FEASIBILITY STUDY OF INSTALLING EGAT IN-HOUSE MICRO HYDRO BULB TURBINE AT HUAI KUM DAM DRAIN PIPELINE

Narong KHAMPOOL[1], Arkon PHOMPHAKA[1], Sirivit TAECHAJEDCADARUNGSRI[2,]*
[1]Mechanical Maintenance Section, Hydro Power Plant Maintenance Department, Northeastern Region Hydro Power Plant, Ubolratana Dam, Thailand.
[2] Assistant Professor, Department of Mechanical Engineering, Khon Kaen University, Khon Kaen 40002, Thailand.
[*]Corresponding author, E-mail: sirtae@kku.ac.th

Abstract: Electricity Generating Authority of Thailand (EGAT) has the major role of developing the national electric power systems to provide an efficient, reliable and electricity service to satisfy the country growing demand. Accordingly, the Energy Ministry of Thailand is promoting portfolio standard of renewable energy such as wind power, solar power, biomass power agriculture waste power, small hydro power, etc. In this study, the major concern is about feasibility of using EGAT In-house micro hydro turbine at the river-outlet of the hydro power dam for a clean and inexpensive energy source without environment impact. Due to the existing dams in Thailand, mainly the hydro electric dam in northern region of Thailand, have a function of supplying water for irrigation over 240,000 acres of cultivation areas in the north eastern province, water supply for the irrigation flows through the river outlet bypassing the hydro power plant.

Feasibility Study of Installing EGAT In-house Micro hydro bulb Turbine at Huai Kum Dam drain pipeline before distributing the stored water for irrigation has been launched in order to set up the model for the other dams to effectively utilized the existing energy. With the low head of less than 30 m, the designed power output of this micro hydro bulb turbine is 70 kW. Using EGAT facilities and turbine fabrication technology in Thailand, the results show that the investment budget is about 1.5 Million Baht. Lastly, with the discount rate of 6% and 12% of 15-year operating project, the benefit-cost ratios are about 7.02 and 5.08 respectively.

Key words: Micro hydro turbine, dam, feasibility, benefit-cost ratio

1. Introduction

Renewable energy technologies use energy resources that are unlimited. Renewable technologies include solar energy, geothermal energy, wind energy, biomass energy and water energy. The main attractions of renewable energy are their environmentally friendly compared to fossil fuels and plenty of supply. Renewable energies such as hydro- or other-forms are available anywhere within one country that making their utilization easier. The European Union is working towards a target of renewable energy providing 12% of total electricity supplies by 2010. The White Paper issued by the European Commission in 1997 attempted to predict which generation technologies could make a major contribution to European energy supplies.

From Table 1, wind and biomass were the two technologies most likely to make the largest increase in renewable energy source. However the cost, suitable size and location are still major factors of the investments.

Table 1 Contribution in generation technologies in European energy supplies [1]

Energy Source	1995 TWh	2010 TWh
Hydro	307	355
Wind	4	80
Solar photovoltaic	270	300
Large (10 MW plus)	37	55
Small (under 10 MW)	0.03	3
Geothermal	3.5	7
Biomass	22.5	230

Hydropower is considered a renewable energy source since the "fuel" for hydropower is water which is renewable and is not consumed in the electricity generating process. Hydro-powers have attracted the public attention since the decade of 19th century. A lot of hydro-power projects are in operation without environmental problems. However some large hydropower projects may have negative environmental impacts on a river unless preventive and protective programs are sufficiently concerned. A large-scale hydro project with a reservoir will affect large amount of land ecosystem. Therefore, it is necessary to reduce the negative impacts as minimum as possible. Hydro-power plant projects, recently, have to be carefully designed while at the same time educating the fact that there are plenty of beneficial public effects, such as water supply for irrigation, flood control, low-cost energy.

In Thailand, there is a large amount of hydro-electric production. Financial supports from the government to existing hydro-power producers mainly are for creating more profit and not to achieve the objective of increasing the amount of renewable energy. Therefore the issue of the environmental friendliness of hydro-power would remain increasingly important. However some hydro-power projects are environmentally advantageous and others are not. Recently, one of the Thai government supports may focus on small hydro-power which is also renewable and more environmentally friendly than large hydro-power.

