IPRO 345: Chicago Sister Cities China: Fuel Cell/Geothermal Sustainable Energy USX Site

Project Plan

Spring 2008

Advisor: Said Al-Hallaj

## 1.0 Objectives

**A.** Create a working software tool that assists in the capacity of planning, decision making and accessing the economic feasibility of implementing an integrated fuel cell technology and geothermal energy system.

**B.** Through a case study approach, research and evaluate the energy needed in residential homes to use as a basis for determining the algorithms employed in the software development.

**C.** Demonstration of the viability of the integrated fuel cell and geothermal system in a specific location through the prototype testing of the database tool.

**D.** Connect an alternative energy source for heating and cooling to the industrial world by providing an efficient way to analyze the design and economic parameters required to implement such an integrated energy system.

**E.** Research on all parameters needed for our project's implementation including environmental laws and regulations, permits, funding, weather, population, and energy consumption.

## 2.0 Background

**A.** The Chicago Sister Cities China Architecture and Engineering subcommittees, as well as HNTB companies, established and secured sponsorship for the formations of our team.

**B.** This internationally jointed team of faculty, students and university administrators are from University of Illinois at Chicago (UIC), Illinois Institute of Technology (IIT), and Tong-ji University (TU) in Shanghai.

**C.** Two different technologies are involved in developing the process. Fuel cell technology is used to generate electrical power as well as to supplement heating power. A molten carbonate fuel cell was selected to be used due to its high operating heat, its ability to utilize a variety of hydrocarbon fuels, and its high efficiency. A geothermal heat pump is being used as the primary source of heating and cooling power. A geothermal heating system is environmentally friendly and can cheaply supply heating and cooling power throughout the year. When necessary the waste heat from the molten carbonate fuel cell can be used to augment the heating abilities of the heat pump system.

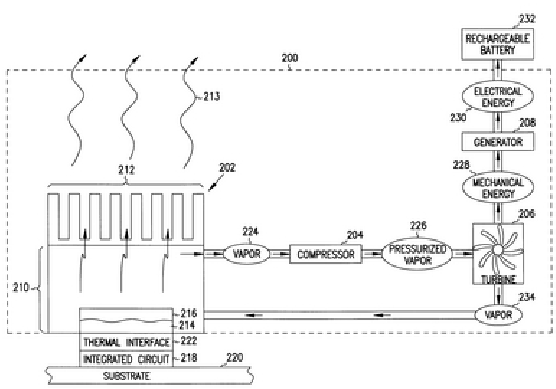
**D.** Fuel Cell technology has been around well over 100 years, in the early 1900's there were many attempts to develop fuel cells that will convert carbon into electricity, but the advent of the internal combustion engine put the fuel cell technology on stand by. In 2000, the US Army Corps of Engineers published a study examining the use of a molten carbonate fuel cell for supplying power to the

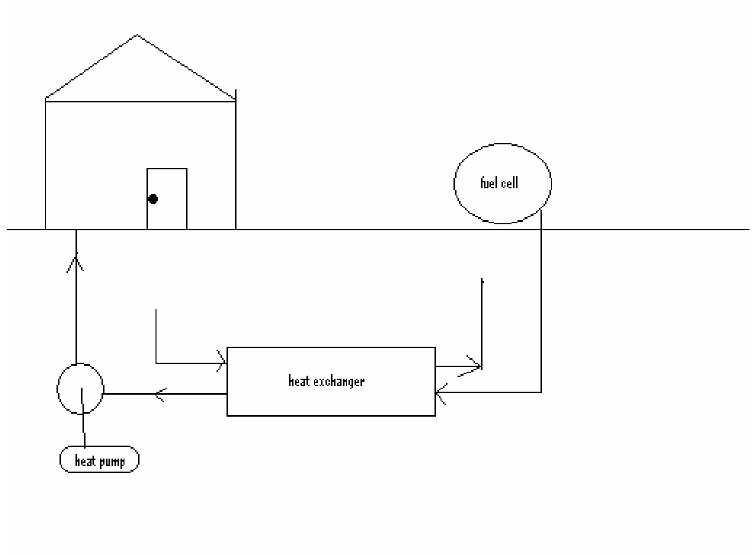
Rock Island Arsenal, IL. In addition to supplying power to the facility, the study also examined using the waste heat of the fuel cell along with additional heat provided by a geothermal heat pump system to offset heating costs. The study found that by using these two systems in conjunction with each other the Rock Island Arsenal could significantly reduce energy costs, as well as significantly reducing environmental pollutants such as $CO_2$. This shows that a combined molten carbonate fuel cell/ geothermal heat pump system can be feasible in certain locations.

