Analysis of Glycerin Uses for the Empower Energy Cooperative:

An outlet for growth

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Abstract

Founded by Ex-Prisoners and Prisoners Organizing for Community Advancement (EPOCA), the Empower Energy Cooperative, a small business, sought a profitable use for glycerin, a by-product of their existing biodiesel production business. With a new source of profit, the Worcester-based cooperative aims to continue to employ ex-prisoners, a goal based on the idea that stable employment aids in lowering the recidivism rates of ex-prisoners. There are many possible applications of glycerin. In order to find the one most suitable to Empower, cost/benefit and market analyses were performed, followed by prototyping of the two highest scoring products. Fire bricks and soap (bar and liquid) were the two recommended products for Empower's future use.

Executive Summary

The Empower Energy Cooperative is an organization focused on giving back to the community through sustainability and job growth. Empower was founded four years ago by EPOCA. EPOCA stands for Ex-Prisoners and Prisoners Organizing for Community Advancement and was founded in Worcester, MA. EPOCA works to lessen the injustices faced by many ex-prisoners, such as Criminal Offender Record Information (CORI) forms. Empower is also Worcester-based and is striving to produce environmentally friendly products and to employ ex-prisoners. Since Empower was created through members of EPCOA, the company does not deny employment to individuals with criminal backgrounds.

The Empower Energy Cooperative promotes sustainability by providing 25 area restaurants with a waste vegetable oil pick-up service. Empower converts the waste vegetable oil into biodiesel and sells it for profit. However, during the conversion process, a glycerin by-product is created. Glycerin is a chemical compound that has a vast number of practical applications.

In order to aid Empower in continuing its mission of sustainability and job growth, our goal was to recommend two products to the Empower Energy Cooperative that they could use in-house or sell for profit. The top two products were soap (bar and liquid) and firebricks. Both of these products have in-house values and could help Empower increase profit margins by reducing expenses. Although these products help to reduce costs, Empower wishes to increase their profits and expand. In order for these products to be marketable and create profits, many improvements must be made. Currently, Empower would be incapable of successfully marketing these products.

To meet the goals of the project we performed a cost/benefit analysis and a survey. Our cost/benefit analysis was used as a comparison tool to evaluate four products: soap, fire bricks, purified glycerin, and antifreeze. In the cost/benefit analysis, we compared the products based on Efficiency, Personnel, Environmental and Monetary categories. These comparisons allowed us to make a justified recommendation to Empower. All of the values and ratings were based on in-house, small scale uses of the products. We rated these categories on a scale of 1 to 5, with 5 being the most favorable. After all four products were analyzed, soap and fire bricks were rated the highest. They had low environmental safety concerns and were cost effective, two important aspects to our sponsor. This was further confirmed when Empower stated that both soap and fire bricks would be very useful in their daily operations.

For the market analysis, the top two products were examined and it was determined what steps would be needed to bring them to market. We discovered that Empower lacks the resources to bring these products to a commercial market. Currently they are not capable of the necessary scale, equipment or funds. Because of these reasons we were only able to recommend in-house uses to Empower.

In the analysis of the survey given to members of EPOCA we concluded that the establishment and growth of companies like Empower is beneficial to the ex-prisoner community. After release from prison, the difficulty of finding employment is increased by CORI checks. Businesses like Empower help ex-prisoners find employment and make smooth transitions back to society. By employing people based on work ethic and not past criminal records, Empower creates a sense of community that discourages recidivism. It was the goal of this project to help Empower continue their mission through the recommendation of new

products. It is our hope that through the implementation on these recommendations that Empower will continue to grow.

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Introduction

The Empower Energy Cooperative was founded in 2007 in Worcester, Massachusetts, with an ambitious goal in mind: to lessen the social injustice many ex-prisoners face once their prison sentences have ended. Presently, the United States is the home of the highest incarceration rate in the world, with about one in every one hundred adults in prison or under probation (Glaze, 2009). After being released from prison, a large percent of these incarcerated individuals deal with the stigma that an ex-prisoner could never be a capable employee. With stiff government regulations such as CORIs (Criminal Offender Record Information), it is becoming increasingly difficult for ex-prisoners to find successful and gainful employment upon their release (Gilbert, 1997). In light of these circumstances, the founders of Empower Energy Cooperative created a business to provide ex-prisoners with sustainable jobs and a feeling of community, with the goal of preventing recidivism (Personal Communication, Sarah Asseffa, 2011).

One of the primary founders of Empower, Luis Bajana, was well aware of the difficulties that lay before him once he returned to his free life after incarceration. With a family to provide for, Luis knew that recidivism was not an option and began working with EPOCA, which stands for Ex-Prisoners and Prisoners Organizing for Community Advancement. EPOCA became a social "crutch" for Luis and led him in the direction of founding Empower (Personal Communication, Luis Bajana, 2011). Much has changed since the founding of Empower and the company is now able to employ and to help more ex-prisoners than ever before.

The three co-owners of Empower, Luis Bajana, Sarah Asseffa, and Scott Guzman realize that if they can enhance their profit margins, then their goal of helping as many ex-prisoners as possible will become more attainable. Therefore, our IQP group was asked to find a way to

transform one of the company's waste products, glycerin, into another profit stream or product for Empower to use in-house. There are many practical applications of glycerin. During this project the top two most feasible and profitable uses were found using a Cost/Benefit Analysis Table constructed by the IQP team based of a template distributed in the ID 2050 class in the previous term. With these recommendations, Empower will be provided with the opportunity to generate more income, or save money with in-house uses. It is the goal of this project that Empower will be allowed to continue their goal of helping disadvantaged ex-prisoners through implementation of the team's recommendations.

When Empower produces biodiesel from waste vegetable oil, waste glycerin is produced. Our first goal was to learn how to purify this crude glycerin byproduct. The crude glycerin is not fit for use in a commercial setting or to be sold to potential consumers. Once we determined a way to purify the crude glycerin, we worked to recommend two glycerin-based products to the Empower energy cooperative. These products could be sold to potential consumers to increase profit or be used within the company to reduce expenses. For each product we investigated, a cost/benefit analysis and a market analysis, which will examine potential markets, was completed. This analysis ranked the recommendations based on four categories including Efficiency, Personnel, Environmental and Monetary.

During the course of this project, two major questions pertaining to the practical and social aspects of the Empower Energy project were addressed:

1. What are the best uses of purified glycerin for the Empower Energy Cooperation?
2. Can this new glycerin product help Empower to continue employing ex-prisoners and help them reintegrate back into society?

In the following chapters we will discuss the background, methodology and results pertaining to the above research questions. A study on the project's social dimensions will begin the background chapter. The background will also include a history on EPOCA, the founding of Empower and a literature review on the known properties and purification methods of glycerin. Six unique uses of glycerin are also explained. The methodology chapter details how the various glycerin uses were compared in a cost/benefit and market analysis, how surveys were distributed and analyzed, and how prototypes were constructed. The results chapter details the findings we came across as we progressed through the project. The final chapter, the conclusions and recommendations, will summarize the social aspects of the project and state the IQP team's final recommendations to Empower.

2. Background

This chapter includes a justification for the project, the history and goals of the sponsor and the scope of the project. Background research on the topic includes a literature review of the challenges faced by ex-prisoners and the properties, purification and possible uses of glycerin.

2.1 Ex-Prisoners

For many of us, when a work application inquires whether or not we have a past criminal record, we are able to answer the question with a quick and thoughtless "No." However, each year an increasing number of individuals are incarcerated in United States' prisons. With this increase of incarceration comes an increase of ex-prisoners being released back into their communities. For these newly released ex-offenders, a barrier is created due to their past criminal records. Since employers have free and easy access to CORI (Criminal Offender Record Information) forms these ex-prisoners cannot hide their criminal history, regardless of the severity of their crime (Ducksworth, 2010). Especially during the recent economic crisis that the United States is enduring, it is becoming increasingly difficult and near impossible for individuals with past criminal records to find meaningful employment. What does this lack of employment mean for the ex-prisoners?

A Worcester-based organization is working to address this question. Ex-Prisoners and Prisoners Organizing for Community Advancement (EPOCA) helps prisoners, ex-prisoners and their families in the transition between incarcerated and free life. EPOCA's specific role in this process and how it came to found Empower will be discussed in the next section of this chapter.

The transition from incarcerated life to free life has been repeatedly noted as a very difficult and arduous task. Ex-prisoners usually need a high level of assistance to make this transition successfully (Patterson and Wheeler, 2008). Assistance is usually in the form of

therapy, abuse treatment, and education. However, many believe that in order for ex-prisoners to prevent recidivism, or being incarcerated again after their release, employment is essential (Patterson, and Wheeler, 2008). Even if an individual is successful with his or her therapy, treatment, and education, their criminal record persists. Because of this, gaining meaningful employment, i.e. beyond part time work, becomes nearly impossible. Without substantial employment, ex-prisoners are more likely to return to the ill-advised habits that led them to prison in the first place.

As recently as the 1970's, "state prisoners were released with $40, a thrift shop purchased suit of clothing, and a bus ticket" (Ducksworth, 2010). Ex-prisoners were released without any support in their transition back into free life, an issue that concerned many people. This prompted the government to provide ex-prisoners with further supervision upon their release (Ducksworth, J., 2010). A great deal has changed since the 1970's in the positive direction; however, the prisoner reentry program still consists of many negative elements. Before these negativities can be addressed, the public opinion of ex-offenders needs to change. Society, as a whole, does a poor job of allowing ex-prisoners to make the transition from incarceration to a free life, thus becoming a contributing member of society (Ducksworth, 2010). For example, an ex-prisoner that has not been behind bars for more than 20 years still possesses a criminal record, regardless of their crime (Ducksworth, 2010). It is this criminal record, although it may be more than 20 years old, which does not allow ex-offenders to find valuable work opportunities. A person's criminal record has been compared to as their "scarlet letter" and it is this scarlet letter that may never allow a person to transition between incarcerated and free life (Ducksworth, 2010).