This study presents the results of the technical and economic feasibility conducted by collaboration between Electricity Generating Authority of Thailand (EGAT) and Faculty of Engineering, Khon Kaen University for the feasibility study of using EGAT In-house micro hydro turbine at the river-outlet of the hydro power dam for a clean and inexpensive energy source without environment impact. Due to the existing dams in Thailand, mainly the hydro electric dam in northern region of Thailand, have a function of supplying water for irrigation over 240,000 acres of cultivation areas in the north eastern province, water supply for the irrigation flows through the river outlet bypassing the hydro power plant.

This feasibility Study of Installing EGAT In-house Micro hydro bulb Turbine at Huai Kum Dam, in North Eastern of Thailand, drain pipeline before distributing the stored water for irrigation has been launched in order to set up the model for the other dams to effectively utilized the existing energy.

Fig. 1 illustrates the conceptual model of compact bulb turbine with direct coupled generator for further modification in order to be installed at specific area.

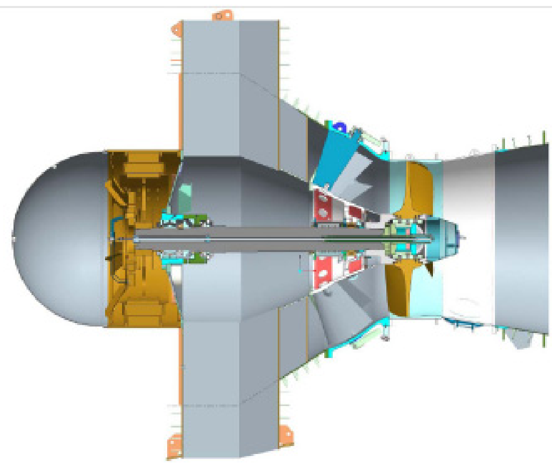

Fig. 1 The model of compact bulb turbine with direct coupled generator for further modification in order to be installed at specific area [2]

2. Project Description

Project location is at the gate house of Huai Kum Dam as displayed in Fig. 2 and Fig. 3. Whilst, Fig. 4 shows the back view of the gate house and the location of drain pipe output.

Fig. 2 Front view of gate house location

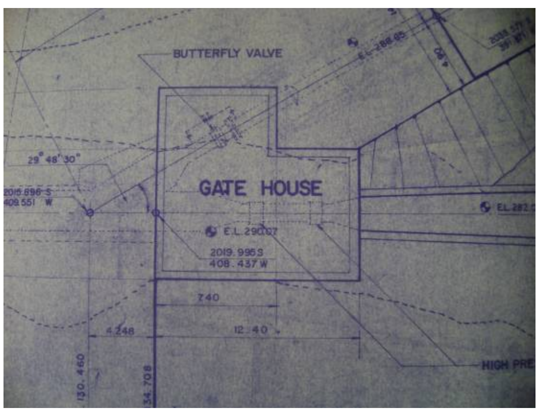

Fig. 3 Gate House where is the location of the project

Fig. 4 Back view of the gate house and the location of drain pipe output

Based on the conceptual design, this project would not have any major modification on any infrastructure of the existing gate house or any new construction for civil work on new power building. And the project would not have any impact on the recent plan for irrigation. In order to meet the purpose micro hydro turbine will be installed by using the piping branch via the air valve, shown in Fig. 5. As shown in Fig. 6 and Fig.7, the air valve will be re-connected with the new piping system where micro hydro turbine will be installed.

Fig. 5 Air valve location in the gate house where turbine piping system will be installed

