University of Illinois at Urbana Champaign

Feasibility of Chip Energy's Biofuel Production Network

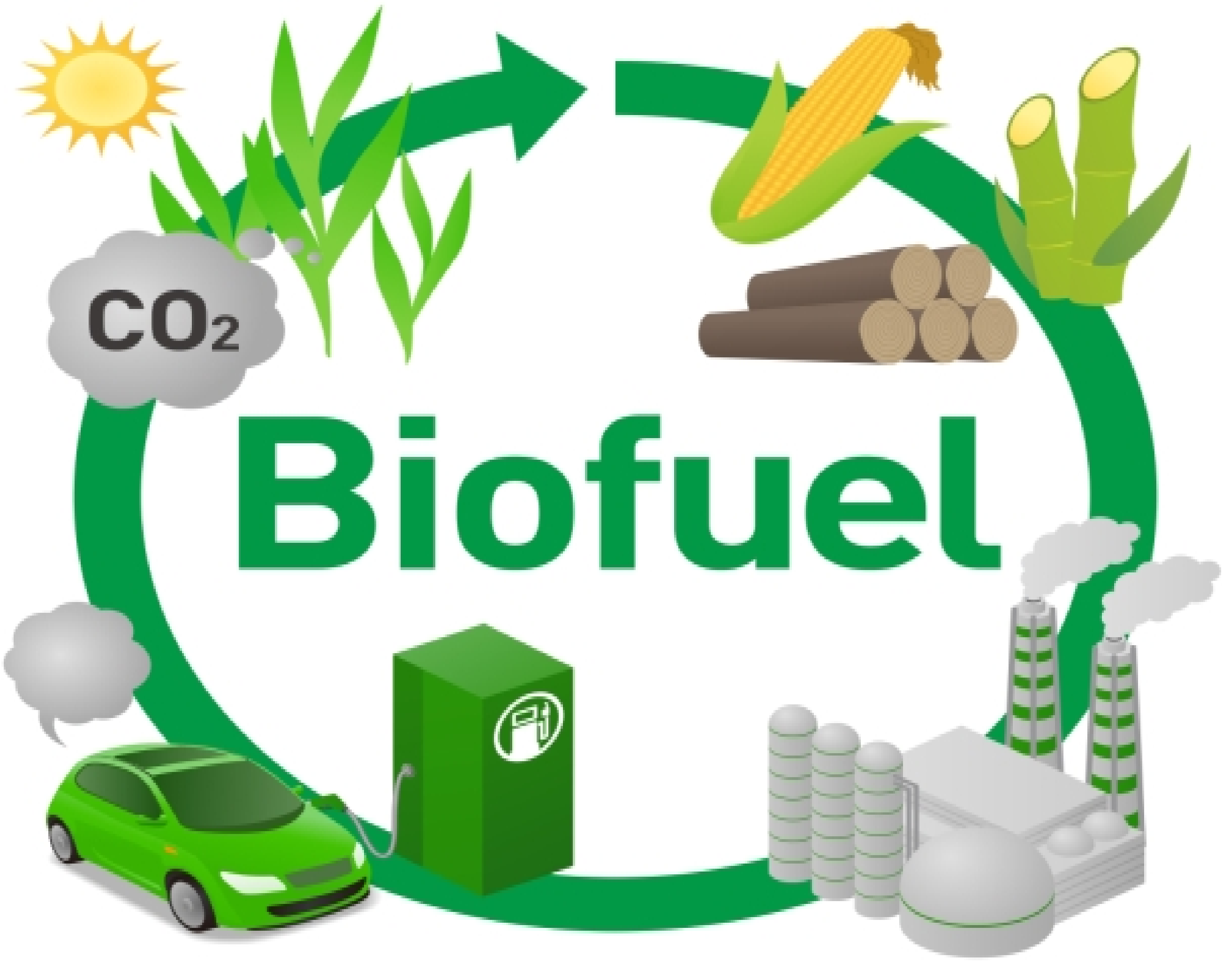

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Table of Contents

Executive Summary 3
Introduction 3
Objectives 4
Scope 4
Task 1: Review Literature 4
Task 2: Conduct Data Verification 5
Task 3: Conduct Verified Data Re-Analysis 5
Task 4: Write Report 5
Results 6
Conclusion 11
Acknowledgements 11
References 12
Group Reflections 14

