1.09
13	209	-94	1.20
14	217	-102	1.30
15	226	-111	1.42
16-50	235	-120	1.53

a/ Dependable capacity equals 115 KW

F. Incremental Costs and Benefits for IERR

($ Million)

Project Year	Incremental Costs: Capital	Current	Total	Incremental Benefits: Total	Net
1	5.40	0.54	5.94	—	-5.94
2	4.61	0.52	5.13	0.49	-4.64
3	—	0.41	0.14	0.54	0.43
4	—	0.32	0.32	0.96	0.64
5	—	0.27	0.27	1.09	0.82
6	—	0.27	0.27	1.25	0.98
7	—	0.27	0.27	1.47	1.20
8	—	0.27	0.27	1.63	1.36
9	—	0.27	0.27	1.80	1.53
10	1.01	0.27	1.28	2.02	0.74
11	—	0.24	0.24	2.31	2.07
12	—	0.24	0.24	2.48	2.24
13	—	0.24	0.24	2.60	2.36
14	—	0.24	0.24	2.71	2.47
15	—	0.24	0.24	2.79	2.55
16-50	—	0.24	0.24	2.81	2.57

IERR = 12.97

G. Sensitivity Analysis

		IERR
1. Capital Costs Rise by 1/3	=	10.22
2. Demand falls by 25% for each year	=	9.99
3. Combination of 1 & 2	=	7.63
4. Indirect Benefits fall by 1/3	=	10.28
5. Combination of 2 & 4	=	7.71
6. Combination of 1 & 5	=	5.90

Table G 13:

Site #6 Khlong Ba

A. Plant

1. Turbine discharge (lps)
   a. Minimum 255
   b. Average (Design) 400
2. Effective head (M) 125
3. Plant Efficiency (%) 72
4. Plant Capacity (KW)
   a. Dependable 250
   b. Average (Design) 355

B. Capital Cost (US$) *

Item	Total	Year 1	Year 2
1. Headworks	26,500	13,250	13,250
2. Headrace	116,850	58,425	58,425
3. Forebay	10,000	5,000	5,000
4. Penstock	73,500	36,750	36,750
5. Powerhouse	15,000	7,500	7,500
6. Power Plant	194,150	—	194,150
7. Trans/Distrib.	60,500	32,267	28,233
8. Road	10,000	5,000	5,000
9. Sub-total	506,500	158,192	348,308
10. Eng, Adm (10% of Item 9)	50,650	36,835	13,815
11. Contingency (15% of Item 9)	75,975	23,730	52,245
12. Total			
a. US$	633,125	218,757	414,368
b. ฿ 1000 (฿21/$)	13,296	4,594	8,702

* Exclusive of cost for transmitting surplus energy to grid

C. Recurrent Costs (฿1000:฿21/US$) *

Project Year	Repair & Maintenance a/	Plant Custodian	Consultants	Total
1	—	—	1010	1010
2	92	24	505	621
3	266	24	246	536
4-10	266	24	123	413
11-50	266	24	—	290

*Exclusive of cost for transmitting surplus energy to grid

D. Energy Demand Projection (KWH per Mo.)

Project Year	Residential & Social Facils.	Commercial Industrial	Agri-cultural	Total	Supplied by Project a/	Annual Project Benefits b/ (ØMillion)
1	—	—	—		—	—
2	6605	4207	513	11,405	0.41	4.54
3	7794	5042	605	13,441	0.73	7.31
4	9193	5931	713	15,837	0.86	7.36
5	10,843	6976	840	18,659	1.01	7.43
6	12,787	8207	989	21,983	1.19	7.50
7	14,895	9313	1141	25,349	1.37	7.58
8	17,348	10,565	1315	29,228	1.58	7.67
9	20,206	11,978	1517	33,701	1.82	7.78
10	23,533	13,576	1749	38,858	2.10	7.91
11	27,409	15,379	2016	44,804	2.43	8.06
12	29,602	16,609	2177	48,388	2.62	8.14
13	31,378	17,606	2308	51,292	2.78	8.22
14	33,777	18,486	2443	53,856	2.92	8.29
15	34,266	19,225	2520	56,010	3.03	8.34
16-50	34,100	19,610	2571	57,131	3.09	8.37

a/See Site #__ footnote to corresponding table.

b/Assumes: Average plant capacity, 355KW; down-time, 1%, line-loss local customers, 15% in year 2, 14% in year 6, 12% in year 11 and 10% in year 16 with linear decreases between years; transmission loss to grid of 10%; an economic value of Ø2.5/KWH for energy delivered to grid; and that grid accepts all surplus energy generated.

E. Peak Demand & Surplus Dependable Capacity

Project Year	Peak a/ Demand (KW)	Surplus Dependable Capacity b/ (KW)	Additional Energy Required by Year c/ (MWH)
2	47	203	
3	57	193	
4	65	185	
5	78	172	
6	88	162	
7	105	145	
8	122	128	
9	139	111	
10	156	94	
11	173	77	
12	182	68	
13	191	59	
14	199	51	
15	208	42	
16-50	217	33	

a/ Equals 250KW

F. Incremental Costs and Benefits: IERR

($ Million)

Project Year	Incremental Costs a/ Capital	Current	Total	Incremental Benefits Total	Net
1	5.91	1.01	6.92	—	-6.92
2	9.36	0.66	10.02	4.84	-5.18
3	—	0.60	0.60	7.31	6.71
4	—	0.47	0.47	7.36	6.89
5	—	0.47	0.47	7.43	6.96
6	—	0.47	0.47	7.50	7.03
7	—	0.47	0.47	7.58	7.11
8	—	0.47	0.47	7.67	7.20
9	—	0.47	0.47	7.78	7.31
10	—	0.47	0.47	7.91	7.44
11	—	0.35	0.35	8.06	7.59
12	—	0.35	0.35	8.14	7.67
13	—	0.35	0.35	8.22	7.75
14	—	0.35	0.35	8.29	7.82
15	—	0.35	0.35	8.34	7.87
16-50	—	0.35	0.35	8.37	7.90
				IRR	45.6

a/ Includes estimates of costs for transmitting surplus energy to grid.

G. Sensitivity Analysis — IERR

1. Capital Costs Rise by 1/3 = 10.22
2. Demand falls by 25% for each year = 9.99
3. Combination of 1 & 2 = 7.63
4. Indirect Benefits fall by 1/3 = 10.28
5. Combination of 2 & 4 = 7.71
6. Combination of 1 & 5 = 5.95

ANNEX F:

SUB-PROJECT SITE SELECTION AND DEVELOPMENT MODEL

1.0. INTRODUCTION TO SUB-PROJECT DEVELOPMENT PROCEDURES

2.0. PRELIMINARY SCREENING (DESK STUDY)

3.0. BASIC FEASIBILITY DETERMINATION (FIELD STUDY)

3.1. Introduction
3.2. Engineering and Environmental Feasibility
3.2.0. General
3.2.1. Local Stream Flow Data
3.2.2. Actual Head Data
3.2.3. Actual Surface Geology Data
3.2.4. Environmental Assessment
3.2.5. Project Data Sheet
3.2.6. Power and Energy Calculations
3.2.7. Preliminary Cost Estimates

3.3. Socio-economic Feasibility
3.3.1. Local Zone of Influence of Project (ZIP) Delineation
3.3.2. Collection of Local Socio-economic Data
3.3.3. Methodology for Power Demand Analysis
3.3.4. Management/Distribution Analysis
3.3.5. Least-Cost Economic Analysis
3.3.6. Financial Analysis

4.0. FINAL ENGINEERING GUIDELINES (To be developed by PGU)

5.0. CONSTRUCTION GUIDELINES (To be developed by PGU)

6.0. ATTACHMENTS

-ATTACHMENT A : INSTRUCTIONS FOR USE OF VILLAGE SOCIO-ECONOMIC SURVEY FORM

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1.0 INTRODUCTION TO SUB-PROJECT DEVELOPMENT PROCEDURES

This model is meant to be simple, understandable and utilizable by a wide range of Thai professional staff with an interest in appropriate selection and development of "micro" (0-100KW) or "mini" (100-1000KW) hydroelectric generation sites in Thailand. The model presented is an integrated one, taking into account engineering, socio-economic and environmental concerns prior to moving forward with the expensive process of final engineering and bid document preparation.

Figure 1 graphically presents the entire site selection and development process, both according to responsibilities by actor (engineer, economist, management) and by activity, over time. Each actor has a responsibility sequence. The RTG has clearly mandated responsibility for analysis and planning of small hydro to NEA. An NEA engineer and economist will be responsible for undertaking the engineering and socio-economic sequences, therefore. The management sequence, however, will require inputs from both the planning agency (NEA) as well as the agency which will actually be responsible for site operation and maintenance following construction (e.g., PEA, EGAT, RFD or RID).

The overall site selection and development process can be regrouped into four major types of activities:

- Preliminary screening
- Basic feasibility determination
- Final engineering
- Construction

Although all four categories are included in Figure 1, the focus of the model contained in this annex will primarily be on preliminary screening and basic feasibility determination. Although of critical importance to national and local planners and field technicians in their attempts to better allocate scarce national revenues, these analytical activities are often dealt with only superficially in the absence of operational selection models.

This model should be only considered an initial attempt to develop a framework of systematic analysis applicable to Thailand. It should and will be carefully studied and improved by NEA and project technicians over the course of project implementation. Future versions of this model should attempt to reduce certain steps and computations (e.g. through computerization or greater use of indicative coefficients) with the ultimate goal of producing a decision-making model which is

- simple but accurate
- field utilizable
- time and cost efficient
- reflective of local conditions

Figure 1: Sub-Project Site Selection and Development

Key Decision Points	Preliminary Screening	Basic Feasibility	Final Engineering					Contracting and Construction		
Months	1	2	3	4	5	6	7	8	9	10
I. ENGINEERING SEQUENCE										
A. Desk Study (1:50000 maps)										
- Est. stream flow										
- Est. head										
- Est. cost (generation and transmission)										
B. Initial Field Study										
- Local stream flow data										
- Actual head data										
- Actual surface geology										
- Significant environmental effects										
- Preliminiary cost estimate (± 30%)										
C. Detailed Engineering Design (contract)										
- Contracting for engineering consultants										
- Local survey (1:1000)										
- Soil studies										
- Final engineering plans, specs., bid documents, final costs										
D. Construction Contract Bid & Selection										
E. Construction Period										
F. Power Plant Procurement										
II. SOCIO-ECONOMIC SEQUENCE										
A. Desk Study (1:50,000 maps)										
- Est. zone of influence										
- Est. power demand										
B. Field Study										
- Local zone of influence delineation										
- Local socio-economic data collection										
- Local power demand study										
- Management/distribution analysis										
- Least-cost analysis										
- Financial analysis										
III. MANAGEMENT SEQUENCE										
A. Preliminary Screening										
B. Establish Feasibility										
C. Power Plant Procurement										
D. Establish Management System										
E. Establish Distribution/Collection Procedures										
F. Train local personnel										
G. Undertake local promotion activities										

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2.0 PRELIMINARY SCREENING (DESK STUDY)

A global analysis of the wide range of micro/mini hydroelectric sites in Thailand could oblige analysts to study literally thousands of individual sites. Thailand's manpower and financial resources are limited, however, as are those of the Project. In order to reduce actual study sites to a manageable number, a preliminary screening is necessary. This screening will permit RTG analysts not only to reduce study costs, but also to expedite the selection of the most appropriate project sites for further feasibility and final engineering study.

It should be noted that, in order to fit USAID expectations, preliminary screening of Project sites has artificially been limited to the 0 - 1000 kilowatt range to conform with UN definitions of micro and mini-hydroelectric generation. The utility of this screening exercise, and indeed the entire site selection model, clearly exceeds these limitations, however, and it could therefore be expanded by RTG personnel to include larger sites as well.

This initial site screening process can be done entirely as a desk study. It will require the services of one engineer and one economist for one to four weeks, depending on the number of site possibilities being screened. Conceptually, preliminary screening should follow the guidelines outlined in the chart below:

		Mini-Hydro	
Screening Activity	Micro-Hydro	W/Grid Hook-Up	W/O Grid Hook-Up
1. Located in Grid Electrification Area	Eliminate	Essential	N/A
2. Estimation of Appropriate Head	Calculate	Calculate	Calculate
3. Identification of User Groups Sufficient to Indicated Utility of Investment*	Calculate	Not necessary	Calculate
4. Note if will replace existing diesel generation	- - - Accords Priority - - -		

It should be noted that the screening sequence varies somewhat depending upon the nature of hydro generation being examined: micro or mini hydro.

