PEM Fuel Cell Technology

Illinois Institute of Technology

February 6, 2009
IPRO 318

Project Leaders: Hannah Zwibelman & Adam Smith

Advisor: Professor Vijay Ramani

Table of Contents

Team Information

Team Roster

Kolade Adebole	kadebowa@iit.edu
Marisol Aguirre	maguirr2@iit.edu
Kathleen Baker	kbaker6@iit.edu
Steven Booher	boohste@iit.edu
Elizabeth Corson	ecorson@iit.edu
Elena Dorr	edorr1@iit.edu
Anam Khan	akhan50@iit.edu
Ellen Kloppenborg	ekloppen@iit.edu
Emily Kunkel	ekunkel@iit.edu
Matthew Marks	mmarks2@iit.edu
Hussein Massoud	hmassoud@iit.edu
Samira Matezic	smatezic@iit.edu
William Mocny	wmocny@iit.edu
Bethany Nicholson	bnichol4@iit.edu
Galina Shpuntova	gshpunto@iit.edu
Adam Smith	smitada3@iit.edu
Bryce Swillum	bswillum@iit.edu
Joshua Willett	jwillet1@iit.edu
Priscilla Zellarchaffer	pzellarc@iit.edu
Yin Zhao	zhaoyin1@iit.edu
Hannah Zwibelman	hzwibelm@iit.edu

Team Member Information

Vijay K. Ramani -Instructor

Adam Smith ARCH - Team Leader – *is in his 5th year of Architecture at IIT. He is interested in the development of technology in society and how it alters the way people live. He offers a different approach to the design aspect of the project.*

Hannah Zwibelman CHE – Team Leader – *is a 4th year Chemical Engineering student who specializes in technical writing and chemistry. She is interested in alternative fuels because she really cares about the environment. Her leadership abilities and problem solving techniques help in giving direction to the group.*

Kolade Adebowale CHE - *is a 2nd year Chemical Engineering student. He is interested in learning about alternative fuels so that he can introduce this technology to his native country of Nigeria. He is analytical and hard working with an avid research in background which supports the groups efforts.*

Marisol Aguirre CHE - *is a second year Chemical Engineering student. She hopes to learn more about fuel cells and working in group settings. This IPRO ight determine her minor and hopes to learn more about chemical engineering as well.*

Kathleen Baker CHE - *is a sophomore Chemical Engineer, expects to expand on her previous knowledge of PEM fuel cells. She hopes to improve her research skills and gain knowledge from her group members on the most effective methods of relaying knowledge to an audience. Kathleen brings her knowledge of MATLAB and Microsoft Excel and PowerPoint.*

Steven Booher ARCH – *is a fifth year Architecture student with an eye for design and a creative mentality. He is proficient in several types of technical and visual software. He is curious about alternative fuel sources.*

Elizabeth Corson CHE - *is a second year Chemical Engineering student involved in Camras, Alpha Sigma Alpha, and Techtonics, among other groups, on campus. Her previous research and teamwork experience will contribute to the success of the group. She hopes to learn more about fuel cells and their potential as providers of clean, renewable energy. She looks forward to discovering the benefits of interdisciplinary work.*

Elena Dorr CHE –*is currently a junior pursuing a Chemical Engineering major with an emphasis in BioEngineering. She is highly analytical with strong communication skills and experience in project management. She would like to develop her knowledge of electrochemistry and skills in group problem solving. Her expectations about the project include working together toward common goals and embracing new ideas.*

Anam Moin Khan ECE – *is a second year Electrical and Computer Engineering major. She hopes to apply her knowledge in electrical circuitry to the project and further explore topics regarding fuel cells. She is interesting in the cost analysis and future of fuel cells in a competitive economy.*

Ellen Kloppenborg CHE – *is a 4th year Chemical Engineering student with experience is research and industry. She brings organizational strengths and skills learned from prior leadership positions to the group. After graduation, she will be working in the energy field so this IPRO will give her further information on the subject.*

Emily Kunkel CHE – *is a second year Chemical Engineering student with a knowledge and passion for fuel cell development. Her background in engineering combined with hard work and knowledge of the subject will contribute to the project.*

Matthew Marks EE - *is a third-year Electrical Engineering major. He hopes to apply his knowledge of circuits to this project, while strengthening his skills in electrical applications. He believes this experience will give him an opportunity to learn more about other majors, and build teamwork skills.*

Hussein Massoud CHE – *is a second year Chemical Engineering student. He worked in an oil field in the summer of 2007 which went dry, this sparked his curiosity to learn and research more about alternative and renewable fuels.*

Samira Matezic CAE - *is a third year Architectural Engineering student. She hopes to use her knowledge in physics and mathematics towards the IPRO. With this IPRO, she hopes to extend her knowledge towards fuel cells.*

William Mocny CHE - *is a 2nd year Chemical Engineering student. Has knowledge of chemical transfer systems and chemistry in general. He is hoping to gain a rich knowledge of how the industrial world works, along with research. He is hoping to specialize in nuclear energy.*

Bethany Nicholson CHE – *is a second year Chemical Engineering major with strength in mathematics and computer science. From this project she hopes to hone her communication and research skills and her overall expectation is to learn more about the scientific truth about fuel cells and their potential as a form of 'green' energy*.