A number of barriers must be overcome by ex-prisoners seeking reentry into their communities. These barriers more often-than-not include: "substance abuse, mental illness, HIV and AIDS, lack of education, unemployment, homelessness, legal barriers to receiving public services, difficulty obtaining state-issued identification, etc." (Patterson and Wheeler, 2008). Many prisoners find themselves challenged by these barriers. The simple solution for many ex-prisoners is to return to the life of crime that they previously pursued before prison and to forget about the social challenges they would otherwise face. In fact, "forty-one percent of inmates released in 2006 are expected to recidivate by 2011" (Williams, 2007). This is a staggering and perplexing statistic that continues to rise. With this statistic, however, comes the question, "What exactly causes recidivism?" Many believe that employment opportunities may pave the way to reduce recidivism. For example, Illinois has employed support services to ex-prisoners that include job readiness education. In Illinois, if ex-prisoners are able to achieve employment for thirty days or longer after their release, their likelihood of recidivism drops by fifty-eight percent (Williams, 2007). However, since government regulations mandate that ex-offenders provide potential employers with their criminal backgrounds, it remains unlikely that these ex-offenders can find withstanding job opportunities (Gilbert, 1997).

According to the Bureau of Justice statistics, in 2009 the number of prisoners in state, federal, and local jails was reported to be 2,284,913 (de Rugy, 2011). The United States' incarceration rate is more than double that of any other liberal democracy in the world. The increasing incarceration rate in the United States is especially mysterious since the number of violent crimes has only increased three percent since 1980 (de Rugy, 2011). Many believe that the increase in prison populations is caused mainly by elected officials vowing for stricter laws and punishments; however, these harsh laws and punishments are causing much more harm than

good (de Rugy, 2011). With the increased incarceration rate, comes an increase in the recidivism rate (Patterson and Wheeler, 2008). As stated previously, it has been found that recidivism can be prevented if ex-prisoners are able to gain employment.

With more prisoners being released from jail than ever before, it is becoming increasingly difficult for ex-prisoners to find beneficial employment opportunities. Also, the increase of annual prison populations is taking an unseen toll on the American economy. $78.95 per day is spent on each incarcerated prisoner and the annual amount of money spent totals $52 billion (de Rugy, 2011). Because of this, if the incarceration rates in the United States continue to increase, not only will there be higher recidivism rates due to lack of employment opportunities, but the amount of money spent by tax payers each year for maintaining these prisoners will continue to rise. Therefore, it is necessary to relinquish the social stigma that is placed upon ex-prisoners and allow them to become contributing community members.

The fact that ex-prisoners have such a difficult time finding substantial employment upon their release becomes even more disappointing when their family members are taken into consideration. Fifty-four percent of inmates in the United States are parents and one in every twenty-eight children has an incarcerated parent (de Rugy, 2011). These children's futures may seem bleak and due to their parent's criminal record, they may never be supported by a steady fixed income. Although only one fourth of these children's parents are violent offenders, the nature of the crimes seldom has little to do with the lack of employment opportunities (U.S. Department of Justice, 2004). For example, it has been found that "past incarceration reduced subsequent wages by eleven percent, cut annual employment by nine weeks, and reduced yearly earnings by forty percent" (de Rugy, 2011). Therefore, even though the vast majority of

prisoners are incarcerated for nonviolent crimes, not only are their futures in jeopardy, but their children's are as well.

The major social problem that the sponsor and their founding organization are determined to face is the social injustice that many nonviolent ex-prisoners experience upon their release. By creating higher profit margins, the owners of Empower are not looking to increase their personal incomes; instead, it is their main goal to increase the number of ex-prisoners' lives that they are able to positively affect through job creation. Empower aims to eradicate the social stigma placed upon their employees and allow them to be beneficial contributors to society. By supporting as many ex-prisoners as possible, Empower will work to ease their burden.

One way to increase the number of people Empower influences is to increase all possible profit margins. By doing this they will be able to provide emotional support, camaraderie and hope within a community of people with shared experiences. The IQP looked to increase profit margins by offering recommendations for the use and/or sale of products made with glycerin, a byproduct of Empower's previously established biodiesel production business. Empower works closely with its founding organization, EPOCA, and it is both of these organizations' goals to have positive impacts on ex-prisoner's lives. In order to further investigate the impact of an organization like EPOCA on the local community, a survey of EPOCA members was conducted, the results of which will be shown later in the Results chapter.

2.2 History

2.2.1 Ex-Prisoners and Prisoners Organizing for Community Advancement

Ex-prisoners and Prisoners Organizing for Community Advancement (EPOCA) was founded in Worcester, Massachusetts in 2004 by a group of hardworking former prisoners (http://exprisoners.org). EPOCA currently has 272 members, consisting of both ex-prisoner and

non-ex-prisoner community members, who are working towards the goal of bettering the lives of released prisoners. They seek to do this by legislative reform, such as reversal of the "Three Strikes" law and change in requirements of CORI forms (Personal Communication, Luis Bajana, 2012).This interest group, along with others, was initiated as a grass roots movement to help better the lives of people being released from prisons (David, 2010).

The organization seeks to deal with the injustice faced by ex-prisoners seeking to return to the workforce and society; this includes the barriers presented mainly by the Criminal Offender Record Information (CORI) forms. A Massachusetts citizen will have a CORI background if they have ever been convicted of a crime under either state or federal law. This form poses a major obstacle for ex-prisoners who are not a threat to society. It often prevents ex-prisoners from gaining employment, finding housing, applying for loans and using services available to other citizens (http://www.massresources.org/cori.html). EPOCA founded Empower Energy Cooperative as a way to offer gainful employment to ex-prisoners. The two organizations continue to work closely today.

2.2.2 Empower Energy Cooperative

Empower Energy Cooperative was founded four years ago by EPOCA. The members of EPOCA were unwilling to wait for the laws regarding CORI forms to be changed, thus they created a business to overcome the restrictions of the forms. Empower, like EPOCA, has the desire to reduce the injustice faced by ex-prisoners desiring to return to work. They are a values-based, employee-owned cooperative working to create local jobs and promote sustainability in the community of Worcester (http://exprisoners.org). Empower remains close to EPOCA today as Luis Bajana, a founding member and part owner, is the current vice president of EPOCA.

Empower Energy Cooperative started as a waste vegetable oil (WVO) pickup service. The idea for this WVO pickup originated within the members of EPOCA. This idea was developed by two previous WPI Interactive Qualifying Projects done in 2009. The projects determined the feasibility of starting the company and converting the WVO into biodiesel to sell on the market. Empower currently picks up oil from over 25 different local restaurants, including WPI's Goats Head Restaurant. Once they have collected the WVO, they use it to synthesize biodiesel. They then sell this biodiesel as off-road fuel to consumers. The cost for Empower to market their product as road-worthy fuel is too expensive for them with their current budget (Personal Communication Assefa, Bajana, Guzman, 2011). The cooperative is looking to grow their business and increase their revenue, while maintaining the distinct goals of sustainability and integrating ex-prisoners back into society by providing gainful employment.

In order for the company to expand, certain economic goals must be met. Empower's production of biodiesel has allowed the company to pay a part-time wage to each of its three employees, but Empower seeks to achieve more (Personal Communication Assefa, Bajana, Guzman, 2011). They wish to start developing a use for a byproduct of their biodiesel synthesis, glycerin. This new use of a waste product may lead to an additional profit stream and could lead to the company being able to pay full time or more part-time wages to ex-prisoners. Once Empower has reached certain economical goals, it can begin to have more of a positive impact on the community through the ability to offer employment positions to ex-prisoners.

Empower would like to employ more ex-prisoners looking to reintegrate themselves into the community as productive, job holding citizens. Empower shares the belief that providing a stable salary to an ex-prisoner, who may not otherwise be able to find a job, will aid in the reduction of recidivism rates (Staff and Uggen, 2001). Empower believes that with glycerin

products as a new source of revenue, they will be able to create new jobs and keep ex-prisoners from returning to prison.

As the Empower Energy Cooperative seeks to attain the goals mentioned above, it also wishes to remain environmentally friendly. Empower initiated its first product through the recycling of waste vegetable oil from restaurants. Glycerin is a waste product of biodiesel production, thus its use will further Empower's goals of sustainability. The cooperative hopes to spread the sustainability movement throughout the community, while using it as a way to provide jobs to ex-prisoners.

2.3 Glycerin

Empower Energy Cooperative presently operates a successful biodiesel production business. A waste product of this process is glycerin. The glycerin produced is crude and contains currently unknown impurities. Currently, the waste glycerin is being stored at Empower's location in Worcester. It is not being used in any way, thus the use of it in-house to lower production costs or the sale of it to outside customers would be profitable to the cooperative. In the following section, glycerin properties, purification methods and uses will be explained. With recommendations for the successful purification and use of waste glycerin, the Team believes that Empower can increase profit margins.

2.3.1 Properties

Glycerin, also known as glycerol, is a three carbon alcohol. The chemical formula for glycerin is HOCH2HOCHHOCH2. It has three hydroxyl groups, one on each of the three carbons. In its pure state, glycerin is a clear and colorless oily liquid. This organic compound also has a sweet taste (Glycerol, 2006). The melting point of pure glycerin is 64°F and the boiling point is 554°F (http://www.hvchemical.com).

There are moderate potential health effects regarding glycerin. It has a Health Rating of 2, which indicates that it may be harmful if absorbed or inhaled. Inhalation, skin and eye contact with glycerin may cause irritation to the contacted areas. In the case of ingestion, nausea, diarrhea or headache may occur. There is some evidence that chronic, long-term exposure to concentrated glycerin may adversely affect the kidneys. To protect from the potentially harmful properties of glycerin, it is recommended that goggles and gloves be used in a well-ventilated area when handling the chemical (http://www.hvchemical.com).