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* While not included in this model for purposes of the PP, it should be noted that normal RTG criteria for screening may occasionally include political or administrative concerns. The Thai 5th Plan makes clear, for example, that the RTG sees the necessity to integrate security planning and equity concerns into the larger economic planning framework.

Each screening sequence is described more explicitly below:

Micro-Hydro Sequence

It now seems sufficiently clear that the RTG expects to hook some 90% of all villages in Thailand to the electrical grid prior to the end of this decade. Given the nature of electric generation and distribution in Thailand and the fact that those agencies responsible for electricity in rural areas have already stretched their managerial capacities to the limit, it can be expected that any micro-hydro site (e.g., less than 100 KW) which is located in a grid electrification area should be eliminated from further consideration. Clearly, the power generated by micro-hydro sites located in a grid area could be sold back to the grid, however, the managerial demands of such a hydro operation would far outweigh the benefits which might be derived from the sale of this small amount of hydro power it generates for the grid.* Observation of this first screening guideline will clearly reduce the number of micro-hydro sites drastically, limiting them in all probability to less than 10% of the total villages in this country. Those sites which successfully pass this first screening activity should then be examined for appropriate estimated head. This may be done by carefully observing 1 : 50 000 scale maps of the area in question and determining whether the topography is appropriate for the size of head necessary to operate the system. For example, in the case of high head applications, this would mean a head of more than 20 meters. If the site under consideration appears to have an appropriate head, the estimated power of the site should be calculated based on the size of the catchment basin and known rainfall in the area. Finally, local user groups should be examined in order to determine whether or not the supply of power developed through the use of this site matches up with an appropriate local demand. The early examination of local demand would include, most particularly, locating populations in close proximity to the site on 1 : 50 000 maps, calculating the amount of people within the theoretical zone of influence of the project , from local census data, and calculating estimated household demand, as well as any other known commercial or other type of demand in the zone of influence of the specific site under question.

Mini-Hydro

There appear to be two different categories of mini-hydro for screening under this project, those hooked to the grid and those not hooked to the grid. Given RTG plans to expand the electrical grid widely, the first option, that of hooking the system to the grid, will clearly be widespread. However, it should simultaneously be noted that, as a generalization, the unit cost of supplying hydroelectricity

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* One important exception should be noted for the record, however. Micro sites in grid areas, while not acceptable to the RTG agency for managerial reasons, could be financially viable opportunities for private investors or cooperatives. Because of current NEA and EGAT regulations restricting private hydro generation, this option does not appear in the model. With hundreds of potential micro-hydro sites in grid areas, such an option should probably be reconsidered by the RTG in the future after careful study of the question.

to the grid will decrease as an inverse function of the size of the generating plant. This would mean that mini-hydro systems intended to be hooked to the grid should probably be in the upper limits of the size category allowed under this project paper, e.g., close to the 1,000 kilowatt limit. The screening exercise should therefore indicate this by favoring those sites which are located at the upper end of the mini-hydro scale. The exact size of the power plant will be estimated, of course, in the second step of the screening exercise. The final step of the screening exercise does not need to be examined carefully as hooking of the system to the grid will assure complete sales of the 24 hour power generation of the hydro unit. Finally, in the case of those mini-hydro systems not hooked to the grid, the sequence of activities should be approximately similar to that utilized for the micro-hydro screening exercise.

Finally, (#4) priority will be accorded to those sites which fit all previous screening criteria and which will replace, either partially or completely, a source of existing local diesel generation.

Systematic utilization of this screening method for all sites under consideration should reduce the number of sites for basic feasibility study to a manageable size. Knowing the amount of funding available to the project or to any future projects, and, furthermore, knowing approximately the cost of the sites which have been pre-screened, it is suggested that project analysts select as many as 50% more sites for basic feasibility determination than can actually be funded under program construction. All sites should receive the same intensity of study in the field, and final screening or selection of those sub-sites for actual development will only be made upon completion of the basic feasibility determination which is the next step in the project decision-making model.

3.0. BASIC FEASIBILITY DETERMINATION (Field Study)

3.1. Introduction

Once a site has been selected for field study, the first prerequisite step should be to gather any desk data available with regard to that site, specifically:

- Have any preliminary engineering studies been carried out on the sites by NEA, EGAT or others - these should be obtained.
- Has any hydrological gauging been accomplished on the site.
- If so, these data should be requested for the field team.
- The closest rainfall gauging station data should be acquired for the life of the gauging installation or for the last ten years.
- Any data on hydrological conditions in nearby drainages should be acquired where specific drainage data is not available.

- If existing diesel generation is now being utilized in the area to be served by the proposed hydro-generation system, use data including peak day, month and seasonal use should be acquired.
- Large scale maps of the study areas should be acquired. These should be at a scale of 1 to 50,000 or larger. They should be maps with topographic relief in the area to be studied.
- If geological mapping is available in the area, it should be acquired.
- Local transportation network and probable access routes should be determined from the map as a guide to site access.
- Any socio-economic data collected in the area should be accumulated.
- Special consideration should be given during the pre-site visit, to the land use and land control mechanisms at the project site, i.e., has the land been set aside as a national park, a national forest, or other special use activity? If so, what requirements are there for:
  - A. A permit to enter and study the area for hydroelectric use (especially RED regulations)?
  - B. What requirements are there if the project is constructed to obtain rights for use of the land or water in the project area?
  - C. What are the restrictions such as water rights which need to be taken into account during the feasibility or final engineering construction stages of the project?

The above data should be put in report from with a narrative section including the desk writer's opinions or impressions which may not be covered under the above items. This report should be made available in two copies for the field team, annexing all of the data which has been accumulated for the evaluation effort. The original of the report should be kept in the project file at NEA as part of the overall development documentation for the project.

This is the first critical juncture in assuring appropriate liaisoning with future site operating agencies. NEA should be sure to establish, prior to undertaking field study, preliminary, informal, contact with the RTG agency (s) tentative presumed most likely to assume post-construction operational responsibilities for the site. Pre-field study coordination planning should be established, including timeframe and nature of site coordination with NEA.

Having reduced the number of proposed sites to a manageable size through the preliminary screening process and having gathered the maximum amount of "desk" data, it then becomes necessary to gather local field data to determine basic feasibility. The term "basic feasibility" may be defined in many ways and should, in fact, be modified over time according to accrued field experience. Here, the term encompasses the integrated analysis of socio-economic, engineering and environmental parameters considered key by the PP design team.

The methodology proposed for field data collection, analysis and decision-making has been deliberately simplified to reduce study costs and to render it field-utilizable. Utilization of this approach will require, nevertheless, that field staff be equipped with a hand calculator (preferably a financial model with discounting and IRR

functions), surveying instruments, a hand auger, a portable soil testing kit and simple water velocity gauge. Personnel requirements will include a civil engineer and energy economist (average two weeks each) and some support staff (laborers, rod man, enumerators).

Based on preliminary discussions with NEA technicians and the experience gained by PP team members to date, the following timeframe would appear to be a reasonable initial estimate for basic feasibility determination per site.

TIME SEQUENCE	PERSONNEL	OBSERVATIONS
Step 1 (2 days) Initial Field Reconnaissance	1 - engineer 1 - economist	Visual field test of preliminary screening assumptions. If confirmed call immediately for support personnel, if not confirmed, move to next site.
Step 2 (10 days) Data Collection	1 - engineer 1 - rod man 3 - local unskilled 1 - economist 2 - enumerators	Engineer will undertake simple surface geology, hydrology and survey work, avoiding expense of full site crew. Will be provided with necessary funding for local hire or may request volunteers from local village.
Step 3 (3 days) Synthesis and Management Recommendations	1 - engineer 1 - economist	Will complete basic feasibility in the field prior to moving to next site or returning to Bangkok.

Because of the approximate nature of the field work, it would seem essential that it take place only during the dry season (i.e., period of easiest hydrology measurement and period of easiest site access) and, even then, preferably during the height of the dry season (February-March). It also should be noted that the above personnel proposal presumes fairly simple hydrological conditions and/or reliable hydrological historical data (preferably the previous 10 years). If an individual site does not bear out this presumption, however, a professional hydrologist may be required. This would also be the case for local geological tests.

Figure 2, attached, outlines schematically the activity sequence to be followed by the field team. Responsibility for undertaking of left-hand column activities lie basically with the field engineer and activities for the right-hand column lie with the field economist. Central column activities and overall decision-making lie jointly with both. Both should arrive in the field simultaneously as well as operate cooperatively throughout the study period.

The PP team has developed this model with a number of assumptions which simplify analysis and reduce costs. Notable assumptions are made explicit below and may be modified as deemed reasonable and appropriate by RTG and Project specialists.

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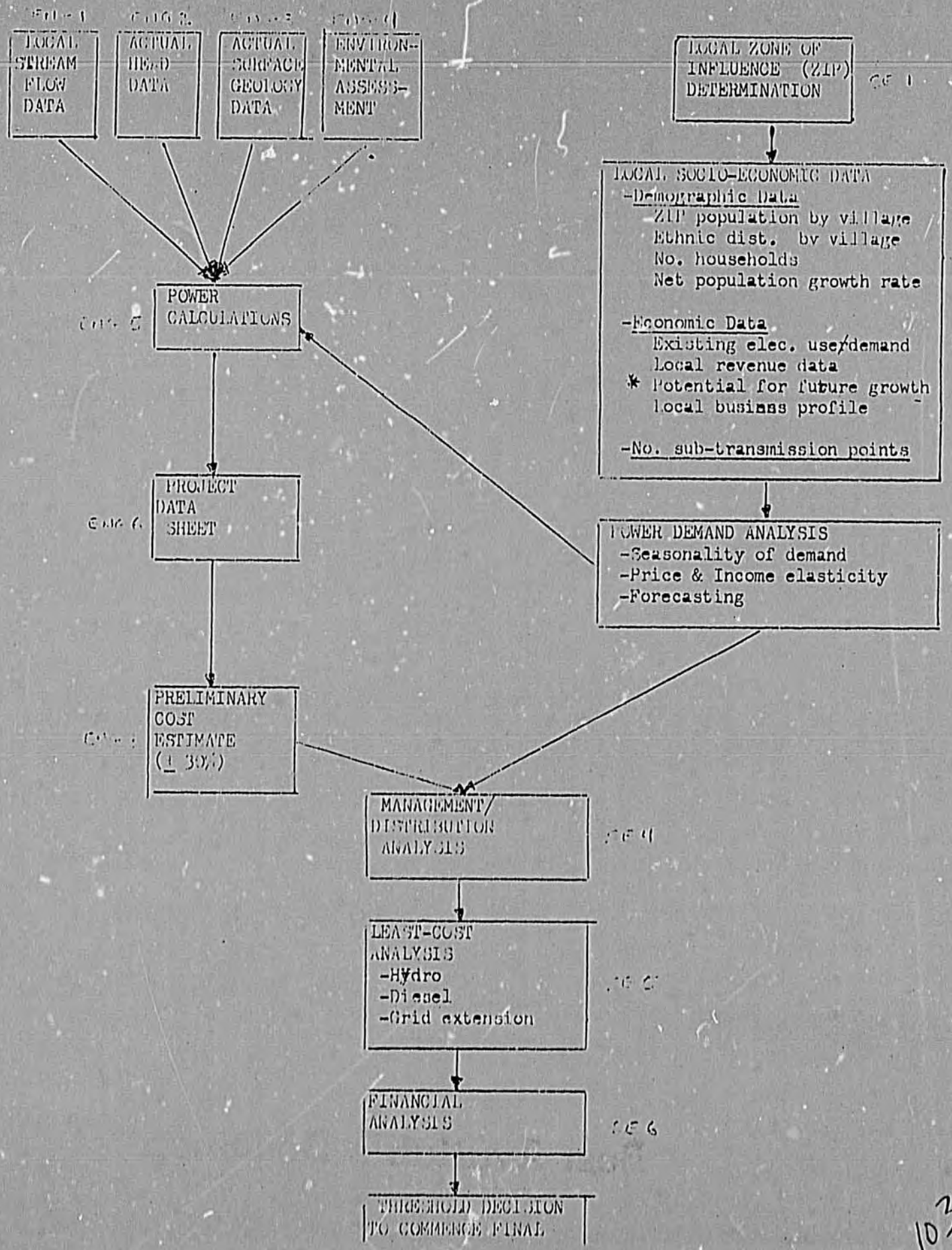
Figure 2: BASIC FEASIBILITY ACTIVITY SEQUENCE



1. Sites under consideration will be constructed as simply as possible and will not resort to dams or pumped storage unless these structures can be shown to be cost-efficient to the project objective of electrical generation.

