Producing biodiesel from soybeans environmental sciences essay

Vasu AddankiRavi Teja PennadaBio-FuelsTeam Project ReportThe report provides details regarding the assessment of the energy needs of the group. This includes heating and powering the homes, cooking food, heating/purifying water, running vehicles, working a 30 acre farm and other miscellaneous needs. This report also explains how these energy needs can be met using local resources emphasizing on the approach of energy production, justifying the technology used. Bio-FuelsTeam Project Report

Introduction

Problem Setup: The compound is located in Par Drive, Rantoul, Illinois, USA. Illinois lies midway between the Continental Divide and the Atlantic Ocean. The State's southern tip is 500 miles north of the Gulf of Mexico. Illinois' climate is typically continental with cold winters, warm summers and frequent short fluctuations in temperature, humidity, cloudiness and wind direction. Many people consider the more moderate temperatures of spring and fall to be the most pleasant. Average annual temperatures range from 48 to 58° F with highs ranging from 57° F to 67° F. Average winter highs range from the 30s to the mid-40s, while average lows range from the teens to the upper 20s. Average summer highs are in the 80s, while lows are in the 60s across the State. Both spring and fall have more moderate temperatures. Average spring highs range from 57° F to 67° F, while average low temperatures range from 36° F to 48° F. Average fall highs range from 60° F to 70° F, while average low temperatures range from 40 to 48° F [1]. The plants that can be grown in Rantoul, Illinois include but not limited to soybeans, corn, peas, tomatoes, squash, asparagus, rhubarb, potatoes and carrots. The main criteria is that the plant must love heat and high humidity

but also must be tolerant of extreme frigid temperatures when the seasons change. The forests consists of a mix of trees including evergreen types, oak, maple, holly, poplar, cottonwood, ash, cherry, weeping willow, birch [2]. Water is naturally available as there are lakes near Rantoul. There are 6 lakes located within 50 miles radius of Rantoul, the closest one being Lake of the Woods located 14 miles from Rantoul [3]. Assumptions: Several assumptions were made while calculating the energy needs of the group and also while calculating the energy to be produced. 1 acre of soybean field produces 47 bushels and 1 bushel produces 1. 5 gallons of biodiesel [8][9]An average American eats about 1600 lbs of food in a year (This estimate excludes food that cannot be produced in this area) [11]Assumptions about vegetable yield: [13]Potatoes – 30000 lbs/acreTomatoes – 25000 lbs/acreCarrots – 18000 lbs/acreCorn – 6000 lbs/acreSoybeans – 2820 lbs/acreAssumptions about the vehicle mileage

Energy Assessment

The energy assessment of the group basically comprises of heating and powering their homes, cooking food, heating/purifying water, running vehicles and working a 30 acre farm. We ran an energy analysis of a typical farm house (4000ft2). This analysis included heating the house, lighting, cooking, and water heating. The total energy used for these was found to be around 35000 KWh for each house. Major portion of this total was contributed by home and water heating. Heating for both the farm houses was calculated to be around 30000 KWh. Cooking contributed about 6000 KWh for both homes. Powering/Lighting the homes was calculated to be around 6400 KWh for both homes (including miscellaneous equipment).

Heating water was calculated to be around 29000 KWh [15]. The tanker truck is assumed to have a capacity of 10000 gallons which is used to transport water from the lake to the compound. The lake is located 14 miles away from the compound. Hence it need to travel 82 times per year to collect the required amount of water. The dump truck is used to transport the agricultural produce, wood from the forests etc, assuming around 100 miles in total. Toyota Hilux & Nissan Leaf are used only to run errands hence assumed to run only 20 miles. VW Transporter is used to transport people back and forth from the forest, field etc hence assumed to run 100 miles [a]. Assuming the energy efficiency of generators to be 10 KWh/gallon of fuel. Vehicles use up about 404 gallons. Electricity used powering/Lighting the homes came up to about 6400 KWh. Hence it uses up to 640 gallons. Cultivation of the vegetables requires about 25. 5 gallons. Therefore, total biodiesel consumption come to about 1070 gallons [a]. According to US Department of Agriculture, an average American eat about 1996 lbs of food per year [11]. Since not all them can be produced in Rantoul and the group has to save some stock for the future, it is assumed that they eat around 1600 lbs per year. Hence, the group on the whole consumes 48000 lbs of food per year. Assuming 7000 lbs of food is allocated for the animals, the total food consumption is 55000 lbs per year [b]. Breaking this down, the food basically consists of potatoes, tomatoes, carrots, corn, soybeans and also meat from cow, pigs, hens, fish etc. Poultry food like milk, eggs etc has also been included. A person, on average, drinks about ¾ gallons of water per day. Hence the group consumes about 8212. 5 gallons of water in a year. Including water consumed by animals, cultivation, production of KOH etc; total water consumed can be assumed to be around 820, 000 gallons [c], as

cultivating one acre of land takes about 27000 gallons of water [16]. Cultivation of the farms takes up about 8. 5 KWh per acre which comes down to about 255 KWh. Cooking food requires us to burn about 3160 lbs of wood. Heating the houses (30000 KWh) requires about 15790 lbs of wood. Production of methanol requires about 68563 lbs of wood. In total we need to burn about 87513 lbs of wood or about 63 trees [d].