Executive Summary

The project in question is designed to analyze the prospective cellulosic material shipping methods proposed by the company, Chip Energy, to be used in supplying the United States biofuel industry. By harvest~~ed~~ing chopped biomass and compacting it to maximize space usage for truck transport within shipping containers, Chip Energy proposes that this simple correction to the biomaterial trucking network in the United States can save at least one fourth the space and half of the money involved compared to the current process that utilizes trucks transporting bales of the biomaterial to accomplish the same job. Analysis of the proposed data from Chip Energy, that conveys the potential space and money saved, is compared to data from professional sources, and a comprehensive review with recommendations is made. Following analysis, the team finds that the company's claims of creating a potential decrease in biofuel production cost by one half and biomaterial storage cost by one fourth is plausible compared to the traditional shipping.

Introduction

According to the article "Planetary boundaries…," each year fossil fuels contribute to heightening environmental degradation of the atmosphere to the point where we ~~are surpassing~~ have surpassed the threshold of 400ppm of Carbon Dioxide in the atmosphere, which is well beyond the 200ppm average that has exist~~ing~~ed for the past 10,000 years~~thousands of years during the Holocene (i.e., the past 10,000 years)~~ (Steffen et al 2015). Currently, the worldwide energy demand is based on finite, unsustainable levels of high emission fossil fuels while renewable/low carbon energy systems are struggling to emerge and mitigate these issues. In particular, biofuel~~s are~~ production is a struggling industry that is having difficulty growing due to low returns on investment. According to the U.S. Department of Energy Efficiency and Renewable Energy's 2016 Billion-Ton Report, the biofuel industry, if used optimally, can potentially go from producing 10% to producing 25% of United States energy without hampering any other bioproduct industry~~ies~~ ("2016 Billion-Ton Report" 2016).

Considering environmental impacts and future consumption of resources, biofuels ha~~s~~ve the potential to reduce net carbon emissions, while also being a more sustainable energy source. Biofuels are classified as cellulosic energy reserves created from organic matter, which can perpetuate a cycle where carbon is recirculated between biomass, fuel, and emissions. Paul Wever states Chip Energy is a growing company with the aspirations to economize the biofuel process with and end goal of at least 30-40% reduction in cost compared to the current industry (Wever 2017).

Similar attempts at expanding biofuel use have appeared to fail in the past decade. The overarching themes that seem to be the issue are the lack of financial returns, minimal national participation, and the current low prices of oil held in the hands of OPEC (Organization of the Petroleum Exporting Countries). For example, KiOR was set on helping the nation transition from fossil fuels to cleaner biofuels, however, the company only made about 5% of their initial investment. Also, the lack of inputs for yields and inefficiency in the new processing technology bankrupted the factory a few years ago (Fehrenbacher 2015).

However, Chip Energy is based in the pre-existing infrastructure of trucks, which are linked to facilities that utilize well-developed components, namely shipping containers. This unique aspect gives Chip Energy an edge that is worth exploring as a new take on the possible production of biofuels.

Objectives

The project of interest is a business feasibility analysis for Chip Energy, which aims to provide a more cost-effective biofuel production structure. Having awareness of these potential shortcomings, the owner of Chip Energy, Paul Wever, claims that the company reduces costs in shipping biomass from suppliers, such as farms, by approximately 40% by relying heavily on using compactors, containers and shorter transit routes~~.~~ (Wever 2017). Wever also believes the company provides a path to a sustainable future for generations by promoting the sale of biofuels near the maximum potential. Hence, the project at hand is reviewing Mr. Wever's company data, comparing that data to the project team's redeveloped versions of the same data, and advising as to whether the business plan feasibly adheres to the claims of maximizing biofuel development through improved economics/logistics.