The glycerin produced at the Empower Energy Cooperative is a byproduct of biodiesel production from waste vegetable oil. Vegetable oil contains triglycerides, which consist of three fatty acid chains with ester bonds to a glycerol. In the production of biodiesel from waste vegetable oil, an alcohol (methanol) and an acid catalyst (potassium hydroxide) are added to the oil. This causes the transesterification of the triglyceride, breaking each triglyceride down into one glycerol and three fatty acid esters (Cerveró, 2008). The fatty acid esters are separated from the glycerol and sold by Empower as "off-road" biodiesel (Personal Communication, Assefa, 2011). The glycerin byproduct must be purified before it may be used for commercial purposes.

2.3.2 Purification

The crude glycerin that comes off the biodiesel production process at Empower contains several impurities, including methanol and potassium hydroxide left over from the transesterification step. The crude glycerin can be flash heated to 194 °F to evaporate off the methanol (personal communication Guzman, 2011). Due to the high boiling point of glycerin, as previously stated, no glycerin should be evaporated and lost during this process. The glycerin is also most likely contaminated with salts and free fatty acids (Albergaria, Averill, Fraser, & Sangenario, 2009).

E. Nor Hidawati (2011) of the University of Malaysia has demonstrated a method of purifying crude glycerin from biodiesel production. This multi-step process has experimentally yielded an average of 87.14 % pure glycerin, with the remaining contents being water and non-glycerol organic matter. To purify the crude glycerol, it is first diluted with water and acidified with sulfuric acid to pH 2. This causes a phase separation of the fatty acids and aqueous materials. The top layer is discarded and the bottom layer is saved and filtered. Diethyl ether is added to the filtrate in a separating funnel in order to remove excess fatty acid. Sodium hydroxide is used to neutralize the solution to pH 7, after which it is heated for two hours at 105°C to remove excess water. To remove salts, methanol is added. This solution sits at 20°C for a half hour and then at 4°C for another half hour. Filtration is needed to remove precipitated salt, and then methanol is evaporated off at 80°C for twenty minutes. Finally the glycerol is vacuum distilled at 0.1 to 3.0 mbar and heated to 150°C (Hidawati & Sakinah, 2011).

Another, slightly different process of crude glycerin purification exists as demonstrated by Konjao, Damronglerd and Hunsom (2010). This process yields 93-94% glycerin, with the remaining 6-7% consisting of water and non-glycerin organic matter. As in the previous method, sulfuric acid is added to the crude glycerin waste product of biodiesel production. The pH is lowered to 1 and the solution is allowed to separate. In contrast to the previous method, the solution is said to separate into three layers; the top consisting of free fatty acids, the middle consisting of glycerin and the bottom consisting of organic salts. The middle layer is collected and filtered, then neutralized with sodium hydroxide and evaporated at 105°C for two hours. Remaining salts are precipitated with ethanol and filtered away. Ethanol is evaporated by heating to 80°C for 20 minutes (Konjao, Damronglerd & Hunsom,, 2010).

The difference in levels of purity of the glycerin obtained from these two different methods may be a real difference or may be due to differences in the contents of the original crude glycerin, as the samples were obtained from different biodiesel manufacturing plants. The major differences between the two methods are the pH after sulfuric acid addition, the absence of diethyl ether to remove excess fatty acids in the second process, and the use of methanol or ethanol to precipitate the organic salts.

A third method also exists however that claims to offer almost one hundred percent chemically pure glycerin from crude glycerin. To do this the crude glycerin must first be diluted to a solution of sweet water which consists of 30 percent glycerin per unit mass in a solution of distilled water (Reents, 1950). If the resulting sweet water solution is turbid lime or alum must be added to settle it (Reents, 1950). The solution of sweet water is then purified using a series of steps consisting of anion and cation exchange chromatography. The sweet water must be filtered before it can pass through an anion exchange bed and then a separate cation exchange bed (Reents, 1950). The single effluent product from these two beds is then passed through a third bed comprised of an unanimated condensation product of phenol and formaldehyde (Reents, 1950). After this step has been completed the solution is then passed through a bed of homogenously mixed anion and cation exchange material (Reents, 1950). The resulting solution is then placed into a vacuum evaporator and heated to 217 degrees Fahrenheit (http://www.engineeringtoolbox.com/glycerine-boiling-freezing-points-d_1590.html). After the vapor has condensed the resulting glycerin is almost 100 percent chemically pure.

As the uses of glycerin are investigated in the following sections, it is important to remember the justification for this research. Empower Energy Cooperative has a source of unused waste glycerin as a byproduct of their biodiesel production business. A profitable use of

this waste glycerin will not only satisfy the cooperative's goal of sustainability, but could provide the funds with which the cooperative can employ more ex-prisoners. As previously discussed, it is believed that employment can lower recidivism rates, thus in the following section we will investigate possible profitable uses for Empower's glycerin.

2.3.3 Uses of Glycerin

It is becoming increasingly important for biodiesel companies, like Empower, to find an outlet for their glycerin byproduct. There is about one gallon of crude glycerin produced for every nine gallons of biodiesel. It is expected that by 2016, 37 billion gallons of biodiesel will be produced annually. This means that there will be approximately 4.1 billion gallons of glycerin produced annually as well. The resulting excess of glycerin byproduct has had a negative impact on its value. In 2009, the market price for purified glycerin was between 60 and 90 cents per pound. Meher et al. believe that small biodiesel companies may be able to benefit from reusing their waste glycerin to offset some of the costs of biodiesel production (Meher, Gopinath, Naik & Dalai, 2009). Some possible solutions for Empower's crude waste glycerin include conversion into propylene glycol, as an ingredient in bar or liquid soap, use in fire bricks or purification for sale to local farms.

Propylene glycol (1,2-propanediol) is a substitute for ethylene glycol, the toxic main ingredient in antifreeze and deicing products. Compared to ethylene glycol, propylene glycol is environmentally friendly and non-toxic, but still functions well as antifreeze. Glycerin can be converted into propylene glycol by a process called hydrogenolysis. This process has been demonstrated in detail by Meher et al. using metal catalysts. This process involves the use of hydrotalcites, which are a class of anionic clays that aid in anion exchange. To prepare the hydrotalcites, the pH is increased using sodium hydroxide and sodium carbonate. Metal nitrates

are added to further increase the pH to 10. The most reactive combination of metals was found to be copper, zinc and aluminum. The precipitate formed in the hydrohalcite mixture is filtered off and dried at 80°C for at least 24 hours. During this time, washing with hot water should be done until the pH has returned to 7.0. The neutral washed precipitate is finally dried at 120°C for 72 hours to obtain the final hydrotalcite catalyst (Meher, Gopinath,, Naik & Dalai, 2009).

Once metal catalyst is produced, it must be reduced by bubbling hydrogen gas through it for three hours at 300°C. This adds hydrogen atoms to the metal catalysts. The mixture should be cooled to 100°C and the purified glycerin should be added quickly. Hydrogenolysis of the glycerin can then take place at 200°C and 200 psig with stirring. Gas chromatography can then be used to analyze the results, and determine the conversion rate of glycerin to 1,2-propanediol. Figure 1 below summarizes the reaction of glycerin to 1,2-propanediol (Meher, Gopinath,, Naik & Dalai, 2009). This process may be too complex for a small budget cooperative like Empower to pursue, but it was still used as a comparison to other products in the cost/benefit and market analysis.

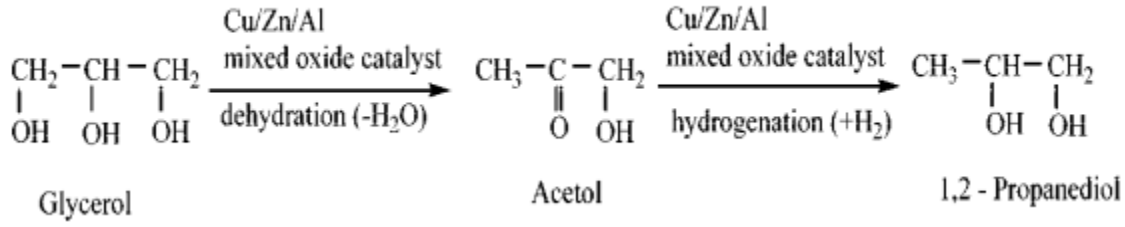

Figure 1: Reaction of Glycerin to 1,2-Propanediol, a component of antifreeze (Meher, Gopinath, Naik & Dalai, 2009)

Hand soap is another use of glycerin. This could provide an easily manufactured product for Empower. Terry McGleish is involved in a small biodiesel business in Santa Cruz, California, and uses waste glycerin to make simple hand soap. The process includes heating

crude glycerin straight from biodiesel manufacturing to either 150 or 175°F, depending on if methanol or ethanol, respectively, were used in the transesterification process. This is done to evaporate remaining alcohol. The glycerin should also be filtered before use in soap making; McGleish suggests using a pair of panty hose or a strainer. No further purification is used in this process. The ratio of ingredients for soap making is not exact. Per gallon of glycerol, 5.5 ounces of lye (sodium hydroxide powder) and one quart of water are generally used. More water will give a soap that produces more bubbles and more lye will yield more grease fighting power (McGleish, 2008).

Before combining the ingredients, the water is heated to 100°F. The lye can then be mixed into the water until it is fully dissolved. The lye mixture is added to glycerin and kept on heat for twenty minutes. The first ten minutes should include mixing and the second ten should include very slow mixing. The mixture can then be poured into a Tupperware container and allowed to set for 24 hours, after which it can be removed and sliced into bars. The soap bars should set for at least another four days before use and be stored in a cool, dry place (McGleish, 2008). This process is simple and would require a small investment by Empower.

