



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DRIVING AND HINDERING FACTORS IN DEVELOPING
PICO-HYDRO GENERATION SYSTEM IN MALAYSIA**

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by

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I hereby, declared this report entitled “Driving and Hindering Factors in Developing Pico-Hydro Generation System in Malaysia” is the results of my own research except as cited in references.

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ABSTRACT

In this era of globalization, people are now more concerned about the system of green technology in reducing a major source capable of generating energy such as fuel, fossil and other energy sources that cannot be renewed in the next decade. In the same time, the implementation of energy renewable and has performed with many countries, including Thailand and other countries. In addition, the use of non-renewable energy is quite expensive and can lead to contamination problems. The world is concerned about the cleanliness of the environment today and focuses more on the fuel sources depleting energy generating performances. This problems can be solved through a method of alternative systems has been conducted, the Pico-hydro system. Pico-hydro has known as source of renewable green energy by using a small river in the generation of electricity without depending on any sources that is renewable. The advantages and benefits derived from this energy capable of improving the definition of the population lives in rural areas even if the power generated is less than 5kW. In addition, the replacement of scarce resources has been completed with the construction of Pico-hydro built that is capable of generating energy in the low range of the base 5kW. Pico-hydro system can be seen through the water moving through the water turns turbines that can cause the resulting drive capable of electricity. This system can generate electricity that can be used every day to improve the quality and standard of living of the population with better. In Malaysia itself, the use of Pico-hydro system is still in its infancy and many of the technologies used were brought in from outside the country. In addition, it can be advantageous to society in rural areas in developing Pico-hydro system. This system can be sustained because the electric system is capable of continuously generated as long as the water source is not lost on this Earth.

DEDICATION

A great dedications and thanks to my family and those who have helped me directly and indirectly in carrying out my project report until success. Initially, I would like to thanks to my parents especially to Encik Ab Rahman bin Ahmad and Puan Noraini binti Shamsudin . Great thankful also to my siblings and friends that very helpful doing this reports until finished. Last but not least, I want to give highly appreciate the contribution and assistance to all that helping me in the success of this report until it totally complete.

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TABLE OF CONTENT

Abstract	v
Dedication	vi
Acknowledgement	vii
Table of Content	viii
Table of Content	ix
List of Tables	x
List of Figures	xi
List of Abbreviation, Symbols and Nomenclature	xiii
CHAPTER 1: INTRODUCTION	1
1.1 Introduction of Pico Hydro	1
1.2 Objective	4
1.3 Problem Statement	5
1.3.1 Weather factor nowadays	
1.3.2 Perception on the Pico-hydro system	
1.3.3 Green energy is more focused on solar energy and less exposure to the Pico-hydro	
1.4 Work Scope	6
CHAPTER 2: LITERATURE REVIEW	7
2.1 Definition of Pico-hydro	7
2.2 Power from Water	8
2.3 Pico-hydro in Globalization	13
2.4 Current Situation for Implementation of Pico-hydro in Malaysia	29
2.5 Pico-hydro versus Solar and Turbine	36
2.6 Water Resources Availability	41
2.7 Technology Availability	42
2.8 Techno-Economic (Price)	61

TABLE OF CONTENT

CHAPTER 3: METHODOLOGY	64
3.1 Introduction	64
3.2 Research Flow	65
CHAPTER 4: RESULT AND DISCUSSION	67
4.1 Introduction	67
4.2 Theme Categorized on 103 Sources	68
4.3 Types of Themes and Description	69
4.4 Classification of Sources Based On Themes	70
4.5 Division of Themes Based On Sources	72
4.6 Outcome of Review Paper	74
4.7 Generic Reference Model for Driving and Hindering Factors	108
4.8 Driving Factors in Developing Pico-hydro in Malaysia	109
4.9 Hindering Factors in Developing Pico-hydro in Malaysia	111
4.10 Propose and Promote the Development of Pico-hydro Technology in Malaysia	112
CHAPTER 5: CONCLUSIONS AND FUTURE WORK	113
5.1 Conclusion	
REFERENCE	114

LIST OF TABLES

1.1	Classification of hydropower generation	2
2.1	Classification of small hydropower station depending on head	10
2.2	Comparison at turbine ,head ,flow and cost (USD/kW)	62
4.1	Classification types of themes and descriptions	69
4.2	Classification types of themes and description	75
4.3	The river basins that stated in Malaysia	111