Galina Shpuntova ME/AERO - *is a 3rd year Mechanical/Aerospace Engineering major. She has lots of academic and professional experience with fluid and gas flow, which can be useful in a project dealing largely with gases. She enjoys chemistry but has not had a chance to study it intensively in the last few years. She would like to further advance her skills in chemistry, as well as to participate in the design process for an engineering project, which is bound to have challenges and learning experiences along the way.*

Bryce Swillum CHE – *is a second year Chemical Engineering student. He wants to increase his technical knowledge regarding fuel cells. He is interested in learning more about the capability of fuel cells using modern technology. His experience in public relations and leadership skills combined with improvisational thinking will help the IPRO investigate environmental implementations of fuel cell.*

Joshua Willett AERO- *is a 3rd year Aerospace Engineering student hoping to apply his knowledge of aerodynamics and thermodynamics to the design of a fuel cell vehicle. I hope to enhance my knowledge of fuel cell and alternative energy sources.*

Priscilla Zellarchaffer CHE – *is a fourth year Chemical engineering student who loves working in engineering groups with like minded individuals. She brings out of the box innovative ideas along with math and analytical chemistry knowledge to the group.*

Yin Zhao CHE/CHEM - *is a 4th year Chemistry and Chemical Engineering student who has research and work experience in the chemical engineering discipline. His strengths are mathematics and problem solving techniques. He is a determined and conscientious student who loves a challenge.*

Team Identity

Name: Fuel Cells for the Future

Logo:

Motto: Fuel Cells: Business or Bust?

Team Purpose and Objectives

Team Purpose

Work as a coherent, ethically-minded group utilizing the strengths of individual team members to accomplish a feasible fuel cell system design that can be commercialized

Objectives

1. Evaluate the feasibility of PEM fuel cells in commercial application, including military and defense, automotive, aerospace, and other specialties

2. Investigate industrial and commercial technicalities of PEM fuel cells and study methods of improving the robustness of catalysts and reducing fuel impurities

3. Compare and contrast the performance and cost of fuel cell and internal combustion engines

4. Design and incorporate a PEM fuel cell system into commercial application and perform a cost and benefit analysis utilizing engineering design principles

Background

Sponsor

This project currently has no sponsor, but is designing a fuel cell intended for commercial use.

User Problems

The user problems faced by this project include those associated with the fuel cell itself and the fuel that is used. The fuel cell presents such challenges as analyzing the performance of electrodes, confronting the high cost of materials, determining the performance and durability of fuel cells, minimizing degradation while maintaining or enhancing performance, minimizing size, and minimizing operating temperature. The fuel creates problems such as lowering or eliminating emissions, producing the fuel, storing the fuel and lowering the costs associated with the fuel. The specific application of the fuel cell designed is also yet to be determined.

Technology and Science Involved

The technology and science involved in this project includes the fuel cell design, the type of fuel used by the fuel cell, the production of the fuel, the storage of the fuel, the engine or other mechanism that harvests the energy from the fuel cell, and the casing or storage of the fuel cell. These topics cover a broad range of science and technology, ranging from biology, chemistry, mechanical engineering, electrical engineering, aerospace engineering, chemical engineering, material science/engineering, manufacturing technology and physics.

PEM fuel cells are powered by hydrogen, which creates a whole host of issues. Hydrogen is extremely difficult to store due to its small molecular size, and one must use physics, chemistry and engineering principles to solve the problem of storage and transportation. The origin of hydrogen is another problem requiring a multidisciplinary array of sciences and technologies. Hydrogen can be obtained from such sources as water, glucose and other carbohydrates from biological waste, and methane and other low-octane number fuels. Each of these fuels requires different refining processes, storage, and methods of converting into hydrogen. Each fuel and method has its own advantages and disadvantages, associated with byproducts, quality, and cost. The application of the fuel cell also determines the need for a mechanical device to use the power that the fuel cell creates, be it a car engine or an airplane.

Historical Success or Failure

Fuel cells for use in vehicles have been around for a few years now. Even though they are very efficient and environmentally friendly, there are still problems that manufacturers face with fuel cells. Some problems that manufacturers have had with fuel cells are operating conditions, cost, safety, competition, and public acceptance.