It is also possible to make liquid soap from glycerin. This could be beneficial to Empower, because liquid soap would be easier to use to clean their facilities. For one liter of glycerin, 80-100 mL of water, 50-75 grams of potassium hydroxide (KOH) and 1/3 – 2/3 cups of essential oil. The glycerin in this method also comes from the biodiesel production process and needs to me demethylated before use. The water is heated to 110°F and the glycerin is heated to 120°F in a separate pot. Once both the water and glycerin are up to temperature, the KOH is added to the water. Be careful not to breathe the fumes from this reaction. Add the glycerin to the dissolved water and KOH mixture, remove from heat source and stir in the essential oil. It is

recommended that the soap is allowed to cure for a week to ten days before use (Homesteading Today, 2007). Liquid soap would be more beneficial to Empower because they could use it to clean their workshop

The next method focuses on an easily made use of the glycerin byproduct; fire bricks. These pellets or bricks can be burned like logs in a fire and produce a similar British thermal unit measurement per pound as propane (http://www.glycerinburners. com/). This makes them more efficient than burning wood pellets in a stove, which release 3,000 BTUs per pound less than the glycerin (Kacvinsky & Manley). The glycerin pellets burn best at higher temperature and can release a potentially hazardous chemical acrolein at low temperatures (http://biodiesel.infopop.cc). This chemical can cause damage to the eyes and potentially the reproductive system (http://msds.chem.ox.ac.uk). A benefit to this method is that the crude glycerin does not need to be purified to be burned as a fuel in this way. It can be used immediately after it has been removed from the biodiesel synthesis (http://www.glycerinburners.com/).

The process to make a single fire brick is not very involved and does not require any specialized machinery, which would be beneficial to Empower. The glycerin can be mixed with a number of wood-based materials including sawdust or shredded paper to form either pellets or bricks. Some care must be taken when mixing the product because making the mixture with too much glycerin could cause a hard residue to be formed after burning (http://biodiesel.infopop. cc). One unit of glycerin can yield up to four units of glycerin mixture. The mixture must then be pressed into the final pellets or bricks. To form bricks, the glycerin mixture can be pressed into a brown paper bag or paper milk carton. However, in order to make fire bricks that could be sold in a market, the quality would have to be improved and quantity would have to be increased.

This would involve manufacturing molds and the use of an arbor press to compact the bricks. Empower already has access to the equipment to make these upgrades.

Another novel use for the glycerin is as livestock feed, particularly cattle feed. In order to use the glycerin in this manner it must first be purified to some extent. The only process that must be done is the demethylation to remove the methanol from the mixture (http://biodiesel.infopop.cc). The methanol is a potentially harmful substance to the animals and directions for its removal can be seen in Section 2.3.2. The use best fits cattle, since these animals are adapted to dealing with high methane levels. Methanogenesis is a process that occurs in the digestive tract of cattle to reduce the harmful effects of methane (http://toxics.usgs.gov). However, the current cost of glycerin as a feed is slightly more costly than the current standard as corn for feed. The cost for glycerin feed per pound is fifteen cents while that for corn is eleven cents (Sims, 2011). Also the glycerin offers less energy than the corn, oils and fats generally used as livestock feed. The use of glycerin as feed is a method mostly used by farmers who produce their own biodiesel to supplement the cost of their feed (http://biodiesel.infopop.cc).

The glycerin produced may also be used as a fertilizer for crops. The initial biodiesel process must also be catalyzed with potassium hydroxide for it to produce glycerin viable as fertilizer, which is true of Empower's biodiesel process. Over time the fertilizer can cause the soil to become caustic due to its basic content, so pH must be monitored. To make fertilizer, methanol must be removed and the glycerol must be diluted with water. As with the previous product, this is a method used mostly by farmers who produce their own biodiesel (http://biodiesel.infopop.cc).

In the following Methodology chapter, an explanation of the cost/benefit and market analysis of the four possible uses of Empower's waste glycerin can be found. The IQP group

used these methods to compare the uses of glycerin in antifreeze, soap, fire bricks, and purification. The analysis led to the recommendation of the top two products to Empower; soap and fire bricks. The goal of this is to allow Empower to benefit from an additional profit stream or reduce expenses in order to improve the lives of ex-prisoners through the creation of jobs.

3. Research Methods

This chapter discusses the steps taken to analyze and develop uses of the crude glycerin waste product. The first step was to determine the different degrees of purification that must be used for each of the different products. A cost/benefit analysis was used to determine the two most feasible uses, as well as a market analysis to locate potential target markets, if any. Finally, the two best potential products, soap and firebricks, were prototyped and presented to Empower.

To investigate the social aspect of the project, a survey was conducted with ex-prisoner members of EPOCA. This method showed the impact that these organizations have on the Worcester community. Results of the surveys provided further justification for the project and helped to explain why a new source of profit for Empower will be beneficial to the community.

3.1 Guiding Questions

The following questions detail the scope of the project. The explanation in parenthesis tells how the question was answered.

1. What are the best uses of pure glycerin for the Empower Energy Cooperation? (linked to the cost/benefit analysis)
2. Can this new glycerin product help Empower to continue to employ ex-prisoners and help them reintegrate back into society? (linked to surveys given to ex-prisoners in EPOCA)

3.2 Justification for Questions

The previously listed questions led to the eventual decision of which glycerin by-product would be the most beneficial for the Empower Energy Cooperative. These questions can be found in Appendix B. The first goal of this project was to develop a procedure to purify the

crude glycerin product. Once purification methods were researched, it was possible to use to create potential new products for Empower. The cost/benefit and market analysis were used to determine which one of these products would be most beneficial. Once the top two glycerin products were determined, they were prototyped. It is possible that Empower will have the chance to hire more ex-prisoners as employees and expand the cooperative through the profit these products could provide, or through the savings they could give if used in-house by Empower. The IQP Team also wished to examine how a job opportunity affects the life of an ex-prisoner. A survey of the ex-prisoners currently involved in EPOCA was given with the help of Luis Bajana, and the data generated was used to determine how imprisonment has affected their ability to find employment.

3.3 Description and Justification for Methods

3.3.1 Cost/Benefit Analysis

A cost/benefit analysis was performed to compare the different possible uses of waste glycerin. A cost/benefit analysis is a tool used to rank solutions to a problem based on relevant criteria. This process provides a consistent scoring system that can be applied to many different solutions to a common problem. A cost/benefit analysis serves as a prediction of the future success of the possible solutions (Williams, 2008). In relation to the proposed IQP, the four possible uses for waste glycerin were compared based on Efficiency, Personnel, Environmental and Monetary aspects. Table 3.1 on the following page shows all the categories and subcategories that were evaluated. This table is based off a worksheet handed out in ID 2050.

	Possible Uses									
	Soap				Fire Bricks		Purification		Antifreeze	
	Bar Soap		Liquid Soap							
Categories	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**
I. Efficiency										
A. Time										
B. Yield										
D. Upgradeability										
AVERAGE										
II. Personnel										
A. Complexity										
B. Involvement										
AVERAGE										
III. Environmental										
A. Safety of materials										
B. Safety of product										
C. Safety of waste										
AVERAGE										
IV. Monetary										
A. Startup costs										
i. Raw Materials										
ii.Equipment										
B. Production/Op. costs										
C. Maintenance										
D. Value of Product										
i. Market value										
ii. In-house value										
AVERAGE										
WEIGHTED AVERAGE										

Table 3.1: Cost/Benefit Analysis Table

The Empower Energy Cooperative asked for two recommendations for uses of their waste glycerin. After research into the many uses of glycerin, the IQP team decided to investigate further the methods for producing antifreeze, soap, fire bricks and purified glycerin. A cost/benefit analysis was conducted to discern the top two uses. This analysis was based on the goals of Empower and was meant to provide them with two products fitting their specific needs. Ultimately, the recommended products will be produced, and possibly sold, by Empower to increase revenue. This could allow them to provide another job or to expand current part time wages of the owners to full time wages. These products may also contain an in house value to Empower that would allow them to reduce expenses and increase their profit margin in that manner. It is important to note that if none of these uses are found to be beneficial, we will recommend that Empower continues with their current glycerin disposal methods.

A template for the cost/benefit analysis can be seen on the previous page, titled Cost/Benefit Analysis Worksheet. This table and a brief written explanation of assigned ratings were presented to Empower at the end of the term. There are four categories; Efficiency, Personnel, Environmental, and Monetary. Each category was assigned a rating of 1 through 5, with 5 being most favorable. The ratings were assigned based on a group consensus for each category. Weighted averages of the individual category averages listed above were used to determine the top two products. This weighted average was based on the importance of each category using a 100 point scale. This method will be further explained in the Results chapter. There is also a column titled Value for each use. This shows the numerical value of the subcategory. The completed cost/benefit analysis can be found in the Results chapter. Following are detailed explanations of the categories and their respective subcategories.

The category titled Efficiency contains three subcategories; Time, Yield, and Upgradeability. Time refers to the total time required to produce one batch of product from start to finish, including the purification needed. It does not take into account if there must be a worker present at all times. A high rating was given to processes taking less time. Yield refers to total units of product produced per batch, for example number of soap bars or liters of fertilizer. Higher ratings were assigned to high-yield processes.

Upgradeability is a subcategory pertaining to the future of the Cooperative. A rating of 5 was given to processes that can be upgraded and improved beyond the initial processes described in this report. For example, it is believed that soap production could be easily upgraded by adding new scents and colors. This category is based on Empower's goal of growth because upgrades to a process can yield more profit and more employment for ex-prisoners.

The Personnel category includes the subcategories of Complexity and Involvement. Complexity refers to the level of knowledge and/or skills required to carry out the process of making a specific product. A process that is easy to perform and does not require special training for employees was assigned a high score of 5. Involvement refers to the labor-intensity of a process. An involved process that requires a worker to be present at all times was given a lower rating. A process allowing the worker to perform other tasks during waiting periods was given a higher rating.

Sustainability is a very important goal of Empower. The glycerin waste product to be used is a renewable resource for the biodiesel Cooperative. The category entitled Environmental will address these goals with the subcategories of Safety of Materials, Product and Waste Products. The subcategories were all given a high rating if the item being rated (materials, products or waste products) is safe for the environment and sustainable. If the process requires

materials that are not sustainable or environmental, it was given a lower rating. Similarly, if there are waste products produced that are hazardous to the environment a lower rating was assigned. Most of the information for this category was found in chemical MSDS sheets.

