Fuel Cells for Stationary Power Generation

BUSINESS PLAN

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1.1 Objectives

The OUFCC will fill the need for a source of electricity that is:

Clean and produces few toxic emissions, depending on the type of fuel used. If pure hydrogen is used as the fuel, the only products of a fuel cell are electricity, water and heat.

Reliable and not susceptible to black-outs or power surges. This is an excellent selling point for areas where the supply of electricity does not meet the demand, such as New York or California.

Independent of a power grid for use in rural areas or in emergency situations.

Optionally dependent on fossil fuel which helps cut dependence on foreign oil, and promotes the use of renewable energy resources.

1.2 Mission

The OUFCC will strive to provide a quality product at a competitive cost. Our company will promote a positive and safe working environment for all employees. The OUFCC will be an equal-opportunity employer.

1.3 Keys to Success

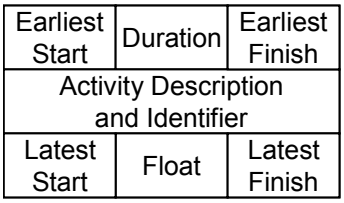
The keys to success will serve to promote the mission statement of The OUFCC. The following are The OUFCC's keys to success:

- ongoing market analysis
- continuing optimization of the manufacturing process
- biennial HAZOP studies
- competitive salaries and employees benefits
- hiring of the most qualified employees regardless of age, gender, race, or ethnicity

1.4 Business Timeline

The chart shown outlines the approximate amount of time allotted for each task, as well as the order in which the tasks will be completed.

The following is the key for the business timeline:



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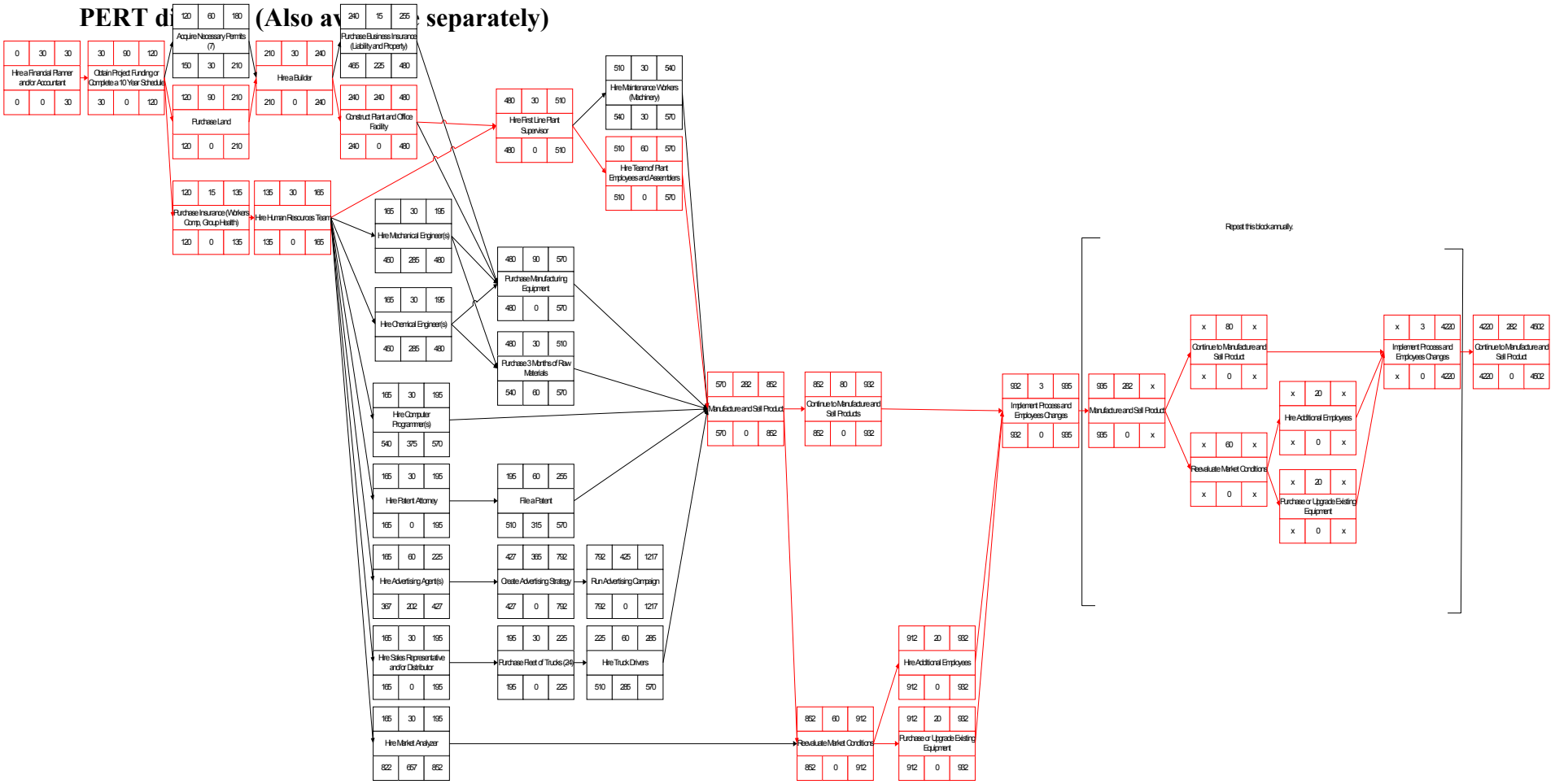