2. Electrical supply and demand will be matched in the following manner:

   - to avoid damage to the generation system, demand will never exceed supply,

   - no "topping off" of hydro generation with diesel generation is anticipated, although any current PEA plans for grid extension into the site area will be considered,

   - local current and future demand will be forecast only from local data gathered during the survey,

   - variants to the standard forecast noted from survey work may be introduced in addition to the reference hypothesis if local conditions indicate the potential for demand stimulation through promotional activities and/or tariff manipulation and such activities are included in the Project.

3. To simplify construction and installation logistics, phasing of construction will not be recommended unless deemed reasonable at intervals greater than ten years.

Conclusion of basic feasibility field study then sets the stage for active coordination of site development activities with the anticipated operating agency (e.g. PEA, EGAT, RFD, Cooperatives, etc.) to guarantee forward planning of construction, procurement, training, etc. compatible with the objectives of both agencies.

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3.2 Engineering and Environmental Feasibility

3.2.0 General

The following guidelines are to provide a qualified site engineer with a list of the data to be gathered for the feasibility. They are not meant to define each step, or to anticipate what might be found at site. It is important that the engineer carrying out the work be a qualified, experienced field engineer, with construction experience. With this background, tasks identified can be carried out by the engineer, and the methods of measurement and calculations will be obvious. The guidelines will not provide, and cannot provide, an inexperienced man with the necessary guidance to perform this portion of the field investigation.

Additional data observed at sites should be added to the site evaluation. The engineer should use good judgment interpreting specific site data to be incorporated in the record, and to be taken into consideration in advising on site feasibility. Photographs should be taken at site and included in the report.

3.2.1 Local Stream Flow Data

If gauging data are not available on the particular stream being studied, or nearby within the watershed, on site data can be used to guide design decisions. If, however, long-term stream gauging data is available, this element of the site study can be eliminated. If stream data are to be collected, the following steps should be taken:

A. Local tradition can provide historical data on how high water rose up the stream bank during maximum flood. Talk to village leaders; older people within the village, and determine, on a specific location, how high people remember the water extending up a vertical bank rock projection or other identifiable feature. Also, evidence of recent high water marks can be found by observing small piles of limbs, debris, or other items carried by flood waters, which are deposited on the side of the stream bank. Indications of stream low water can also be gathered from local sources, to arrive at a "best guess" on the normal low water, and possibly the extreme low water at a specified location. A cross section of the stream can be measured at the point where these high and low levels have been estimated, and, based on the measured average of stream velocities through the area, estimations of extremes of high and low water quantity can be obtained.

B. At the section of the stream with uniform velocity and, hopefully, confined banks, where high and low water indicators are identified, cross-sections should be measured for the various flow perimeters in that section.

The velocities can be measured by various instruments available for that purpose. The hydrologic branch of NEA should make these instruments available, so that accurate evaluation in existing flows can be made at the time of the site visit, and high and low velocities extrapolated. Lacking these instruments, an estimation can be made of the surface velocities by measuring a course along the stream bank, dropping a floating twig or other item in the stream, and by use of a stop-watch, determining the surface flow along a pre-measured course. From these data, the engineer can calculate the flow within the stream. Wherever possible, the site study should occur in March or April, to give an indication of the low flows within the water course. If time and site conditions allow, consideration should be given to constructing a temporary weir for measuring flows for the initial study, and for use in continuing measurements where this is desirable.

C. The total watershed area contributing water to the stream bed can be determined using one in fifty-thousand scale maps, or other larger scale maps. The most accurate rainfall data for that watershed should be obtained, and calculations should be made to determine the theoretical run off within the watershed, for comparison with other estimates. This should be done even if on site hydrologic investigations are made.

3.2.2 Actual Head Data

The engineer visiting the site should determine the most appropriate site or sites for the water diversion structures. Once these sites have been selected, utilizing one in fifty-thousand or a larger scale topographic maps, the engineer can determine what gross head may be available at various locations along the stream where the power house; the potential for the power house locations can be observed from these maps. Each location should be studied to determine the site conditions at the diversion and power house locations. Once the locations for the diversion structure and power house have been determined, the field survey should be undertaken. The engineer, utilizing a hand level and level location, to determine the gross head available between the head race intake and the tail race. Also, by use of the hand level, the engineer should locate the approximate head race location on the side slope, and measure the length of the head race and the length of the penstock.

The total gross head will be utilized in calculating potential power. The location of the head race will be utilized in determining the cost of the head race.

The general geology, evidence of rock outcrops, should be noted along the head race and should be recorded. The general condition and side sloping along the head race should be observed, and a recommendation made on whether the head race should be constructed as

an open flume or whether it will be a closed type (pipe), and whether the pipe can or should be buried.

All of these recommendations are preliminary. However, they will serve as a basis for costing and as a basis or comparison between alternating sites. Careful records of all field notes should be maintained, and become a permanent part of the project directory.

3.2.3 Actual Surface Geology Data

The geology should be evaluated, especially at the diversion structure, to indicate the difficulty of construction, porosity of the soil, and the susceptibility of the soil to erosion. Test pits should be dug at the approximate location of the diversion structure abuttments. They should be dug deep enough to predict the need for and extent of cut off walls at the diversion works, and at the downstream end of the run off apron. Additional testing may be required at the location of the sand trap and head works of the head race, so that costing of these facilities can take into account any rock excavation which may be encountered. Geology along the head race shall be observed from the surface and, if necessary, observed by digging test pits in order to more accurately estimate the cost of the proposed head race construction. Surface geology should also be observed at the site of the power house and at the site of the tail race. The engineer should recommend the type of discharge works at the tail race and indicate whether energy dissipators will be required. The engineer should also observe the bed load of the stream, in order to advise on the sand trap and intake works for the head race. Heavy bed loads will require that special care be taken during the intake and sand trap design, to assure that the abrasive or other materials are not allowed to enter the head race. Heavy bed loads will also require special design and construction, to allow for frequently flushing the sand trap. Bed load data will also be used in determining the feasibility of providing limited storage for the peak power generation on a daily basis. (Storing water to allow for increased generation during a 3 to 4 hour period each day).

3.2.4 Environmental Assessment

Drawing from the data collected from Sections 3.2.2 and 3.2.3, the engineer should write a short section on environmental impact, which would result from the construction of the project. A check-list of some of the items to be considered is attached as Figure 3. Special consideration needs to be given to the effects on the aquatic life, should most or all of the water be diverted from the stream bed between diversion works and tail race during the extreme low water periods. It should be noted that the area between the intake works and the head race should not contain farming land which can be irrigated, or is now being irrigated, unless special provisions are made to provide water for irrigation purposes; i.e., if the water is diverted away from the irrigations works, it may be possible to provide pump irrigation, or to divert adequate waters from the head works to the irrigation system.

The probability of severe erosion along the entire head race, along the penstock and that diversion and tail race areas should be assessed. In addition, the effects of constructing either temporary or permanent access roads to the site should be reported on, from the environmental standpoint. The capability study should have a separate section titled, "Environmental Assessment", which will report on probable effects of the project from an environmental standpoint, including the effects on wildlife and human lives within and below the project area.

Figure 3:

IMPACT IDENTIFICATION AND EVALUATION FORM

	Impact Identification and Evaluation 2/
1. Changing the character of the land through:	
A. Land clearing	
B. Changing soil character	
2. Altering natural defenses	
3. Foreclosing important uses	
4. Jeopardizing man or his works	
5. Health:	
A. Changing a natural environment	
B. Eliminating an ecosystem element	
6. Other factors:	

2/ Use the following symbols:
N - No environmental impact
L - Little environmental impact
M - Moderate environmental impact
H - High environmental impact
U - Unknown environmental impact

ENVIRONMENTAL EVALUATION

Instructions for filling out Environmental Evaluation Forms:

1a. "Land Clearing", requires evaluating the effects of land clearing, for constructing head race, penstock, and other civil works, land cleared for construction, water diversion, access roads, or other activities, whether temporary or permanent.

1b. Evaluate changes in soil character, which might be brought about by project, through potential erosion, or construction disturbances, such as mixing the upper layers or lower layers of the in-place soil. Also, include the effects of borrowing or wasting soils at the construction site.

2. Evaluate the effects of changing the site conditions, in any way which may expose the natural resources to erosion, de-forestation, de-vegetation, or other, for possible damage.

3. Foreclosing Important Uses, refers to utilizing the site in such a way that construction permanently dedicates natural resources, so that, in the future, the site cannot be restored in such a way that these opportunities can be exploited.

4. Jeopardizing Man or his Works, requires that the investigator observe existing uses, and note those uses which may be altered, due to construction. Farming systems must be observed, to assure that water avilable for use, or being used, is not withdrawn by virtue of the construction. Also, life styles or living conditions of people within the project area should be observed, and effects on these conditions should be documented.

5.A. Changing a Natural Environment, should be evaluated as it pertains to health. This could include construction elements, which become vector facilitators for such diseases as malaria and scistosomaisis. Information on facilities can be discussed with public health officials, who can assist in advising on the effects on local health due to project construction.

B. Eliminating an ecosystem, requires an evaluation, with regard to its effects on health. For instance, the effects on health of completely de-watering sections of water force, by diverting an entire stream's flow through the hydroelectric system.

6. Other Factors: Any items observed which may affect the environment should be noted by the investigators, and evaluated, if possible, or discussed in the field report, for further consideration on over-all project feasibility.

3.2.5 Project Data Sheet

Figure 4 contains Project Data Sheet, which should be filled out by the engineer after the field investigation work is completed. The form is self-explanatory. However, several headings are elaborated on below:

A. Head Data: The type of diversion is, in most cases, projected to be a weir. The project data sheet should show "Weir", the total length and the average height, i.e., Weir, 30 meters by 3 meters. The height will be the average height above ground level at center line on the stream.

B. Elevations under "Head Data" will be from fixed datum, established at the site, and are not expected to be corrected to elevation above sea level.

C. Under "Head Data", the design head will be calculated at this stage as a gross head, less ____ for each lineal meter of head race and penstock.

D. Under "Water Ways", the intake should note whether gates are required, and the statement "simple", or "complex" sand traps should be noted. On the rest of the items under "Water Ways", the lineal meters of each item should be listed.

E. The power plant turbine type should contain the engineer's evaluation as to the generic type of turbine, and the number of units proposed to be installed with the approximate size.

Figure 4:

PROJECT DATA SHEET

Project No: _____ Project Title: _____

District: _____ Province: _____

General:

Drainage area Km 2 _____

Head data:

Type of diversion _____

Elevation at diversion _____

Elevation at tailrace _____

Design head, after losses _____

Waterways:

Intake _____

Open Channel (if required) _____

Pipeline (if required) _____

Penstock _____

Tailrace _____

Power Plant:

Turbine Type _____

Special Items:

Access road to site _____

Project roads _____

Special work (if any) _____

3.2.6 Power and Energy Calculations

Here again, the table is self-explanatory. However, the following is given as a guidance in filling out several sections:

A. Turbine Discharges. The maximum and minimum quantities are the engineer's best estimate of the total gross available during wet season and the expected low flow during dry season. The design flow will be calculated by taking the least quantity of flow available during 80 percent of the year, based on the preliminary flow duration curves, or estimate of the flow duration prepared from hydrologic data available to the engineer.

B. Plant Capacity. Installed capacity is the engineer's best estimate, based on availability of flow and existing maps in the project area. If the system is to be connected to the grid, the installed capacity could be the maximum, which can be installed to utilize the average wet season flow. This will be a projection from the existing needs for power in the area to be served, or the grid, and should include, as an attachment, the basis for reaching the recommended installed capacity.