**E.** There are three sets of parameters that are involved in the designing process. The first branch is the environment and law unit which will address the issues of permits needed as well as the environmental regulations. It will also investigate the weather conditions and the areas' needs. The second is economics unit which will investigate the grants and subsidies along with the price of excess energy created by the system. Another area of parameters that must be investigated is the design of the system, which includes the energy needed to supply heating and cooling, the amount of power generated, and the mechanics of the system.

**F.** After the completion of the research phase. The information gathered will be organized and entered into a computer program. This program will then be able to analyze a selected site to determine if a combined fuel cell and heat pump system would be technically, economically and ethically feasible.

**G.** By creating software that will assist in introducing an unfamiliar technology to society it is very important that the ethical, moral and cultural issues will be addressed. These issues will set a guide for future use of the new technology and will create boundaries that must be held. To begin with, the more pertinent issue of the project is concerning the regulations for digging, constructing, and fully implementing the system into a society. To prevent a society from rejecting this system, one must be aware of environmental issues and also be knowledgeable about the fuel cell and its positive effects on the environment. Other benefits in using this technology include promoting local jobs, efficient energy, health benefits/environmental, reduced energy costs and reduce dependency on depleting resources.






**3.0 Methodology/Brainstorm/Work Breakdown Structure**

**A.** Design and implement software for assessing the feasibility of implementing of a hybrid energy system consisting of geothermal energy and fuel cell technology.

**B.** In order to accomplish said task in section 3.0A the team will focus on the potential implementation of the project at the 640-acre U.S. Steel Duluth Works site (USX site). By using this site we can gain an understanding of all factors that need to be addressed. As a group we have decided to move through the research and development phases as a complementary and cohesive. Through this process we hope to all gain a better understanding of the fuel cell/geothermal system and also to have a more fruitful end result.

**C.** We have a large team which provides us with an array of technical and professional skills sets. In the research segment of the group we have scheduled many presentations in which each member of the group shares information with the other team members. However, the design team is primarily responsible for finding and coordinating the data organization process with the contract programmer.

**D.** The parameters and information needed for our project will be complied into an organized format that will come from the collaboration between our sub teams. We are all responsible for creating a comprehensive and understandable way to organize the algorithms that will complement our software.

**E.** In the final stage, we will be presenting to The Chicago Sister Cities China Architecture and Engineering subcommittee as well as our parallel team from UIC.

**F.** Final adjustments to the programming and software will be worked out with the contract programmer hired to assist with the prototype testing phase. An IPRO deliverable report will be generated by individual subgroups being responsible for their topics as well as by cohesively working with the other subgroups. The rough draft will be posted on the igroups website and will be read by all group members. We will have an open forum for any suggestions to make any necessary changes.

**G.** Not applicable.

**4.0 Expected Results**

**A.** The results of this IPRO will be used to judge whether or not the design tool produced is a working model.

**B.** Expected data from research will be the parameters needed in a first-case analysis tool for implementation of molten carbonate fuel cells. The tool itself will be tested and the data from the testing will be an indication of the accuracy of the tool.

**C.** The potential product that will evolve due to research and testing is a first-case analysis tool for determining whether molten carbonate fuel cells are a viable energy solution for any project site.

**D.** Our potential outputs through the execution of assigned tasks are to gain appropriate data on Geothermal Energy and Fuel Cell Technology, and to share our known and learned information with other group members. We will also work together as a group to provide the best product while being team players.

**E.** Our expected results in terms of prototypes and other deliverables are a working tool to carry out first-case analysis for implementation of molten carbonate fuel cells and a final report and presentation on our project.