This is done by reviewing the logistic accuracy of the claims, such as the increased shipping efficiency using ~~ground~~ biomaterial that has been ground instead of baled. The team also provides a strict economic evaluation of Paul Wever's price data for Chip Energy using a financial cost/benefit analysis. Dana Gunders explains in the Natural Resource Defense Council article "Left Out…" that as much as 34% of crops are left unharvested in farm fields on average (Grunders 2016). Morgan White, the Director of Sustainability at Facilities and Services at the University of Illinois Urbana-Champaign, also explains that people generally are unwilling to change and adapt to new sustainable technology, especially if there are no immediate benefits (White 2017). Knowing this, the project team can evaluate generally how much ~~costs~~ money Chip Energy, and possibly the biofuel industry, can save from shipping the product to the appropriate destinations. The analysis also allows Paul Wever to see if, compared to traditional shipping, the claims/data substantiating Chip Energy's economized biomass shipping are indeed true and economically valuable enough to continue pursuing.

Scope

The project is divided into four primary tasks that determine and compare the logistics of Chip Energy's business objectives to the market, decide what objectives needed the most review based on the market, and conduct the necessary review with reconstructed data from the current market.

Task 1: Review Literature:

The purpose of the first task is to evaluate the goals of Chip Energy and compare them to similar pre-existing businesses to determine economic feasibility.

In the first subtask, qualitative data is obtained from relevant successful companies, like Praful International, to understand their respective businesses and find any immediate shortcomings of Chip Energy compared to the developed businesses.

The data is reviewed in the second subtask for similarity in objectives, general emissions procedures, costs of abatement, and magnitude of success to see if Chip Energy even has feasible goals in mind.

The third subtask is performing an initial screening of the company objectives to determine if they are at an immediate disadvantage to the present comparable market.

Task 2: Conduct Data Verification:

Task two is to retrieve relevant market and resource data along with Chip Energy's company data to decide which components of the company plan may or may not be consistent with the relevant data. As a result, recommendations for business changes can be made if any logical or quantitative inconsistences in the Chip Energy data are exposed, and the weakest of the company goals become the subject of complete re-analysis.

The first and second subtasks involve contacting representatives and reviewing sources such as Paul Wever of Chip Energy to collect relevant quantitative data regarding the numerical claims of Chip Energy's plans and the business figures, such as production cost and profits per unit volume, of other successful entities involved in the biomass production process.

Using data of this nature, the third subtask involves the discovery of the weakest goal(s) and/or inaccuracies in Mr. Wever's business plan.

Doing so, in the fourth subtask, the plan(s) can be reconstructed using calculations with new perspectives and numerical data in accordance to what is found.

Task 3: Conduct Verified Data Re-Analysis:

The third task is to take the subject(s) of re-analysis and reprocess the calculations with the revised values based on the relevant data. Applying that reworked information, recommendations to repair the weak company objective(s) are made while the assessments of benefits/costs in a style reminiscent of a sensitivity analysis are applied.

The first and second subtasks involve data analysis with the redesigned calculations from part two being performed to review their consistency with the initial outputs given by Mr. Wever.

In the third subtask, if any negative discrepancies arise, recommendations for improved company performance, such as different processing station placement, revised shipping methods, and larger consideration of cost from environmental impact, is constructed along with documentation of any newfound benefits and confirmed data. Together, these calculations are used to conclude and/or verify how feasible and beneficial the company aspirations of Chip Energy are.

Task 4: Write Report:

Task four is primarily organizing the data in the first three steps into a comprehensive report and PowerPoint to effectively convey the conclusions.

The four subtasks of this step involve processing and editing the raw research data into a concise report, which clearly conveys the conclusions regarding the capability of Chip Energy's goals to be developed into a successful business venture and determines if the company owner, Paul Wever's, personal data, that supposedly confirms said success, is verified.

Results and Discussion

The resulting analysis outlined in table one concludes that the claims Paul Wever of Chip Energy made regarding his biomaterial shipping plan are true. The unit dimensions of a round bale, square bale, and shipping container are first verified by the article "Biomass Densification for Energy Production" and are shown to be nearly the same. These specifications are then reevaluated and used to find unit volumes of the same entities that are fairly consistent with the preexisting data except for the internal volume of a shipping container, which is found to be 1170 cubic feet, according to the article "Shipping Containers: 40ft, 20ft, 10ft & 8ft shipping containers for secure storage and shipping" instead, of the 1161 cubic feet specified by Chip Energy.