C. Dependable Capacity. Calculating the dependable capacity, use the "Flow, dependable", listed under the category "Dependable Capacity". Calculating the head at dependable flow, use the design head listed under the category "Head". The "Capacity, dependable" will be calculated from the formula: KW = QH x 7.54. This is derived utilizing efficiencies: Q in cubic meters/sec of the generator, 95 percent, and the turbine at 80 percent. The actual turbine efficiencies may vary, depending on the type of turbine and the quality of manufacture. However, for the purpose of feasibility, efficiencies noted above will be utilized in calculations.

Figure 5:

POWER AND ENERGY CALCULATIONS

Project No: _____ Project Title: _____

District: _____ Province: _____

Item No.	Description	Amount	
1	Turbine discharges:		
	Maximum	_____	liters/sec
	Minimum	_____	liters/sec
	Design flow, average	_____	liters/sec
2	Head:		
	Gross head	_____	meters
	Losses	_____	meters
	Design head	_____	meters
3	Plant Capacity:		
	Installed capacity	_____	KW
4	Dependable Capacity:		
	Flow, dependable	_____	liters/sec
	Head, at dependable flow	_____	meters
	Capacity, dependable	_____	KW

1.2.7 Preliminary Cost Estimate

In calculating the costs, use an average cost of _____ per kilometer. For Item 9, "Engrg , Admin., Constr. Mgmt", utilize a figure of 12 percent of the estimated cost of Items 1 through 4 and Items 6 and 7. (No percentage factor will be applied to Item 4 "Power House"). Other items will require that the engineer, based on his background and knowledge of construction costs, and based on his estimate of the complexity of the work, give his best estimate of each item in the table.

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Figure 6:

TABLE NO. _____

COST ESTIMATE

Project No: _____ Project Title: _____

District: _____ Province: _____

Item No.	Description	Amount
1	Headworks	_____
2	Headrace	_____
3	Penstock	_____
4	Powerhouse	_____
5	Power Plant	_____
6	Transmission/Distribution	_____
7	Special Items/Road	_____
8	TOTAL DIRECT COST	_____
9	Engrg, Admin., Constr. Mgmt (12 Percent)	_____
10	Sub-Total	_____
11	Contingencies (20%)	_____
12	TOTAL CONSTRUCTION COST	_____
	TOTAL PROJECT CAPITAL COST	_____

Note: All costs in equivalent U.S. Dollars at $1 = [illegible]

3.3 Socio-Economic Feasibility

3.3.1 Local Zone of Influence of Project (ZIP) Delineation

It is critical to carefully map the expected zone of influence of the project site (ZIP) in order to clearly circumscribe and understand power demand as well as to determine total transmission and distribution costs. ZIP boundaries should be marked on 1:50 000 scale maps based on such criteria as natural obstacles (swamps, high mountains) or logical grouping of local villages and potential commercial uses (mines, isolated small factories, etc.). Establishment of the ZIP can ultimately become the subject of considerable local political lobbying. A threshold criteria, such as cost per inhabitant of transmission, may have to eventually be developed to introduce a measure of objectivity into this process.

Initial ZIP demarcation will be modified somewhat during the course of local field activities. Major modifications will require recommencing the socio-economic study, however, as they will have a major impact on the data base used for analysis.

3.3.2. Collection of Local Socio-economic Data

This exercise will be the most time-consuming, but also the most important, of the socio-economic activity sequences as it establishes the basic data for all socio-economic analysis and will give the study team a much more intimate notion of the utility and acceptability of electricity at the local level.

Using the 1: 50 000 map, the economist should list all villages or other key electricity user locations within the ZIP. All relevant village-level data available in official statistics should be gathered as early as possible to help orient the study (e.g. 1980 census, District CD officers, local DLA officer). Figure 2 indicates the types of data considered important to the study. Normally, those villages closest to the source of generation (i.e., those sure to be electrified) should be surveyed first. The final list of villages will only be known once a reasonably close estimate of site power capacity is determined.

Key to the collection of local socio-economic data is the undertaking of a detailed survey in each ZIP village. Complete instructions and an acceptable initial survey format are included in Attachment A. As villager perceptions of what is being requested of them will vary, not to mention the quality of survey enumerators, study personnel should be prepared to alter somewhat the standardized format wording based on their field experience, so that the quality of information gathered is as high as possible.

Finally, following completion of his data collection, the economist should confer with the engineer to map out most appropriate routing for all transmission lines, distribution lines and main stepdown transformers.

3.3.3 Methodology for Power Demand Analysis

General

Unless specific demand forecasts are already established (e.g. local mining or major business venture) the economist should estimate growth rates for each demand sub-category: household demand, business demand, public services demand. Two rates will be established, one (x) for the initial period 1-10 years and a second rate for the period 11-30 years (all calculations will be made over a 30 year timespan). The second rate will normally be conservatively calculated (given the higher base and the difficulty of forecasting 11-30 years in the future) as three-fourths the initial rate (.75X). It should be remembered that growth rates are exponential, not linear functions, e.g., 5% growth over five years represents an aggregate 28% growth (1.05 x 1.05 x 1.05 x 1.05 x 1.05, or 1.05^5), not 25% (5% x 5 years).

Sub-category Growth Forecasts

a) Household Demand: Household demand in the first year of power generation will be calculated from the survey data, as corroborated by official statistics. Average surveyed demand per household (kwh) should be multiplied by all households hooked to the system. Growth rate extrapolation will be based on net population growth, and anticipated income growth in accordance with the following formula:

$$(a) + (b \times c) = d$$

where a = estimated population growth rate

b = est. growth rate of household income

c = income elasticity

d = Growth rate of household demand

Items a, b and c may be calculated in the following manner:

Item "a" (population growth) - As a element of household demand forecasting, it is not clear if population growth or "housing unit" growth is the critical factor to be calculated. It has been assumed herein that they are roughly similar, although population growth is proposed for calculation as it is a figure commonly used by government agencies, and potentially more reliable. Population growth in the village being surveyed can be determined from question # A. (1). (2). and as corroborated by District, CD and census data.

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Item "b" (income growth) - An appreciation of current levels of local income can be established using District data and corroborated by questions # A (I.4.), (I.5.), (I.7.-9.), (II.1.-8.), and B (II.1-4). An order of magnitude appreciation of future income growth should be based on the size of the income base calculated previously and the potential for expansion of the primary income occupations in the village. Knowledge of planned future developments in or near the village (new road, irrigation improvements, etc.), subjective impressions furnished by the village head and households surveyed, and District data will be particularly relevant.

Item "c" (income elasticity) - The income elasticity of electrical power should be assumed to be 1.2 unless other reliable historical data is available. Project impact studies should permit further refinement of this coefficient based on actual field results. Questions # B.(V) (2.-3.) may also be useful in establishing a localized coefficient.

b) Business Demand: Business demand in the first year of power generation will be calculated from the survey data, as corroborated by official statisites. Question # A. (IV.) is the primary source of local data for this calculation. Growth rate extrapolation will be based on general economic growth estimates and known planned growth for specific ventures. In no case should the business demand growth rate be less than that of local population growth, however.

c) Public Services Demand: Public services demand in the first year of power generation will be calculated from survey data, as corroborated by official statistics. Question # A (III.) is the primary source of local data for this calculation. Local officials should be questioned about anticipated future developments in education, health, public works, etc. to circumscribe long-term growth in this area.

Aggregate Forecasts

The base year data and growth estimates generated by the previous exercise must be recapitulated in an easy-to-read format which will illustrate total estimated power requirements over time and according to seasonal and hourly fluctuations. The following procedure is suggested.

1) Immediately upon completion of the interviews in a given village, Figure 3 should be completed, indicating characteristic user patterns for key-electrical appliances in only that village. This information is drawn directly from question # B.(V.)(4.). In the absence of local knowledge of power requirements for each appliance, the values registered in Figure 4 may be used.

2) Determine visually which items utilize the vast majority of power generation (use 80-90%). Generally no more than five items will consume most power in a small rural village, although this number could vary in either direction.

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3) Establish aggregate-hourly variation forecasts for each village in the ZIP then for the entire ZIP, using the format shown in Figure 5.

4) Establish aggregate seasonal variation (monthly) forecasts for each village in the ZIP, then for the entire ZIP, using the format shown in Figure 6.

5) Finally, order of magnitude forecasting of ZIP demand over the 30-year life of the small hydro installation should be carried out according to the format shown in Figure 7.

3.3.4 Management/Distribution Analysis

This analysis can ultimately only be completely by the management entity in charge of operating the sub-project site - a prerogative they will undoubtably wish to exercise. However, the study team techniques can and should make detailed recommendations on this topic based on their localized field knowledge, and should be involved in any future management - related discussions with the management agency.

No simple method can be suggested for this analysis. Rather a series of issues will be raised below under each topic requiring local appraisal and recommendation.

Management Analysis: Who should manage the sub-project? Options range from specialized agencies like PEA, EGAT, or private generation groups to select line agencies with some management capacity (RFD, RID) or eventually some form of cooperative movement. Do these candidates have a good local record of performance and good local reputation? Will local villagers cooperate freely with them? Does the management agency have any procedires, such as standardized procurement specifications, which need to be taken into consideration by the study team? What are the requirements for proper management of the sub-project (personnel, training, logistic support, housing, spare parts, repair facilities, etc.) over time?

Distribution Analysis: What is the most appropriate system to utilize for distribution to prospective clients, respecting objectives of low-cost, maintenance - free monitoring: standard individual meters, power limiters, adapted metering, collective metering. Give sizes and specifications.

Tariff/Collection Analysis: Experience in rural electrification indicates that financial returns from energy sales are often low in the early years, even when consumer demand is good. This may be particularly true of hydropower systems because of their lumpy, up-front investment costs and the fact that load factors develop from low levels, not to mention the difficulties of establishing efficient collection and administration systems in the early years. The selection of appropriate tariffs can therefore be a difficult issue. For those sites where RTG policy will permit flexible setting of tariffs, it is suggested that the study team initially attempt to

Figure 3: Characteristic User Patterns

Name of Village:

Item	Watts/ Item	No. of Items	Use Patterns	
			Daily Pattern	Seasonal Pattern
1. Light				
2. Fan				
3. Refrigerator				
4. Water Pump				

Figure 4: Power Requirement Tables

Items:	Power Requirement (one item only)
1. Light (either incandescent or fluorescent)	40 w.
2. Fan	35 w.
3. Refrigerator	180 w.
4. Radio	5 w.
5. Television	100 w.
6. Iron	300 w.
7. Sewing Machine	100 w.

