Pusat Khidmat Maklumat Akademik
UNIVERSITI MALAYSIA SARAWAK
94300 Kota Samarahan

TURBINE SELECTION FOR MINI HYDROELECTRIC PROJECT

P.KHIDMAT MAKLUMAT AKADEMIK
UNIMAS
1000133638

ALEXIS JELAI ANAK NGILAH

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(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat tetap: No. 30 Taman Jasmine,
96100 Sarikei, SARAWAK.

DR ANDREW R.H. RIGIT
Nama Penyelia

Tarikh: 15 April 2004

Tarikh: 15 April 2004

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LIST OF CONTENT

ACKNOWLEDGEMENT iv

ABSTRACT v

ABSTRAK vi

LIST OF FIGURE vii

LIST OF TABLE viii

LIST OF SYMBOL ix

Chapter 1: Introduction

1.1 Introduction 1

1.1.1 History of hydro power 1

1.2 The need of hydro power at global world 2

1.2.1 Development of hydropower in Malaysia 5

1.3 Problem statement 8

1.4 Objective and scope of the study 10

1.5 Summary 10

Chapter 2: Literature Review

2.1 Introduction 11

2.2 Classification of hydro power and installation 11

2.3 Basic civil work and component 14

2.4 Energy uses 16

2.5 Advantages and disadvantages of hydro power 19

2.6 Types of turbine 20

2.6.1 Impulse turbine 22

2.6.1.1 Pelton turbine 23

2.6.1.2 Turgo turbine 26

2.6.1.3 The Ghatta and the multi purpose power unit 28

2.6.1.4 Crossflow turbine 30

2.6.2 Reaction turbine 31

2.6.2.1 Francis turbine 32

2.6.2.2 Propeller turbine 34

2.6.2.3 Kaplan turbine 34

2.6.2.4 Reverse pump turbine 36

2.7 Summary 36

Chapter 3: Methodology of research

3.1 Introduction 37

3.2 Observation and data collection 37

3.3 Data calculation and analysis 38

3.4 Pelton wheel turbine 39

3.4.1 Pelton wheel efficiency analysis 41

3.5 Water wheel turbine 48

3.6 Summary 50

Chapter 4: Data Calculation and analysis

4.1 Introduction 51

4.2 Data analysis 52

4.2.1 Pelton wheel turbine analysis 52

4.2.2 Water wheel turbine analysis 57

4.3 Comparison for turbine and selection 60

4.4 Case study: electrification for Kampung Wong Pandak, Lubok Antu 62

4.5 Summary 64

Chapter 5: Conclusion and recommendation

5.1 Conclusion 65

5.2 Recommendation 66

BIBLIOGRAPHY 67

APPENDIX 69

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ABSTRACT

The objective of this report is to study hydraulic turbines used in mini hydroelectric power stations and compare the turbines in terms of power produced and their efficiency. This report gives information on how to improve the efficiency of the turbine and steps that can be taken in order to increase the turbine performance. This will help to reduce the energy wastage from the turbine and optimize the power usage.

The method was used in this project was to calculate the power and efficiency of the turbine and the data was collected from the site, which is in Lundu district. There are three mini hydro power stations in the district, which are Gunung Gading, Peninden, and Sebako mini hydro power stations. Meanwhile for the specification and the structure of the hydro system, the data was obtained from the Sarawak Electrical Supply Corporation (SESCo) office.

A case study was also conducted, which involved the electrification of the rural area, with a suggestion for a new mini hydro power plant to be implemented. The case site was Wong Pandak, Lubok Antu.

ABSTRAK

Laporan ini adalah bertujuan untuk mengenal pasti turbin air serta perbandingan di antara dua turbin tersebut. Selain daripada itu, kajian ini mampu untuk meningkatkan kecekapan (dalam nilai peratusan) serta langkah-langkah yang dapat diambil bagi meningkatkan keupayaan sesuatu turbin air. Ini akan mengelakkan pembaziran tenaga dan mengoptimumkan pengunaan tenaga tersebut bagi kegunaan sesuatu kawasan.