The trailer payloads are then reevaluated by multiplying the newfound biomaterial density ranges, which are shown by other experts to differ substantially from that given from Chip Energy, by the volumes of the entities and number of units of each entity Chip Energy says can be shipped per 53 ft. trailer load. The results are displayed in Table 1 and are based on the following formula.

Payload Capacity = (Density of Material)*(Volume of Material Unit)*(Unit Shipping Capacity of Trailer)

Table 1: Trailer Payload Comparisons (Chip Energy Data vs. Report Data)

Unit Type	Round Bale	Square Bale	Shipping Container
Unit Dimension	6 ft diam.	3x4x8 ft	8x 8.5x20 ft
Unit Volume [ft^3]	141	96	1161
Packed Density [lb/ft^3]	Avg. 8	Avg. 10	Avg. 18
Units per 53 Foot Trailer	30	42	2
Trailer Avg. Payload [lb] .	33,840	40,320	41,796

Unit Type	Round Bale	Square Bale	Shipping Container
Unit Dimension	6 ft diam.	3x4x8 ft	8x8.5x20 ft
Unit Volume [ft^3]	141	96	1170
Packed Density [lb/ft^3]	10-12	13-16	13
Units per 53 Foot Trailer	30	42	2
Trailer Avg. Payload [lb] .	42,300-50,760	52,416-64,512	30,420

The team discovered that a typical biorefinery needs 240,000 tons of biomass per 300 day working year to operate according to “Cellulosic Biofuels: Analysis of Policy Issues for Congress” (Bracmort, K. et al. 2011). That means 800 tons need to be received per day. From this, the total annual shipments needed and shown in Table 2 are found using the following formula and the range of payload capacities calculated earlier.

Daily Shipments = (800 tons)/[(Payload Capacity)/(2000 lbs./ton)]

Using this calculation for the range of daily shipments, the annual shipment ranges for each biomaterial are found by simply multiplying the daily shipment values by the 300 days per working year. These results are also shown in Table 2 below.

Table 2: Total Biomaterial Deliveries Comparison (Chip Energy Data vs. Report Data)

Biorefinery Assumptions: 336,000 annual tons;300 Handling working days; 1120 ton/day			
Number of Deliveries			
Daily	67	56	54
Annually	19,859	16,667	16,079

Biorefinery Assumptions: 240,000 annual tons; 300 Handling working days; 800 tons/day			
Number of Deliveries			
Daily	32-38	25-31	53
Annually	9,600-11,400	7,500-9,300	15,900

Next, using the per shipment labor times provided by Chip Energy regarding how long it takes their crews to load and unload a truck, the total hours of labor are added, and it is assumed the truck drivers utilized the same time to ship the material due to the need to reasonably quantify their varying delivery times. The daily/annual labor hours can then be found by multiplying the per shipment hours by the daily/annual shipments calculated per material. In Table 3, these values are shown, along with the range of labor costs provided by the paper “Biofuel Crop Sustainability,” by multiplying the ranges of labor time by the labor rates are calculated with the following formulas (Singh, B.P. 2013).

Annual Labor Time = (Daily Shipments)*(Handling Time)*(300 Working Days)

Labor/Shipping Costs = (Annual Labor Time)*(Labor Rate)

The annual fuel costs are simply found by multiplying the range of 2017 fuel prices provided in the article “Gasoline prices may hit 3-year high in 2017 as cheap gas era ends” by the total annual shipments of each material.

Annual Fuel Costs = (Annual Deliveries)*(Fuel Cost)*(10 Gallons)

It is assumed that only ten gallons were necessary per trip because the distances per shipment given by Chip Energy are supposed to be within about 50 miles of a biofuel refinery and at a very low estimate of 10 miles per gallon per truck that would get you 100 miles per tank for a 100-mile round trip. This data is also present in Table 3.