LIST OF FIGURES

1.1	Turbine rotation method for impulse and reaction method	3
2.1	Classification of hydropower following by energy produced	8
2.2	Head and flow in water	9
2.3	Loss of power at every level during conversion of a water jet to Electricity	11
2.4	Peltric set of pitch circle diameter with 2 nozzles	13
2.5	Compact fluorescent lamp and radio operated by home hydro system	14
2.6	Schematic diagram of Pico-hydro power plant	15
2.7	Schematic diagram of implementation of connection system of 500W Pico-hydro power plant generator	15
2.8(a)	Installation of very low head turbine	16
2.8(b)	Very low head turbine developed by Phillipe Lautier	16
2.9	Installation of Pelton turbine in Kathamba	15
2.10	Installation of pump as turbine in Thima	15
2.11	Installation of Pico-hydro system in Pueblo Nuevo	19
2.12	Power pole by using trees freshly cuts	20
2.13	Hydrotech turgo turbine TN-1000 with Bark system to be installed at site C	21
2.14	Hydrotech turgo axial turbine HT-200 with Tangprang system to be installed at site A and site B	22
2.15	Two hydrotech Axial turbine HT-200 with Tangkaad system to be installed at site D	22
2.16	Combination of two Pelton wheels via mechanical transmission	23
2.17	Engine assembly and experimental set up for village lighting	24
2.18	Side and end view of 6 pole AFPM machine	25
2.19	Corpulence's Pico-hydro power generation system	26
2.20	Installation of Corpulence's turbine	27
2.21	PVC pipes on sides supported floating waterwheel	28
2.22	Installation of Pico-hydro in UKM, Bangi	30

LIST OF FIGURES

2.23	Pico-hydro turbine systems	31
2.24	Proposed project of Pelton turbine in Pico-hydro system	32
2.25	Nomogram graph for selection turbine	32
2.26	Process of water flow out from sling pump	34
2.27	Schematic diagram of Solid Work for complete sling pump	34
2.28	Low head Pico-hydro at UKM (Universiti Kebangsaan Malaysia)	35
2.29	Comparison of different parameters from different sources	37
2.30	16 years operation of solar PV system in Simikot,Humla	39
2.31	Installation of Pico-hydro Propeller turbine	40
2.32	Lighting system for use at home	40
2.33	Modelling of proposed barrage location with channel	41
2.34	Floating water wheel in tidal irrigation at Telang	42
2.35	Impulse and reaction turbine	43
2.36	Test rig of hydro home system	44
2.37	Computational fluid dynamics of turbine model	45
2.38	Model of turbine	52
2.39	Pico-hydro system in practical view	54
2.40	Centrifugal pump systems in practical view	55
2.41	Laboratory-scaled test fixture	56
2.42	Siphone model turbine in Bristol University's hydraulic lab	58
2.43	Pico-hydro Propeller modified turbine in Thapene village	59
3.1	Flow chart of the research flow	65
4.1	Themes categorized on 103 sources	68
4.2	Division of the sources based on theme	70
4.3	Division of theme based on sources	72
4.4	Generic reference model for evaluation of driving and hindering factors.	108
4.5	Levels of river	110

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

PSI	-	Pound per Square Inch
GPM	-	Gallons per Minute
CFS	-	Cubic Meter per Second
HHS	-	Hydro Home System
PCD	-	Pitch Circle Diameter
CFL	-	Compact Fluorescent Lamp
PHPP	-	Pico Hydro Power Plant
VLH	-	Very Low Head
PAT	-	Pump As Turbine
HOMER	-	Hybrid Optimisation of Multiple Energy Sources
ELC	-	Electronic Load Control
IMAG	-	Induction Motor-As-Generator
AFPM	-	Axial Flux Permanent Magnet
COE	-	Cost of Energy
PV	-	Photovoltaic
SHS	-	Solar Home System
RESs	-	Renewable Energy Sources
CAPEX	-	Capital Expenditure
OPEX	-	Operational Expenditure
PDR	-	People's Democratic Republic
IAG	-	Isolated Asynchronous Generator
IELC	-	Integrated Load Controller
THD	-	Total Harmonic Distortion
DVFC	-	Decoupled Voltage and Frequency Controller
CFD	-	Computational Fluid Dynamics
SEIG	-	Self Excited Induction Generator
AI	-	Artificial Intelligence
SPS	-	Stand-Alone Power System

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AGC	-	Automatic Generation Control
PSO	-	Particle Swarm Optimization
IPM	-	Interior Permanent Magnet
IG	-	Squirrel Cage
DFIG	-	Double Fed Induction Generator
ANOVA	-	Analysis of Variance
PHIL	-	Power-Hardware-In-The-Loop
ALCC	-	Annual Life Cycle Cost

CHAPTER 1

INTRODUCTION

1.1 Introduction of Pico-hydro

In the era of globalization, people concerned about the system of green technology in reducing the use of primary resources which are non-renewable fuels, fossil and many others. In addition, the pollution problem will arise and the cost is relatively expensive if the use of the energy used cannot be used continuously renewed. The world is now focused entirely on the reduction of the electricity generated and subsequently has a significant impact on the concerns on nature around. The alternative methods were carried out by generating electricity derivation from hydropower system to solve this problem.