Figure 5: ZIP Hourly Variations
(Base Year Only)

Est. Avg. Demand (KW)

Hour	50	100	150	200	300	400
00:00-02:00						
02:00-04:00						
04:00-06:00						
06:00-08:00						
08:00-10:00						
10:00-12:00						
12:00-14:00						
14:00-16:00						
16:00-18:00						
18:00-20:00						
20:00-22:00						
22:00-00:00						

Figure 6: ZIP Monthly Variations
(Base Year Only)

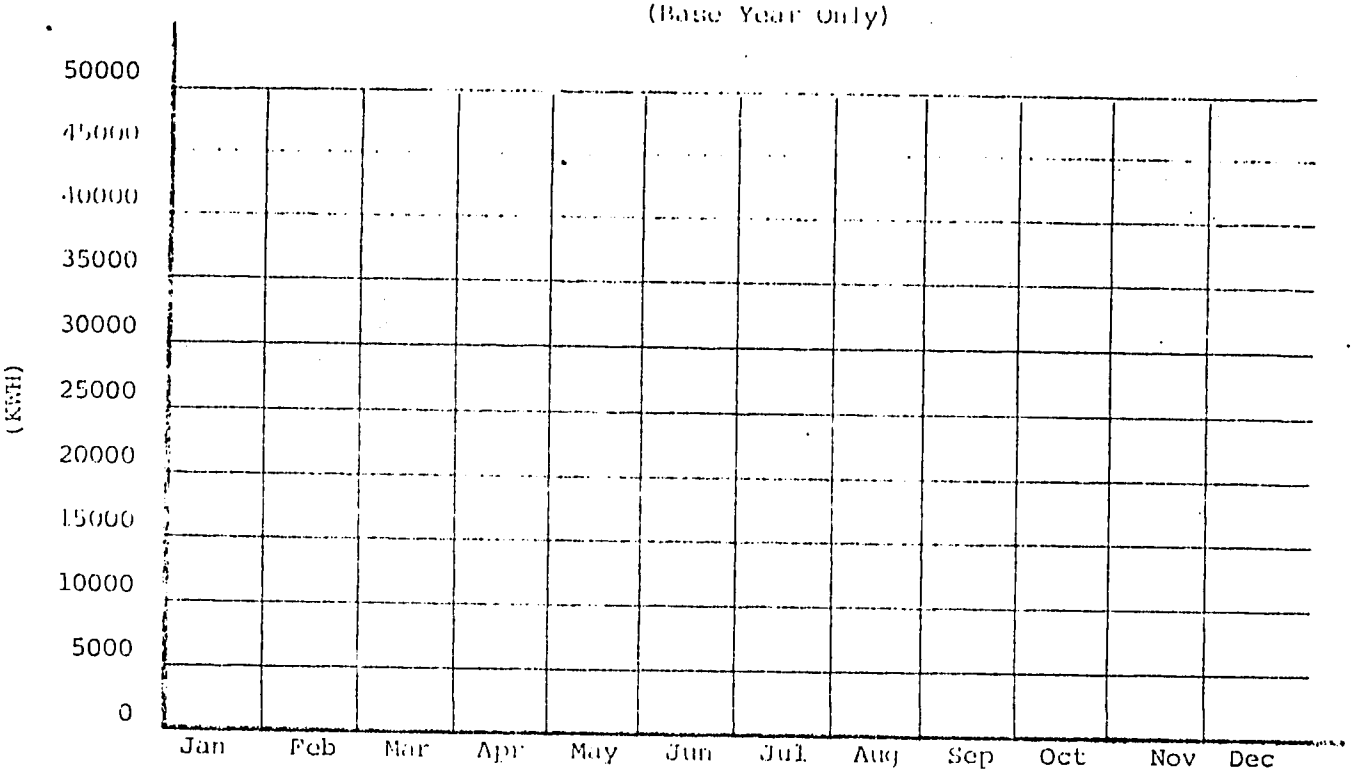

Figure 7: ZIP Demand Forecast

Year	Energy (in KWH)			
	household	Business	Public Services	Total
Base Yr.				
Base + 10				
Base + 20				
Base + 30				

utilize the current and projected EGAT tariff schedule in their financial analysis (see "3.3.6. Financial Analysis"). If the initial financial rate of return is very high (> 8%) or if the study team's village survey research has indicated that villager response will be poor at those tariff rates, further analysis should be undertaken, of the possibility of manipulating tariff levels. Study conclusions on the important issue of tariffs may vary considerably from one site to the next. If final conclusions deviate significantly from official RTG policy for reasons of social acceptability or financial viability, the study team should be careful to underscore the importance of such deviations for the successful development of the site in question.

For example, in a remote rural area, where no electricity has previously existed and where aggregate demand is composed exclusively of small village households, it may be appropriate to stimulate early interest and utilization of electrical energy through artificially low tariffs in the early years to obtain a high load factor. Conversely, in an area of primarily commercial demand (e.g. mining) but where the load factor is low, recommendations might call for an initially high tariff, or phasing of generation installations, or both.

All of the discussion of establishment of tariffs will be but a paperwork exercise, however, if an efficient and locally acceptable collection and enforcement system is not developed. Using local field data and understanding, the team will be expected to recommend such a system. Normal procedures will probably dictate the regular use of collection agents from the agency which operates the generation unit as well as the practice of cutting off unpaid power until settlement of the debt. Because of the remote nature of some sites or because of special distribution systems, study recommendations may differ from standard procedures, however.

All recommendations on management and distribution concerns generated by this analysis should be included in the site feasibility study report and discussed fully within the intended operating agency upon return of the NEA team to Bangkok.

3.3.5 Least-Cost Economic Analysis

The least-cost analysis works from the premise that the RTG has already made a commitment to furnish electricity to all areas of Thailand before 1990 (See Thai 5th National Plan). Previous steps in this assessment of basic feasibility will have already determined power demand requirements over time. Given the commitment to move ahead with rural electrification and knowing the nature of local demand, this attachment them studies the comparative effectiveness (cost) of the micro-mini hydro generation system with other delivery options. In the Thai context this comparison should explore three options: hydro generation, diesel generation and extension of the existing grid. Clearly, hydroelectric, even small hydroelectric generation, will not always be the least-cost solution to local power generation needs.

Cost comparison analysis should utilize the format illustrated in Figure 6, attached. Step-by-step instructions on the completion of this format as well as the ensuing analysis is noted below. All costs should be calculated in "economic" terms, i.e., net of all subsidies and taxes (internal economic transfer payments) and be calculated according to the same base year (no allowance is made for inflation over time). Figures noted below are calculated in 1982 base year terms. The salvage value of all options may be assumed to be zero at the end of each option's useful life. To compensate for the differential valuation of different investments over time, total costs of each energy option will be discounted at the theoretical opportunity cost of capital of 12%. Discounting over the estimated useful life of the project of 30 years will result in totals ("net present worth") for each option, which can be quantitatively compared. The lowest net present worth (NPW) indicated the least-cost electrification option. If the hydro option under consideration does not pass the least-cost test, relevant decision-makers should seriously reconsider the project and explore the acceptability of other electrification options.

1) Step #1: Calculation of Costs

a) Hydro Generation Costs: The theoretical useful life of the basic hydro generation system may be calculated as 30 years. All costs have therfore been presented in Figure 6 over a 30-year timeframe. "Capital Costs" (Column H1) will generally all be incurred in year 1 and should include all tax-free costs of construction, equipment, engineering design and supervision related to the power generation system. Transmission and distribution costs will, however, be treated separately below. During the life of the system some components (miscellaneous equipment and facilities) will wear out and require replacement. Rather than define as capital costs, this model will deal with replacement costs under Column H2, "Operation and Maintenance". The tax element of capital costs may be calculated as 5% of the total.

Operation and maintenance costs for small hydropower systems are difficult to forecast accurately and are directly related to local site conditions and the quality of site management. This column will include routine maintenance and operation (wages, services, equipment and parts) and the previously-noted costs of equipment replacement. For simplicity, O&M costs will be calculated at 2.0% of total capital costs (Column H1) for every year of plant operation.

Transmission and distribution costs (Column H3) must also be added to the cost comparison. This will reflect one of the inconveniences of small hydro schemes, namely the need to occasionally invest considerable money in transmission while carrying but a very small load. In the absence of local estimates, representative current (1982) construction costs for both standard 22 KV transmission line and of the associated distribution system (distribution line, step down transformers) may be calculated as 255,000 Baht/kilometer, irrespective of the type of terrain. O&M costs for the transmission/distribution system may also be added to Column H3 at the rate of 1.0% of capital costs for every year of operation.

Figure 6: Format for Least-Cost Analysis

(000 ฿)

	Hydro				Diesel					Grid Extension		
[illegible]ar	H1: Capital Costs	H2: Operation Maintenance	H3: Transmission & Distribution Costs	H4: Total	D1: Capital Costs	D2: Operation Maintenance	D3: Fuel Cost	D4: Transmission & Distribution Costs	D5: Total	G1: Capacity Costs	G2: Cap[illegible] Costs & Maint[illegible]	G3: [illegible]

[illegible] Present [illegible]

→ → →

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b) Diesel-driven Generation Costs: The reference situation being compared in this analysis is that of 24-hour power availability (hydro and grid extension options). For purposes of comparison, this analysis will consider that capital costs (Column D1) of diesel system will include multiple diesel generation units (12 hours each).

A local tax-free price of 450,000 Baht per 50 KW diesel unit may be utilized for this model. It may be assumed that the diesel engine only will require replacement every five years, at an estimated cost of 200,000 Baht/unit in 1982 prices, (estimated life of 10,000 hours, plus one overhaul, or total 20,000 hours) but that other elements of the power plant will continue to function over the entire 30-year useful life of the system.

Operational and maintenance costs may be calculated (Column D2) as 3.0% of the initial capital costs noted in Column D1.

Fuel costs (Column D3) should be calculated by multiplying local pump costs times the coefficient of 0.87 to adjust for Thai produce taxes.* Because of the exceptionally high projected increases in petroleum costs, fuel costs may also be differentially inflated at 3% per year, compounded, over the entire thirty-year period. In the absence of local data, fuel consumption may be estimated at 15 liters/hour of use per 50 KW unit.

Transmission and distribution costs (Column D4) should normally be less than in the hydro case, given the possibility of locating diesel generation in one of the villages to be supplied with power. As with the hydro case, costs of transmission and distribution should be calculated as 255,000 Baht/kilometer and operation and maintenance costs (include in same column) as 1.0% of capital costs for every year of operation.

c) Grid Extension Costs: Extension of the existing electrical grid is a viable option for comparison only if the grid has sufficient surplus capacity to feed the extension, or, if an additional generation capacity is built to handle the new requirement. Current EGAT methodology is to assume full utilization of existing power and add a "capacity cost" to the grid extension option. The size of capacity extension must include not only the extra load requirement in the project zone of influence, but also the energy loss in the transmission and distribution systems. EGAT assumes energy loss in transmission as 3% and in distribution as 8%. Once the new capacity requirement has been established, capacity costs may be calculated at 24,500 Baht/KW and associated generation costs at 0.7 Baht/KWH.** This information should be noted in Column G1.

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* Taxes are actually applied on fuel at the refinery, prior to transportation. Use of the 0.87 coefficient against local pump costs will provide sufficient accuracy for the purposes of this model, however.

** Utilizes 1981 EGAT calculations plus 10% for inflation to establish 1982 base year.

Capital costs (Column G2) of actual transmission (22 KV) and distribution line construction may utilize 255,000 Baht/kilometer, irrespective of terrain and O&M costs (same column) may be calculated at 1.0% of capital costs.

2) Step #2: Discounting

Total costs should be calculated for each generation option for each of the 30 years shown in Figure 6. These totals should then be discounted at the theoretical opportunity cost of capital, which may be assumed at 12% for rural Thailand.

3.3.6 Financial Analysis

Current national policy in the power sector is to encourage investments and tariffs which permit the sector to be financially viable. It is, therefore, broadly expected that hydroelectric investments should not only pay for themselves over time, but, even further, that they should generate the capital necessary for future investments in the sector. Accordingly, this decision-making model includes a simple financial analysis which will provde a good indication of individual sub-project financial feasibility and an indication of appropriate tariff rates over time to attain that goal.

This analysis will also complement the previous least-cost analysis in that it will give an indication of absolute project worth (financial costs and benefits over time) instead of simple comparative worth (economic costs only, over time for several generation possibilities). This analysis will also take into consideration the type of funds utilized and eventually will indicate the types of financing acceptable for this type of investment.

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Figure 7: Format for Financial Analysis

(000)

Year	Outflow				Inflow			
	1) Capital Expenditures (Construction of Generation & Distribution)	2) Operating Expenses & Maintenance	3) Debt Service	4) Total Outflow	5) Loan Funds	6) Energy Sales	7) Total Inflow	8) Net Cash Flow
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

Information necessary to this type of analysis is illustrated in Figure 7, attached. All financial inflows or outflows should be presented in current-year baht, including all estimated contingencies and inflation for each year of the entire 30-year life of project. The project can be assumed exempt from major income or corporate taxation and to have a salvage value of zero at the end of year 30. Minor taxes on construction and social charges for personnel will be retained.

Column # 1: Should include all capital expenditures for construction of generation, transmission and distribution components of each individual site.

Column # 2: Should include all routine maintenance and operation as well as periodic equipment replacement (see "least-cost analysis", Attachment C). Total O&M may be taken as 2.0% of total capital expenditures (column 1) for every year of plant operation.

Column # 3: Should include all debt service charges (interest and/or principal) according to the conditions of available financing.

Column # 4: "Total Outflow" is the sum of columns 1-3.

Column # 5: Should include any inflow of borrowed capital in the year that those funds are made available to the sub-project.

Column # 6: Should include all inflows generate by the sale of energy production. Equal to the number of kwh times expected kwh tariff in the year oc calculation.

Column # 7: "Total inflow" is the sum of columns 5-6.

Column # 8: "Net Cash Flow" is sum of columns # 4 and # 7 (may be positive or negative in any one year).