2. Company Summary

2.1 Company Ownership

The University of Oklahoma Fuel Cell Corporation (The OUFCC) will be legally structured as a corporation. For the first year, control will be exercised solely by the seven founders of the corporation. Following the first year, 51% of the control will depend upon stock ownership. During this time, control will be exercised through regular board meetings, the board consisting of the seven founders and the chief executive officer, and an annual stockholders' meeting. Dr. Miguel Bagajewicz will be the chief executive officer.

2.2 Start-up Summary

The start-up expense is about $41.2 million, which allows for initial legal expenses, licenses, utility patents, and permits. This amount will come from the company's loan. In addition to these start-up costs, approximately 20% will be to the company account for emergency purposes; this money will come from an investor. All additional money needed will either be received from investors before the onset of the project (see business timeline), or will be promised by investors, and a schedule of payments will be made.

The fixed capital investment (FCI) is the capital needed to provide the necessary manufacturing and plant facilities. This investment represents the capital required to purchase and install process equipment including piping and insulation within each fuel cell manufacturing process. It also covers overhead costs such as land, transportation, and administration needed. Cost indices were used to calculate the FCI based on our estimated cost of machinery.[1] We estimated that it would cost about **$3,988,100** to purchase equipment for the three different production lines of the maximum capacity of 1000 fuel cells for each type. These production lines are for the solid oxide fuel cells, phosphoric acid fuel cells and the proton exchange membrane fuel cells. The working capital (WC), which is the capital needed for the operation of the plant, was **$ 5,368,430**.

The total capital investment (TCI), which is the sum of the fixed capital investment and the working capital, was also calculated. Based on the fixed capital investment, we estimated that The OUFCC will have a total capital investment of approximately **$41,157,930.**

The net present worth of the project is approximately $83.2 million and the rate of return is 23%.

[1] Peters, M.S. & Timmerhaus K.D., *Plant Design and Economics for Chemical Engineers,* McGraw-Hill, New York (2002), p165

2.3 Company Location and Facilities

The company will be located in Wyoming in order to reduce the cost of transporting raw materials and in order to best target our predicted market. Besides these two factors, there are several others that decide the company location. The office space is estimated to be 10,000 square feet. A dedicated telephone and fax line as well as a high-speed internet connection will be installed. An interactive website will also be developed which will serve as a marketing tool. The domain name of "www.**oufcc.com**" has already been reserved.

3. Services

The OUFCC will offer innovative and economical design services so that the fuel cell can be installed in the optimal location within the business since the fuel cells that we produce will be used in buildings such as:

- Banks
- Post Offices
- Police Stations
- Hospitals

We will meet our client's needs on all sizes for those building applications in the future. The OUFCC will now focus on producing 200-250kW fuel cells. However, our equipments are capable of producing 100kW fuel cells, which may be considered as our future products in order to reduce cost.

3.1 Service Description

Project Consulting: Project Consulting is proposed and billed on a per-project and per-milestone basis. It offers a client company a way to harness our specific qualities and use our expertise to develop and/or implement plans, from conceptual planning to turnover. Proposal costs will be associated with each project. The business may be offered special low-interest loans and grants by the government for the purchase.

Forensic Investigation: A group of engineers will be responsible for troubleshooting buildings where damage of catalyst, electrolyte, and electrode and/or failure due to unexpected technical error during manufacturing process may occur. Our reports will outline the description of the problem, the nature of the mechanism which has caused damage and/or failure, and a list of options for remedial action including estimated budget costs for implementation

3.2 Technology Competitive Comparison

Our company will provide the customers with the benefits that some other competitive technologies do not have[2].