The world is covered with 70% with water and the remaining is the land [1]. According to the facts, the percentage of water is divided into two, which are 97% is salt water and the rest 3% is fresh water which is the percentage of 0.3% of the fresh water covering areas such as rivers, lakes and swamps [2]. Although the percentage of the range is small, but the river has played a crucial role in everyday use in functionality other than mining, recreation, cooling, agricultural sector and transportation medium [2]. In addition, the river is able to generate hydropower that is beneficial not only in power generation but also provides a positive impacts on our country's contribution to green energy accordance with the vision Ministry of Energy, Green Technology and Water [3]. Pico-hydro power generation capable of producing the maximum output from 5kW and below.

Although the production of Pico-hydro power generation produces a relatively small amount of power but it is able to target the power generation utility in small community such as transmit power to the bulb, lamp, radio, television and others [1]. Nowadays, research and innovation in the development of green technology is getting a positive response despite the lack of in-depth exposure to the community. A sustainable effort in implementing this technology is considered in terms of production capacity of electric power generation, the cost of implementation, product size, design and installation of electrical generation products [1].

Pico-hydro is the one of six types of hydropower generation systems that included with large-hydro, medium-hydro, small-hydro, mini-hydro and micro-hydro. The classification of hydropower was divided by power capability in producing power according with the range of minimum to the maximum range. Hydropower generation system can be classified into six levels that have been shown in Table 1.1 [1].

Table 1.1: Classification of hydropower generation [1]

Hydro Power	Capacity	Description
Large-hydro	>100MW	Usually feeding a large electricity grid
Medium-hydro	15-100MW	Usually feeding a grid
Small-hydro	1- 15MW	Usually feeding into a grid
Mini-hydro	100kW-1MW	Standalone scheme
Micro-hydro	Up to 100kW	Provide power for small community for rural industry in remote area
Pico-hydro	Under 5kW	Require only small capacity

In this project, hydropower generation system that emphasized Pico-hydro is capable of generating in the range of 5 kW or less. Pico-hydro is a green energy using small stream that can generate electricity without dependency of any sources of non-renewable energy. Although in principle income is less than 5kW of power, but the benefits and capabilities that could be provided to increase the level of population in rural areas [1].

Basically, Pico-hydro generation power system can be viewed through the water moving through the water spins turbines that can cause the drive to be moved to generate electricity. Generally, the water turbine is divided into two reaction turbines and impulse turbines. The two turbines will be acted upon by water, which changes pressure as it moves through the turbine and generate power. This water will pass through the tunnel and the turbine blades rotate when the water through it. Energy will result from this action. Figure 1.1 illustrates the turbine rotation to impulse and reaction turbines.

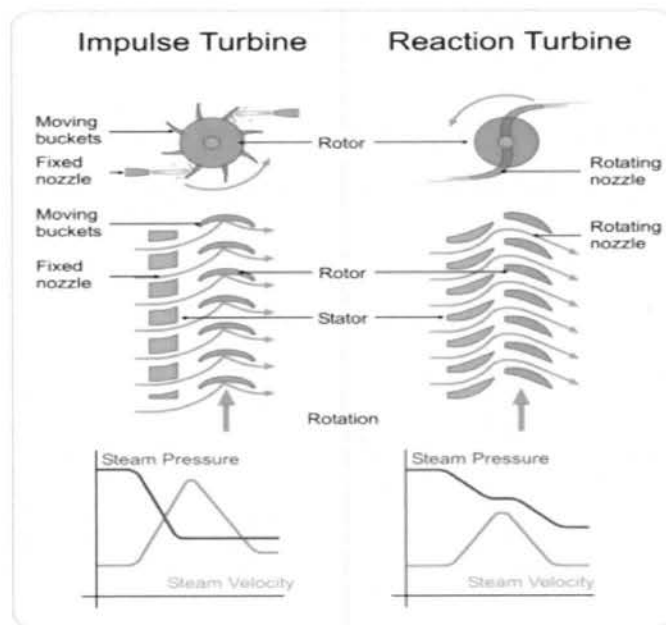


Figure 1.1 Turbine rotation method for impulse and reaction method

The electricity that been produced can use as daily purposes in order to improve a better life. In facts of that Malaysia is still beginner in the use of Pico-hydro systems.