When complete, the net cash flow over the entire project life exhibited in Column # 8 should be run through an internal rate of return analysis, either using an appropriately programmed hand calculator, or through the more time-consuming discounting method. This will result in a financial rate of return for the sub-project under consideration. This rate of return (ROR) should be at least 8% over the whole project life, in accordance with EGAT general policy goals for return on investment.

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ATTACHMENT A:

INSTRUCTIONS FOR USE OF VILLAGE SOCIO-ECONOMIC SURVEY FORM

The attached form is intended for use in surveying all villages located within the zone of influence (ZIP) of the individual hydroelectric generation sub-projects. Data generated by the survey will be mainly useful in power demand forecasting and as baseline data for subproject monitoring and evaluation. The format is deliberately focused so as to answer specific forecasting questions and is kept as simple as possible to render it understandable and time efficient for enumerators and respondents alike.

Every village located in the influence zone should be surveyed. It is estimated that roughly one day should be allowed for each village survey, although small villages may be done more quickly. Investigations will be done both at village level - using questionnaire and instruction Form A to interview the village headman and/or other types of village leader. At the household level, questionnaire and instruction Form B will be used. A representative sample should contain 5-10% of all village households. The following procedures are suggested, although improvements to the questionnaire and survey techniques can and should be incorporated as appropriate.

1. Personnel Requirements: Economist - with some background and experience in local electricity design and evaluation, in addition to his capability to build up a good relationship to villagers. This person should have full responsibilty to select and train field supervisor(s) and enumerator(s), and to conduct the overall survey. Since the enumerator's role is crucial to the whole site selection process, special criteria and procedures should be established for their recruitment. Highschool or university graduates with an interest in rural development (agriculture, agricultural economics, rural studies etc.) should be accorded priority. A particular emphasis motivation and morale should be utilized. This might be observed during an orientation period or personal interview. In regions where local dialects (e.g. Northern Thai, Southern Thai) are widely spoken, enumerators must have these language skills.

2. Pre-survey Requirements: The eocnomist should gather village pre-survey demographic and economic data from both secondary sources (NSO, DOLA and DCD, etc.), and from primary sources - at province or district level, prior to commencing actual village surveys (the District Community Development Officer may be one of the best local sources of official data). Complete lists of households and rough mapping of each particular village could be collected during the pre-survey to provide

insights into the statistical techniques to be utilized for sampling design.* An introduction to the nature of work being undertaken should be made for Amphoe officers, Kamnan (District Officer) and village headman as well. Prior to commencing actual field work, enumerators should be described and questions should be pre-tested as required.

3. Survey Requirements: The model assumes a total of two weeks for establishing basic feasibility of each site. Survey work for a typical village will require an average of one day. If the villages-level formalities were completed in the pre-survey period, the eonomist should immediately administer Form A. If appropriate Form B should also be begun simultaneously and also will be done through the rest of the day. Prior to the sample households list, an enumerator will try to locate them and conduct interview to the household head or another relevant person. One enumerator should be able to run at least 6 questionnaires per day while allowing enough time to undertake minor field audits, to revise any omitted parts or the reconfirm unclear responses with respondents. Enumerators should be carefully supervised during the one and half day orientation and another half day to practice of survey work first two days of survey work to ensure that their comprehension of questions and relationship with the villagers is correct.

4. Other Administrative Issues: To enter any particular village, a letter of introduction from the Amphoe headquarters might be useful in initial contacts with the headman. Good understanding of the Team's purpose will be conveyed to villagers by the head and so benefit the survey.

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* E.g., for the Mae Chaem Luang site, households were assembled in spatial order (according to village numbering system) and a random sample of very 6th households was selected. Adjustments were then made for simple stratification according to ethnic affiliation. Household heads not available for interviewing of the time when enumerators stopped in, were replaced by their next-door neighbor.

Project: Micro/Mini Hydroelectric AID Project No. 493-0324

Village Code Number .....

Questionnaire Form A*

Name of Village ..... Village No. .....

Tambol .....

Amphoe .....

Changwat .....

Name of enumerators .....

Name of supervisor .....

Date of interview .....

*Form A for village leader, district officer, school teacher and/or any type of person knowledgeable about the village.

Questionaire Form A

I. Population and Land Profile

(1) No. of households . . . . . .

(2) No. of households (. . . yrs. ago) . . . .

(3) No. of inhabitants (live minimum 1 yr. in village) . . . . . .

(4) No. of houses with hard roof . . . . . .

(5) No. of villagers gone out to work and send money back . . . . . .

(6) Population: a. Local Thai . . . . . .%

b. Sino-Chinese . . . . . .%

c. Ethnic groups. . . . . .%

Karen . . . . . .%

Hmong . . . . . .%

Others (Specify) . . . . .%

(7) No. of land for lowland rice cultivation . . . . . rai

Average size of lowland rice field per HH . . . . . rai

(8) No. of land for upland rice/upland crop . . . . . rai

Average size of upland field per HH . . . . . rai

(9) No. of orchard land rai

Average size of orchard land per HH . . . rai

II. Main Occupation of Households

(1) No. of households that usually plant rice . . . . . .

Percentage of glutinous rice is . . . . . .%

(2) No. of households usually plant cash crop . . . . . .

Type of main cash crops a. . . . . .

b. . . . . .

c. . . . . .

(3) No. of households that raised buffaloes and cow mainly for sale . . .

(4) No. of households that raised pigs mainly for sale . . . . . .

(5) No. of households that raised chicken mainly for sale . . . . . .

(6) No. of households engaged mainly on labor employment . . . . . .

(7) No. of households that produce home industry products mainly for sale . . .

(8) Other main occupations (specify and give number of households) . . . .

. . . . . .

. . . . . .

. . . . . .

III. Existing Public Institutions (Within the Village)

Name	Existing Yes	Existing No	Degree of Activeness During a Year	% of Participati
1. Wat				
2. School				
3. Health Center				
4. Newspaper Reading Place				
5. Market (morning market or any other similar)				
6. Other institutions:				
Cooperatives group				
Farmer's group				
Youth or housewife				
Occupational Development				
7. Village Committee				
Village Development				
Wat Committee				
School Committee				
Irrigation Committee				
8. Others (Specify)				
_____				
_____				

IV. Business Profile

Types	No. of Employees	No. of Yrs. in business	Seasonality of Activity
1. General Store			
No. 1 Name_____			
No. 2 Name_____			
No. 3 Name_____			
No. 4 Name_____			
2. Grocery			
3. Food shop			
No. 1 Name_____			
No. 2 Name_____			
4. Tailor/seamstress			
5. Barber & beauty salon			
6. Agric. produce			
7. Blacksmith/carpenter			
8. Gas pump			
9. Others (Specify)			
_____			
_____			

V. History of Electricity Use

Has your village been electrified? ( ) Yes ( ) No

If yes, give details:

	Size of Generator Capacity	Years of Installation	Owners	Users (Specify)	Period of Utilization Mon/Yr	Day/Mon	Hr/Day
1.							
2.							
3.							
4.							

VI. Community Participation

	How Often During a Year	Number of Active Members
1. Village owned development program		
2. Special government programs		
a. Job creation program		
b. Crop price support program		
c. Others (specify)		
3. Agricultural development program		
4. Health & population planning program		
5. Private agencies		
a. Pesticide & insecticide vendors		
b. Pharmaceutical advertising		
6. Security development program		
7. Others (specify)		

Instruction Form A

General Information

1. Questionnaire Form A is designated to be used for village headman, district officer, school teacher and/or any other type of person knowledgeable about the village. At least one representative besides village headman should be interviewed to confirm the village data and information obtained from any particular village.

2. Researcher and/or supervisor will use this form to conduct interviews, especially with village leaders, etc. They should also actively involve themselves in the use of the form by enumerators during fieldwork.

3. Introduction to the project and purpose of the work should be stated clearly by researcher/supervisor at the beginning. The introduction of him/herself is also necessary. Preparations should be made to answer any of the respondent's questions as well.

4. Some definitions

   Household is defined as a person or group of persons living together under the same roof and having a common arrangement (shared purchasing, cooking, eating) for the preparation and consumption of food.

   Local Thai means local typical Thai population. They might be distinguished by region since they use different dialects for example Northern Thai, Southern Thai, Northeastern Thai, Eastern Thai and Central Thai.

   Sino-Chinese refers to a group of Chinese people (some are Thai citizens by law) who maintain and practice their ways of living as typical Chinese way eating habits, costume, ceremony, tradition and manners, etc.

   Ethnic groups refers to any group of people who show clear distinctions in most ways from typical Thais. Usually, it refers to various types of hilltribes such as Karen, Hmong, Lisu, etc.

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Individual Question Instruction - (Only those questions that need clarification - the others are omitted)

I. Population Profile

(2) No. of households (.....yrs. ago).

This is to estimate population growth. Normally, one would put down the number of households ten years ago. For recently established villages, however, choose a shorter time frame. The number of years should be identified exactly prior to the survey for each.

(6) Population (By percentage).

Percentages can be computed later if absolute number (No. of households for each group) are obtained instead of percentage.

(7) No. of land for lowland rice cultivation.

The total number of rice field in rai that have been utilized by villagers so far, (not distinguished in term of ownerships).
Average size (in rai) of lowland rice field per household refers to the normal size of lowland rice field that has been utilized so far.

(8) The same concept as (7) but it explores the total amount of land for upland rice or upland crops have been utilized by villagers as well as the average size no matter who they belong to.

II. Main Occupation of Households

To obtain occupation profile of villagers, seven or more major activities have been listed out. The respondent is expected to give rough number of households that directly involve in rice, cash crops, livestock raising, labor employment and home industry.

III. Existing Public Institutions (within a village)

Types of institutions include both physically existing ones such as wat, school, newspaper reading places, market place, etc., and non-physically existing such as various groups such as - cooperatives', farmers', youths', housewives' and occupational development groups etc. For village committee types, they are such as village development committee, school committee, wat committee, irrigation committee, etc.

Heading of columns "Existing" needs the mark "✓" on Yes or No for existing or non-existing in that particular village.

Column "Degree of Activeness". The information needs are similar to II but since the activities do not occur at any particular time, but occur intermittently during or throughout the year, state the frequency per year the activities actually occurred. If not very frequent, also state the months they occurred.

Column "Percentage of Distribution". Give number of households which participate as percentage of total number of households in the village.

IV. Business Profile

The types listed are the common business shops found within a village. Some are quite small (size, annual turnover, number of employees) and are seasonally active.

No. of Employees - Means number of persons who are hired in business both temporary or permanent. Specify also what type (temporary or permanent). This includes the unpaid household members but excludes the entrepreneurs)..

No. of Years in Business - If less than a year, write "less than one year" in this column.

Seasonability of Activity - Specify time during a year that those shops are very active as it. If not relevant, write "non-seasonal".

V. History of Electricity Use

Some areas have had electricity usage for some time. This section explores how it was, who owns it and its utilizations. This is essential to design the project so it needs some degree of effort to obtain information by careful interviewing as well as researchers' own observation.

VI. Community Participation

To know the interest of villagers in public works as well as the directions of interest in various types of tasks, the information might be used to help design a relevant system of electricity installation and operation.

NOTE: Before ending, interviewers may add more questions on general expectations on any changes which will occur suddenly if a village is electrified such as - there will be more/store open ~~now~~, more activities etc. Also the respondent's estimate of how much percentages of household will immediately hook up the grid.

Project: Micro/Mini Hydroelectric AID Project No. 493-0324

Village Code Number.....

Questionnaire Form B*

Name of respondent.....Household address.....

Name of village.....Village No.....

Tambol.....

Amphoe.....

Changwat.....

Name of enumerator.....

Name of supervisor.....

Date of interview.....

*FORM B. for household interview either be the household head or any other person residing in household who is knowledgeable on household earnings, living conditions and attitudes especially on electricity utilization.

Questionnaire Form B

I. Household members

Ethnic group (specify).....

No. of persons stay in (live minimum 1 yr).....

Main activity during a year (15 yrs and older person(s))

	Name	Relationship to HH head	Main activity during Dry season	Main activity during Wet season
1.				
2.				
3.				
4.				
5.				

