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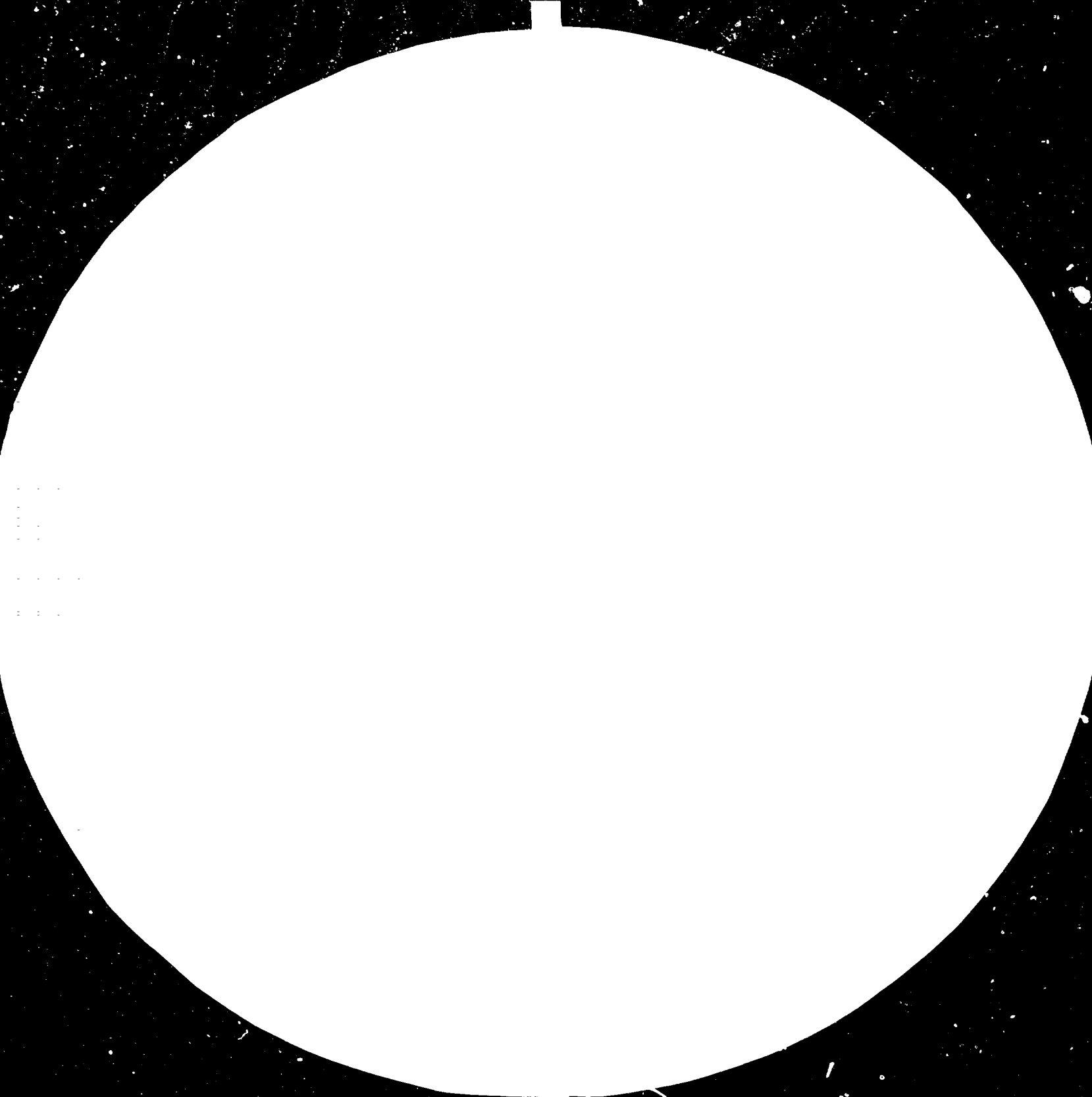
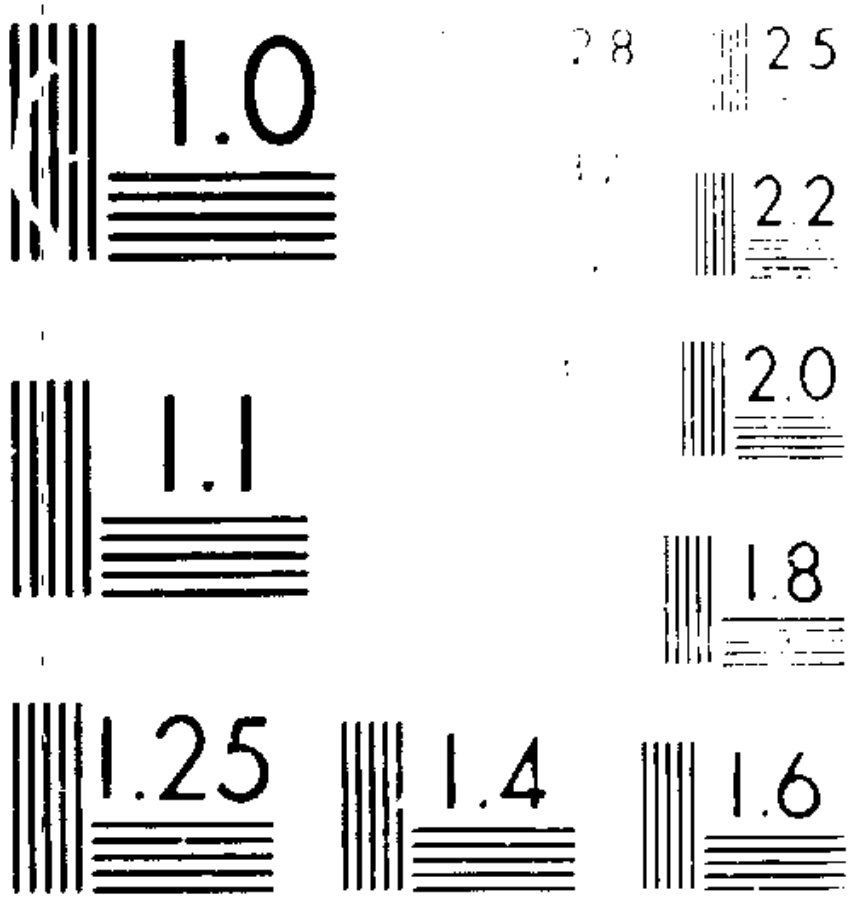
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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REPORT FORMAT OUTLINE FOR FEASIBILITY STUDIES MINI-HYDRO POWER GENERATION PROJECTS