Operating conditions for fuel cells have been a problem in the past because fuel cells involve water, which freezes at a temperature at which the atmosphere frequently reaches. Attempts have been made to incorporate a pre-heating system for the fuel and the water in the cell to keep it from freezing in places such as Canada and Alaska where it is frequently below the freezing temperature of water (32 degrees F).

Cost is one of the main problems manufacturers have faced. Since platinum is usually used as the catalyst, the cost of fuel cells is relatively high for consumers. Attempts at reducing the cost have been somewhat successful, because of the use of carbon enriched platinum instead of using pure platinum. Since platinum costs so much, the use of other metals would be ideal to reduce the total cost of the fuel cell. Research into cheaper catalysts like nickel-tin nanometal catalysts are still in progress.

Safety has been another concern for fuel cells, especially with hydrogen powered fuel cells. The hydrogen is stored in a high pressure container in the car. Since hydrogen is a highly explosive gas, this is very dangerous. Attempts have been made to build storage devices that are highly pressurized but resistant to damage. Although this seems to be dangerous, consumers must take into consideration the risk they are already taking with a container of gasoline in their car.

Competition with other markets is also a problem that fuel cells have faced. Since car companies have been significantly improving the efficiency of their gasoline powered vehicles, fuel cells seem less necessary to consumers. Consumers seem to have flocked more towards hybrid vehicles because it is not such new technology.

Hydrogen powered fuel cells caused a problem with the distribution of hydrogen around the country, because the country is lacking in hydrogen fueling stations. This problem is being solved with the use of hydrocarbon powered fuel cells, which uses hydrocarbons which get converted into hydrogen on board to power the fuel cells. This has proven to be a reasonable answer to the problem, but since it still relies on fossil fuels, it is not a completely environmentally friendly solution.

Public acceptance has grown over the period of time since fuel cells have been introduced. The public has concerns about safety and reliability of this fuel system, just as they did with electric and hybrid powered cars at first. This needs to be solved by familiarizing the consumer with the new product, just like they were slowly familiarized with hybrid and electric cars.

Ethical Issues

The main ethical issue involved in fuel cells is safety. Fuel cells involve the reaction of hydrogen gas, which is highly explosive, especially when under the high pressure that is needed for the fuel cell. High pressure storage tanks for hydrogen must be located in the car, just like gasoline tanks in the automobiles today. It is necessary to keep the hydrogen under high pressure for storage purposes, but this makes it more susceptible to explosion. A small spark or leak could ignite the hydrogen fuel tank and the results could

be fatal. This high risk in storage can be reduced by using hydrocarbons to fuel the fuel cell. Although hydrocarbons such as methane are still explosive, they are much less of a safety risk than the storage of highly pressurized hydrogen gas.
However, the use of hydrocarbon fueled fuel cells brings up the ethics behind environmental concerns. Car companies have been trying to move further away from the total use of hydrocarbons to fuel cars. By using hydrocarbons instead of pure hydrogen gas, there will be more environmental harm. Hydrocarbons in fuel cells still create harmfully emissions to the environment; while hydrogen powered fuel cells only emit water as a waste product. In the end, the use of hydrogen is more of a safety hazard for the passenger but better for the environment, and the use of hydrocarbons is less of a safety hazard but still harmful for the environment.

Business or Societal Costs

There are, as mentioned previously, a variety of ways to manufacture both fuel cells and the fuel that runs them; this variety makes it difficult to evaluate the exact cost of this technology. Additionally, the increase in demand for certain fuels would change the market and prices. However, it is possible to focus on the differences between existing and fuel cell technology at the current time to get a rough idea of the financial viability of this project.

An internal combustion engine (ICE), on average, delivers around 150 horsepower, which is equal to about 115 kW of power, for a price of a little over $3000. At the present time, fuel cell power costs around $200 per kilowatt; therefore to power the car as the ICE does, a fuel cell would need to cost over $20,000.

Additionally, the fuel cell vehicle requires a specific type of fuel, generally either hydrogen or methane (if a reformer is placed on board). Gasoline can also be reformed into hydrogen, but this is far less practical in terms of both efficiency and cost. Natural gas costs about $ 0.857 per gallon, but contains only around 90% methane; this is further decreased by the fact that reforming the methane yields only about 75% of that amount of hydrogen gas. This means that a gallon of natural gas results in less than 0.7 gallon of hydrogen. Added to this is the fact that hydrogen is much less energy-dense than hydrocarbon fuels—it takes more gallons to obtain the same energy. In the end, it comes out to about $8 per gasoline gallon equivalent of hydrogen. However, it is necessary to keep in mind that this is a cost for the energy contained in the fuel; a fuel cell vehicle will be roughly twice as efficient as an ICE vehicle, therefore the cost on a mileage basis will be more like what we know see as $4 per gallon, which, it should be noted, was reached and broken in the summer of 2008 in some parts of the United States.