II. Land holdings and annual production.

1. Number of lowland rice cultivation.....(rai)

2. Number of upland rice/cashcrop cultivation .....(rai)

3. Annual production

	Total production Volume (Specify Unit)	Total Value (Baht)	Amount Sold	Income Earnings
Crop				
a. Non-glutinous rice				
b. Glutinous rice				
c.				
d.				
e.				

	Amount Sold	Income Earnings
Livestock/fishery		
a. Cow & buffalo	_____	_____
b. Pig	_____	_____
c. Chicken	_____	_____
d. Fish	_____	_____
Homemade product		
a. Pottery	_____	_____
b. Carving	_____	_____
c.	_____	_____
d.	_____	_____
Labor employment		
a. Farm labor	_____	_____
b. Other (specify)	_____	_____
.....	_____	_____

4. Describe any types of primary processing which have been made in HH before consumption or trade. Specify clearly on any equipment/instrument needed.

.....

.....

.....

.....

.....

.....

III. Household belongings - existing electrical items and or which potentially for electrical replacements.

Items	Number	How often you use mon.yr.	day/mon.	hr./day
For lightening				
Kerosene lighting	_____	_____	_____	_____
Candle	_____	_____	_____	_____
Flashlight	_____	_____	_____	_____
Gas lighting	_____	_____	_____	_____
Pump	_____	_____	_____	_____
Flourescent	_____	_____	_____	_____
Incandescent	_____	_____	_____	_____
Other (specify)	_____	_____	_____	_____
.....	_____	_____	_____	_____
Home appliance				
Radio/cassette	_____	_____	_____	_____
Iron, charcoal	_____	_____	_____	_____
Sewing machine, foot	_____	_____	_____	_____
Ice box	_____	_____	_____	_____
Refrigerator, gas	_____	_____	_____	_____
Electrical fan	_____	_____	_____	_____
Iron, electric	_____	_____	_____	_____
T.V.	_____	_____	_____	_____
Refrigerator, electric	_____	_____	_____	_____
Sewing machine, electric	_____	_____	_____	_____
Rice cooker, electric	_____	_____	_____	_____
Other (specify)	_____	_____	_____	_____
.....	_____	_____	_____	_____

Items	Number	How often you use mon.yr.	day/mon.	hr./day
Equipment				
Water pump	_____	_____	_____	_____
Mill	_____	_____	_____	_____
Other (specify)				
.....	_____	_____	_____	_____

IV. Household sources of cash credit.

Total amount of existing debt .....baht

Sources of credit

Friend, relatives, neighbors _____baht with ____% interest rate.

Business-patron (storekeeper, employer, etc.)_____baht with _____% interest rate.

Commercial source (BAAC, Commercial banks)_____baht with _____% interest rate.

Amount needed if HH is electrified (approximate) _____baht.

Potential sources of credit and terms

	Source	Amount needed	Interest Rate	Repayment Period
1.	_____	_____	_____	_____
2.	_____	_____	_____	_____
3.	_____	_____	_____	_____

V. Household power demand

1. Existing power consumption (only power that electricity could substitute for)

Type	Price per Unit	Monthly total units	Annual expenses (baht)
Kerosene	_____	_____	_____
Candle	_____	_____	_____
Batteries	_____	_____	_____
Diesel (not for car)	_____	_____	_____
Gas	_____	_____	_____
Benzine (not for car)	_____	_____	_____
Others (specify)			
.....	_____	_____	_____
.....	_____	_____	_____

2. Future power consumption

(1) If your village were electrified would you be willing to pay the ..... baht necessary to hook up to your household?

( ) Yes (skip to (3))

( ) No. Explain why.....

(2) If you receive some appropriate credit to pay for the hook up cost, would you be willing to do?

( ) Yes

( ) No. Explain why .....

If both (1) and (2) are no. Stop the interview otherwise proceed.

(3) Do you want to use electric power in your own house if it costs you

(a) double what you pay for your existing power?

( ) yes ( ) no

(b) Half as much as you pay for your existing power?

( ) yes ( ) no

(c) as much as you pay for your existing power

( ) yes ( ) no

(4) If you get electricity, what items would you buy first within the next 2 years?

Type	Rank first-five priorities	Expected number	How to obtain: Own money	How to obtain: credit	How to obtain: Other (specify)	How often to use: mon/yr.	How often to use: day/mon.	How often to use: hr/
Light (specify)								
Flourescent								
Incandescent								
Radio/Cassette								
Electric Fan								
T.V.								
Rice cooker								
Iron, electric								
Refrigerator								
Sewing machine								
Water pump								
Other (specify)								
.....								
.....								
.....								

VI. Participation and form of maintenance

1. If your village is electrified, would you be willing to contribute any of these following:

( ) money

( ) material

( ) labor

( ) Others (specify)

.....

2. What form of maintenance organization do you think is appropriate to your community?

( ) Village committee

( ) Tambol committee

( ) Cooperative group

( ) Youth group

( ) Other (specify)

.....

.....

Instruction Form B

General Information

1. Questionnaire Form B is designated to be used for household sample for household heads or any other person residing in household who is knowledgeable on household earnings, living conditions and attitudes especially on electricity utilization.

2. This form will be used by enumerators to conduct an interview of sample household which have been identified by supervisors prior to the interview. After these forms have been used in the field, enumerators should review, edit and hand it to their supervisor as soon as possible. It is best if revisions can be made in the field since some omitted parts or unclear responses can be reconfirmed with the respondents.

3. Enumerators need to understand the tasks, the project and its purpose clearly enough to make a good introduction for the household samples. Individual techniques might be developed to build up a strong relationship between him/her with the villagers - explaining the purpose, introduction at the door, answering some respondent's questions and setting the stage for the good interview. Also, they should practice some techniques of "probing" and try to avoid jotting down too many "don't know" answers.

4. Some definitions.

   Note all definitions on Instruction Form A: Household, local Thai, sino-chinese and ethnic groups.

   The village code number on the cover page refers to the computer code which is commonly assigned to a particular village throughout the country. (Enumerators do not need to fill out by themselves).

Individual Question Instructions: (Only those questions that need clarification - others are omitted)

1. Household members.

   Identify the number of total members who live in at least one year or more. List members who are fifteen years and older and explore the main activity of each during the wet and dry season. Household head should be the first person on this list. Note: The names are not required to be perfectly correctly spelled since they ~~will benefit for smoothing the interviewing~~ and for psychological reasons only. (are unimportant to facilitate interview)

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II. Land holdings and annual production.

(1) & (2) Providings number of land have been used by household in rai whatever how many pieces are and who owns those land. Make distinguish between low land rice field and upland rice/cash crop plantation.

(3) Annual production. It includes all production figures throughout a year (crop year not calendar year). Be sure to have both wet and dry season harvest for crop production. For livestock/fishery and homemade products, the amount sold are applicable. For labor employment, specify the total amount (in terms of numbers of units or days of work in column "amount sold") and income earning (baht) measured throughout a year.

(4) Describe any types of primary processing. It is designated to explore the traditional practices of some primary processing on household production such as milling of rice, threshing of maize or bean, smoking for fish, etc. There might be some demand potential for electricity utilization for replacement of traditional equipment/instruments. As some processing might be done by household own instrument while some are not, mark (*) beside any equipment/instrument that belongs totally to household.

III. Household belongings.

It is expected that enumerators will gather information on only those household assets which could be replaced by electrical devices. All other belonging are omitted.

IV. Household cash/credit.

To trace out household existing cash/credit and plan, this section is designated to obtain existing amount of credit, sources and terms. It is anticipated that a household will require some source of credit after the village or his house has been electrified. Sources of credit are grouped into three main categories based upon the differences in interest rates. Approximate amount of credit needed after household is electrified, their sources and terms will be explored.

V. Household Power Demand.

The estimated demand for electricity of a household should be carefully considered to obtain the "effective demand". In other words, the demand figures should be obtained under the support of "purchasing power" both for investment cost and operation cost. This section will explore the question of household capacity to self-finance electrification versus any requirement for credit.

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1. Existing power demand consumption. This focuses only on the items that could be substituted by electrical power such as kerosene, candles, batteries, diesel/benzine etc. Each category will be noted for the price per unit, amount of uses per month in term of volume (specify unit clearly) and finally, total annual expenses.

2. Future power consumption.

To explore households willing to get electricity if they need to bear costs both hook up and operational cost. This is one of the [illegible] data [illegible] demand functions. [illegible] to complete questionnaire and [illegible] some technique is prob during the simulation as well as field test periods.

(1) Ask if a household needs to pay for a _____ baht (depending upon the engineering estimate how much it costs for a hook-up), are they willing to pay for this?

(2) The same as (1) supposes a household receives some form of credit for hook-up cost.

If both responses (1) and (2) are no, stop the interview otherwise proceed.

(3) This is to check the desire of a household to have electricity in his house if he has to pay double as much, equal and half as much baht he uses to pay for power uses.

(4) Explore household willing to obtain if they get electricity.

Column heading "Rank first five priorities" would be filled in by numbers (1, 2, 3, 4, up to 5) according to the respondent's plan. The rest of column will be filled corresponding to those 1 to 5 items.

Column "Expected number" would be filled in by desired numbers to obtain for each corresponding items.

Column heading "How to obtain" is asking for a mark (✓) for a relevant answer. If they choose "others", specify the concepts behind as much as possible. (If the space provided is not enough use the back of that questionnaire page wherever you want to).

Column heading "How often to use" is designed to obtain the frequency of electricity utilization to provide information for demand estimation and its fluctuation during a year.

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Annex G: Methodological Note on Financial and Economical Analysis in Sub-Site Selection

In project analysis there is a critically important distinction to be kept in mind between two complementary points of view. For any project one is interested, in the first instance, in the total return to the whole society, or economy, of all the resources committed to the project, regardless of who contributes them and regardless of who receives the benefits. This is the social or economic return of the project and is determined by applying economic analysis. In contrast, the individual financial entities which participate in a project - farmers, businessmen, public agencies, etc. are each properly concerned about the return to the equity capital contributed by them. This is the financial return to an equity participation in a project and it is determined through financial analysis. Some economists term the financial return, the "private" return, although financial analysis may quite properly be used for analyzing public sector investments.

This Project Paper has developed an analytical model which uses an "economic least-cost approach" on the economic side and a "financial cost-benefit approach" on the financial side. Because this approach is somewhat unorthodox and differs appreciably from the initial sub-site selection methodology attempted, it is felt that a justification of the PP rationale should be made explicit in this annex.

Economic Analysis

Conceptually, economic analysis should try to quantify all sub-site economic costs and benefits stemming from the project realization. After careful study of the literature and the field needs of the Project, any attempt at cost-benefit economic analysis was deemed inappropriate due to difficulties in measurement of meaningful field data.

An initial attempt at economic cost-benefit analysis, which has been resumed in the PP for reference, drew its methodology essentially from the World Bank's appraisal of the IBRD/PEA Accelerated Rural Electrification Project.[1] Most importantly, the initial analysis borrowed directly the IBRD measurement procedures for "indirect benefits" which were to be assigned to the benefit stream. Indirect benefits included all social benefits presumed generated by the project (e.g. estimated costs saved by no longer using kerosene lights, battery-run TV, diesel pumps and rice mills, kerosene refrigerators, etc.) and were calculated by applying co-efficients to the "direct benefit" (i.e., actual energy revenue from sales) stream. This approach,

1. IBRD. "Thailand:Appraisal of the Accelerated Rural Electrification Project," Report No. 1467a-TH, February 1, 1978.

while perhaps reasonable when measuring order of magnitude benefits for a large electrification program such as that studied by the World Bank, was far too general to be of utility to the selection of specific sub-sites. This was especially true in the PP analysis as most of the sub-site impact areas under consideration did not commonly contain such indirect benefit items as TV sets, fans, refrigerators, irrigation pumps, etc., even though an average 70% of total benefits were attributed to the indirect category.

This ambiguity in sub-site benefit valuation was of particular concern to the PP team since one of the primary goals of the project is to generate a simple but workable field assessment model which could be utilized by RTG personnel in its selection of individual sub-sites.

A decision was made, therefore, to limit economic analysis of future sub-site selection to that of a least-cost comparison of the three major options currently available for site development: hydro, diesel, or grid extension. This decision was rendered even more appropriate by the RTG political decision to extend electrical energy to the whole of Thailand by 1990. It could then be assumed that the primary concern of the economic analysis should be to indicate the least-cost option of supply. This logic is respected in the PP model through the discounted comparative analysis, over time, of the primary electrification options available to the project area.