Higher Efficiency: Fuel cells operate at approximately 60% efficiency, and may operate at up to 85% efficiency with the implementation of cogeneration. Mainstream power generation methods, for example combustion turbines, operate at only 20-45% efficiency.

Quiet Operation: This is especially beneficial to businesses such as banks that require communication with the customer. Utilizing a back-up fuel cell rather than a generator would provide quiet operation that would not disrupt business in the building. In the event that a generator is used for back-up power generation, this could be noisy depending on the vicinity of generators and possibly cause the business to lose customers.

Cogeneration: Cogeneration will produce both electricity and thermal energy. This thermal energy may be used for any purpose from heating the building to providing hot water.

Fewer maintenance costs: Fuel cells have no moving parts, and therefore rarely require maintenance. The only scheduled maintenance is the replacement of the catalyst, which usually occurs 6 to 10 years after implementation of the fuel cell. Usually at this time, the fuel cell unit is replaced by the consumer.

3.3 Technology

Fuel cells are electrochemical devices that convert a fuel's chemical energy directly to electricity. A typical fuel cell consists of three main parts: an anode, a cathode, and an electrolyte. Both the anode and cathode are two electrodes at opposite sides of the fuel cell. The anode is negatively charged and the cathode is positively charged. The electrolyte is in the center of the fuel cell, or in-between the anode and cathode. The electrolyte is generally a substance that can be liquid, solid or a porous membrane. These main parts of a fuel cell may be seen in Figure ii below:

[2] Website Source: http://www.energy.ca.gov/distgen/equipment/equipment.html

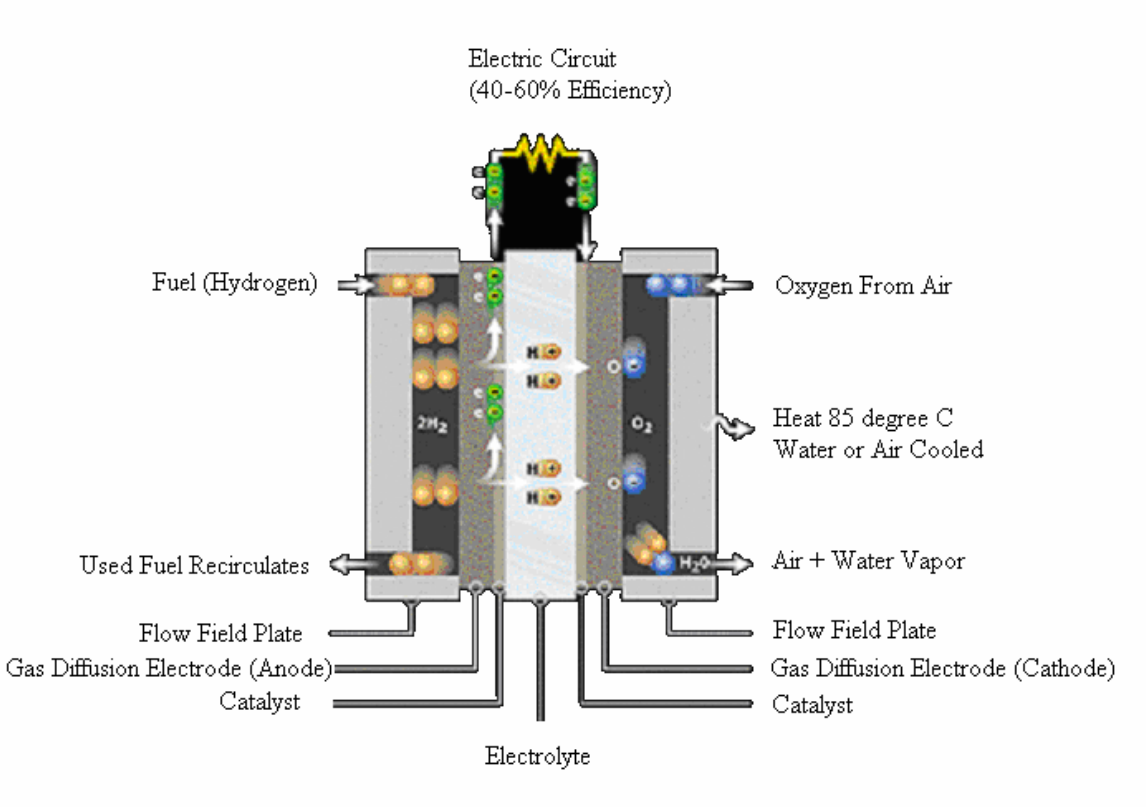


Figure ii. Structure and Operation of a Fuel Cell[3]