Pendekatan atau kaedah analisis yang akan digunakan didalam kajian ini adalah kaedah pengiraan dan data yang ingin diperolehi pula akan di dapatkan terus daripada kawasan kajian iaitu dari daerah Lundu yang mana terdapat 3 buah stesen mini hidro elektrik iaitu Gunung Gading, Peninden dan Sebako. Manakala bagi bahagian struktur atau spesifikasi turbin serta jet air pula, data tersebut akan diperolehi melalui buku panduan penyelengarran serta binaan mini hidro berkenaan daripada ibu pejabat Perbadanan Pembekalan Lektrik Sarawak (SESCo).

Suatu kajian kes juga akan dijalankan yang mana akan melibatkan pengagihan kuasa elektrik serta cadangan bagi pembinaan stesen mini hidro elektrik di kawasan luar bandar. Kawasan kajian kes tersebut adalah Wong Pandak, Lubok Antu.

LIST OF FIGURE

TITLE	PAGE
Figure 1.1: Development of hydropower worldwide	4
Figure 1.2: Summary of Problem statement	9
Figure 2.1: Basic Civil Component of Hydro power	15
Figure 2.2: Runner of a Pelton turbine	24
Figure 2.3: Bucket shape	25
Figure 2.4: Turgo runner blades and water jet	27
Figure 2.5(a) Multi-Purpose Power Unit	28
Figure 2.5 (b): Traditional wooden runner and metallic runner	29
Figure 2.5 (c): Improved metallic runner	29
Figure 2.6: Francis turbine	33
Figure 2.7: Kaplan turbine	35
Figure 3.1(a): Inlet valve velocity	40
Figure 3.1(b): Outlet valve (Pelton's wheel triangle diagram)	40
Figure 3.1(c): Angular displacement at jet head	41
Figure 3.2: Condition of head of nozzle and blades.	42
Figure 3.3: Triangle velocity diagram of Pelton wheel.	44
Figure 4.1: Triangle velocity	54
Figure 4.2: Water wheel turbine	57
Figure 4.3: The dimension of the water wheel turbine	58
Figure 4.4: Non schematic diagram of modification	61
Figure 4.5: Non schematic diagram of electric supplement to Kampung Wong Pandak	63

LIST OF TABLE

TITLE	PAGE
Table 1.1: Hydro electric generation in 1990 (in TWh)/year)	3
Table 1.2: Hydroelectric projects in Malaysia	6
Table 2.1: Type of Hydropower and description.	12
Table 2.2: Consumptive and productive use a distinction can be made between the use of	17
Table 2.3: Summary comparison of electrical versus mechanical energy option	18
Table 2.4: Groups of impulse and reaction turbines	21

LIST OF SYMBOLS

P	= pressure
V	= velocity
H / h	= height
ρ	= water density
g	= gravitational force (9.8 m/s^2)
f	= friction coefficient
D	= diameter
L	= length
rpm	= revolution per minute
β / α	= Angle
P_o	= Power output
P_i	= Power input
Q	= Flow rate (kg/ms)
k_b	= friction coefficient at blade
k_m	= friction coefficient at mechanical
[illegible]	= efficiency
F	= Force
S	= surface

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Water characteristics, besides being used to move any kind of dirt, also can produce energy. Energy that contain in the water has two types, which are potential energy, which is cause by the height, and the kinetic energy as a result of the water flow. The potential contained within the water can be used to move hydraulic, which can be used to generate electricity. This study will cover the selection of turbine for mini – hydroelectric power station and the calculation of the power output for the turbine, with known parameter such as water height flow rate, turbine revolution per minute (rpm), angle displacement for water jet and velocity of water flow.

1.1.1 HISTORY OF HYDROPOWER

The basic principle of hydropower is that water had been piped from certain higher level to lower level, which will cause pressure difference. The water pressure difference will be used to move hydraulic turbine movement conversion of the potential energy of water into mechanical energy. After that, the hydro turbines will convert water pressure into mechanical shaft power, which is used to drive an electricity generator, a grinding mill or some other useful devices.

From its history, the use of failing water as a source of energy is known for a long time. During ancient time, the use of waterwheels was already in use, such as for agriculture and water supply for village or a place. But only at the beginning of the ninetieth century with the invention of the hydro turbine the use of hydropower got a new impulse. More efficient and powerful turbines began to replace water wheels from the mid – ninetieth century, which led to generation of electricity in the twentieth century (Allen, 1992).