**F.** The results we expect will address the problem and concerns of the sponsors. They expect a tool for first-case analysis of implementation of molten carbonate fuel cells and we are planning to meet their expectations.

**G.** All data gathered from research will indicate which factors need to taken into consideration for making a first-case analysis on the viability of molten carbonate fuel cells on project sites. Those aspects of design will be put into the tool, and thus the data will be incorporated into the solution.

## 5.0 Project Budget

| *Item* | *Quantity* | *Price($)* | *Purpose* |
|---|---|---|---|
| Printing | | 50 | For printing our project abstract. For making copies throughout the semester. |
| Contract Programmer | 10/hr<br>150 project hours | 1500 | To hire a programmer to organize our information into a database tool |
| Food and drinks | | 250 | To buy pizza for 28 people during the midterm presentation and final presentation phases |
| Travel money to USX site | | 200 | This would serve as an opportunity for the group to evaluate a potential case study site |
| Published articles site fee | | 400 | This would enable us to access the needed ports of information for our project |
| **Total Budget** | | **2400** | |

## 6.0 Schedule of Tasks and Milestone Events

| *Task* | *Members Responsible* | *Hours total* | *Dates* |
|---|---|---|---|
| Research Environmental impact/guidelines/regulations of fuel cells | Maruja Yoshimura | 17 hours | February 17th-March 25th |
| Research Environmental impact/guidelines/regulations of geothermal pumps | Abhishek Prabha Kumar | 17 hours | February 17th-March 25th |

| ***Task*** | ***Members Responsible*** | ***Hours total*** | ***Dates*** |
|---|---|---|---|
| Research codes and laws (federal, state, city) pertaining to fuel cells | Suk Hwan Yun | 17 hours | February 17th-March 25th |
| Research codes and laws (federal, state, city) pertaining to geothermal pumps | Nick Leep | 17 hours | February 17th-March 25th |
| Research site conditions necessary for a fuel cell/geothermal system | Daisy Agose | 15 hours | February 17th-March 25th |
| Research environmental conditions in Chicago | Eliza Bober | 12 hours | February 17th-March 25th |
| Put together work for Midterm presentation | Eliza Bober | 5 hours | February 29th - March 2nd |
| Plan database format | Eliza Bober | 3 hours | March 10th – March 17th |
| Organize research into database | Daisy Agose<br>Eliza Bober<br>Abhishek Prabha Kumar<br>Nick Leep<br>Maruja Yoshimura | 36 hours | March 17th - April 4th |
| Develop code of ethics | Nyah Zarate, Raisa Pelae, Christian Arnoux, Cheryl Mukai | 20 hours | March 7th |
| Attend ethics presentation | Raisa Pelae, Christian Arnoux, Cheryl Mukai | 4 hours | February 15 &16 |
| Edit and finalize project plan | Nyah Zarate, Daisy Agose, Brian Hogan | 5 hours | February 10th – 22nd |
| Research costs (electricity, fuel, machinery, installation) | Jonathan Lockridge, Yoon Sung Chung, Matt Dado, Yun Jin Lee | 55 hours | February 10th – March 14th |
| Research federal, state, and local subsidies | Richard Byrne, Funso Ajigbo, Gregory Enadeghe | 55 hours | February 10th – March 14th |
| Research fuel cell implementation | Chris Wolcott, Jaehyuk Kim, Jae hyung Park, Won woo Park, Min Zheng, Jennifer Peavler | 60 hours | January 31st – March 4th |
| Determine aspects of design included in tool | Brian Hogan, Jennifer Peavler, Chris Wolcott | 10 hours | February 21st – March 4th |

| *Task* | *Members Responsible* | *Hours total* | *Dates* |
|---|---|---|---|
| Perform calculations on existing sites | Brian Hogan, Won woo Park, Jaehyuk Kim, Min Zheng | 40 hours | February 28$^{th}$ – March 20$^{th}$ |
| Develop database for tool | Brian Hogan, Won woo Park, Alex Horner | 15 hours | March 20$^{th}$ – March 27$^{th}$ |
| Build software tool | Hired CS programmer | 100 hours | March 27$^{th}$ – April 8$^{th}$ |
| Test design tool on project sites | Brian Hogan, Jae hyung Park, Alex Horner | 20 hours | April 8$^{th}$ – April 24$^{th}$ |
| Design Website | Nyah Zarate | | |