Essentially, the cost of fuel is ceasing to be an issue in the development of fuel cell vehicles. It is the capital necessary to invest in the infrastructure to make this fuel available that is the greatest hurdle on the fuel side of the problem. The cost of the fuel cell mechanism itself is a hurdle on the other branch of the project.

Proposed Implementation

Once designed, the project idea will be pitched to experts who can determine a possible outlet. From there, sponsors with interests in the implementation of our fuel cell design will be sought out. After finding sponsors and receiving the appropriate funding, a factory will be constructed that will facilitate the production of fuel cells. Each individual fuel cell will then be installed in the application of choice.

Similar Solutions

Polymer-electrolyte membrane (PEM) fuel cells are not a new concept, they have existed and been successfully implemented since the 1960's, for example, in the NASA Gemini program. The problem now is making the fuel cells ever more affordable, compact, and efficient for more widespread use. New technology arises continuously, but this project focuses on using existing, established technologies to create the most practical fuel cell possible at this time.

The fuel cell, in contrast to the internal combustion engine, works on the principle of converting chemical energy into electrical energy, which can then be used to run a motor, generating mechanical energy. This is far more efficient than burning the fuel to produce thermal energy (heat), which is then converted to mechanical energy. However, this conversion (thermal to mechanical energy) is know to have limited efficiency, even in the ideal case.

Hydrogen gas flows into the fuel cell at the anode (negative electrode), where it separates into electrons and protons with the help of a catalyst. The protons then flow through the membrane, while the electrons are repelled and must flow out through the anode. On the other side, air or oxygen is supplied to the cathode. This oxygen reacts with the protons coming through the membrane and electrons off the cathode (positive electrode) to create water by the air stream. If the anode and cathode are connected to a load, such as a motor, an electric current will flow, powering the device.

While the total power generated depends on the area of the fuel cell, reasonable sizes of fuel cell will not generate enough power to run any significant device. In fact, most fuel cells typically generate about 0.7 volts per cell. Many fuel cells must be stacked in series to create enough power for a car.

The typical catalyst for the reaction in the fuel cell is platinum, which is extremely expensive. Platinum is already used in vehicles, but the amount of platinum needed for a fuel cell is many times greater. This has been the main hurdle for fuel cell technology. Although alternatives for platinum are being sought, none have yet been found, although some ways of reducing the amount of platinum necessary have been found somewhat effective.

Another hurdle is the storage of hydrogen, which can be resolved by producing hydrogen from hydrocarbon fuels, particularly natural gas (methane). There are several ways, including catalytic reforming and steam reforming. The reforming process requires a series of reactions that must take place at specific temperatures; most at temperatures higher than the operation temperature of the fuel cell. The reforming process also results in impurities that must be filtered out of the gas stream before entering the fuel cell, or they will render ineffective the platinum catalyst. Ironically, one of the ways of getting rid of the contaminant carbon monoxide is to use platinum as a catalyst to preferential oxidation, which essentially burns most of the carbon dioxide and a little hydrogen in the stream.

Other impurities also decrease the performance of the fuel cell. These include ammonia, excessive water vapor, sulfur and its compounds, and particulates. While research has made some leeway into eliminating the effects of these impurities, many of these means are still expensive and still do not provide optimal performance.

Critical Documents

Green Power, by Office of Transportation Technologies, US DOE
New Material Needs for Hydrocarbon Fuel Processing by Farrauto et. Al.
California Fuel Cell Partnership, http://www.cafcp.org/

Team Values Statement

Desired Behaviors

1. **Show up on time for meetings** – Being on time to scheduled meetings is respectful to the rest of the team.
2. **Respect each other's views and opinions -** Students should not be biased on the basis of other's major or race or anything that appears to be discriminatory. If someone is offended in a group, that affects his/her productivity and they will not express their opinion anymore.
3. **Avoid unnecessary competition -** This is unhealthy for the team and should be avoided.
4. **Avoid misconceptions -** It is desirable to have appropriate discussions to dispense with all issues that could be misconstrued by team members.
5. **Do not plagiarize -** Unauthorized use of existing technology or information is not encouraged and that is viewed as infringement of intellectual property.
6. **Acknowledge help or support -** Upon successful completion of the project, the group should acknowledge any help or support that was used during the course of the project.
7. **Avoid unauthorized disclosure of information** - this can occur due to conflict of interest. The members of the IPRO are to use the information about the various technologies developed in the IPRO for the purpose of the project itself.

Addressing Problems

Problems that arise should be brought to the attention of sub-group leaders. Depending on the nature of the problem, the two of them can work through the issue or discuss it as a sub-team as needed. Larger problems should be brought up to the overall team leaders by the sub-team leaders and either worked out among the leaders, talked over with the professor, or discussed as a whole team based on the type of problem.