1.2 THE NEED OF HYDRO POWER AT GLOBAL WORLD

Only ten countries, of which Norway is one, depend on hydropower to supply over 95% at their electrical energy needs (Veltrop, 1992). Hydropower is a clean, renewable sources and its engineering technology is well developed. Veltrop (1992) also claimed that development of this large hydroelectric potential requires markets for energy, financing to cover high initial capital cost, strengthening institutional aspects, and rationalizing political process.

Between 1940 and 1980, global water use doubled, and it's expected to develop again by the year 2000 (Veltrop, 1992). In develop country, the need of hydropower is high since it is use to increase agriculture productivity and food distribution, deliver basic educational and medical services; establish adequate water supply and sanitation facilities, and build and power new job-creating industries.

Worldwide, only 15.2% of the technology is possible hydroelectric energy was developed by 1990 as shown in Table 1.1 (Veltrop, 1992) and in Figure 1.1 (Veltrop, 1992).

Continent	**Technical Potential (1)**	**Generated in 1990 (2)**	**(2) as % of (1)**
Africa	1344	50	3.7
Asia	4214	387	9.2
Australia	203	38	18.7
Europe	836	483	57.8
North America	969	573	59.1
Latin America	3486	380	10.9
USSR	2950	223	7.6
World	14000	2134	15.2

Table 1.1: Hydro electric generation in 1990 (in TWh)/year)

(Source: Veltrop, 1992)