Fuel cells are called electrochemical devices because there are two chemical reactions taking place at the electrodes. They use hydrogen as the fuel and oxygen as the oxidizing agent. Hydrogen can be reformed from natural gas, methanol or other fuel sources in a reformer before it enters the fuel cell. Hydrogen flows to the anode side of the fuel cell while oxygen flows to the cathode side, where electrochemical reactions take place. These two reactions require catalyst to occur. The catalyst is coated at the interface of each electrode with the electrolyte.

The type of catalyst used depends on the operating temperature of the fuel cell. At the anode, the catalyst helps to split the hydrogen molecule into hydrogen ions (positive protons) and negative electrons. If the electrolyte is a porous membrane or a liquid solution, it allows only the positive protons to pass through it to the cathode side. The anode repels electrons and electrons cannot pass through the electrolyte; as a result, electrons follow an external circuit to the cathode and create an electric current. At the same time, at the cathode side, the catalyst breaks down the oxygen molecules and facilitates the electrochemical reaction between hydrogen ions, electrons, and oxygen that produces heat and water. In the case where the electrolyte is a solid, the ion exchange occurs due to the ionic conduction of oxide ions.

[3] Website Source: http://www.rmi.org/sitepages/pid537.php

3.4 Future Services

In the future, we will also offer the following services to satisfy our customers' demands.

Quality Control and Assurance: Serving the needs of our customers, we will ensure that our employees are qualified to perform specific tasks. For this purpose, we will work toward the plan of opening an employee training program. On-site inspections are required four times per year.

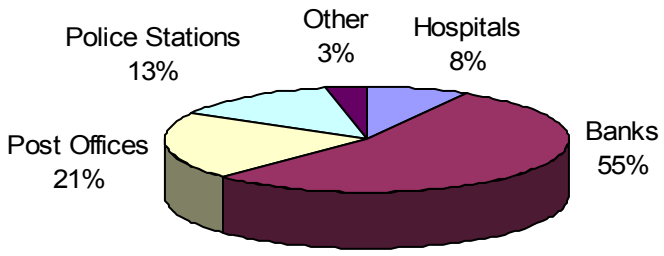
Fabrication and Detailing Drawings: Serving the special needs of customers on specific sizes and types of fuel cell, The OUFCC will be working toward offering more advising services in the future.

Toll-Free Communications: We will provide our clients a toll-free number for technical support 24 hours a day.

4. Market Analysis Summary

4.1 Market Segmentation

The market consists of small commercial businesses and government-funded institutions that would benefit from a constant supplementary power source or a source of back-up emergency power. The major client within the territorial governments is the Department of Energy. The business participants are small commercial buildings such as banks, post offices, police stations, and hospitals, as shown in Figure iii below:



Total Number of Businesses: 150,116

Figure iii. Market Analysis by Business Application

4.2 Competition and Buying Patents

Pricing of projects and billing rates are variable. In consulting at this level, it is easier to be priced too low than too high. However, there may be clients and potential clients who expect to pay substantial fees for the best quality professional advice, the total price including advising can not be too low and it will includes 2% - 5% more of the fuel cell price.

The most important element of general competition, by far, is what it takes to keep clients for repeat business. It is worth making huge concessions in any single project to maintain a client relationship that brings the client back for future businesses.

4.3 Main Technology Competitors

So far, the following technologies have been considered as competitors of fuel cell technology.

Microturbines: Microturbines have an advantage of small size, low emission levels, and low maintenance[4]. However, they have low thermal efficiencies of 15-30% while those of fuel cells are at least 35%. In addition, microturbines have a limit on the number of times they can be turned on and shut down. This requires that the systems run continuously, which could waste energy if they are used for individual areas or as autonomous units, especially when residents do not need all the energy. They are noisy and can cause large amounts of noise pollution for nearby residents[5].

Combustion Turbines[6]: Combustion turbines have the advantage of being a mature technology and inexpensive; and therefore, are strong competitors of fuel cells. However, they have low thermal efficiency of 20 – 45%.