Methodology/Brainstorm/Work Breakdown Structure

Define the Problem

In order for fuel cells to be used for applications in today's world, a fuel cell engine should be designed that is efficient and appropriately priced for the given market. This IPRO will survey the current PEM fuel cell and internal combustion engine technology and identify the strengths and weaknesses of each system. Based on this information, the team will create a design at a commercial scale that incorporates the research results and optimizes performance and economics of fuel cell technology

Method of Solving the Problem

Process

Preliminary research will lead to a decision on the path forward regarding the application of choice. The option that represents the most cost-effective and utilizable design system will be further investigated and implemented in detail using the full input of the team

Summary Tasks and Subtasks

Preliminary research is split into three subtasks: costing of fuel cell and internal combustion engines, impurities and side reactions that negatively impact the performance of a fuel cell and the possible solutions that may alleviate these issues, and the chemical, industrial, and environmental analysis of the fuel production process needed for the fuel cell feed stream.

A decision will be made upon the availability of preliminary research results. If a fuel cell engine is not appropriate for commercial applications, a market must be found with fewer budgetary constraints. Once a specific application is found, the team should be able to produce a fuel cell design that meets the specifications. The teams will be divided up into sub-groups consisting of costing, design, and project management to accomplish subtasks. These tasks for the design team include choosing a temperature and pressure range for the fuel cell engine, ensuring that materials used will be effective at that range, and determining the size and number of fuel cell stacks required to produce the necessary power. For each potential solution, the team should find the size of the engine, the power produced, and the efficiency of the process. These findings should be checked to see if they match the requirements of the application. When researching different designs, the power outputs, fuel requirements, efficiencies, and temperature and pressure ranges can be recorded in a table for convenient comparison. No physical tests will be performed, but theoretical values can be evaluated to determine the best course of action. Sub-team tasks will be combined at the final step to produce a conceptual design of a commercial fuel cell system and analysis of the financial aspects involved, as well accomplish IPRO office objectives and deliverables in a timely manner.

Time Management

A preliminary study will be performed and is expected to be concluded during the initial weeks of this IPRO. The sub-teams will work with available data and resources during the conceptual design stage. However, the final design system will vary depending on factors such as sensitivity and availability of information relating to military technology, cost-effectiveness, scale of potential application, and infrastructure associated. While a final design will be presented, the details will be based on the system studied, which cannot be determined at this time.

Testing Tasks and Subtasks

The design will be submitted to a panel of experts led by the IPRO advisor, Dr. Vijay Ramani, who is proficient in this field, and he will assess the feasibility and potential application of such a system.

Documentation of Research and Testing

Each sub-team member will be responsible for writing up the information they collect each week. This information will be combined into reports generated by the team at two points in the semester. These reports will fulfill the requirements of the IPRO office and will be included in the submission to Dr. Ramani.

Analysis of Test Results

A conceptual design will be summarized in a project report and submitted for evaluation.

Generation of IPRO Deliverable Reports

The reports will be generated using reports created by individual team members based on their weekly work. Compilation will be done by chemical engineering seniors. Other team members will be tasked to create the poster and presentations with the support of the entire team.

Expected Results

Expected Activities

1. Background research on:
   - internal combustion engines
   - PEM fuel cells
   - impurities present in these systems that affect performance

2. Literature survey in recent technology development in the area of:
   - research
   - costs involved with building and incorporating this design

3. Compile and analyze data collected

4. Design of a fuel cell system for commercial application in accordance with learned engineering principles

Expected Data

After a compiling ample research, the data will show that fuel cells are not on a competitive basis with existing internal combustion engine technology. Technical hurdles and challenges still exist and need to be overcome, however there are certain areas that fuel cells exhibit a competitive edge in, such as environmental friendliness, stealth, and efficiency.

Potential Products

A potential product will be the design of a fuel cell system that can be realized using existing technology and having commercial or military practical applications.

Expected Deliverables

1. Economic analysis
2. Fuel Cell System Design
3. List of Potential Applications
4. Final report
5. Final Presentation
6. Poster

Challenges, Risks, Assumptions

1. Emerging technology not well established
2. Infrastructure not in place

3. Arguable, speculative results
4. Lack of industrial scaled data

Expected Results Incorporation

This project will survey the state-of-the-art technology and pinpoint a direction toward which future efforts can be focused.