One of the most important categories is the Monetary category, which deals with the economics of products. Empower has a small budget, limiting the options of products they will be able to produce. The four subcategories are Startup Costs, Production/Operating Costs, Maintenance and Value. Startup Costs consists of Raw Materials and Equipment that need to be purchased to produce a batch of product. The different products were rated in comparison with one another, with the least expensive product being ranked highest. Production/Operating Costs includes Electricity per batch. Low values for these categories yielded high ratings. The Maintenance category was a speculation into the cost of routine repairs and replacements of equipment. Low maintenance processes were given a high rating.

Also under the Monetary category is Value. This includes the Dollar Value of the product which was calculated on a per batch basis. A high sale value was given a high rating. The final product may also be used by Empower for in-house purposes. This In-House Value category was given a high rating if the product is useful to Empower.

The average of each category was taken and the averages were compiled into a weighted average for the product. The final weighted average was based on the needs of Empower. A hundred point scale was used where Empower assigned percentages to each of the four categories. They assigned 20% to Efficiency, 17% to Personnel, 30% to Environmental and 33% to Monetary. Each category average was multiplied by the corresponding percentage to yield the final weighted average.

The two highest scoring products were recommended to empower as potential new sources of income. It is the aim of Empower to use the new source of profit to expand the number of employees or the wages of its current employees. Prototypes of the two highest scoring products were also made at Empower's facilities. The following Laboratory Testing section details how prototypes were made.

3.3.2 Market Possibilities

The cost/benefit analysis revealed the best product for the use of Empower's glycerin, but whether or not Empower would be able to sell or use its new product needed to be examined individually. Although the Efficiency, Personnel and Environmental categories may have shown a strong rating, whether or not the product will have value to the cooperative is most important and could essentially veto the findings in the cost/benefit analysis. Because of this, if a product is not useful to Empower it was excluded from the final recommendations. Possible markets for selling and using the products were investigated through discussions with Empower employees. For example, hand soap could be sold at a farmers market or to other cooperatives, but not to pharmacies or grocery stores because of the high shelf fee. This information was used along with the results of the cost/benefit analysis to recommend two products to Empower.

3.3.4 Survey

A survey is defined as a method "to collect information to describe, compare, or explain knowledge, attitudes, and behaviors" (Fink 1995). The team utilized this method to attain information about the difficulty of finding employment after being incarcerated, and the effect this can have on ex-prisoners. For the purpose of this project 30 copies of the survey and cover letter, both included in the Appendix, were distributed to ex-prisoner members of EPOCA through Luis Bajana. The surveys were filled out voluntarily by EPOCA members as they came

into Luis' office. We received a total of 8 surveys from ex-prisoners. They gave insight into the reality faced by ex-prisoners during their integration back into society.

The questions in the survey were chosen to give local insight into the impact that employment can have on the ex-prisoner community. Questions 1 and 2 were background questions. Questions 3, 4 and 5 inquired about the level of difficulty in finding employment and the satisfaction that ex-prisoners may find in their job. Question 6 told if they had difficulty finding employment based on CORI checks, which is a major focus of EPOCA. Question 7 uncovered reasons why they chose to become members of EPOCA. Combined, questions 1-7 gave an overview of the social aspect of the project. We obtained information from this survey to answer two questions:

- How does being an ex-prisoner affect job opportunities that the individual would otherwise be qualified for?
- Do organizations like EPOCA and Empower help to overcome these barriers and if so, how and if not, what can be changed?

3.3.5 Institutional Review Board

In order to conduct surveys, the team had to comply with the Institutional Review Board policies. The Institutional Review Board is a service that aims to provide more ethically bound service through review on research methods applicable to human subjects (http://www.irbservices.com/). Survey questions were submitted to the IRB and were given an exemption.

4. Results

This chapter includes a detailed explanation of the data collected throughout the term. It includes a description of the cost/benefit analysis and prototypes. It also discusses the results of the survey and its implications.

4.1 Cost/Benefit Analysis Results

A cost/benefit analysis was completed in the fifth week of the project. This was a tool to determine, both qualitatively and quantitatively, the top glycerin products. The completed cost/benefit analysis table can be seen in Appendix A. At the end of each section there is a table with the values and ratings for the corresponding category. The products compared were soap (both bar and liquid), fire bricks, purification and antifreeze. Liquid and bar soap were analyzed individually, but were regarded as one product in the final recommendations because of their similarities.

Through discussions with Empower, it became clear that a product that could be used by the cooperative to reduce costs would be the most beneficial. Empower does not have the funds to invest in the equipment necessary to produce the potential products on a large scale; bringing a new product to market is not feasible at this time. They also do not have the funds to pay the high shelving fees to sell the products using a third party vendor, for example a local convenience store. This would limit Empower to sell their products to a limited market, such as friends and other coops. For this reason, we conducted the cost/benefit analysis as if the products were going to be produced on a small scale and for in-house use. As such, the assigned values and ratings are applicable to small scale and in-house products.

The ratings were determined by all members of the group. Each member researched one product and assigned values to all subcategories. The group compared the four products and

collectively assigned ratings. The top two scoring products were determined to be soap and fire bricks. Fire bricks had a final weighted average of 4.20 and soap had final weighted averages of 4.32 and 4.37. These final averages are very close, so the prototypes helped to determine the top recommendation. Prototypes are discussed in the following section.

4.1.1 Efficiency Evaluation

The category of Efficiency was rated based on three subcategories; Time, Yield and Upgradeability. Table 4.1 is a summary of the Efficiency category. Time refers to the total time it takes to produce the final product. The glycerin uses were ranked against each other for this subcategory. Soap takes around one week to make, so it was given the lowest rating of 1. Antifreeze takes 28 hours and was given a rating of 3. Fire bricks were given a rating of 4 because they take 13 hours to make and dry. The highest rating, 5, was given to purification because it only theoretically takes 5 hours.

Yield refers to how much product is produced based on the amount of glycerin used. Soap and Firebricks both do not have any waste, thus they received the highest rating of 5. When making antifreeze, there is a 50% yield of product. Antifreeze was therefore assigned a rating of 2. Purification has an even lower expected yield of 30%, thus it was given a rating of 1.

The last subcategory of Efficiency was Upgradeability. We discovered that products were either upgradeable or not. This led us to simply rate products a 1 if they were not upgradeable and a 5 if they were. Both liquid and bar soap could be improved by purification of the glycerin to remove the smell and brown color. The fire bricks could not be upgraded because purification is not necessary and they are a very simple product. Purification procedures could be upgraded by purchasing or building more sophisticated purification equipment. Antifreeze cannot be

upgraded either because once the equipment is purchased, there would be no need for additional items equipment.

	Soap				Fire Bricks		Purification		Antifreeze	
	Bar Soap		Liquid Soap							
	Value	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**
I. Efficiency										
A. Time	6 days	1	7-10 days	1	~13 hours	4	~5 hours	5	28 hours	3
B. Yield	45 bars	5	1.1 liter plus water	5	7 Bricks	5	30% (3.15 lb)	1	0.5 gallon	2
D. Upgradeability	purification	5	purification	5	No	1	Yes	5	none	1
AVERAGE		**3.67**		**3.67**		**3.33**		**3.67**		**2.00**

Table 4.1: Efficiency Values and Ratings

4.1.2 Personnel Evaluation

The Personnel category was comprised of two subcategories, Complexity and Involvement. The values and ratings for Personnel can be seen in Table 4.2. Complexity referred to the degree of difficulty of making each potential product. Products that can be made with a limited amount of knowledge of the process were ranked higher than products that require a higher degree of knowledge. Both types of soaps and the firebricks require a minimal amount of knowledge and the degrees of difficulty are very low. For example, when creating firebricks, one simply needs to combine ingredients and allow the products to dry. Because of this, bar soap, liquid soap, and firebricks were given a rating of 5. For purification and antifreeze, the complexity levels were higher. We have determined that purification requires lab experience, such as knowledge of certain equipment, and a general knowledge of chemical principles. Therefore, we have given purification a rating of 3. Finally, for antifreeze, some training is required for the operation of the reactor or autoclave. Also, there are chemicals involved that the operators would have to have knowledge about. Antifreeze was given a rating of 2 in the Complexity subcategory.

The second subcategory of Personnel is Involvement. These ratings were determined on the amount of labor intensive work that is required. Bar soap, liquid soap, and firebricks were rated the highest in this subcategory because of the minimal amount of work that is required for these products. For example, while creating bar and liquid soap only about one hour of labor was required to make a batch of product. The rest of the time required to make these products was comprised of letting the soap sit and harden. The same was true for the firebricks. One batch of firebricks required about one hour of labor and the remaining time was used to allow the product to dry. Because of these reasons, bar soap, liquid soap, and firebricks were given a rating of 5. Purification was given a rating of 3, because involvement is required for all 5 hours of the process. Finally, antifreeze was given a rating of 3 as well because of the moderate intensity of work. The glycerin must be purified first to eighty percent before the process can even begin. However, once the glycerin has been purified, the intensity of making antifreeze is not very high; it only needs to be put into the autoclave, along with the appropriate chemicals.

	Soap				**Fire Bricks**		**Purification**		**Antifreeze**	
	Bar Soap		**Liquid Soap**							
Categories	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**
II. Personnel										
A. Complexity	minimal	5	minimal	5	Minimal	5	Moderate	3	High	2
B. Involvement	minimal	5	minimal	5	Minimal	5	Moderate	3	Moderate	3
AVERAGE		**5.00**		**5.00**		**5.00**		**3.00**		**2.50**

Table 4.2: Personnel Values and Ratings

4.1.3 Environmental Evaluation

The Environmental category consisted of three subcategories: Safety of Materials, Safety of Products and Safety of Waste. Table 4.3 contains the values and ratings for this category. Glycerin is a common material in all of the products and in the Safety of Materials subcategory, so we chose to address its safety concerns first. According to the National Fire Protection

Agency (NFPA), glycerin received a safety rating of two. This means that it can be harmful if absorbed or inhaled (http://www.hvchemical.com). This safety rating was taken into account throughout the Safety of Materials subcategory.