and

MINI-HYDRO POWER GENERATION PROJECT STUDY GUIDELINES

(As Used in the Republic of the Philippines)*

by

Zenaida A. Santos**

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** Executive Director, Mini Hydro Development Office
National Electrification Administration (NEA).

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REPORT FORMAT OUTLINE FOR FEASIBILITY STUDIES
MINI-HYDRO POWER GENERATION PROJECTS

(As Used In the Philippines)

I. PROJECT DESCRIPTION

1. Introduction
   - 1a. Project Background
   - 1b. Objective
   - 1c. Data Base Source

2. Location
   - 2a. Location Plan and Access
   - 2b. Vicinity Plan and Access

3. Access
   - 3a. Site Access Information

4. Plant Ownership and Funding

5. Existing Electric Facilities
   - 5a. Existing Power Systems and Power Sources Map

6. Present Demand and Energy Usage
   - 6a. Demand, Energy and Consumers Curve

7. Estimated MHG Plant Potential

II. GENERAL PROJECT INFORMATION

1. Geography and Topography of General Area

2. Climate
   - 2a. Climate and Rainfall Map

3. General Conditions of Area

4. Seismicity

5. Site Investigation Work
(names, times, places, activities)

III. SITE CONDITIONS ASSESSMENT

1. Topographic Data

2. Socio-Political Assessment

3. Environmental Assessment

4. Land Rights

5. Water Rights

6. Local Materials Availability
(optional depending on project nature and magnitude)

IV. HYDROLOGY

1. Drainage Area
   - 1a. Drainage Area Map

2. Rainfall
   - 2a. Rainfall Tabulation

3. Existing Stream Flow Records

4. Flow Duration Determination
   - 4a. Stream Flow Record (if any)
   - 4b. Revised Flow Duration Curve

5. Siltation Studies or Estimates

6. Water Quality

   6a. Water Analysis Report

7. Flood Studies or Estimates

V. SURFACE GEOLOGY

1. Description of Observations on:

   dam and intake structure, headrace, forebay penstock, powerhouse, tail race.

