IPRO 343 Project Plan

Title: Technical and Market Integration of Hydroelectric Energy

1. Objectives

The objectives are to design a small hydroelectric power plant on an existing low head dam on Fox River and investigate and evaluate the technical and market integration issues of the new hydro-electrical energy into the current power grid.

2. Background

Hydroelectric power is one of the type of renewable energy which utilizes kinetic and potential energy of water that has been diverted by a dam. Its power output is proportional to the height difference between the portions of upstream and downstream of the river from the dam and also the amount of water flow. Some of the main parts that consist in a hydroelectric power plant are the turbine; which converts the mechanical energy into rotational movement, the generator; which converts the rotational movement into electric current, and the powerhouse; which transfers the power output from the generator to the power lines.

Hydroelectric energy is most common in mountainous terrain where there are significant variations in height that provides sufficient potential energy to be converted into usable power. This environmental advantage inspired us to build enormous dams in those areas. However the idea that hydroelectric power plants can be built only in large scale areas such as mountainous terrain brought limited exploration of this kind renewable energy resource. At this moment the energy crisis has begun and hydroelectric power has been reviewed again from a different perspective. This time, it is the perspective that while decreasing the environmental impact, small but numerous plants can be installed in low head dams across any river to supply clean and renewable energy for the community.

The main sponsor of this project is Dr. Alexander Tseng who is a pioneer in bringing together solid turbines and generators from China and American switchgears and computer controls it to develop highly-efficient and low-costing hydroelectric power plants. He believes that the low head hydroelectric industry has not yet been exploited as it should have in the United States. He compares 2000 small low head hydroelectric plants operating in China with an approximated 100 in the United States to stress the point of how this kind of energy is wasted every second in this country. Dr. Alexander Tseng is highly convinced that small hydro industry is the answer to what USA and other countries have been looking for to prevent pollution and at the same time to keep up with the daily increasing demand of clean and renewable energy. It is his goal to introduce IIT as the pioneer build small hydroelectric plants in this nation and the Fox River has been appointed as the starting point of this challenge.

The crucial points to consider when building a small hydroelectric plant are the cost and profit that these small units can generate for the investors. One of the biggest challenges of this project is to make it feasible in terms of economic aspects and power output. In order to face this problem we will do our design based on small but highly efficient turbines which are specially designed for small head hydroelectric plants. The department of electrical engineering at IIT has already purchased two 5 KW (kilowatt) units, that are very economically versatile and it is expected to be a good first approach for initiating the design and solving the problem. In addition, there is another turbine unit called 'siphon turbines', which uses the siphon effect to take advantage of the height difference of the dam. The siphon turbines are currently used in the small hydro located in the city of Kankakee, IL. This small plant has 3 siphon turbines with a power capacity of 400KW, with each having a total output of 1.2 MW capable of delivering power to the water treatment plant situated two miles away. During certain times of the year when the flow of the river is strongest, more electricity than is required for the treatment plant is produced, giving the opportunity to deliver lower-cost power to the city of Kankakee. This situation is very similar to that in the city of Elgin, the place where it is one of the potential localities for the first low head hydroelectric power plant to be built by a university of Illinois.

There has been a history of attempts to build small hydroelectric plants on the Fox River, however it ended up failing. One thing which we are aware of is the American Hydro Company that made a feasibility study to build a low head hydro in the north Elgin dam, but the cost was too high at almost 5.2 million dollars. The equipment alone was quoted for almost 1.3 million dollars for the turbine. The study of this brought a conclusion that the project was not economically feasible. The negative result of this study was because the American Hydro Company did not approach the project with a new perspective, but instead with the standard procedures of building medium and large-scale hydroelectric plants.

In order to accomplish this project, we will have to face problems which will be the landscaping and environmental impact on the cities by the new units. For that reason, we are planning to design the powerhouse and the unit covers consistent with the architectural theme of the city and utilize low impact turbines, which have low revolution, decreasing the mortality rate of aquatic life passing through them.

We are convinced that this project is feasible if the university and the sponsors work together, bringing new technology and involving experts in the field and also creating a full-time program in order to realize the goal.

3. Research Methodology

The IPRO 343 team intends to use the following approach to research:

A. Site Evaluation:

- Brief evaluation of the three suggested sites by previous IPRO 319
- Evaluate site conditions; dimensions, environment, and zoning

B. Economic Feasibility

In order to identify the best dam from the cost- benefit angle our group should follow the following path:

- Obtain technical and historical data from each dam by public documents and field trips to the most promising locations.
- Interviews with experts in the area of hydropower. Input from relevant individuals involved with the Dayton facility will be pursued.
- Analyze the data collected based on the following points:
    - Actual physical condition of the dam.
    - Potential power produced by the dam.
    - Feasibility of combining the existing dam with modern generators and turbines available in the market.
- Research the parameters to calculate the cost of the following areas:
    - Maintenance of the dam.
    - Maintenance of the turbines and necessary auxiliary equipment.
    - Installation and maintenance of the Power transmission lines.
    - Possible modifications to the existing dams.
    - Operation of the Hydropower plant per year.