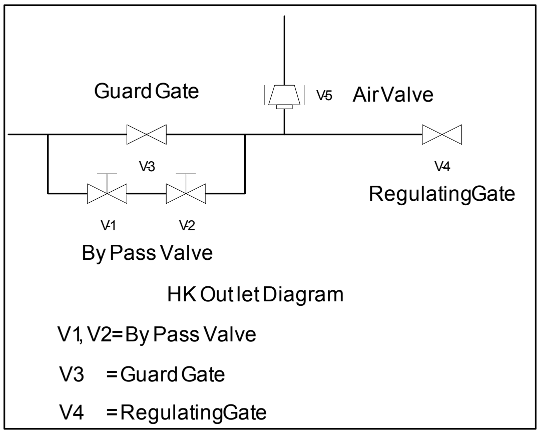

Fig. 6 Piping System before installing the micro hydro turbine

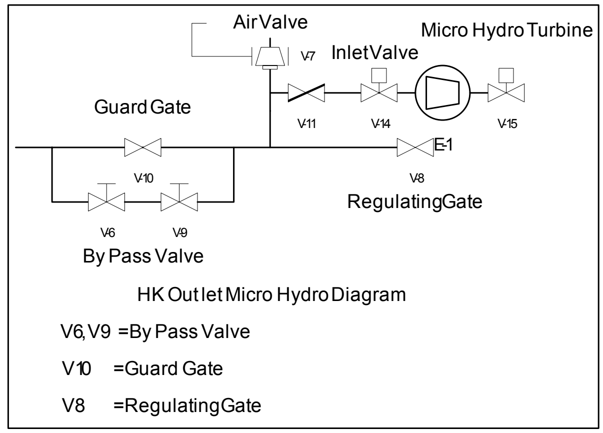

Fig. 7 Piping System after installing the micro hydro turbine

Table 2 Water flow at river outlet (unit: mcm)

year/month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	1.53	0	0	0	5.48	11.2	0	1.23	0	7.45	0	0	**26.89**
2001	0	3.76	0	0	0	4.09	4.8	3.75	0	0	0	0	**16.40**
2002	2.77	3.87	0	0	0	13.9	2.73	12.7	0	0	0	0	**35.97**
2003	7.61	2.02	1.95	0	0	15.9	0.8	0	1.46	0	0	0	**29.74**
2004	5.05	0	0.11	0	3.96	5.77	0	0	1.32	7.93	4.21	0	**28.35**
2005	5.76	5.62	2.42	0	0	6.88	0	3.68	0	0	0	0	**24.36**
2006	7.6	2.75	4.17	0	0.8	9.34	1.15	15.6	0	0	0	9.93	**51.34**
Maximum	**7.61**	**5.62**	**4.17**	**0**	**5.48**	**15.9**	**4.8**	**15.6**	**1.46**	**7.9**	**4.21**	**9.93**	**51.34**
Average	**4.33**	**2.57**	**1.24**	**0**	**1.46**	**9.69**	**1.35**	**5.28**	**0.4**	**2.2**	**0.6**	**1.42**	**30.44**
Minimum	**0**	**0**	**0**	**0**	**0**	**4.09**	**0**	**0**	**0**	**0**	**0**	**0**	**16.4**

Table 3 Water flow at river outlet (unit: m^3/s)

year/month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	0.57	0	0	0	2.05	4.32	0	0.46	0	2.78	0	0	**0.85**
2001	0	1.55	0	0	0	1.58	1.79	1.4	0	0	0	0	**0.52**
2002	1.03	1.6	0	0	0	5.36	1.02	4.75	0	0	0	0	**1.14**
2003	2.84	0.83	0.73	0	0	6.13	0.3	0	0.56	0	0	0	**0.94**
2004	1.89	0	0.04	0	1.48	2.23	0	0	0.51	2.96	1.62	0	**0.90**
2005	2.15	2.32	0.9	0	0	2.65	0	1.37	0	0	0	0	**0.77**
2006	2.84	1.14	1.56	0	0.3	3.6	0.43	5.83	0	0	0	3.71	**1.63**
Maximum	**2.84**	**2.32**	**1.56**	**0**	**2.05**	**6.13**	**1.79**	**5.83**	**0.56**	**2.95**	**1.62**	**3.71**	**1.63**
Average	**1.62**	**1.06**	**0.46**	**0**	**0.55**	**3.74**	**0.5**	**1.97**	**0.15**	**0.82**	**0.23**	**0.53**	**0.87**
Minimum	**0**	**0**	**0**	**0**	**0**	**1.58**	**0**	**0**	**0**	**0**	**0**	**0**	**0.52**

3. Water demand for irrigation in Huai Kum

Data of water flow average at river outlet, Table 2, has been recorded from year 2000-2006. The average of water flow per month for the 6-year base period was 2.54 million cubic meters (mcm). And most likely there is no water flow over river outlet in November - December and in April - May. However, the average per year of water flow at 30.44 million cubic meters (m^3) from Table 2 or the annual average of water flow rate of 0.87 cubic meters per second (m^3/s) from Table 3 is sufficient for running this EGAT micro hydro turbine at 0.392 m^3/s for almost 70% of the year.

4. Analyzes

4.1 Turbine output power

The power output from any hydro-power turbine is given by:

$$P = 9.8 Q H \eta_T \qquad (1)$$

where, P = output power (kW)
H = hydraulic head (m)
Q = flow (m^3/s)
η_T = total system efficiency

Therefore the output power can be estimated using the hydraulic head of 26 m., the average head different between the Huai Kum dam's reservoir and the outlet elevation, and the flow rate of 0.392 m^3/s, the average annual water flow through the 30 cm. drain pipe. Assume the total system efficiency of 70 %, thus the output power is about 70 kW.