2. Description of Recommended Detailed Investigation (if any)

   2a. Table of Detailed Investigations

3. Initial Conclusions

VI. ENERGY AND POWER DEMAND DESCRIPTION

1. Load Growth and Forecast

   1a. Load Growth Chart

2. Assumptions, Factors and Considerations

3. Grid Connection

VII. PROJECT PLANNING

1. Layout Concepts

2. Design Discharge

3. Hydraulic Heads

4. Capacity Determination

5. Energy Generation

6. Civil Works Features including construction water diversion

7. Mechanical Equipment and Auxiliaries

8. Electrical Equipment, Auxiliaries and Facilities

9. Project Schedules (bar chart)

VIII. PROJECT CAPITAL INVESTMENT ESTIMATES

1. Engineering Costs

2. Administrative Costs Including Project Development Costs

3. Construction Costs

4. Equipment Costs

5. Contingencies and Escalation

IX. OPERATIONS, MAINTENANCE & REPAIR ESTIMATES

1. Annual Operation, Maintenance, Repairs

2. Probable Occasional Major Incremental Repairs or Additions

X. NEA PROJECT DEVELOPMENT CRITERIA

1. Capacity Limits

2. Energy Costs
   - 2a. Isolated
   - 2b. Grid-Connected

3. Benefit/Cost Ratio

XI. FINANCIAL AND ECONOMIC ANALYSIS

1. Incremental Cost Analysis
   - 1a. Unit Number vs. Total Project Cost, Incremental Cost, Incremental in (%).
   - 1b. Unit Number vs. Generating Expenses, Incremental Cost, Incremental in (%).
   - 1c. Unit Number vs. Annual Energy, Incremental Energy, Incremental in (%).
   - 1d. Average Generating Cost per KWH, Incremental Generating Cost per KWH/unit, Incremental in (%).

2. Benefit/Cost Analysis (Internal to Project)

3. Economic Benefits to Locality or Host Government

4. Conclusion and choice of Number of Units

5. Funding Terms

6. Operating Revenues

7. Operating Expenses

8. Cash Flow

9. Financial Ratios

10. Sensitivity Analysis (KWH Variation)

    a. water availability

    b. selected critical issues not included in the capital cost estimates

    c. increases in construction costs

XII. PROJECT SUMMARY

1. Financial Summary

2. Technical Summary

3. Critical Issues

XIII. CONCLUSIONS

XIV. RECOMMENDATIONS

MINI-HYDRO POWER GENERATION PROJECT STUDY GUIDELINES

(As Used in the Philippines)

I. PROJECT DESCRIPTION

1. Introduction

a. Project Background

Discuss the power situation, including the power sector, power development, mini-hydro development in the area and role of the project in the government development plan.

Give the historical background, mentioning previous investigations made, difficulties encountered and the present power status.

b. Objective

c. Data Base Source

Necessary data for the feasibility study submitted by the A&E.

Climatological data available at PAGASA[1] and stream flow data from NWRD[2], NIA[3] and NPC.[4]

2. Location

Describe the project location and accessibility and prepare a location and vicinity map.

a. Location plan and Access

b. Vicinity plan and Access

3. Access

a. Site Access Information

4. Plant Ownership and Funding

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[1]PAGASA - Phil. Atmospheric, Geophysical, Astronomical Services Adm.

[2]NWRC - National Water Resources Council

[3]NIA - National Irrigarion Administration

[4]NPC - National Power Corporation

5. Existing Electric Facilities

   a. Existing power system and power sources map.

6. Present Demand and Energy Usage

   a. Demand, Energy and Consumers Projection Curve

7. Estimated MHG Plant Potential

II. GENERAL PROJECT INFORMATION

1. Geography and Topography of General Area

   Philippine Topographic Map, scale 1:50,000 M and contour interval of 20 m. are available at the Bureau of Coast and Geodetic Survey.
   Discuss the general topography of the site and vicinity.