If Empower were to produce soap there would be small negative impacts on the environment. The processes for making both bar and liquid soap poses little hazard to the environment, with the exception of the lye used. Potassium hydroxide was used for liquid soap and sodium hydroxide was used for bar soap. Each of these materials received a NFPA health rating of three as each is a corrosive base. Potassium and sodium hydroxide are corrosive to living tissue and toxic if absorbed. Gloves should be worn and can be made of butyl rubber, nitrile rubber, and/or polyethylene. Goggles and clothing that cover skin should also be worn (http://www.certified-lye.com). This led to the process of soap making receiving a rating of 2.5 for Safety of Materials. The glycerin based soap products are safe for use on skin, thus they received a rating of 5 for Safety of Product (McGleish, T., 2008). There are also no waste products produced in synthesis of soap resulting in the subcategory of Safety of Waste obtaining a rating of 5.

Fire bricks offer an option that will satisfy the environmentally conscious owners of Empower. The materials used in the production of fire bricks (wood chips, glycerin, and milk cartons) are safe with the exception of the glycerin which received a NFPA rating of 2, as stated above. This led to fire bricks receiving a rating of 5 in the Safety of Materials subcategory. The next subcategory examined was Safety of Product. Fire bricks were determined to have a value of 2.5. The fire bricks earned this value because if the bricks are burned at too low of a temperature, acrolein fumes will be released into the air. If inhaled, these fumes may cause cancer in the lungs and upper respiratory tract (http://www.sciencelab.com). Therefore the fire

bricks must be added to an active fire in an area with adequate ventilation, allowing the firebricks to burn at a high enough temperature for the acrolein to decompose and not be hazardous (http://www.environment .gov). There is also no waste produced in the creation of fire bricks so the product received a 5 in the subcategory of Safety of Waste.

The environmental effects of purification of glycerin were also researched. The materials used for the purification of glycerin include heavy metals, which can be hazardous to humans. This led to the process of purifying glycerin receiving a rating of 4 for Safety of Materials, which is between the ratings for soap and fire bricks. The pure glycerin product is safe; depending on the level of purification it can be ingested safely by humans and animals. This resulted in the Safety of Product subcategory earning a rating of 5. However, methanol is produced as a toxic byproduct. This byproduct received a NFPA safety rating of 3. This means that the methanol may be fatal or cause blindness if swallowed. The vapor is harmful and flammable. Liquid methanol is also flammable, and harmful if swallowed, inhaled, or absorbed through the skin, causing eye, skin, and respiratory tract irritation. It can also cause central nervous system depression (http://www.midi-inc.com/). This led to the purification of glycerin obtaining a rating of 3 for Safety of Waste.

The environmental effects of the production of antifreeze from glycerin were also assessed. The hazards of the materials are due to glycerin and the copper chromide catalyst. The catalyst received a NFPA safety rating of 2, meaning it must be kept away from heat and ignition sources. It is harmful if swallowed or inhaled, and must be used in adequate ventilation. Contact with eyes, skin, and clothes should be avoided. Lastly, copper chromide should be kept in a sealed container (http://www.sciencestuff.com). This resulted in the Safety of Materials subcategory earning a rating of 4, due to the dangers of glycerin and copper chromide. The

propylene glycol also received an NFPA safety rating of two, therefore the same safety measures should be observed. This resulted in the antifreeze receiving a rating of 5 for the Safety of Products subcategory. The only byproduct produced in this reaction is water, which is a safe. Thus the antifreeze obtained a value of 5 for Safety of Waste.

	Soap				Fire Bricks		Purification		Antifreeze	
	Bar Soap		Liquid Soap							
Categories	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**
III. Environmental										
A. Safety of materials	NaOH	2.5	KOH	2.5	safe	5	safe	4	safe	4
B. Safety of product	safe	5	safe	5	burn temp.	2.5	safe	5	safe	5
C. Safety of waste	none	5	none	5	none	5	Moderate	3	water	5
AVERAGE		**4.17**		**4.17**		**4.17**		**4.00**		**4.67**

Table 4.3: Environmental Values and Ratings

4.1.4 Monetary Evaluation

A very important factor of the cost/benefit analysis for Empower was monetary costs, due to fact that Empower is a small company with a small budget. In order to evaluate the Monetary category, we looked at the following subcategories: Startup Costs, Production /Operation Costs, Maintenance and Product Value, which can be seen in Table 4.4. In the Start-Up Cost category we evaluated the raw material costs and the equipment costs. In the Production and Operation Costs we evaluated the electricity costs. Under Maintenance we evaluated how much it would cost to maintain the current equipment and raw materials used to make the different products. In Product Value we evaluated the Market Value and the In-house Value.

The materials that we used to make bar soap were NaOH, distilled water, demethylated glycerin and a container as a mold for the soap. We also added scents to the soap to attempt to change the smell. The equipment needed would be a pot and something to heat up the water and soap mixture on. When we made a small batch we determined that raw materials can range from $7.54 to $13.50 with a one-time cost of $4.97 for the equipment. Empower already has the

materials necessary to make bar soap with the exception of a mold for the soap, sodium hydroxide and scents for the soap. This would reduce costs greatly and make the costs very small for Empower. For this reason we assigned a rating of 4 to Raw Materials and Equipment.

There is very little electricity used in this process except when the soap must be heated. We determined that there was no maintenance needed for the upkeep of the soap making equipment. For this reason we gave Production and Operating Costs a rating of 5. In discussing the Product Value we decided that, if the soap was viable to sell, it would bring $80.00 - $125.00 per batch to Empower. Since this was the highest value, we awarded this a rating of 5. We gave a rating of 4 to the in-house value because the soap could be used to clean up around the shop and potentially reduce in-house costs for buying soap.

We also considered liquid soap. The materials we used were KOH, distilled water, demethylated glycerin and a container to hold the soap. The equipment needed would be a pot and something to heat up the water and soap mixture on. When we made a small batch we determined that raw materials can range from $7.54 to $13.50, just like the bar soap and there were no equipment costs. For this reason we awarded rating of 5 to Equipment and 4 to Raw Materials. The Production and Operation Costs subcategory was similar to that of bar soap and was assigned the same ratings of 5, because this process requires very little energy use. There is also no maintenance for the upkeep of the soap making equipment, thus we gave Maintenance a rating of 5.

In discussing the Product Value we decided that it could potentially bring $80.00 - $125.00 in revenue if the color and scent could be improved. Due to the amount of product that can be attained with such costs we have awarded this a rating of 5. We believe the costs will be

low because Empower already has most of the materials and equipment necessary. We gave a rating of 4 to the In-House Value because the soap could be used to clean up around the shop.

We also evaluated the monetary costs and value of firebricks. Firebricks are very inexpensive to make. The only equipment we purchased was a turkey baster to transfer the glycerin. As such we only spent about $5.00 and awarded Raw Materials and Equipment a value of 5. The Production and Operating Costs were given a rating 5 because there is no electricity required to make this product. This process does not require any maintenance so we awarded it a 5. Fire bricks, although very inexpensive, could be hard to market. We could not find a value for fire bricks or another company selling them. Since we were only evaluating products on a small scale basis, producing and selling enough fire bricks to make a profit is not feasible with the methods evaluated. As such we have awarded the Market Value a rating of 1. We have awarded the In-House Value a rating of 5 due to the fact that fire bricks burn longer and hotter than regular wood and could reduce heating bill costs.

We were not able to purify the glycerin, so our evaluation is based on research as opposed to experimentation. In the Raw Materials subcategory we awarded a rating of 3 and a rating of 1 to Equipment. In order to purify glycerin the company would need a safe lab area to purify and then test the purity levels of the glycerin. This is very costly and is not affordable to Empower, as such we have given these categories low ratings. The Production and Operation Costs subcategory was given a rating of 1. This process is long and involves heating materials and running equipment for a long period of time, making the estimated energy cost higher than soap making and fire bricks. For Maintenance, we assigned a value of 2.5 because the process requires an experienced worker to look routinely check equipment. Market Value and In-House Value were given a rating of 1 because even 100% pure glycerin does not have much value in

any markets. One gallon of glycerin only sells for $1.98 to $2.84. Also Empower could not use it to their benefit in-house

Antifreeze is another expensive process. Empower does not have resources as far as raw materials and equipment are concerned. It would cost around $6,000 to purchase the necessary equipment and $700 to buy materials. For this reason we awarded a 1 for Raw Materials and a 1 for Equipment. This process also requires a lot of electricity to make a final product and as such we have awarded the Production and Operating Costs category a value of 1. Maintenance of the equipment it is also costly so we have awarded the Maintenance subcategory a rating of 1. Antifreeze is valuable if brought to market and as such we have awarded this a value of 3. This product could be profitable if brought to market but the company would be more likely to lose then gain money from such an expensive process. We determined an In-House Value rating of 2 due to the fact that antifreeze could be used in the vehicles that collect waste vegetable oil. This rating is low because the cost of purchasing antifreeze for the vehicles would be less than the cost to produce it.

	Soap				**Fire Bricks**		**Purification**		**Antifreeze**	
	Bar Soap		**Liquid Soap**							
Categories	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**
IV. Monetary										
A. Startup costs										
i. Raw Materials	$7.54 -13.50	4	$7.54 -13.50	4	$5.00	5	$24.19	3	$700	1
ii.Equipment	$10 one time cost	4	$0.00	5	$0.00	5	13.98 w/o condenser	1	$6,000	1
B. Production/Op. costs										
i. Electricity use per batch	very little	5	very little	5	$0.00	5	High	1	High	1
C. Maintenance	none	5	none	5	none	5	yes	2.5	for autoclave	1
D. Value of Product										
i. Market value	$80-125 per batch	5	$80-125 per batch	5	None	1	$1.98 - 2.84	1	$25/ gallon	3
ii. In-house value	use to clean	4	use to clean	4	heat	5		1	for pick up cars	2
AVERAGE		**4.50**		**4.67**		**4.33**		**1.58**		**1.50**

Table 4.4: Monetary Values and Ratings

4.2 Market Possibilities

After learning about the resources available to Empower we have concluded that currently they are not able to bring any of the products to market. They do not possess the equipment to produce either soap or fire bricks on a large enough scale. Also, the current products are not fit to be sold to everyday consumers. To sell the products in a commercial setting, Empower would need to pay a high shelving fee, something that is not in their current budget. This fee could be upwards of $10,000 (personal communication, Chickery Kasouf 2012). This limits Empower to selling their products to small markets, such as other coops and local farmers markets. More possibilities may arise if strategic advertising plans are implemented and the products are improved upon based on the recommendations in the following chapter.