Table 3: Annual Material Labor and Equipment Cost Comparisons (Chip Energy Data vs. Report Data)

Unit Type	Round Bale	Square Bale	Shipping Container
Handling Time est.			
Infield Loading [min/truck]	60	40	10
Delivery Unload [min/truck]	40	30	8
Total Handling			
Daily [hrs]	112	65	16
Annually [hrs]	33,500	19,600	4,860
Annual Labor & Equipment			
Manual ($30/hr)	$1.05M	$588,000	$145,800
Trucks ($20/hr)	$670,000	$392,000	$97,200
Fuel ($3.50/gal for 10 gal)	$695,065	$583,345	$562,765

Unit Type	Round Bale	Square Bale	Shipping Container
Handling Time est.			
Infield Loading [min/truck]	60	40	10
Delivery Unload [min/truck]	40	30	8
Total Handling			
Daily [hrs]	100	70	18
Annually [hrs]	30,000	21,000	5,400
Annual Labor & Equipment			
Manual ($11-20/hr)	$330,000 - $600,000	$231,000 - $420,000	$59,400 - $108,000
Trucks ($12.96-30.36/hr)	$388,800 - $910,800	$272,160 - $637,560	$69,984 - $163,944
Fuel ($2.25-2.83/gal for 10 gal)	$216,000 - $322,620	$168,750-$263,190	$357,750-$449,970

The environmental/spatial footprint of each material in storage before shipment is then calculated by multiplying the total inventory units Chip Energy reports to expect to store on site by the largest surface area of the three entities of biomaterial, and then these values are divided by the total number of units Chip Energy claims to be able to stack. For the round bale, the surface area used is the circular end, for the square bale the largest rectangular side is used, and for the shipping container the 8 ft. x 20 ft. = 160 sq. ft. side is reported to be the bottom. Table 4 displays this information as well using the following formula.

Spatial Footprint (Acres) = [(Inventory Units)*(Largest Unit Surface Area)]/[(Unit Stack Height)*(43,560 ft. / acre)]

Table 4: Storage Space Comparison (Chip Energy Data vs. Report Data)

Unit Type	Round Bale	Square Bale	Shipping Container
Storage (for 10 days)			
Inventory Units	20100	23520	1080
Individual Foot print [ft^2]	30	32	160
Stack Height [units]	3	6	5
Space Required [acres]	4.61	2.88	0.79
Space Saved [acre]	3.82	2.09	

Unit Type	Round Bale	Square Bale	Shipping Container
Storage (for 10 days)			
Inventory Units	20100	23520	1080
Individual Foot print [ft^2]	28	32	160
Stack Height [units]	3	6	5
Space Required [acres]	4.31	2.88	0.79
Space Saved [acre]	3.52	2.09	

The total cost and of labor, trucking, and fuel for shipping from Tables 3 and 4 along with the spatial footprint of storing each biomaterial are added and compared to those presented by Chip Energy. Then the range of difference in costs/space usage between each biomaterial and Chip Energy's shipping container method are determined and shown in Table 5 using the following method.

Max. Difference = (Highest Biomaterial Method Cost)-(Cheapest Chip Energy Shipping Estimate)

Min. Difference = (Lowest Biomaterial Method Cost)-(Most Expensive Chip Energy Shipping Estimate)

By conducting this analysis, we have found that Chip Energy indeed saves about a minimum of one-fourth the land for storage before shipping versus the conventional biomaterial shipping methods as promised, but Chip Energy's shipping process does not guarantee the proposed minimum financial savings of about ~~of~~ one-half and instead could induce losses of up to around $50,000 annually. These final results are also evident in Table 5 below.

Table 5: Overall Cost/Space Savings (Chip Energy Data vs. Report Data)

Unit Type	Round Bale	Square Bale	Shipping Container
Space Required [acres]	4.61	2.88	0.79
Space Saved [acre]	3.82	2.09	
Total Cost	$2,370,065	$1,563,345	$805,765
Annual Container Savings	$1,564,300	$757,580	
Minimum Container Savings			

Unit Type	Round Bale	Square Bale	Shipping Container
Space Required [acres]	4.31	2.88	0.79
Space Saved [acre]	3.52	2.09	
Total Cost	$934,800 - $1,833,420	$671,910- $1,320,750	$487,134- $721,914
Annual Container Savings	$212,886- $1,346,286	$(-)50,004 - $833,616	
Minimum Container Savings	$212,886	$(-)50,004	

The reason behind the lessened cost savings than predicted is because of the increased number of deliveries needed to supply the necessary biomaterial for a typical biorefinery. In fact, it can take up to twice as many shipments to accomplish this task which offsets the savings in labor, trucking, and fuel per shipment shown for Chip Energy's biomaterial shipping plan. Instead, it is found that the reevaluated labor costs are generally cheaper than Chip Energy predicted. This reduces the savings that the decreased manpower needed for Chip Energy's plan requires and leaves the plan more apt to losing profit on the increased shipments needed to supply a biofuel refinery.