C. Long-Term Assessment:

- Determine environmental effects.
- Determine time and efficiency.

D. Project Requirements:

- Delineate and divide various responsibilities among team members
- Develop and maintain up-to-date and thorough representations of the team's progress and milestones
- Continuing to monitor individual participation and performance to ensure everyone gets a sufficient background of all aspects of the project

- 3D CAD drawings of the dam, the loading zone, and the actual parts being treated must be generated.

- Dam surveys must be conducted and used in conjunction with the drawings to determine ideal loading conditions.

- WZXJ-5/1800 turbine generator set & WZHL-5/1800 turbine generator set

	TURBINE CHARACTERISTICS			GENERATOR CHARACTERISTICS			
	MODEL	HEAD ft	FLOW cfs	MODEL	VOLTS	AMP	HZ
WZXJ-5/1800	XJ-13-L-15/4	131	0.8	T2S52-4-5	120/208	15.8	60
WZHL-5/1800	HL-240-LJ-14	16-36	1.9~2.8	T2SS-5KW	120/208	18.1	60

4.0. Expected Results

A. Expected activities of results involved in the project.

For the expected results, we will modify the most suitable existing dam and build a green hydropower station, and hope our research and design work would provide feasible and scientific schemes and parameters for building this hydropower facility on Fox River. According to our estimated results, the electricity generated by this small hydropower station will also feed a distant or a local load from the small hydroelectric source, which could be run-of river. Through our market analysis, optimizing the operation and maintenance scheme , the candidate client should consume more reliable and cheaper power electricity; while the investor and owner of the small hydropower facility obtains benefit from this project. The most significant environmental impact of small hydro development we must consider will be the positive aspect of the small hydro plant generating electricity without emissions associated with conventional power stations. In addition, we should consider the effect in fish passage and its protection including water quality during the process of designing the project.

B. Data of results from research or testing involved in the project.

Expected data from calculating parameter of electrical and mechanical equipments can be represented as following. For the turbine we expect to find the Model, Turbine Output Power, Rated speed, Nominal diameter of runner, Diameter of jet, Design head, Volume of Water Flow, Weight, and Turbine efficiency. For the generator, we expect to find type, capacity, rated voltage, rated current, phases, frequency, power factor, speed control, voltage regulation method, weight, speed, exciting current, exciting voltage, and output of the set. For the layout and size of dam and hydropower house, we expect to find length, width, height, space between the side walls, and radian. All above parameters of hydropower facilities will exactly label in the final blueprint according to the real scale.

For researching market operation of hydropower stations, bid price, annual power production, LMP, maintain cost, operation cost, Revenual, and profit should be recorded.

There are some testing investment cost and economics The measurements are rating, Turbine-generator and control, Mechanical and, electrical equipment, civil engineering, supervising and administration, engineering and design, contingencies, project total, annual bond payment, annual operation and maintenance, Total annual payment, Total energy output, annual income, and net annual income.

Environmental impact data are also required to be taken. The evaluation items are river flow, water quality, numbers of fish, kind of threatened and endangered species, and status of cultural resource.

C. Potential products resulting from research and testing.

Potential products

- Three dimensional blueprints of the dam, hydropower house, and other related facilities.
- The model and main parameter of electrical and mechanical Equipment
- Control and operation scheme of the hydropower station. The annual profit analysis of hydropower station under the power market environment
- Economic and investment cost analysis report
- Overall environmental impact report

D. Potential outputs of out project are as follows

- A suitable position to build small hydro generator from a set of candidates
- An efficient hydro unit to be used, and a contracture to make use of water at its most efficiency
- Output of hydro power at each time based on the information of available water flow and users demands
- The impact of hydro power to power market, and how to dispatch hydro energy to get the most economics

E. Deliverable expected results by the project team

.

Our potential outputs should be deciding a most suitable position to build small hydro power generator. We need to choose a proper kind of hydro unit and design a contracture to make use of water at its most efficiency. After that, we will decide how much hydro energy should be generated at each hour based on the information of available water flow and users needs (this information could be forecast based on available history data). Further more, we can add hydro power to the power market and calculate the impact of

hydro power on LMPs and other aspects. It could be expected that LMPs decrease as hydro power introduced into power market.

F. Expected problems to the sponsor/customer

The key goal of the sponsor/customer is to develop renewable sources of energy to meet the energy, economics, and security issues. Our design, choosing a most suitable position to build small hydro power generator, a proper kind of hydro unit and design a contracture to make use of water at its most efficiency, can make a more efficient use of water flow, which will decrease the usage of other conventional fuels. With the analysis of economical issue, the sponsors can expect income to cover their investments.