Project Budget

Budget			
Item	**Description**	**Cost**	**Basis for Cost Estimate**
Display Supplies	For displays at IPRO Day	$200	Office Depot and Fed Ex prices for poster board, office supplies, and printing
Food	For meetings and group gatherings	$500	Allowing approximately $20 per person for the semester, with about 25 people
Model Fuel Cell	To show appearance of a fuel cell	$200	Fuel Cell Car and Experiment Kit costs $150-$200

Schedule of Tasks and Milestone Events

Milestones	Start Date	Completion Date	Due Date	Hours / # Team Members
Set Team Objectives	1/20	1/27		2 / 25
Background Research	1/29	2/12		15 / 25
Project Plan	2/3	2/4	2/6	6 / 25
Feasibility Study	2/3	2/26		12 / 7
Mid-Term Review Presentation	2/26	3/2	3/2 - 3/12	10 / 4
Final Design	3/12	4/16		12 / 14
Final Economic Analysis	4/2	4/21		8/7
Exhibit and Poster	4/16	4/23	4/27	10 / 8
Final Presentation	4/16	4/23	4/29	10 / 4
Final Report	4/16	5/7	5/8	12 / 25

Set Team Objectives

Work with advisor to set down team objectives to be completed for this semester.

Background Research

Break up into three subgroups, cost analysis between fuel cells and existing internal combustion engine technology, evaluation of fuel sources, and examining the affect of impurities on catalyst robustness in fuel cell performance. A basic understanding of fuel cell technology is needed to expand the literature search.

Feasibility Study

Use compiled research to make an informed decision on fuel cell use in the automotive industry. Also look into further applications based on this research. Group members must be able to perform a detailed cost analysis.

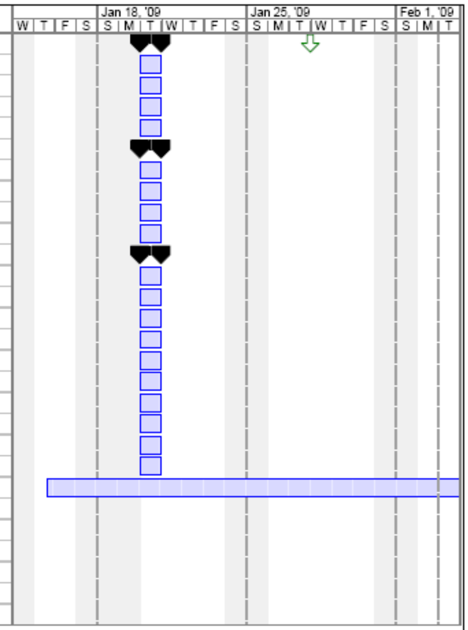
Final Design

Study the materials and methods of construction needed to implement the design. Based on this information and additional research on the application of choice, the design will be optimized to fit into the available footprint and work with the technology. Chemical and mechanical engineering knowledge will be required for much of this work, but other disciplines can contribute at the research stage and help compile and present the data.

Final Economic Analysis

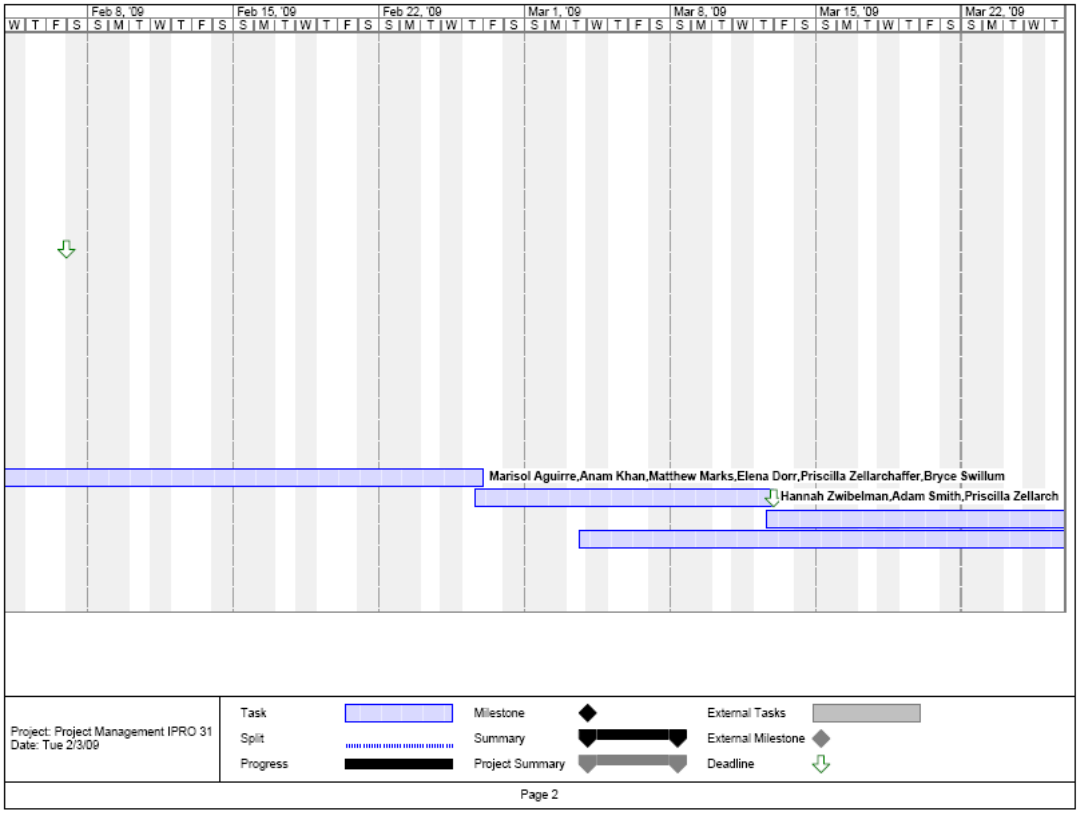
Collect costing data from accessible information and compile in accordance to the final design specification. Specialty material cost may be obtained from venders or estimated based on available data. Basic economic and accounting knowledge is required, and all majors are expected to contribute, with the non-chemical engineer majors taking a leading role.