For small-sized reservoir electric power station (Run-of-river type), as suggested by Arnupap [3], the plant factor, PF, in Thailand is about 50-100% (generally using PF = 70%). Plant Factor is given by:

$$PF(\%) = \frac{\text{Annual energy production (kWh) x 100}}{\text{Installed capacity (kW) x 8760 (hr)}} \qquad (2)$$

4.2 Economic Assessment

The present value (PV) methodology is used to calculate the breakeven price to sell energy from this hydro-power resource. Known as discounted cash flow analysis (DCFA), PV analysis is an economic method of equating a past, present, and future costs and revenues to a common point of time value. The 12% is commonly accepted discount rate in developing countries hydro-power resources and has been used in this study. Often referred to as the cost to produce, the breakeven price is defined as the minimum per unit price that would have to be charged by the investigator to recover a direct costs, indirect costs, and a rate of return etc. Therefore, if the calculated breakeven price is lower than the market price, the investigator would find the project economical. Conversely, if the calculated breakeven price is higher than the market price, the project would be economical.

This study assumes a base year of 2008. All costs and revenues before 2008 are inflated to 2008 values by using an inflation rate from the inflation report in Table 4, from the monetary policy committee, Thailand. In this study, we conservatively assume that the unit cost of electricity is fixed at the current value. For this study, we assume the investigator has sufficient understanding of the financial and technical requirements of micro hydro-power development. Therefore, lack of knowledge will not contribute to project failure. The total cost of main equipments, piping system installation and civil work is reasonably estimated at 1.5 Million Baht. Based on the assumptions of a 10 and 15-year operating life, the analysis will conservatively assume 3% per year of total cost for maintenance. The discount rate of 6% and 12% are used for comparing the results with the plant factor of 70%.

Table 4 The Inflation Report from The Monetary Policy Committee, Thailand

Summary Inflation Forecast as of July 2008			
%	**2007**	**2008**	**2009**
GDP Growth (old)	4.8	4.8 – 5.8 (4.8 – 6.0)	4.3 – 5.8 (4.5 – 6.0)
Core Inflation (old)	1.1	2.8 – 3.8 (1.5 – 2.5)	3.0 – 4.0 (2.0 – 3.0)
Headline Inflation (old)	2.3	7.5 – 8.8 (4.0 – 5.0)	5.0 – 7.5 (2.8 – 4.3)

5. Results

Results are presented in Table 5 comparing different economic models between 10-year and 15-year projects at 12% discount rate and plant factor of 70%. And when comparing between the discount rate of 6% and 12% of 15-year operating project, the benefit-cost ratios are approximately 7.02 and 5.08 respectively.

Table 5 The comparison of different economic models between 10-year and 15-year project.

Economic Analysis	10-year Project	15-year Project
Benefit and cost ratio	4.20	5.08
Net Present Value	4,665,251.13 Baht	5,928,066.33 Baht
Payback Period	1.57 years	1.56 years
Internal Rate of Return	79.26%	74.31%

6. Conclusions

The potential for Installing EGAT In-house Micro hydro bulb Turbine at Huai Kum Dam drain pipeline is very encouraging. This project can be added to a number of existing irrigation energy recovery schemes. With the low head of less than 30 m, the designed power output of this micro hydro bulb turbine is 70 kW. Using EGAT facilities and turbine fabrication technology in Thailand, the results show that the investment budget is about 1.5 Million Baht. Furthermore, with the discount rate of 6% and 12% of 15 years operating project, the benefit-cost ratios are about 7.02 and 5.08 respectively.

References

[1]. Maria Somaraki, *A Feasibility Study of a Combined Wind - Hydro Power Station in Greece*, October 2003, University of Strathclyde, Department of Mechanical Engineering.
[2]. Andritz Vatechydro co., *Low Head Hydro Turbines*, Joule Centre Annual Conference, 3rd April, 2008.
[3]. Arnuparp Wongrakon, *Efficiency comparison between small hydro turbine*, Master Thesis, Kasetsart University, 1998.
[4]. G.C. Thurston and M. M. Plum, *The feasibility of hydraulic energy recovery from geopressure – geothermal resources*, U.S. department of energy, September 1991.