2. Climate

   Records of monthly average rainfall, temperature, humidity, evaporation and no. of rainy days are available at PAGASA.
   Data cover at least 10 years of record.
   The period of records for every station are available on request.
   Observations of the different climatological elements are made at least daily.
   Broken rainfall records are available at some towns and cities.
   Daily rainfall records are also available on request from PAGASA.
   Maps showing climatological normals were prepared by PAGASA and available on request.
   Climate map is also available on request.

3. General Geologic Condition of Area

   A geologic map of the Philippines subdivided into regions and islands was prepared by the Bureau of Mines and available on request.
   Determine the general geology of the area.

4. Seismicity

Records of earthquake are available at the Philippine Volcanology Office.

Discuss the earthquake magnitude and occurence and relevance to the design considerations for structure.

5. Site Investigation Work

Discuss site investigation work conducted to include names, time, places and activities.

III. SITE CONDITION ASSESSMENT

1. Topographic and Hydraulic Data

Determine the existence and true value of the gross head as well as the discharges and determine also the topographic conditions at the sites of major civil works components and as affected by flood and pondage.

2. Socio-Political Assessment

Make an assessment of the social and political condition at the project site and vicinity for implementation guidance and decision, as they may stop increase costs or have scheduling influences.

3. Environmental Assessment

State ecological impact of the project on the flora and fauna, as well as the social impact.

4. Land Rights

Land rights for the project are the cooperatives's responsibility.

Right-of-way acquisition and access road construction is primarily the responsibility of the electrice cooperative in cooperation with the local government.

Assistance is given by NEA in special cases.

5. Water Rights

Application for water rights to NWRC is to be made by the electric coop with the assistance of the NEA. Prior water rights in the area should be taken into consideration.

6. Coordination with other Agencies

Projects that may interfere with the mini-hydro projects must be coordinated with the agencies concerned.

7. Local Materials Availability

Locally available materials are to be used for project construction as much as possible. Depending on the project nature and magnitude available, information on sources, quantity and prices of construction materials within the vicinity should be gathered and assessed for decision on alternative material sources. (Necessary investigations for bulk material needs will be conducted with prior NEA approval).

IV. HYDROLOGY

1. Drainage Area

Give the size using available topographic map and also description of the watershed area to include relief, vegetation, available data on soil condition and estimated surface storage.

a. Drainage area map.

2. Rainfall

Daily rainfall records of at least 10 years are available from PAGASA. Describe rainfall occurrence, existing rainfall station in the vicinity.

a. Rainfall data tabulation to include average monthly rainfall, average no. of rainy days and rainfall intensity-duration-frequency data.

3. Existing Streamflow Records

Daily streamflow data are gathered at NWRC nearby stream flow gauging stations most of which have more than 10 years of collected data.

Discuss the availability of streamflow gauging station and records of the vicinity to include name, location, length of stream flow record.

Tabulation of stream flow data.

4. Flow-Duration Determination

Mini-hydro site streamflow and rainfall records are generally non-existent. Stream flow data for the site are calculated by correlation from the available NWRC stream flow record within the vicinity with at least 10 years of record.

Site streamflow data are also calculated by rainfall-run-off or rainfall-discharge. Correlation with at least 10 years of rainfall data.

a. Tabulation of stream flow data for site

b. Revised flow-duration curve

From the estimated streamflow data, a flow-duration relation is established and graphed. The flow-duration data and curve are adjusted by using actual site dry season discharge measured on site visits.

5. Siltation Studies and Estimates

Normal erosion from watershed areas may be considered at 5 to 15 Tons/Ha and 20 and above for accelerated erosion or use available data.

6. Water Quality

Conduct physical and chemical test of the river water.

a. Water analysis report, to include effects on concrete and metals.

7. Flood Studies or Estimates

Estimate the design flood for spillway and maximum flood level at the powerhouse site using the regional frequency curves developed for the area or by the Rational Formula using at least a 100-yr. rainfall intensity.

Check the estimated maximum flood level by observations of flood level signs and interview of local residents.

Determine inundation effects and prepare additional topographic data as needed.