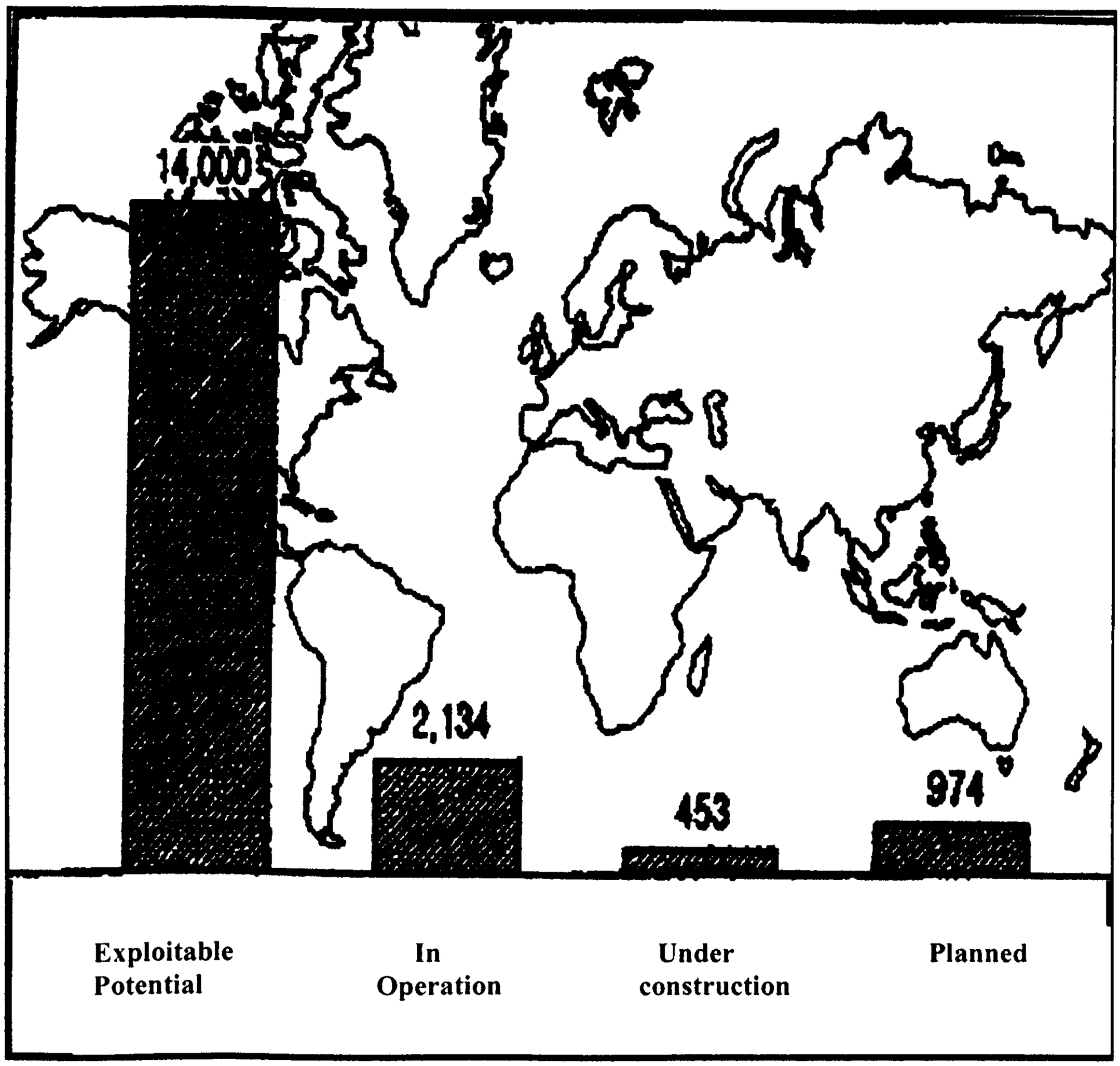

Figure 1.1: Development of hydropower worldwide

(Source: Veltrop, 1992)

A very small percent of all village and rural people in developing countries is served by electricity. The World Bank estimates installed generating capacity in developing

countries in 1980 at 242 gigawatts, or 12% of the world total. Between 1973 and 1978, consumption of in those countries grew at an average of 8 percent a year, compared with 3.5% a year in the industrialized countries. However, their per capita consumption in 1978 was estimated to be only 331 kWh, compared, with 6509 kWh in the developed countries (Stephenson and Petersen, 1991).

Roughly half of the world's hydropower potential is in the developing countries (about 1200 gW), but only 10% had been developed. Many hydro sites that were previously uneconomical have become generally feasible in the recent years, but there is along lead-time for large hydro projects. Potential of mini hydro projects that have shorter lead times are estimated to comprise 5% to 10% of the world's total hydro resources; however, their relatively high investment costs may make mini hydro projects uneconomical for village system with low load factors. If they can be connected to a power grid, they can be using more effectively, (Stephenson and Petersen, 1991).

1.2.1 DEVELOPMENT OF HYDROPOWER IN MALAYSIA

Hydroelectric energy, the pioneer of power generation in Malaysia set to develop but was hampered due to the economic and technical limitations. The first major hydroelectric project in Malaysia is the 27 MW Chenderoh Hydroelectric Power Station, which was commissioned in 1929 (Kie T.L.P, 1998). Due to the fluctuating fuel oil prices at 1970's and Malaysian insisting of not developing nuclear power plant, hydroelectric power is being increasingly utilized to make a significant contribution to the nation's energy

requirements. Table 1.3 shows the various hydropowers project either are already online or still under study.

	Station	Installed Capacity (MW)	Year of Commission
1.	Chenderoh	40	1930
2.	Temengor	348	1984
3.	Batang Ai	108	1985
4.	Kenyir	400	1987
5.	Pergau	600	1997
6.	Bakun	2400	(Under Construction)
7.	Murum	900	(Under Study)
8.	Pelagus	770	(Under Study)
9.	Baleh	900	(Under Study)

Table 1.1: Hydroelectric projects in Malaysia

(Source: Kie, 1998)

In Malaysia, there are two organizations that responsible for electric supplement and organize the hydropower station, which are Tenaga Nasional Berhad (TNB) and Sarawak Electrical Supply Corporation (SESCo). Their utilities are to generate electricity and supply the electric energy to the national grid.

For several rural area that be reached is not economical to national grid mini hydro power stations were installed. Example, of this mini hydro power station at rural area is Gunung Gading Lundu, Peninden and Sebako mini- hydroelectrics Sarawak.

Mini hydroelectric in Malaysia was built in the 80's as part of the Government rural Electrification Program through Lembaga Letrik Negara. These mini – hydroelectric schemes are based on run – of – river ranging from 50 kW to 500 kW capacities (Baynard, 2002).

With the present rate of expansion of rural electrification of about one percent per year, only about 25% of all rural people will have electricity by the year 2000 (Stephenson and Petersen, 1991). Often electrification of a village does not provide for supplying power to households, but only to pumps, wells, and cottage industries. When power supplied to households, it's often for only 2 to 3 hour in the evening (Stephenson and Petersen, 1991). Construction of small hydropower plant in the rural areas is an important means of improving quality of life.