Energy Production

The required energy needs can be met by both, producing biodiesel from soyb1eans and also by burning hardwood. The biodiesel produced from soybeans is used in running the generators and the vehicles. The energy produced from burning wood is utilized in heating the house, cooking, purifying water, producing methanol and KOH. Firstly, we must take into consideration the acres of land to be cultivated for vegetables so as to meet the food requirements of the group and animals. Allocation of land for cultivation [13]: 1 acre of potatoes: 30, 000 lbs1 acre of tomatoes: 25, 000 lbs1 acre of carrots: 18, 000 lbs2 acres of corn: 12, 000 lbs25 acres of soybeans: 70, 500 lbsThis brings the total weight of the food produced per year to 155, 500 lbs. Since there is ample food for the whole group and also the animals, the whole soybean harvest can be used to produce biodiesel. Purifying water: Water can be purified by either boiling it or by using moringa seeds. Moringa is a plant that can be grown in Illinois itself and its seeds are highly potent. For purifying the waer using moringa seeds, we must first collect the pods from the plant and then remove the seeds. Depending upon the quantity, crush the required numer of seeds in to the water. In general, 1 seed kernel can clean 1 liter of water. Mix seed powder with clean water and

form a paste. Mix this paste with some clean water and shake it so as to activate the coagulants. Filter this solution into the water that has to be treated using a screen. Stir it for a while and allow it to settle down. Clean water is filtered out before use [10]. Making Lye (KOH) [17]: Lye is a powerful base (alkali) that can be created using rain water and wood ashes. Lye created from wood ash is potassium hydroxide (KOH) whereas commercial lye is composed of sodium hydroxide (NaOH). Modern chemical engineering has all but replaced the traditional method of producing lye. Production of lye requires only two ingredients: wood ash and water. Collect rainwater -- it should be free of chemicals and excessive mineral levels that are found in city and well water. Using wood ash from broad-leaved hardwood trees will result in better quality lye than if you use ash from soft woods or conifers. Before discussing how to make lye, it is important to note that lye is very dangerous and extreme caution should be used when making or handling lye -- whether commercial or homemade. First, 2-3 gallons of soft water is collected (easily available as rain water or purify water collected from the lake). The purer the water, the more potassium that can be leached from the ashes. Next, a wooden barrel is taken and a hole is drilled approximately 2in above the base. We made sure that the cork fits snugly into the hole. Since lye is caustic, necessary precautions were taken. We then put the barrel on a brick base someplace where it will not be disturbed. Next, we cover the bottom of the barrel with some palm-sized clean rocks (eg. River rocks). Cover the rocks with approximately 6in of straw (hay or grass). This will filter the ashes and help lye drain cleanly. Next we must collect ash. If not enough, we burn some hardwoods in a fireplace or woodstove where the ashes won’t mix with anything else. After the ash is completely cold, scoop it

out and fill the barrel with it. Amount of ash required depends on the amount of the lye we are making and also the concentration of the lye being produced. Next soak the ashes by pouring the soft water we collected earlier. After a day, the first ash should settle and then we can add more ash. Since we need highly concentrated lye to produce bio-diesel, we must add more ash to it. Hence, more ash is add regularly and the extra water is drained. Once it is ready it is used to make bio-diesel. Once made, it has to be used as quickly as possible for better results. Amount of ash required in this process can be obtained from what's left from cooking food, heating water, production of methanol etc; therefore no extra wood needs to be burned. Making methanol [12]: Methanol, or wood alcohol, is a clean burning fuel additive, as well as an effective solvent. It is extremely flammable, so great care should be taken in making this substance. A distillery unit, or still, will be needed to hold the wood that you will be using to extract the methanol from. It should resemble the stills used to make liquor. It should be a closed system, with a place to insert wood and then be completely closed, with a pipe to catch the condensed vapor and transport it to a separate container. Put the wood in the unit. The wood can be chunked or shaved, but the smaller the pieces of wood, the easier the methanol will be extracted from it. You will need to heat the unit, usually by open flame. This will superheat the wood inside, keeping it shielded from the actual flame, and so reducing the possibility of combustion. The methanol will vaporize and rise up to the top of the still, where the cooler air will begin the condensation process. The condensed, liquid, methanol is then collected separately. Only 0. 02 lbs of methanol can be produced by burning 1 lb of wood. Since 20% methanol is required for every gallon on soybean oil used, a total of 68563