Reciprocating Engines[7]: Reciprocating engines are also strong competitors of fuel cells because they are becoming the most common and the most technically mature of all distributed energy resource and available from small to large size. However, they have low thermal efficiency of 25 – 45% and require emission control for NOx and CO.

Stirling Engines[8]: Stirling engines are not currently commercially available. Their strengths are low noise, low emissions, and low maintenance. However, they have a very low efficiency of 12 – 20% and are expensive.

Photovoltaic Systems[9]: Although photovoltaic systems are commercially available and environmental friendly, they have a very low thermal efficiency of 15 – 25% and are very expensive.

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[4] Website Source: http://www.visionengineer.com/mech/microturbines.shtml
[5] Website Source http://www.its.caltech.edu/~sciwrite/journal03/A-L2/Arcia.html
[6] Website Source: http://www.energy.ca.gov/distgen/equipment/combustion_turbines/combustion_turbines
[7] See Ref. 5
[8] See Ref. 5

Wind Systems[10]: Wind systems are currently commercially available. They have no emissions and require simple installation. However, they become a strong competitor to fuel cells only in specific high-wind areas and they cause a high bird mortality rate.

4.4 Market Forecasting

In the first few years of operation, as a new technology, the cost of fuel cells is expected to be high. However, it will be reduced in the last few years of project life time. In the future when the fuel cell technology will become more popular and widely accepted the production of fuel cells will be increased. In addition, due to the possible market incentives, the cost of fuel cells is expected to be reduced. Based on these two expectations, we forecast the cost of fuel cells in the next ten years as following:

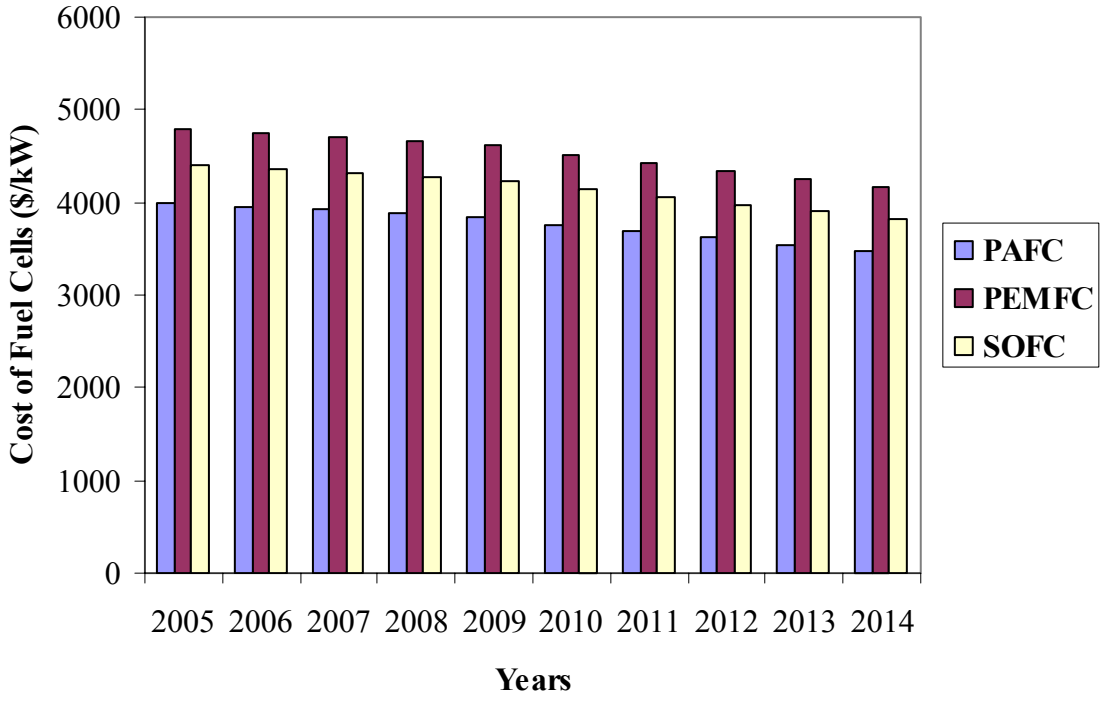

Figure iv: Projected Cost/kW of Installed Capacity[11]

[9] See Ref. 5
[10] See Ref. 5
[11] Vanston, John, Elliot, Henry. "Fuel Cell – A Technology Forecast." Technology Future Inc.