G. Expected results that will be incorporated into the proposed solution or solution framework.

In this project, we are expecting to build a hydro plant over the Fox River. To achieve this goal, we need to go there for a field trip and collect all the data needed. Then we will choose a suitable hydro turbine which can fit the practical conditions of the intended location and design all the relevant details. At last, an evaluation on the connection of this hydro plant with real power grid will be done based on the output of the hydro plant. The expected results such as benefiting the community can be tested by evaluating the social welfare resulted from this project such as environmental protection, low-cost power supply, water flow control and so on.

5.0. Project Budget

A. Create and itemized list of proposed spending. Incorporate as much detail as possible and define the listing in chronological order.

Table 1. Itemized budget for the project:

Sub Team	Materials	Expected Expenses ($)
Design	Books	100
	Materials for Drawing	100
	Cost for Modeling	100
Marketing	100-pack blank CD-ROM Media	35
IPRO Team	Printing	30
	Gas cost for field trip	100
	Cost for Photocopying	30
Grand Total		495

The success of our project is strongly dependent on the availability of these resources.

6. Schedule of Tasks and Milestone Events

A. Time Table with each task flow

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Get Organized															
Introduction Hydroelectric															
Find Site and proper equipment															
Marketing sub team															
Hydroelectric Power System Design sub team															
Environment sub team															
Prepare for the presentation & final report															
Exhibit (Poster)															
IPRO Day															

Additional table by using MS project plan is shown on attached file

B. Ipro due dates

9/1: Syllabus Due
9/8: Project Management Workshop
9/9: Project Management Workshop
9/22: Project Plan due
10/6: IPRO Proposals Due
10/7: Midterm Report Due
11/13: IPRO day guidelines and Tips Session
11/22: Exhibit Poster Due/Abstract Due
11/27: Website URL Due
11/29: Presentation Due
11/30: Final Report Due
12/1: IPRO Deliverables CD Due/IPRO Day

C Entails and Skill set needed for each task

a) Find Site and proper equipment

- Understand and explore the power efficiency of each type of generator and turbines
- Having enough potential sites information such as water flow, landscape, and head of the dam

b) Hydroelectric power system Design

- Fundamental power system knowledge
- Capable of using graphical programs such as auto CAD or Pro-e

- Building Models
- Understanding and utilizing the Small Hydro Project Analysis Software (RETScreen International)

c) Market Integration of Hydroelectric power

- Use the program, Marsi, which was developed by the ECE department at IIT to study the marketing impact of an additional plant on the existing system.
- Utilize the expertise of Ph D. students in our group.

D Members' working hours for each specific tasks & project

Table 2. Title….

Name	Work time hours per week	Work time hours for semester	Find Site and proper equipment	Marketing	Hydroelectric Power System Design	Environment	presentation/ final report	Slack Time
Choe, Hyung	6	90	24			36	20	10
Burgos-Lopez, Mauricio	6	90	24		36		20	10
Ha, Sooyoung	6	90	24		36		20	10
Lee, Chi Hwan	6	90	24		36		20	10
Liu, Cong	6	90	24	36			20	10
Song, Chang	6	90	24			36	20	10
Wang, Jianhui	6	90	24	36			20	10
Wu, Lei	6	90	24	36			20	10
Total		720	192	108	108	72	160	80

Blue : Hours Available Red: Working hours

7 Individual Team Member Assignments

A. Team Members' Background

Burgos-Lopez, Mauricio: Electrical Engineering, Experience in Hydroelectricity project by previous IPRO
Choe, Hyung: Electrical Engineering, Experience in IPRO
Ha, Sooyoung: Mechanical Engineering,
Lee, Chi Hwan: Mechanical Engineering
Liu, Cong: Electrical Engineering, PHD
Song, Chang: Electrical Engineering
Wang, Jianhui: Electrical Engineering, PHD
Wu, Lei: Electrical Engineering, PHD

B. Team Leader and Each Leader for each sub team

Team Leader → Choe, Hyung
Marketing team → Liu, Cong
Design/ Technical team → Burgos-Lopez, Maurici
Environment team → Song, Chang

C. Responsible for the each sub team

Marketing team- responsible for finding potential electricity customers around the area
Design team- Works with Technical Team. Drawing the Hydroelectric System by AutoCad. This team will be responsible for visualizing what the whole team has achieved.
Technical Team – This team will be responsible for designing the Hydro-System. Determining the most efficient design.
Environment Team- determining whether the Hydro-System would have any effect on the environment. Will also determine whether the visual of the Hydro-System fits into the surrounding atmosphere.

8. Designation of Roles

Name	Sub Team	Role	Additional Role
Choe, Hyung	Environment	Team leader	Time Keeper/ Master schedule Maker
Burgos-Lopez, Mauricio	Design	Sub leader	Agenda Maker
Ha, Sooyoung	Design		Weekly report collector/ summarizer
Lee, Chi Hwan	Design		
Liu, Cong	Marketing	Sub leader	
Song, Chang	Environment	Sub leader	Minute Taker
Wang, Jianhui	Marketing		
Wu, Lei	Marketing		