ID		Task Name	Duration	Start	Finish	Predecessors
1		**Set team objectives**	**1 day?**	**Tue 1/20/09**	**Tue 1/20/09**	
2		Evaluate the feasibility of F	1 day?	Tue 1/20/09	Tue 1/20/09	
3		Develop different methods	1 day?	Tue 1/20/09	Tue 1/20/09	
4		Compare and contrast	1 day?	Tue 1/20/09	Tue 1/20/09	
5		create a design at a comm	1 day?	Tue 1/20/09	Tue 1/20/09	
6		**Background Research**	**1 day?**	**Tue 1/20/09**	**Tue 1/20/09**	
7		internal combustion engine	1 day?	Tue 1/20/09	Tue 1/20/09	
8		PEM fuel cells	1 day?	Tue 1/20/09	Tue 1/20/09	
9		impurities present	1 day?	Tue 1/20/09	Tue 1/20/09	
10		costs involved in new and	1 day?	Tue 1/20/09	Tue 1/20/09	
11		**Project Plan**	**1 day?**	**Tue 1/20/09**	**Tue 1/20/09**	
12		Team Information	1 day?	Tue 1/20/09	Tue 1/20/09	
13		Team Purpose and Objecti	1 day?	Tue 1/20/09	Tue 1/20/09	
14		Background	1 day?	Tue 1/20/09	Tue 1/20/09	
15		Team Values Statement	1 day?	Tue 1/20/09	Tue 1/20/09	
16		Work Breakdown Structure	1 day?	Tue 1/20/09	Tue 1/20/09	
17		Expected Results	1 day?	Tue 1/20/09	Tue 1/20/09	
18		Project Budget	1 day?	Tue 1/20/09	Tue 1/20/09	
19		Schedule of Tasks and Mil	1 day?	Tue 1/20/09	Tue 1/20/09	
20		Individual Team Member A	1 day?	Tue 1/20/09	Tue 1/20/09	
21		Designation of Roles	1 day?	Tue 1/20/09	Tue 1/20/09	
22		Feasibility Study	18 days?	Thu 1/15/09	Thu 2/26/09	
23		Mid-Term Review Presentation	4 days?	Thu 2/26/09	Thu 3/12/09	
24		Final Design	17 days?	Thu 3/12/09	Thu 5/14/09	
25		Final Economic Analysis	15 days?	Tue 3/3/09	Fri 4/24/09	
26		Exhibit and Poster	6 days?	Tue 3/31/09	Thu 4/23/09	
27		Final Presentation	6 days?	Thu 4/16/09	Thu 5/7/09	
28		Final Report	10 days?	Tue 3/31/09	Thu 5/7/09	