Lastly, Chip Energy's biomaterial shipping network does show vastly more potential to be an economically and environmentally feasible alternative to biofuel production because the analysis performed leaves much more room for potential savings, up to 6.5 times less biomaterial storage space needed and up to a million dollars annually saved over alternative methods according to Table 5, than it does potential costs, which are at worst a $50,000 loss versus shipping biomaterial square bales. It is then quite possible that, if used by multiple biorefineries, the overall large potential savings of Chip Energy's biomaterial shipping methods can lessen the energy/land costs to produce biofuels, like ethanol, well below the energy/services they provide, or raise their return on investment (ROI).

Biofuels currently have an ROI of around one, equal resources used as outputted, which is not profitable, but with Chip Energy's model the United States biofuel industry could potentially increase their ROI well above one. This can make biofuels a realistic future alternative fuel source for the U.S. on its quest to gain energy independence from foreign countries, namely the petroleum producing Middle East, while additionally, doing so at a lessened environmental cost because of the lack of land needed to store the biomass. This is besides the fact that biofuels can be renewed/regrown yearly compared to fossil fuels which take millions of years to develop.

Conclusion

After careful analysis and comparison of results the feasibility of Chip Energy's claims that the cost of biomaterial shipment can be cut in half by delivering chopped product versus baled product has been verified. This is shown in the results table through the final values in which $200,000 to $1.3 million can be saved by using shipping containers compared to round bales and -$50,000 to $800,000 compared to square bales. From this, it is recommended that Chip Energy be cautiously optimistic with their business model and run an experiment with their ground up biomass due to the possibility of the $50,000 loss. However, overall, the average savings by using shipping containers is positive. Sensitivity analyses of the labor costs, transportation costs, storage space, and fuel costs reveal that a slight change in any of these factors will not result in a large change in the savings that Chip Energy will achieve. These savings lead to the possibility in which biofuel can be used at a comparable cost to fossil fuels at current prices.

On the same hand, Chip Energy's claims that storage space needed for biomaterials can be decreased substantially through the usage of shipping containers is also verified through analysis. Comparison between total acreage needed between round bales, square bales, and shipping containers leads to a final value of roughly one fourth reduction in space needed, as seen in Table 5.

Acknowledgements

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Group Reflections

After completing this project, the group felt the best parts about the experience were the sense of comradery and the fact that we all did are part to make a large task at hand actually seem easy. During the process, we thought that the decision to cut back our project scope to account for only the biomaterial shipping aspect of Chip Energy was a good idea because it helped us focus on an idea and the benefits/costs it could produce. If we did not do such we would have had too many concepts to master in too little time. We also were happy that we decided to use a side-by side comparison of Chip Energy data to ours while placing our data in portions next to the respective calculations/explanations of that specific piece of information. That helped convey our large table of information in small doses while the reasoning behind each component was fresh in the reader's minds. We believe that report structure was a strong aspect to our paper because it made our analysis seem fluent and cumulative in the end.

The biggest thing we would change as a team would be providing more input as to how the biomaterial would be processed before shipping, or how it is chopped and packed, and which materials would be processed. We believe that this was a confusing component most readers were unsure of and it made the task of conceptualizing the entire process difficult because the reader could not see how the material came into the hands of the trucking fleet or what types of farms/crops would be targeted. With those details, we believe our report would have been easy to understand from a process standpoint and also easier to explain because understanding the depth of the process makes the impact of the results, or potential reduced costs/storage in biomaterial shipment, more striking to the reader.

Besides the lack of depth we had in describing the process Chip Energy is perfecting, we believe our report was very effective in helping verify and describe to readers the cost analysis of Paul Wever's biomaterial shipment plan that claims to help reduce biofuel costs, and we are especially proud because we believe the report helped further recognize the capability to produce cheap, renewable biofuels by supporting Mr. Wever's findings. The report was also a great teamwork experience to everyone in the group due to the lessons it taught regarding the skills and effective usage of "dividing and conquering" work.