1.3 PROBLEMS STATEMENT

Although micro- hydropower is one of the most environmentally benign methods of generating electricity, it is no totally without environmental problem (Fraenkel P.*et.al.*, 1991). Question needs to be assumed are:

- Will the efficiencies of this hydropower station are at it optimum operation?
- Does the turbine operate at optimum efficiency?
- Does the weir and resistant within the hydro power system will effect the performance of power generated?

Although there are many part of the hydropower station, our only focus is to study on the mechanical system of the power generator, which is the turbine. According to Fraenkel et.al (1991), the electrical power demand will vary both during the day and seasonally through the year. That is why we need to find a solution to make the turbine as well the hydropower to operate and meet the energy demand.

The selection of the best turbine for any particular hydro site depends on the site characteristics, the dominant factors being the head available and the power required (Harvey et.al, 1993). This selection of best turbine will help the hydro power station to operate and produced electricity at it optimum region. Beside that, the selection of turbine should be considered before implement the hydro plant so that it will avoid the capital cost of implement increase.

Another thing that we need to reconsider is the power that had been used to rotate the turbine, which is usually, depends on the water pressure. Harvey et.al (1993) claimed that, often the device that is driven by the turbine say an electrical generator needs to be rotated at a speed greater than the optimum speed of a typical turbine.

The problem statement in highlight in this study is summarized in a flow chart as shown in Figure 1.2.