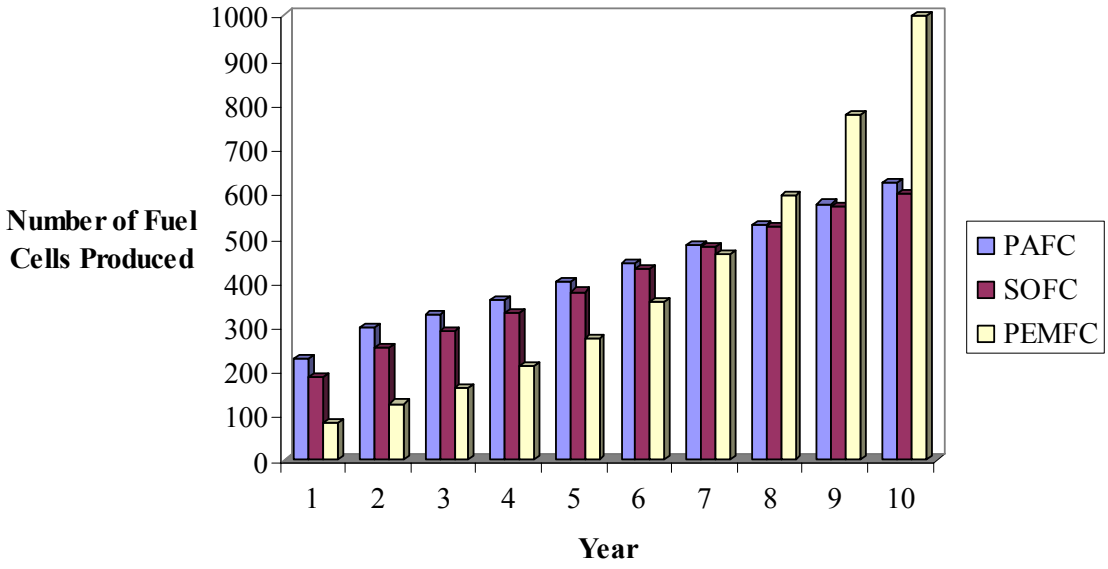

Figure v. Number of Fuel Cells Increases by Demand in Ten Years.

The number of PEMFCs produced will be increased every year while that of PAFCs and SOFCs will be decreased due to the development of technology. However, there will be other effects on production rate of fuel cells, such as the prices of oil and platinum. The price of platinum can be expected to have little change but the prices of oil and gas are forecasted to be increased every year[12]. There will be a better market when oil and gas prices go up, then we can have a higher demand because our fuel cells can run off of other sources.

5. Strategy and Implementation Summary

5.1 Marketing Strategy

The OUFCC will compete with other fuel cell companies by providing a quality product at a competitive cost. Three types of fuel cells will be manufactured so that the consumer is given a wide variety of choices from one vendor. The OUFCC will also implement an aggressive advertising strategy, as well as offer the most competitive warranty, trial-period, and consultation benefits possible. The competitive warranty and consultation services are outlined below:

On-site consultation to determine what, if any, additions and/or changed should be made to the existing electrical infrastructure in order to incorporate a fuel cell system.

Delivery of the fuel cell system to the purchaser.

[12] http://www.energyshop.com/energyshop/pricearticles.cfm

Trial-period of one year beginning upon the date of installation when the fuel cell may be returned to the manufacturer, minus shipping costs, in the event of dissatisfaction of performance.

Warranty period of two years beginning upon the date of installation during which The OUFCC will perform on-site consultations and/or repairs in the event that the fuel cell is not performing as promised.

5.2 Sales Strategy

The OUFCC will hire a sales representative that will focus on negotiating prices for raw materials as well as oversee the delivery process. In addition, a market analyst will be employed to constantly reassess the fuel cell demand and current competition.

An advertising team will be employed to develop a detailed advertising strategy. The goal of the advertising strategy is to increase the annual profit (either by increasing the selling price or by selling more products) by an amount significantly larger than the advertising investment. The following are advertising methods that will be employed, and will be considered in detail by the advertising team:

- Advertisements in scientific journals
- Government endorsements
- Participation (demonstrations) in various conferences
- Hiring a team of salesmen to personally visit potential consumers
- Television Advertisements

$2,000,000 will be allocated for the advertising plan. It is predicted that by utilizing the advertising strategy explained, profit will increase by 10% each year.

6. Management Summary

The OUFCC will consist of highly qualified team of employees who are experts in their respective area of the company. Dr. Miguel Bagajewicz will be a Chief Executive Officer.