**7.0 Individual Team Member Assignments**

| *Name* | *Major* | *Position* | *Skill* |
|---|---|---|---|
| Daisy Agose | Chemical Engineering 4$^{th}$ year | Team Leader<br>Site Requirements Research | MatLab, Hysys, Excel |
| Eliza Bober | Architecture 4$^{th}$ year | Sub-Team leader<br>Environment Research<br>Sub-team clerical | Presentation Experience, IPRO Experience, Word, Excel, Photoshop, Illustrator and AutoCAD |
| Abnishek Prabha Kumar | Chemical Engineering 2$^{nd}$ year | Environmental – geothermal research | Teamwork, Excel, Word, Photoshop, AutoCAD, MatLab |
| Nick Leep | Chemical Engineering 2$^{nd}$ year | Geothermal codes and laws research | MatLab, Excel, Word, HTML |
| Maruja Yoshimura | Chemical Engineering 2$^{nd}$ year | Environmental – fuel cell research | Very Organized, Word, Excel |
| Suk Hwan Yun | Chemical Engineering 2$^{nd}$ year<br>Environmental Engineering (in Korea) | Fuel Cell codes and laws | Looking into Environmental Effects and Alternative Energy<br>Basic Computer Skills |
| Jonathan Lockridge | Architecture 4$^{th}$ year | Sub-team Leader | Auto CAD, CS3, 3dmax, VIZ, Carpentry |
| Yoon Sung Chung | Material Science | Economics sub-team | Bilingual |

| ***Name*** | ***Major*** | ***Position*** | ***Skill*** |
|---|---|---|---|
| Mathew Dado | Chemical Engineering 2nd year | Economics sub-team | Strong Technical and Analytical skills |
| Richard Byrne | Chemical Engineering 2nd year | Economics sub-team | Strong technical and analytical skills |
| Funso Ajigbo | Chemical engineering | Economics sub-team | Bilingual, good organizer, MatLab, Hysys, Excel |
| Gregory Enadeghe | Chemical engineering | Economics sub-team | Strong Technical and Analytical skills |
| Yun Jin Lee | Mechanical engineering | Economics sub-team | Bilingual, MatLab, Hysys, Excel |
| Brian Hogan | Chemical Engineering 4th year | Design sub-team leader | Strong technical and analytical skills |
| Chris Wolcott | Chemical Engineering 2nd year | Design sub-team | Strong technical and analytical skills |
| Jennifer Peavler | Chemical Engineering 3rd year | Design sub-team | MatLab, Hysys, Excel |
| Jaehyuk Kim | Architecture 4th year | Design sub-team | Strong technical and analytical skills |
| Jae hyung Park | Aerospace Engineering 4th year | Design sub-team | Strong technical and analytical skills |
| Won woo Park | Architecture 4th year | Design sub-team | Strong technical and analytical skills |
| Min Zheng | Chemical Engineering 3rd year | Design sub-team | Strong technical and analytical skills |
| Alex Hornero | Chemical Engineering 4th year | Design sub-team | Bi-lingual, strong technical and analytical skills |
| Raisa Pelae | Chemical Engineering 4th | Ethics sub-team, minute taker | MatLab, Hysys, Excel |
| Nyah Zarate | Chemical Engineering 4th year | Ethics sub-team, IPRO deliverables | MatLab, Hysys, Excel |
| Christian Arnoux | Chemical Engineering 4th year | Ethics sub-team | MatLab, Hysys, Excel |
| Cheryl Mukai | Chemical Engineering 4th year | Ethics sub-team | Strong technical and analytical skills |

**8.0 Designation of Roles**

**A.** Meeting Roles

a. Minute Taker: Raisa Pelae
b. Agenda Maker: Daisy Agose
c. Time Keeper: Raisa Pelae

**B.** Status Roles

a. Weekly Timesheet Collector: Raisa Pelae
b. Master Schedule Maker: Daisy Agose