1.2 Objective

Based on the title of this project, objectives for driving and hindering factors in developing Pico-hydro generation system in Malaysia are:

- (a) To revisit at least 100 reports and papers of different innovative small hydro technologies that has been implemented overseas and in Malaysia.
- (b) To identify at least 5 core themes based on 100 papers, using retrieved works and case evidence from previous reports.
- (c) To develop the generic reference model for Pico-hydro technology in Malaysia based on driving factors and hindering factors.

1.3 Problem Statement

In order to develop the Pico-hydro system in Malaysia, there are few factors of driving and hindering that influenced the developments. These main factors affect the key to the development of implementing Pico-hydro system such as:

1.3.1 Weather factor nowadays

Nowadays, Malaysia faces the proportion of rainfall slightly following the prolonged summer. This caused by lack amount of water flowing from the small stream to generate the electricity. These give a significant impact in generating energy that can generate electricity range less than 5kW.

1.3.2 Perception on the Pico-hydro system

The government especially was aware on the impact and importance of Pico-hydro to the nation, especially to areas inland since the Pico-hydro system in Malaysia is still in the beginning level.

1.3.3 Green energy is more focused on solar energy and less exposure to the Pico-hydro

Normally the green energy focused more on solar panel in the community. The solar panel acquired within 10am to 2pm only for the peak hours. Community more focused on the solar panel to generate the electricity and less exposure to the Pico-hydro system that concentrated effectiveness 24 hours as the installation of water based resources needed from the small stream to generate the electricity.

1.4 Work Scope

In order implementing the development of hydropower Pico-hydro system generation, researches are needed to be done. Furthermore, this study presents a systematic review of literature associated with the essential driving factors and also factors that hindering this technology from expending. These factors are useful to refining the decision for developing Pico-hydro system.

The aim of this paper is to provide a survey of water related innovations which have been done in previous studies and be adapted with the situation in Malaysia. The review will identify at least five core themes based on 100 technical reports. Generally, the themes are:

- (a) Community (A)
- (b) Resource Potential (B)
- (c) Technology (C)
- (d) Economy (D)
- (e) Environment (E)
- (f) RE Policy (F)
- (g) Political (G)

The fives of theme, starting from A until E, will be discuss in the report, using the retrieved works and case evidence from previous reports complemented by additional literature. A thorough understanding on the barriers and enablers in the development process is necessary to assess the applicability of employing and managing this green technology. Therefore, the generic reference model has been developed for water harvesting technology based on systems theories.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of Pico-hydro

In this chapter, the study more focused on the explanation development of Pico-hydro generation system. This chapter also includes about the information that was conducted to evaluate the development of Pico-hydro according to the division of the theme. The sources were selected based on the keywords that relate and the similarity with the Pico-hydro power generation. The sources came from at least 100 types of papers and reports of different innovative from the previous until nowadays that implemented and unimplemented from any countries that varies included in Malaysia. The crucial objective of this project is to evaluate the development and the decline in the performance of Pico-hydro development in our country. Furthermore, the research also included in all over the country in the worlds. Nowadays, the main sources of energy becoming depleted such as fossil fuels, lignite, gas and others sources that cannot be renewable. Hence the renewable energy sources are needed to overcome due to these problems. The renewable energy comes from many sources likes PV (Photo Voltaic) panel that absorbed the radiation from the sun-rays, wind turbine that generated from wind and hydropower energy especially the Pico-hydro generation power.

Thus, the division of hydropower generation according to the power that generate to 10MW and above. The Figure 2.1 below depicted the classification of energy that produced for each type of hydropower [1].However the convergence is

leading to the development of the Pico-hydro that the range less than 5kW and below.



Figure 2.1 Classification of hydropower following by energy produced [1]

The division of hydropower can be described into two parts, namely the natural cycle of water that flows and cycles also involved in hydropower stations. In terms of capacity, cost-effective, size, design and installation of Pico-hydro power compared to other hydro power. Thus, the Pico hydro system are greater and benefit much. In addition, Pico-hydro system also provides many benefits and could also raise the living standards of people in poor countries and rural areas because it is difficult for the government to set up a grid of transmission lines and lower costs of the larger hydro system. Implementation and development of the Pico-hydro turbine installation has been done by generating less than 5kW in a remote area but there is a view limited to Pico-hydro hydro technology in Malaysia.