4.2 Prototypes

4.2.1 Fire Bricks

When creating the firebricks, different techniques were used in order to determine the best tactic for making this product. Eight different types of firebricks were created and later tested to determine which firebrick burned the longest and maintained the best shape while burning. Two different types of wood were experimented with, sawdust and wood chips. Also, two different types of glycerin byproduct, glycerol (with methanol still present) and glycerin (demethylated), were tested. Three of the fire bricks we made can be seen in Figure 4.1.

The first firebrick was created using a layering technique. The milk carton was filled halfway with sawdust and then the glycerol was added on top with a turkey baster. Then the sawdust and glycerol were compacted using a two-by-four and a piece of cardboard. This method was repeated until the milk carton had been filled. For the second firebrick, we decided to mix the sawdust and wood shavings in a bucket before putting the mixture in the milk carton.

This provided even distribution of the glycerin and allowed all of the wood to become saturated with glycerin. Again, this firebrick was compacted using the same method as before.

These mixing and compacting methods were used for creating the remaining firebricks. The third firebrick was comprised of a mixture of sawdust, woodchips and glycerol and the fourth was created using only woodchips and glycerol. For the remaining four firebricks, the same methods were used; however, demethylated glycerin was used instead. Also, the last four firebricks were baked in front of a portable heater in order to dry and solidify better. After testing all eight of the prototypes, it was determined that the firebrick comprised of the sawdust, woodchips, and unpurified glycerol burned the best and maintained its shape the longest.

Currently, it would be difficult to market the firebricks and create a profit. The reason for this is that the firebricks are packaged in used milk cartons. There is little visual appeal of this product in its present state. In order for the firebricks to be marketable, they must be packaged in a more reasonable manner.

Figure 4.1: Fire Bricks

4.2.2 Bar Soap

The production of a prototype for bar soap was a very straightforward process. We followed the process as outlined in the background and had no issues. Once the lye had been dissolved into the water the demethylated and strained glycerin was added making the contents of the pot a brownish color. We then added a 1 ounce bottle of lavender scent to try and remove the overpowering smell of French fries coming from the mixture. After we had let the soap congeal over the course of a few days it still remained the brownish color and had a gelatinous quality to it not a solid bar. The smell of French fries persisted as well. This led us to the conclusion that unless the glycerin can be further purified, removing the smell and making the glycerin a near clear color, it could not be sold to a consumer. There is still some in house value to the product because it could be used for general purpose cleaning. At the present time this soap would not be fit for sale to a consumer but if the glycerin was more refined there remains the potential to bring this product to market. Figure 4.2 shows the bar soap before it had hardened.

Packaging of the bar soap would not be necessary if it is only going to be used in-house. The soap can be stored in any air tight container. If the soap were to be sold, packaging could range from $3-8 per batch. All items can be found at WalMart, including plastic bags, ribbon, paper labels and tissue paper. Before packaging can be seriously considered, Empower must find a method to make the soap appealing to the consumer.

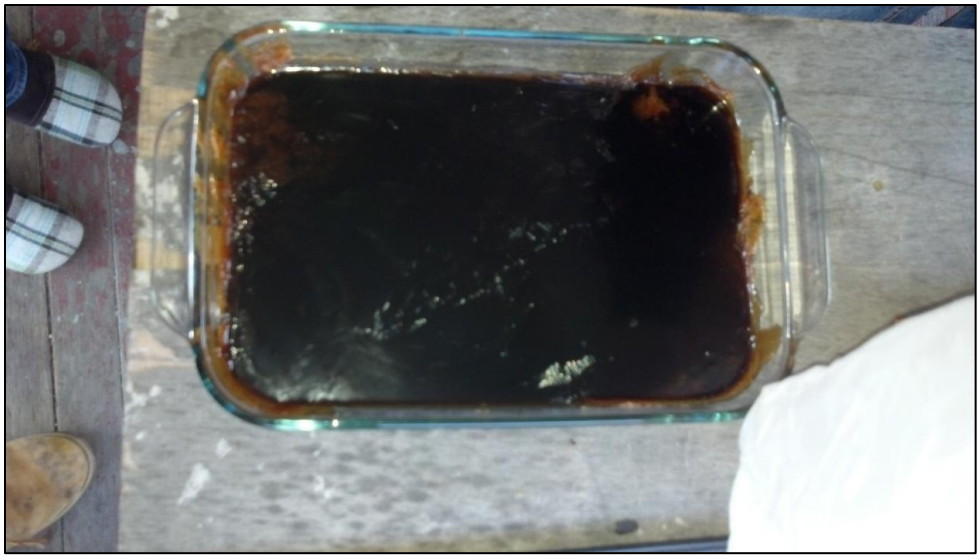

Figure 4.2: Glycerin Bar Soap

4.2.3 Liquid Soap

In creating our liquid soap prototype we used the following materials: KOH, water, and glycerin. When the KOH was added to the water there were slight fumes that were dissipated while stirring the mixture. After mixing the KOH solution with glycerin we were able to produce a liquid mixture that appeared to have the quality of soap, but lacked the usual thickness of soap. After waiting about a week the mixture solidified. We then diluted it with water in order to create a consistency that we considered reasonable. The soap still contained the odor of waste vegetable oil, but this is because no fragrance was added and the glycerin was not purified fully. When the soap was tested, it proved effective in cleaning greasy barrels used to store waste vegetable oil.

In the liquid soap's present state, it could not be marketed due to its heavy scent of waste vegetable oil. However, improvements could be done in order to mask this smell, such as the addition of a perfume. Also, if the glycerin used to make this soap were purified further, it is quite possible to market and sell this product. It is possible that this soap could have industrial applications, such as cleaning floors and machinery. Figure 4.3 shows the liquid soap.

Figure 4.3: Glycerin Liquid Soap

4.3 Surveys

The initial intent of the survey was to have around 30 responses from EPOCA members. The purpose of the survey was to determine how organizations like EPOCA help ex-prisoners reintegrate into society. Unfortunately, we were only able to generate eight responses. Because of this, the data is inconclusive. However, even though there were a limited number of responses, we were able to find trends in the data. 75% of the EPOCA members had been denied employment as a result of a CORI check. The CORI background check proved to be a major obstacle for many of these people. For example, one respondent said I was "fired when [the] CORI came back." Also, another person responded, "they just stated that due to my CORI I wasn't able to get hired permanently." Only two people have been able to maintain a job and the rest are still unemployed. Many of the EPOCA members blame this on the strict laws regarding CORI forms. Because of this, one of the main goals of EPOCA is to reform the CORI laws.

Of the eight responses, the longest amount of time a person had been out of jail was ten years and the shortest was two months. However, the person who had been out of jail for ten years is still unemployed and dealing with the same issues as the person who has been out of jail for two months. Also, it did not seem to matter whether a person committed a violent or non-violent crime, finding employment still proved almost impossible. Most of the people who were surveyed joined EPOCA in order to help create opportunities for other people facing the same issues. EPOCA's goal is to change the way society acts towards ex-prisoners and to help these people with their transition back to society. By creating organizations like Empower, E.P.O.C.A. can help offer job opportunities to the unemployed without the concern of being denied due to a CORI check. 100% of the survey responses state that they would buy products made by Empower. This would potentially create a strong market for any product that Empower could sell. This could lead to a positive change for both the Empower Energy Cooperative and for members of EPOCA.

5. Conclusion and Recommendations

The goal of this project was to recommend two products to the Empower Energy Cooperative that they could use in-house or sell for profit. Empower is a Worcester-based cooperative that provides jobs to ex-prisoners and produces environmentally friendly products. The two recommended products were soap and firebricks, which can both be used by Empower to save money. In the current state of production, these products are only usable in-house. It is Empower's goal to expand and increase their profits, thus these products would need to be improved upon in order to be marketable.

After all four products were analyzed in the cost/benefit table, soap and fire bricks were rated the highest. These products scored especially high in the Environmental and Monetary categories, which were the most important categories to Empower. They both have in-house uses and the potential to be sold in a market. Empower has stated that both soap and fire bricks would be very useful in their daily operations.

In order to make the firebricks marketable, it would be advantageous to find a way to package the firebricks in something other than milk cartons. In order to do this, a mold could be made out of metal in which the wood and glycerin would be placed. This mold would allow the firebrick to be compressed using a device such as an arbor press. Mechanically compressing the firebricks would help them to maintain their shape. A metal mold would also allow the firebricks to be baked in an oven which would provide further structure. Once the firebricks have been compressed and baked, they would be removed from the mold and wrapped in paper. The paper wrapping could include a design and be used as a label. This tactic would allow the firebricks to be much more marketable than they are now.

For sale of both glycerin bar and liquid soap, purification is essential. Currently, the smell and color of the finished soap make it undesirable for the consumer. Purification to remove the smell and brown color could be attempted using the methods outlined in the background chapter. Once purification of the glycerin is achieved, fragrance and color could be added to the soap. It was our original intent to use laboratory space at WPI to determine the best purification technique. However, due to unforeseen circumstances space was not available. Also, Empower did not have the necessary equipment or chemicals for purification to be attempted. In the future, an IQP could work specifically on the purification of glycerin from the biodiesel process.

Although we only received 8 responses to the survey, we were still able to draw conclusions about the ex-prisoner population in Worcester. The results of the survey proved that businesses like Empower are beneficial to the ex-prisoner community. Such organizations provide opportunities to ex-prisoners that would otherwise be unavailable. By not requiring CORI checks, Empower employs people based on current work ethic and not criminal background. It is our desire that our recommendations to Empower will help them to continue promoting sustainability and providing jobs to ex-prisoners.