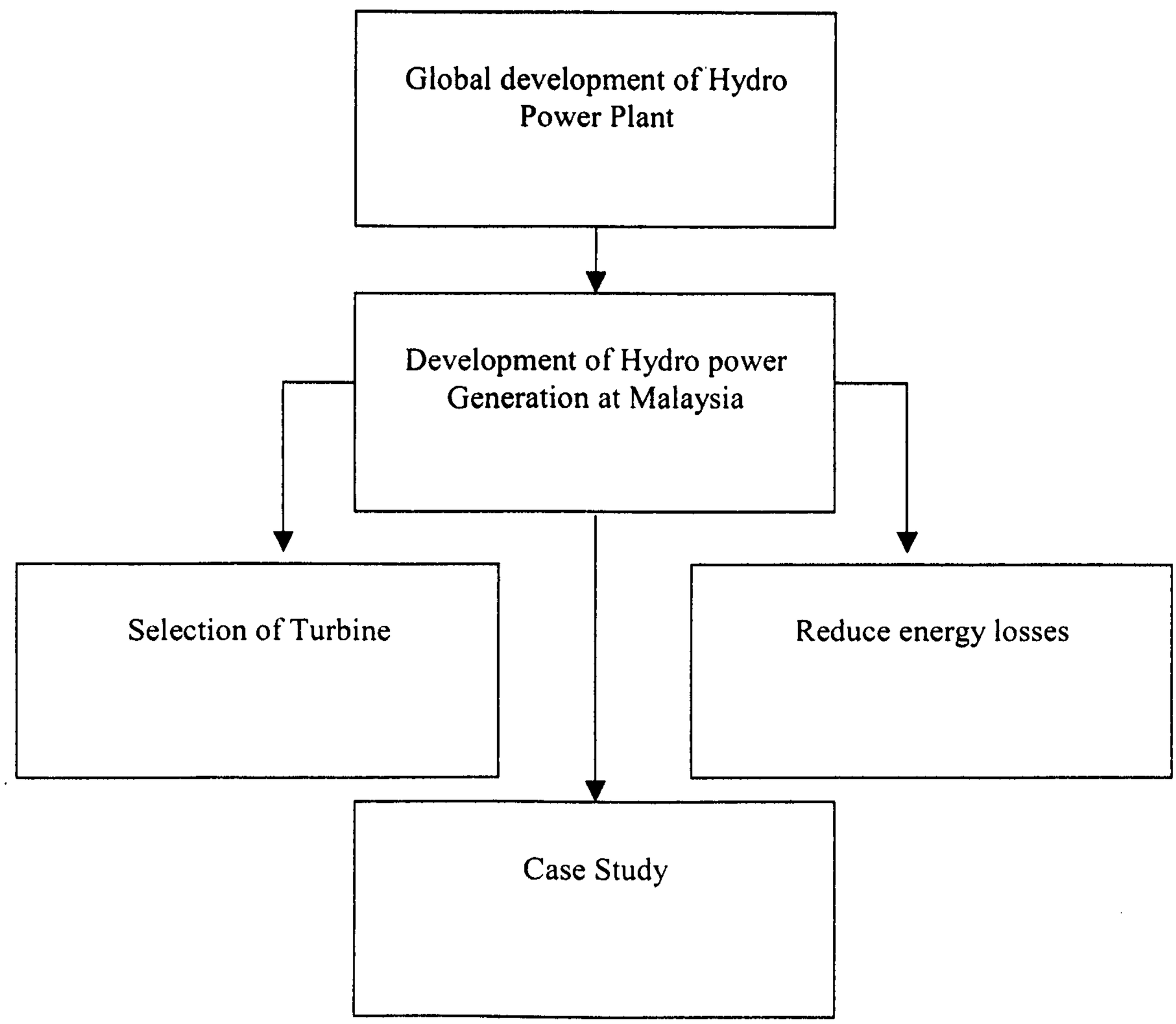

Figure 1.2: Summary of Problem statement

1.4 OBJECTIVE AND SCOPE OF THE STUDY

This study aims at turbine selection for mini-hydro plant in Malaysia especially at rural area. The main objective of this study is to investigate:

1. Type of turbine and comparison between the turbine usage and performance
2. Choosing the turbine and find the optimum region of operation for such turbine in order to optimize the usage of water resources.
3. A case study of a potential hydroelectric project in Sarawak.

1.5 SUMMARY

This chapter introduces the hydropower generation not only in Malaysia but also the usage of power generation throughout the world. This chapter also introduces the problem in generating electricity from hydropower. Hence, it reviewed the development of hydropower generation in the country and its potential.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This literature review is based on development and basic component of a hydroelectric used to, which include the types of turbines operate the hydroelectric system. From this literature review also it will basically stated the past experiment or work that had been done by several people and use the statement or result of their research to support my project. Beside that, by having the literature review, it will refer to other people past gain and some of their experiment.

2.2 CLASSIFICATION OF HYDROPOWER AND INSTALLATION

There are various types of hydropower and its size. The major different among this hydropower are their energy output and size. Hydropower installation can be classified as follows:

Hydropower Type	Description
Large	All installation with an installed capacity of more than 1000 k W (According to some definition more than 10 000 kW)
Small	General term for installation smaller 1000 kW (or < 10 000 kW). Also used for installation in the range between 500 and 1000 kW.
Mini	Capacity between 100 and 500 kW.
Micro	Hydropower installation with a power output less than 100 kW (or less than 1000 kW).

Table 2.1: Type of Hydropower and description.

(Source: http://www.microhydropower.net/introduction.html)

Large-scale hydropower stations are equipped with large dams and huge water storage reservoirs. In these reservoirs large amount of water can be stored when supply of

water is higher than demand. Water from wet periods can be used in this way to supplement water supply in dry period (or even dry years).

In the sixties and seventies, large hydropower stations looked as the solution to the energy crisis in developing countries. In that period, many large-scale hydropower schemes are built. Examples of large hydropower station were in Aswan (Egypt, Tarbelal (Pakistan), Cabora Bassa (Mozambique) and Kariba (Zimbabwe).

The enthusiasm for projects like those has disappears nowadays> the extreme high sums of money involved the long the money-recovery time and the huge environmental costs are debit to this. Especially the high environment costs are the point of great concern: losses of fertile arable land, force migration of large group of people and the danger of malaria and bilharzias inherent to non-moving water.

Small-scale hydropower stations combine the advantages of hydropower with those of decentralized power generation, without the disadvantages of large-scale installation. Small scale hydropower has hardly disadvantages: no costly distribution of energy, no huge environmental cost as with large hydro, independent from imported fuels and no need for expensive maintenance. It also can be use decentralized and be locally implemented and managed. Power generated with small hydro station can be used for agro-processing, local lighting, water pumps and small business.

The use of power generated with small hydro station can be divided in productive or consumptive use. A use called productive as an activity is performed in which money (or something equivalent) is exchanged for a service. Most of those activities will take place in small business.