2.2 Power from Water

In addition, to avoid any changes and damage to the environment, Pico-hydropower system is the best alternative way of generating electricity without the need for a small green building large dams. The decision to use the Pico-hydro as it will help to generate power with smart and cost-effective technology that does not give any adverse effect to the environment or social supply electricity to the community in a remote area off the electrical grid. Pico-hydropower system is based

on the simple concept of hydropower where the flowing water will turn a turbine that drives the generator will generate and with it, the electricity will be generated. This is one of the main components in the medium-term concept of hydropower for energy production in the build environment under 5 kW power range.

However, there are ways to use water power to generate electricity and it is better to start with the basic concept of the power of water, head and flow. Figure 2.2 depicted the difference between the two components of water power [1].

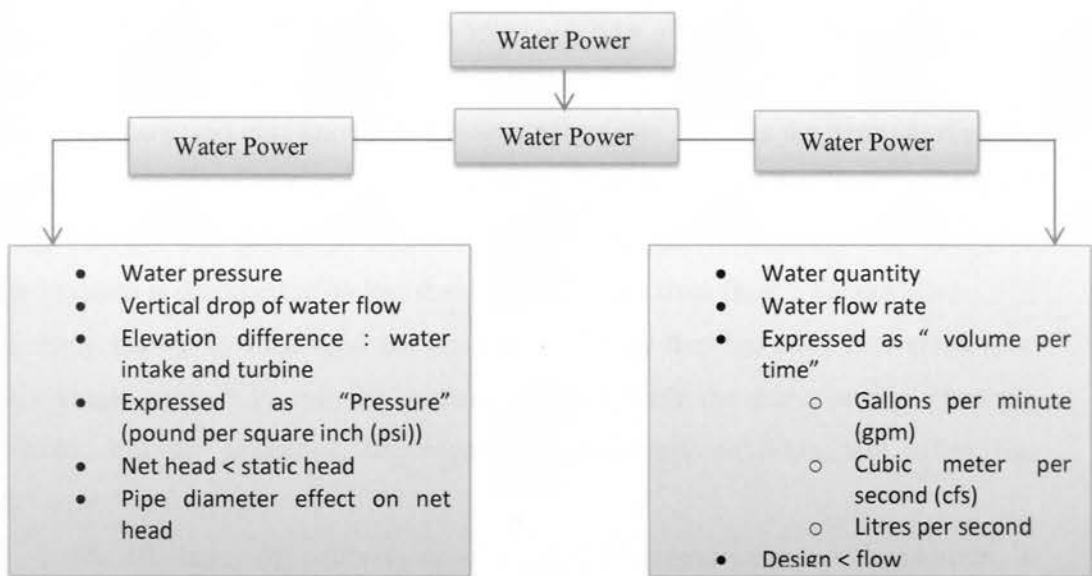


Figure 2.2 Head and flow in water [1]

Head has been referred to the air pressure at which it can determine the fall of the water vertically. Head is the height difference of the water intake passed through the turbine. Feet, meters or pounds per square inch pressure known as vertical distance that referred to the head. Meanwhile, the head of static pressure is the pressure that exists when the water was turned off. Normally, the net head is less than the static head due to the loss of friction between the water and the pipe. Based on Table 2.1, some experts have established certain heads water flow measurements to classify the small hydro power station [1]. The Table 2.1 shown on the classification of small hydropower station depending on head. The class that represents on the table are low head, medium head and high head [1].

Table 2.1: Classification of small hydropower station depending on head [1]

Class	Head
Low Head	$H < 10$ meters
Medium Head	$10 \text{ meters} < H < 30$ meters
High Head	$H > 30$ meters

Furthermore, components or other factors that play a crucial role in leveraging the power of water is flow [1]. Flow refers to the quantity of water to be the main turbine and also known as the water flow rate [1]. It is the amount of water passing per second, and it can also be expressed as the sum of the time traveled by water, with the unit cubic meters per second [1]. By norm, the maximum flow of a hydro system is designed to be less than the maximum river flow. Meanwhile, efficiency known by measured the amount of energy that has been converted. For every single part in Pico-hydro system included with the water intake channel, penstock, turbine, generator, transformer and transmission wires will affect the efficiency of the system.

The efficiency (η) will vary depending on the measured power. In addition, if there are more components involved in the generation system, it must be more than the losses appear simultaneously with efficiency will be reduced. In production of allotted amount power at the plant high head schemes, it is common practice to use equipment that is small and low cost compared with the necessary equipment of head low on site [1].

There exists a nation that argument for a sufficient power for effective power production. It is better to use more of the head that more than high head micro hydro, wheel head low water needs more water to run. However, nowadays, there are also researches in the low-flow study the proven system designed and able to generate electricity with high efficiency.

Thus, Gopal Reddy.K et al. elaborated an inducement of water is one of the key drivers in the system. The main drivers in the system are water and closely