Based on the PP team experience in developing the site selection model, it is suggested that future project analysts focus on the following issues early in their examination of the least-cost methodology:

1. Shadow Wage Rates

Given that sub-site construction should take place during the dry season, which also coincides with the season of the year of highest un and underemployment in rural areas of Thailand, it is suggested that analysts examine the possibility of developing shadow wage rates to be applied to the costs of construction. This may be particularly important for the micro/mini-hydro electric construction option, since an estimated 20-30% of total construction costs can, in most cases, attributed to the costs of unskilled labor. In economic terms, therefore, the application of a shadow wage rate to the cost comparison may further enhance the value of the hydroelectric option.

2. Co-Efficients and Basic Data

A number of numerical assumptions have been introduced into the least-cost economic analysis in order to render that analysis simpler in utilization. Included, in approximate

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of presentation in the analysis, are such items as: an estimated useful life of the project of 50 years; a calculation for operation and maintenance costs of 2.0% of total capital costs for every year of hydroelectric generation plant operation; an assumption of basic annual overhead and maintenance costs of 2.0% of capital costs for diesel generation; an assumption of diesel engine replacement every five years, given an estimated life of 10,000 hours, plus one overheal, or a total of 20,000 hours; an assumption that diesel fuels sales in Thailand include a 15% produce tax; an assumption that fuel costs may be differentially inflated at 3% per year compounded over the entire life of the project; an assumption of representative grid extension costs per kilometer; an assumption that operation and maintenance costs of grid extension projects may be calculated at 5% of capital costs for every year of operation. These numbers all represent but the Project Paper team's best estimate according to available data and should be examined for reliability and for eventual price changes over time.

3. 24 Hour Operation Assumption

The least cost economic analysis has been developed for comparative purposes with an assumption of 24-hour power availability. This was chosen only for comparative reasons as hydro and grid extension options both should have 24-hour power availability. In point of fact, however, it would be extremely rare to find a case of diesel generation which is available on a 24-hour basis. Indeed, one of the primary advantages of diesel generation in small, isolated areas is clearly the adaptability of diesel to the variability of power demand over the day and over the year. It may be that a more appropriate comparison would be that of 8 or perhaps 12-hour availability depending on the realistic expectations of electric utilization in the sub-site area. Should this type of comparison be utilized, however, it would tend to favor the diesel option, as rural isolated sites are most likely to have a sluggish demand curve in the early years of operation, leading to the underutilization of the real capacity of a hydro-driven system. The most appropriate comparison situation can only be derived after field experience and a better understanding of RTG concerns in this sector.

Financial Analysis

The utilization of financial analysis of the individual sub-project sites has been chosen for a number of specific reasons. First, as was noted in the description, current national policy in the power sector is to encourage sectoral financial viability. This normally would not necessarily mean that every individual project sub-site should require an appropriate financial internal rate of return, as long as the overall power sector was financially viable. It does provide project analysts and management, however, with a useful decision-making tool for measuring absolute, as opposed to comparative worth,

of a sub-project site. Normally this absolute (cost-benefit) type comparison would take place in economic analysis. For the reasons stated previously, however, it is felt that measurement of the economic benefit stream would be misleading if not entirely impossible to undertake in the context of this decision-making model.

Other reasons also work in favor of the utilization of a financial cost-benefit analysis. These include a simplified calculation of project costs and benefits since these costs and benefits will be in terms of actual monetary inflows and outflows and will not require the considerable amount of generalized conjecture which was the case with the economic benefit analysis. Data collection will also be simplified in this respect. Of further interest to the RTG in keeping with their policy of financial viability, such a financial analysis may assist the government in thinking through the implications of appropriate tariff levels for energy utilization in the sub-site area. And finally, current USAID policy favors a realistic look at the financial as well as economic viability of U.S. Government investments abroad.

As a general rule, it probably can be anticipated that the financial analysis will be more rigorous than an economic cost-benefit analysis would be given that the financial costs are only marginally higher whereas a substantial portion of the economic benefits may not be captured in the financial benefit stream. If the sub-site in question passes the financial rate of return test successfully, there is reasonable basis for considering it to have simultaneously a favorable economic rate of return.

Once in the field, it is suggested that project analysts focus their attention on the appropriateness of co-efficients and data base assumptions presented in the financial analysis in a fashion similar to that suggested previously under the economic analysis discussion. Included in this list, in approximate order of presentation, are: an assumption that the project will be exempt from major income or corporate taxation; that salvage value will be zero at the end of year 30; assumptions on taxes, calculated on construction and social charges for personnel; capital expenditure costs for generation transmission and distribution; a 2% estimate for overhead and maintenance; an assumption that an acceptable financial rate of return for the sub-site should be 8% over the project life.

Finally, it needs to be underscored that, in calculating all parts of this model, the basic goal of the PP team has been to develop a rational, simple and field-utilizable framework for sub-site selection of micro/mini-hydro electric projects in Thailand. This model can not be expected to be definitive in its approach. The time, resource, and personnel limitations of the project paper did not permit an analysis at

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that degree of refinement. Rather, it should be considered a starting point from which future project staff may revise and perfect it to best meet the feasibility and administrative requirements of the RTG.

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ANNEX H: INDICATIVE TERMS OF REFERENCE FOR KEY PROJECT PERSONNEL

TITLE: NEA Project Manager
STATION: Bangkok (NEA); occasional field travel
DURATION OF CONTRACT: NEA line employee

DUTIES:

1. Head of POU; ultimately responsible for all managerial decisions related to the Project; liaisons closely with NEA management, particularly Deputy Director General.

2. Works closely and shares operational responsibilities with the contract Senior Engineer/Project Coordinator.

3. Responsible for the entire organization of the POU, and for activities carried out by that organization. This will require a delegation of authority to various staff members, as well as defining the responsibilities those positions carry in project activities.

4. Responsible for administering the program within the terms of the loan agreement and for coordinating with AID to assure that approvals and documentation meet the terms of the loan agreement.

5. Responsible for publishing and distributing quarterly reports on the project activities, three copies of which will be sent to the Project Officer at USAID, Bangkok.

6. Coordinates with, and notifies, both AID and NEA management levels, on problems requiring policy action by either of these agencies, in order to carry out the activities of the project.

7. Responsible for scheduling and contracting for technical assistance, to support the various project activities in such a way that professional assistance is made available in a timely fashion, to carry out management, construction, procurement, and manufacturing for other activities on a timely basis.

QUALIFICATIONS: Project Manager:

The Project Manager must have served with NEA for a period of not less than five years, in a position of responsibility, and have an intimate knowledge of contracting financial and other standards established by the GOT or NEA. He should have a good grasp of the English language, and be able to converse and understand technical subjects in English. He must be a proven administrator and manager, of not only projects, but direct line staff.

SPECIAL OBSERVATIONS: Reports to NEA Deputy Director

TITLE: Senior Engineer/Project Coordinator
STATION: Bangkok (NEA); occasional field travel
DURATION OF CONTRACT: 45 months (est. March 1982 - Dec. 1985)

DUTIES:

1. Senior Project consultant to NEA management and Project Manager. Responsible for developing daily work plans for operational staff, both engineering and soico-economic aspects.

2. Reporting directly to the Project Manager, he is responsible for carrying out project assignments which cover a broad range of project activities, including contracting for professional services of construction activities. These activities are to be carried out within the agreed policy lines and contracting restrictions imposed by both NEA and AID. Guidelines on these policy determinations are available, and the incumbent must become familiar with both systems in order to assure that these policies are adhered to.

3. Actively involved in the promotion and detailed development of all Project-related planning and analytical activities. He should work closely with the Socio-economic Analyst and NEA's Planning Division on these activities.

4. A direct line officer of the construction manager, he is responsible for review or final designs, contract documents, specifications, or projects to be undertaken. Most of this work will be carried out by the construction manager. Quality on these activities remains the responsibility of the Senior Engineer.

5. He will assist in preparing the quarterly reports for NEA and AID. He will assist in following up with periodic inspections of work in progress, to insure that quality standards and schedules are met.

6. Identify special training of utility to the Project and undertake "on-the-job" or arrange for special Project training.

QUALIFICATIONS: Minimum 10 years experience in hydroelectric engineering, planning and construction in developing countries, preferably part in SE Asia. Past experience and specialized training in "run-of-river" hydroelectric schemes desirable. Should have minimum Bachelor degree in engineering (civil or mechanical), as well as supplemental degree in Economics, Planning or Public Administration.

SPECIAL OBSERVATIONS: Should be flexible, innovative organizer; capable of managing operational details of overall Project. Some Thai language, or at least past exposure to Thai culture desirable. Reports to NEA Project Manager.

TITLE: NEA Field Engineer
STATION: Bangkok (NEA); per;haps 50% of time in field
DURATION OF CONTRACT: NEA line employee

DUTIES:

1. Forms a team and shares responsibilities with contract Construction Manager to ensure generally high standards of design and construction throughout.

2. Undertake relevant engineering analysis for selection of second tranche sites.

QUALIFICATIONS:

SPECIAL OBSERVATIONS.

TITLE: Construction Manager
STATION: Bangkok (NEA); perhaps 50% of time in field.
DURATION OF CONTRACT: 39 months (est. May, 1982 - Aug. 1985)

DUTIES:

1. Form a team and share responsibilities with NEA Fields Engineer to ensure generally high standards of site engineering design and construction throughout.

2. Assists in contracting for final engineering design and supervision.

3. Assists in contracting for power plant procurement and civil works construction.

4. Training of NEA employees, as required.

QUALIFICATIONS Minimum 5 years experience in supervision of design and construction of hydroelectric sites in developing countries. Minimum Bachelor's degree in Civil Engineering.

SPECIAL OBSERVATIONS: Willing to travel and work in isolated areas. Good spoken Thai required. Past experiences in Thailand or SE Asia desirable.

TITLE: Socio-economic Analyst
STATION: Bangkok (NEA); perhaps 20% of time in field
DURATION OF CONTRACT: Total 18 months; utilized over four separate periods beginning July, 1982 and ending November 1985.

DUTIES:

1. Generally responsible for detailed development of socio-economic analytical models and concepts promoted by the PP and the POU Project Coordinator, including:

   - site selection model (socio-economics, computerization as deemed appropriate, forecasting, survey techniques)

   - manufacturing promotion analysis

   - consumer promotion analysis

2. Undertake socio-economic analyses for selection of second tranche sites.

3. Furnish advice and socio-economic anaysis to NEA and RTG on sectoral planning, as required.

4. On-the-job training of NEA employees as deemed appropriate.

5. Responsibility for establishing basic evaluation methodology for overall Project.

QUALIFICATIONS: Minimum 10 years experience in socio-economic planning and analysis of infrastructure projects, preferably in areas directly related to hydroelectric generation. Should have PhD degree in economics or sectoral planning or other relevant social science field. Fluent in written and spoken Thai. Should have basic understanding of survey research techniques. Understands and is able to operationalize Project concerns of distribution and equity analysis at local as well as higher levels.

SPECIAL OBSERVATION: Because of nature of contract, and necessity to use the same analyst over the life of Project, NEA may have difficulty locating an appropriate candidate. Should explore all available sources, including University, free-lance consultant, TISTR, as well as local consulting firms.

TITLE: Consumer Promotion Specialist
STATION: Bangkok (NEA); perhaps 50% of time in field
DURATION OF CONTRACT: 14 months; utilized over two separate periods beginning July, 1982 and ending September 1984).

DUTIES:

1. Responsible for field examination of all "downstream" Project activities, including but not necessarily limited to:

   - the productive use of local electricity generation

   - local operation of the Project generation system (coop or private ownership)

   - modification of hook-up costs or user tariff schedules

   - local training needs

2. Will participate in 1984 Project evaluation exercise.

QUALIFICATIONS: University education. Minimum 5 years experience in consumer promotion-related activities and/or small-scale rural industry and electrical applications thereto. Fluent written and spoken Thai, knowledge of local Thai dialects desirable. Professionally motivated to assist in development of rural areas. Some previous training in economics. Innovative and analytically oriented.

SPECIAL OBSERVATIONS: Willing to travel under difficult rural conditions. Preferably of rural origin. Some skills listed herein may have to contracted to other individuals.