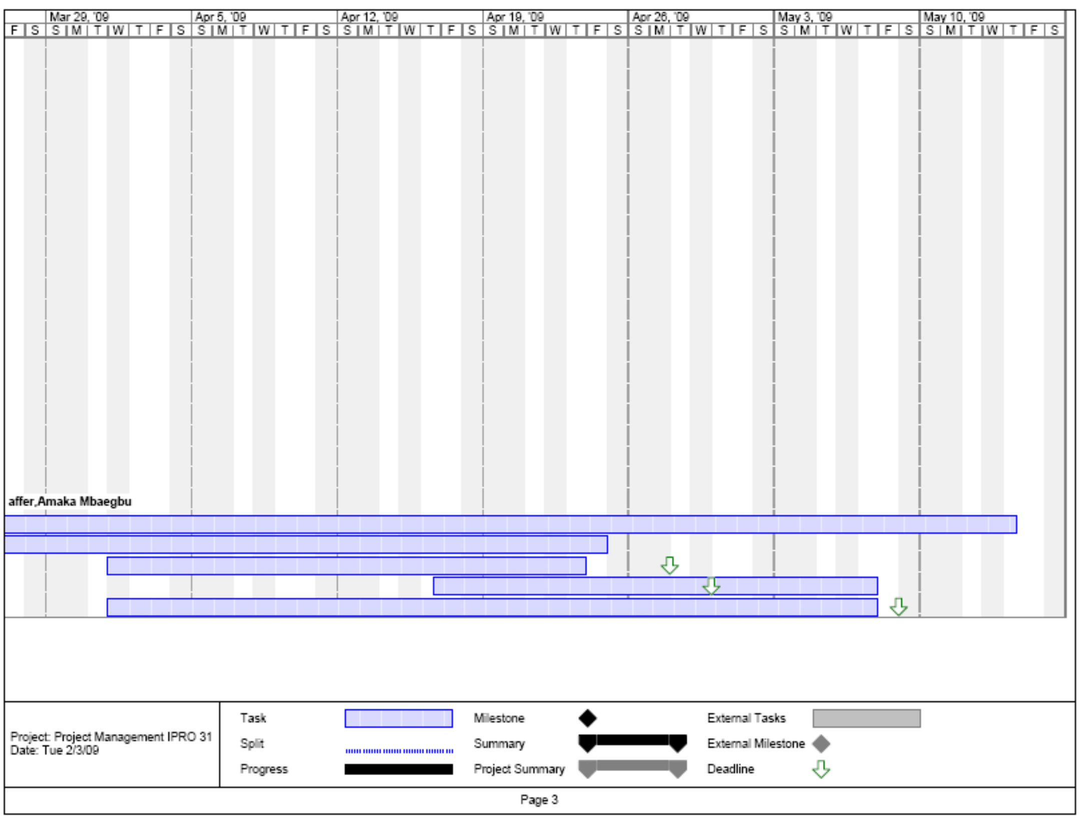


Project: Project Management IPRO 31
Date: Tue 2/3/09

Page 1



Feb 8, '09
Feb 15, '09
Feb 22, '09
Mar 1, '09
Mar 8, '09
Mar 15, '09
Mar 22, '09
Marisol Aguirre,Anam Khan,Matthew Marks,Elena Dorr,Priscilla Zellarchaffer,Bryce Swillum
Hannah Zwibelman,Adam Smith,Priscilla Zellarch
Project: Project Management IPRO 31
Date: Tue 2/3/09
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 2



Mar 29, '09
Apr 5, '09
Apr 12, '09
Apr 19, '09
Apr 26, '09
May 3, '09
May 10, '09
affer,Amaka Mbaegbu
Project: Project Management IPRO 31
Date: Tue 2/3/09
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 3

Individual Team Member Assignments

Sub-Groups

Cost Analysis

Researching the economic feasibility of commercial fuel cell

Name	**Role**	**Concentration**
Joshua Willett	Cost Analysis Team Leader	Cost of fuel cell.
Priscilla Zellarchaffer		Researching cost of gasoline as fuel source.
Samira Matezic		Researching the production cost of hydrogen from CH_4.
Matthew Marks		Cost of combustion engine.
Marisol Aguirre		Researching cost of JP-5 as fuel source.
Bethany Nicholson		Researching cost of JP-8 as fuel source.
William Mocny		Researching the production cost of hydrogen from CH_4.

Fuel Analysis Team Research different method of obtaining and storing Hydrogen.		
Name	**Role**	**Concentration**
Anam Moin Khan	Fuel Analysis Team Leader	Water Gas Shift reaction.(GWS)
Adam Smith		Researching storage and transportation of Hydrogen.
Galina Shpuntova		Preferential Oxidation
Elizabeth Corson		Catalytic Reforming
Kathleen Baker		Steam Methane Reforming (SMR)
Hussein Massoud		Desalination and Electrolysis for Hydrogen production

Impurities Team Research different method to prevent catalyst poisoning and membrane failure		
Name	**Role**	**Concentration**
Ellen Kloppenborg	Impurities Team Leader	Research membrane failure
Yin Zhao		Research anode
Hannah Zwibelman		Research fossil fuels
Elena Dorr		Polymer electrolyte
Steven Booher		Research fossil fuels
Emily Kunkel		Research catalyst
Bryce Swillum		Research cathode
Kolade Adebowale		Research catalyst
Ryan Kyle		Polymer Electrolyte

Designation of Roles

Meeting Roles

Minute Taker - Galina Shpuntova

Agenda Makers - Prof. Vijay Ramani, Adam Smith, Hannah Zwibelman

Status Roles

Weekly Timesheet Collector/Summarizer - Anam Moin Khan

Master Schedule Maker - Hannah Zwibelman