6.1 Management Team

Chief Executive Officer

Dr. Miguel Bagajewicz B.S. Chemical Engineering, Universidad Nacional del Litoral, Argentina
M.S. Chemical Engineering, California Institute of Technology
Ph.D.Chemical Engineering, California Institute of Technology

General Operations Manager

Caroline Ihejiawu B. S. Chemical Engineering, University of Oklahoma
M. S. Operations Management, University of Texas

Sales Manager

Jennifer Treece B. S. Chemical Engineering, University of Oklahoma
M. B. A. University of Arkansas

Marketing Manager

Kristen Martinez B. S. Chemical Engineering, University of Oklahoma
M. B. A. University of Oklahoma

Computer and Information Systems Manager

Justice Diven B. S. Chemical Engineering, University of Oklahoma
M. S. Management Information Systems, University of Kansas

Financial Manager

Eric Daugherty B. S. Chemical Engineering, University of Oklahoma
M. S. Finance, University of Arizona

Transportation, Storage and Distribution Manager

Lola Soyebo B. S. Chemical Engineering, University of Oklahoma
M. B. A. University of Ohio

Engineering Manager

Thu Nguyen B. S. Chemical Engineering, University of Oklahoma
M. S. Engineering Management, University of Missouri

6.2 Personnel Plan

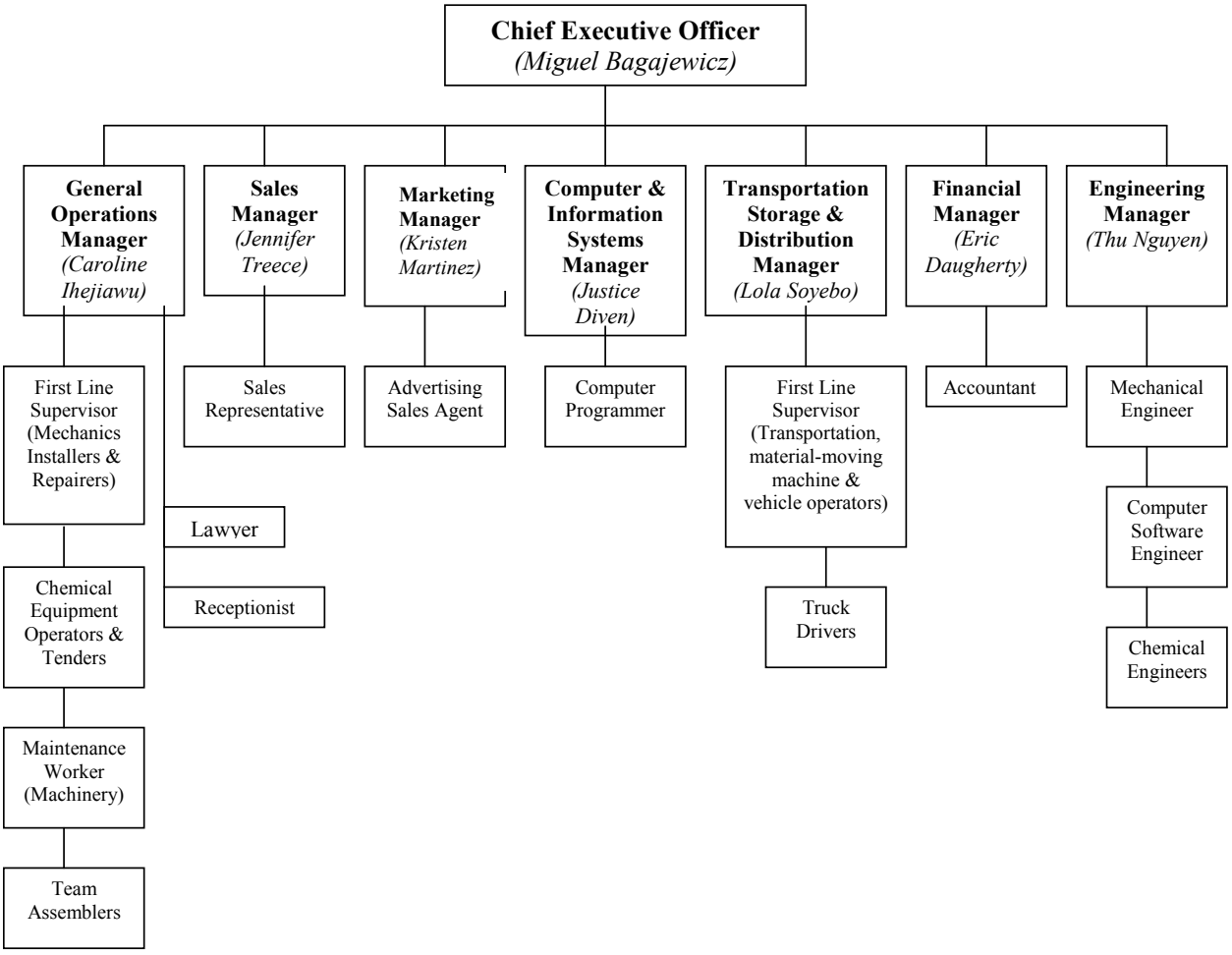

Figure vi: Organizational Chart

7. Financial Plan

We will look for investors and government grants as much as we can. The rest of the money that we can not ask for from them will be from our loan. Our financial plan will go into for basic stages:

Seed Financing: This will be the initial investment we use to start the company and for registration. Also, in this stage, the money will also be spent to begin the development of a sample website. These funds will come from our own loan, and the amount is $20,000,000.

First Stage Financing: Once our business idea is fully formed, we will look for the funds to get the site ready for launch and support the first few months of commercialization. The amount will be $10 million and it will come from our investors.

Second Stage Financing: Once the site is up and running, we will look for the funds for advertising, marketing support, building the customer base, and ensuring that there will be enough money for the production growth. The amount will be $5 million and will be obtained from government grant.

Third Stage Financing: At this stage, we will look for the funds to bring the company to an initial public offering (IPO). These funds will be paid off with the processes from the offering. An amount of $2 million will be obtained from our loans.

With this financial plan, the cash flow is predicted as shown in Figure vii with the net present worth of **$83,154,900** and return of investment of 23%.

The cash flow is projected for the first 5 years can be viewed in Figure vii below:

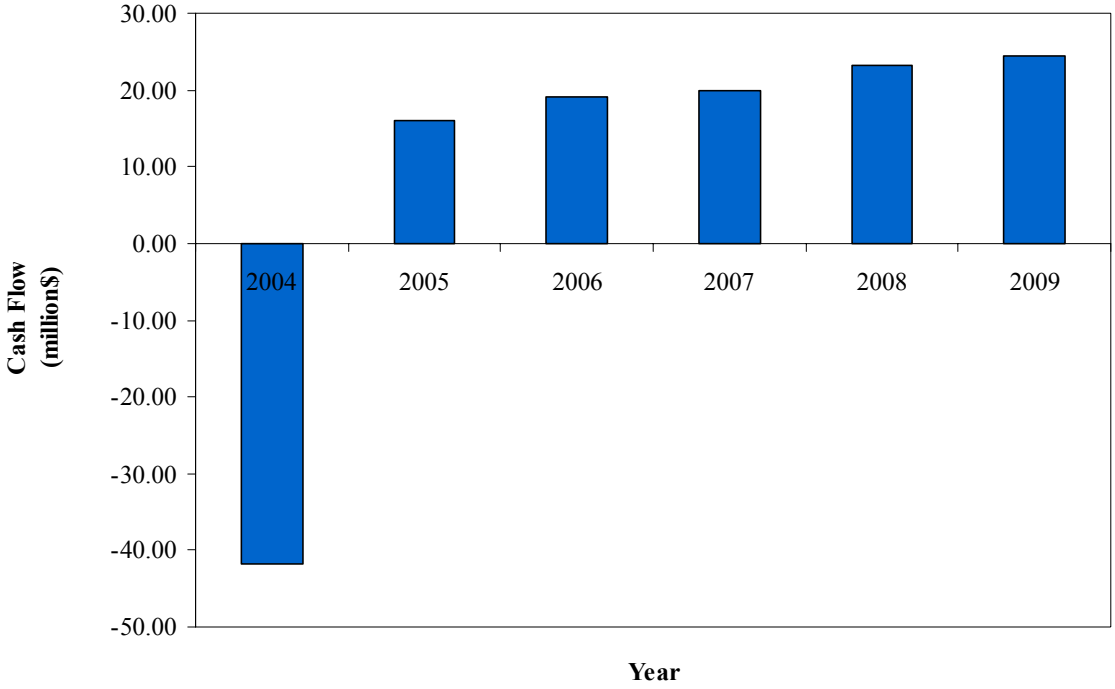

Figure vii: Projected Cash Flow for the First 5 years of Operation