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Appendix A: Completed Cost/Benefit Analysis

	Possible Uses									
	Soap				Fire Bricks		Purification		Antifreeze	
	Bar Soap		Liquid Soap							
Categories	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**	**Value**	**Rating**
I. Efficiency										
A. Time	6 days	1	7-10 days	1	13 hours	4	5 hours	5	28 hours	3
B. Yield	45 bars	5	1.1 liter plus water	5	7 Bricks	5	30% (3.15 lb)	1	50% (.5 gallon)	2
D. Upgradeability	purification?	5	purification?	5	No	1	Yes	5	none	1
AVERAGE		**3.67**		**3.67**		**3.33**		**3.67**		**2.00**
II. Personnel										
A. Complexity	minimal	5	minimal	5	Minimal	5	Moderate	3		2
B. Involvement	minimally	5	minimally	5	Minimal	5	Moderate	3	minimal	3
AVERAGE		**5.00**		**5.00**		**5.00**		**3.00**		**2.50**
III. Environmental										
A. Safety of materials	NaOH	2.5	KOH	2.5	safe	5	safe	4		4
B. Safety of product	safe	5	safe	5	burn temp.	2.5	safe	5	safe	5
C. Safety of waste	none	5	none	5	none	5	Moderate	3	water	5
AVERAGE		**4.17**		**4.17**		**4.17**		**4.00**		**4.67**
IV. Monetary										
A. Startup costs										
i. Raw Materials	$7.54 -13.50	4	$7.54 -13.50	4	$5.00	5	$24.19	3	$700	1
ii.Equipment	$4.97 one time cos	4	$0.00	5	$0.00	5	13.98 w/o condenser	1	$6,000	1
B. Production/Op. costs										
i. Electricity use per	very little	5	very little	5	$0.00	5	High	1	High	1
C. Maintenance	none	5	none	5	none	5	yes	2.5	for autoclave	1
D. Value of Product										
i. Market value	$80-125 per batch	5	$80-125 per batch	5	No market value	1	$1.98 - 2.84	1	$25/ gallon	3
ii. In-house value	use to clean	4	use to clean	4	heat	5		1	for pick up cars	2
AVERAGE		**4.50**		**4.67**		**4.33**		**1.58**		**1.50**
WEIGHTED AVERAGE		**4.32**		**4.37**		**4.20**		**2.97**		**2.72**

Appendix B: Data Matrix

What do we need to know?	Why do we need to know this?	What kind of data will answer the question?	Where can we find the data?	How will we collect the data? (Methods)	How will data be analyzed?	How will data be portrayed in the proposal?
What are some simple and cost effective uses of pure glycerin?	to find a source of profit or in-house use	(See Cost/Benefit Analysis)	Online resources, sponsor meetings	research	cost benefit analysis, prototypes	summary chart, pictures
Can this help to reintegrate ex-prisoners back into society and to lower re-incarceration rates?	to see if Empower can truly have a positive impact on the community	background research, survey and interviews of ex -prisoners	through interviews and surveys, online research	interviews, paper survey for EPOCA members	comparison of ex-prisoners who did and did not get involved in their community or find work	comparison charts, discussion

Appendix C: Glycerin Product Fact Sheets

Glycerin Fire Bricks

Materials: crude glycerin (no filtering or demethalation step required), sawdust, wood chips, paper milk cartons or another mold

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Procedure:

1. In a plastic container, add sawdust and/or wood chips to desired volume. We found that a 1:1 mixture of sawdust and larger woodchips burned the longest.
2. Add crude glycerin, mixing after each addition. Continue adding until the mixture is saturated.
3. Pour glycerin and sawdust mixture into paper milk carton. Pack down firmly.
4. Allow the bricks to dry for approximately one week before burning, or try baking in an oven for a shorter drying time.
5. Add brick to hot fire. Burn while still in paper carton.

WARNING!

Must burn above 536 degrees Fahrenheit. Only add to an already burning fire; do not use to start fire.

Safety:

- Glycerin – NFPA Health rating: 2. Harmful if absorbed or inhaled.

Costs: $0.00 if materials are found in-house. We suggest asking restaurants for empty cartons.

Glycerin Bar Soap

Materials: Purified glycerin (demethalated and filtered), lye (sodium hydroxide), water, fragrance

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Procedure:

1. Heat 1 quart of water to 100 degrees Fahrenheit.
2. Add 5.5 oz. of lye (sodium hydroxide) to the warm water and stir to dissolve.

   WARNING!

   Fumes from this reaction are caustic and harmful to the respiratory system. Wear a mask and work in a well-ventilated area.
3. Add lye mixture to one gallon of glycerin and heat for 20 minutes, stirring constantly for the first 10 minutes and occasionally for the second 10 minutes.
4. Pour into a flat bottomed plastic container and let sit for 24 hours.
5. Cut into bars.
6. Allow the soap to cure for at least 5 days before use.

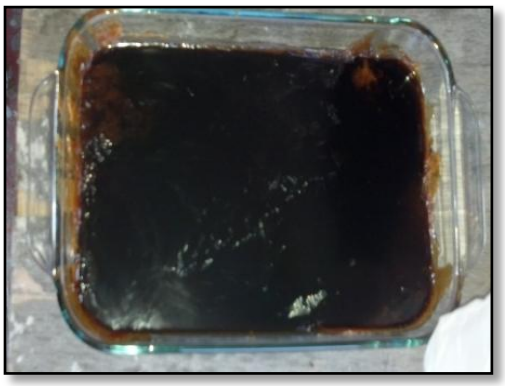
Modifications:

- Add more water to increase foam.
- Add more lye to increase the grease-fighting power.
- If higher purity glycerin is achieved, add fragrance, which can be found at craft stores for about $2.00.

Safety:

- Glycerin – NFPA Health rating: 2. Harmful if absorbed or inhaled.
- Lye (sodium hydroxide) – NFPA Health rating: 3. Corrosive to living tissue and toxic if absorbed. Gloves should be worn and can be made of butyl rubber, nitrile rubber, and/or polyethylene. Goggles and clothing that cover skin should also be worn.

Costs: Lye $14.61 from Biodiesel Supply Store and Chemicals at Amazon.com, plastic tub $4.97 at WalMart



Glycerin Liquid Soap

Materials: Purified glycerin (demethalated and filtered), potassium hydroxide, water

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Procedure:

1. Heat 80 – 100 mL of water to 110 degrees Fahrenheit.
2. At the same time, heat 1 L of glycerin to 120 degrees Fahrenheit in a separate container.
3. Add 50 – 75 grams of potassium hydroxide to the warm water and stir to dissolve.

   WARNING!

   Fumes from this reaction are caustic and harmful to the respiratory system. Wear a mask and work in a well-ventilated area.

4. Add glycerin to dissolved KOH. Remove from heat and stir.
5. Allow soap to sure 7 – 10 days before use.
6. Final product should be thick. Add water to make soap more liquid.

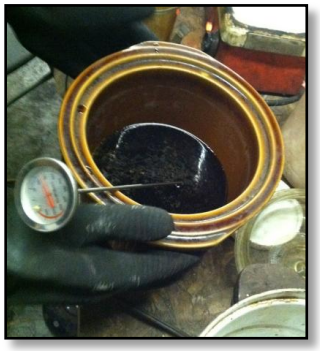
Modifications:

- Add more water to increase foam.
- Add more KOH to increase grease-fighting power.
- If higher purity glycerin is achieved, add fragrance, which can be found at craft stores for about $2.00.

Safety:

- Glycerin – NFPA Health rating: 2. Harmful if absorbed or inhaled.
- Potassium hydroxide – NFPA Health rating: 3. Corrosive to living tissue and toxic if absorbed. Gloves should be worn and can be made of butyl rubber, nitrile rubber, and/or polyethylene. Goggles and clothing that cover skin should also be worn.

Costs: Potassium hydroxide (already have in-house)



Appendix D: WPI IQP Survey Questions

1. How long have you been out of prison? _____ (to the nearest month)
2. Were you incarcerated for a violent or non-violent crime? _____
3. On a scale of 0 – 5 how difficult was it to find employment after being released? (Circle 0 if unemployed)

   very difficult not difficult

   0 1 2 3 4 5
4. How long have you been employed? _____ (to the nearest month)
5. On a scale of 1 – 5, how satisfied are you with your current job? (Circle 0 if unemployed)

   not satisfied very satisfied

   0 1 2 3 4 5
6. Were you ever denied employment after a CORI check or given another explanation for the decision?

   _____

   _____

7. What made you decide to get involved in EPOCA?

   _____

   _____

   _____
8. Would you specifically buy a product made by Empower? Please circle.

   YES NO

Dear EPOCA Member,

We are a group of students from Worcester Polytechnic Institute working on our IQP project. We are working for the Empower Energy Cooperative looking into potential uses for the waste glycerin produced from their biodiesel. While talking with Luis Bajana we have learned how EPOCA helped to found Empower. This has made us want to take a closer look at EPOCA to see the effect that it has on the community. We hope to do this with the attached survey. Please read and sign the consent form below.

Thank you for your time.

Emily Johnson, Ijeoma Ezeonyebuchi, Chris Welsh, Stephen Allen

SURVEY CONSENT FORM

I agree to participate in a survey for a study about the transitional period for ex-prisoners returning from incarceration. I acknowledge that the survey will inquire about personal experiences and my involvement with EPOCA. I am aware that any materials taken from this survey will disguise all names of persons and places so as to preserve my anonymity and privacy. I understand that I will not receive feedback on my survey. I understand that after the study has concluded, the all survey materials will be kept privately in the researcher's archives for future reference. I understand that if my feelings for this survey change at any time, the survey can be discontinued.

If you have any questions about the survey or the study please feel free to contact our IQP group at: Empowerc12@wpi.edu

Signature:_____ Date:_____