V. SURFACE GEOLOGY

1. Description of observation: dam and intake structure, headrace, forebay, penstock, powerhouse and tailrace.

2. Description of recommended detailed investigation (if any)

   a. Table of detailed investigations - pits, boring, sample tests, coring, pressure tests, permeability, (trenching & geophysical methods).

3. Initial Conclusions on Surface Geology

VI. ENERGY AND POWER DEMAND DESCRIPTION

1. Load growth and Forecast

   a. Load growth chart

2. Assumptions, Factors and Considerations

3. Grid Connection

VII. PROJECT PLANNING

1. Layout Concept

   Run-of-river type of mini-hydro with or without pondage is generally adopted with judicious consideration of the available natural head for increased plant capacity, considering occurrence of extreme events. The general layout of the scheme of development is governed by the topography and geology of the area. The scheme of development, structure type and size are formulated during the field investigation.

   Prepare map of the general layout of the scheme of development.

2. Design Discharge

   Discharge for firm capacity is considered at approximately 97% of the time in the flow-duration curve.

   Discharge for maximum capacity is generally considered at 25% of the time for the storage type of development and 40 to 50% of the time for the run-of-river type.

   For flat efficiency, hydraulic turbines as crossflow machines with operational range of Q_{max} to 1/6 Q_{max} the maximum discharge may be taken as 6 times the firm discharge, which may be in the neighborhood of 25% of the time. Other discharge criteria are adopted for peculiarities of flow.

3. Hydraulic Head

The gross head is established by running a line of levels from the river section at the dam site to the powerhouse site.

4. Capacity Determination

The maximum capacity of the plant is calculated by the formula:

$P_{max} = 9.81 \times \eta_{t\,max} \times \eta_{gmax} \times Q_{max} \times H_n$ where

P_{max} = max. plant capacity, KWH

η_{tmax} = max. efficiency of turbine

η_{gmax} = max. efficiency of generator

Q_{max} = max. design discharge, cumecs

H_n = net head, m

The firm capacity is approximately calculated by

$P_f = 9.18\eta_{tf} \times \eta_{gf} \times Q_f \times H_n$ where subscript f stands for firm.

5. Energy Generation Potential

The annual energy generation is computed by use of formula (1) or (2):

(1) For Preliminary Estimates:

$E = 8760 \times \alpha \times B \times P_{max}$ where E = KWH

α = annual utilization factor

B = assumed factor for plant efficiency drop

= 0.8

(2) For Feasibility Analysis:

$$P = \sum_{i=1}^{n} (Q_i \times \gamma_i \times 9.81 \times H_e$$

where Q_i = ith Q value from Flow-Duration Curve

γ_i = eff. of turbine and generator at Q_i

H_e = nethead, m

$$E = \sum_{i=1}^{n} 24 (P_i \times D_i)$$

D_i = no. of days i to i^{-1} interval

P = kW

E = kWH

C. Civil Works Features, including construction water diversion.

Describe the general layout of the scheme of development.

Base the elevations of the major civil works components on ground survey.

Describe the civil works components as dam and intake, headrace, desilting structure, forebay, penstock, power house and tailrace together with specific site conditions.

Describe upstream and downstream developments, if any.

7. Mechanical Equipment and Auxiliaries

Describe the selected type of the hydraulic turbine together with the controls and auxiliaries.

8. Electrical Equipment, Auxiliaries and Facilities

Describe the generator type together with the auxiliaries and facilities.

9. Project Schedule (Bar Chart)

Prepare project schedule from pre-construction to construction phase for implementation guidance.

Subdivide the schedule into management sectors for financing, engineering, procurement, construction and commissioning.

2. Benefit/Cost Analysis (Internal to Project)
3. Economic Benefits to locality or Host Government
4. Funding Terms

5. Operating Revenues
6. Operating Expenses
7. Cash Flow
8. Financial Ratios
9. Sensitivity Analysis

   Consider:

   a. Water Availability & kWH Variation
   b. Selected Critical Issues Effects (not included in capitalized cost estimates)
   c. Increases in Construction Cost.

XII. PROJECT SUMMARY

1. Financial Summary
2. Technical Summary
3. Critical Issues

XIII. CONCLUSIONS

XIV. RECOMMENDATIONS