lbs of wood or 49 trees has to be burned down [5][d]. Producing biodiesel from soybeans [5] [7]: The most common method for producing biodiesel is transesterification. Transesterification is a common method for biodiesel production from vegetable oils and animal fats and usually preferred instead of direct esterification. Catalyst used here will be KOH. For clean, un-used soybean oil, there is a base amount of catalyst that has to be dissolved into the methanol to make a complete reaction. For KOH, the commonly accepted amount is 7 grams of KOH per 1 liter of soybean oil to be converted. Purity must also be taken into account. It is important to factor in purity with KOH since it is usually about 90%. To factor in purity in your calculations, divide the base catalyst amount by the % purity. We usually carry KOH with a purity of 90% or so, which makes the calculation 7g/0. 99 = 7. 707g of KOH per liter of oil. Soybeans are harvested based on the amount of biodiesel being processed. After harvesting, they are dried and precautions should be taken that the beans are properly dried as the presence of moisture lowers production rate. Next comes the process of dehulling, in which the outer covers of soybeans are removed. Then these seeds are transferred to a grinding chamber where they are reduced to smaller chunks by using oil extraction mechanical press. Purification can be done by using various filtration techniques. This is the mechanical part of the process. Now coming to the chemical part, methanol and the catalyst (KOH) are mixed together into a solution. Mixing methanol-KOH solution can be tricky. Since we’re dealing with larger amounts of methanol, we cannot simply shake it up like in a test batch and sometimes there’s too much catalyst required to just let it sit overnight and dissolve. The best solution to this, is to find a propeller, run it to a shaft which comes up and through the cover in the tank and is

sealed off with some washers so that it’s free to rotate, and then use a power drill to attach to the shaft and spin the propeller at rapid speeds. Amazingly, it will only take less than a minute for KOH to dissolve into methanol with this set-up, if even that long. The methyl catalyst is then slowly mixed into the soybean oil for a certain period of time. Once a complete reaction is made, the methyl esters will replace the free fatty acids in the soybean oil and drop out as a glycerin by-product. After a few hours of settling, you’re left with biodiesel on the top and glycerin on the bottom. The amount of methanol required for the process is about 20% of the volume of the oil to be processed. Some brewers use 21% or even 22% to be sure there is enough. The reaction between methanol and the catalyst is exothermic. It is extremely important to make sure there is no water in the soybean oil before processing. Settling is the easiest way to remove water. If soybean oil is left in a cone tank for 2-3 weeks and left untouched, all of the water can be drained out the bottom readily. This process can be sped up by installing a heating element at the bottom of the tank and gently heating the oil up to and maintaining it at about 100°F to 110°F for 4-6 hours. This can be done by placing the tank over burning wood. The heat decreases the density of the vegetable oil greatly while the water’s density remains about the same, settling the water down faster than normal. After the initial 4-6 hours of maintaining heat, the vegetable oil should be completely separated after 12 hours, preferably 24 hours. We need about 1070 gallons of biodiesel to generate enough electricity and run the vehicles and the farm equipment. To produce this, we need to harvest about 15. 2 acres of soybeans. The rest can be used to eat and feed the animals. Energy from burning wood: Hardwood is collected from the forest which is easily accessible. Hardwood trees that

usually grow in this area include but not limited to oak, maple, holly, poplar, cherry, weeping willow, birch [2]. These can be used to heat the house, cooking food, heating/purifying water. One oak/birch tree usually weighs around 1600 to 1800 lbs [14]. After cutting it and arranging them in cords, the weight comes down to 1200 to 1400 lbs (about 75%-85%) [14]. Burning wood produces about 1. 9 KWh/lb. From the calculations, we found out that for cooking food requires us to burn about 3160 lbs of wood. Heating the houses (30000 KWh) requires about 15790 lbs of wood. Production of methanol requires about 68563 lbs of wood. In total we need to burn about 87513 lbs of wood or about 63 trees. Hence, 63 trees worth of wood can be collected from the forest and transported back to the compound for the energy purposes [d].

Shortcomings

Several problems were found while assessing the energy to be produced. Biodiesel produced cannot be used for heating as it takes up a lot of energy cannot be sufficed by biodieselProduction of methanol from burning wood is highly inefficient as it produces only 0. 02 lbs per 1 lb of wood. Therefore, 68563 lbs of wood is required just for making methanol which is equivalent to 49 trees.

Summary

FuelAmount of biodiesel required – 1070 gallonsAmount of biodiesel that can be produced – 1762. 5 gallonsFoodAmount of food required – 55000 lbsAmount of food that be produced (from farming alone) – 155, 500 lbsWaterAmount of water required – 820, 000 gallonsAmount of water that can used (from Lake of the Winds) – 105, 250, 010 gallonsWoodAmount of

wood required – 87513 lbsAmount of wood that can be used – 12, 600, 000 lbs