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# Utilizing Campus Biomaterial for Renewable Energy Sources

## Abstract

This project aims to explore the potential of using organic waste collected from the Cal Poly Humboldt’s campus and converting it into usable renewable energy production. Specifically, the focus will be on converting campus biomass into biofuels, such as biodiesel or bioethanol, and biogas. By utilizing existing campus biomass materials, this project can help promote sustainability, reduce waste, and minimize the environmental impact of transporting waste. This project will also include an educational component focused on composting to increase the campus’s composting participation, which can further contribute to the availability of organic material for biofuel generation.

## Introduction

Biomaterials have many uses in modern day ranging from medicine to solving environmental issues (Science Direct). They have been prevalent throughout human history and uses continue to adapt through the years. Through organic materials including firewood and woodchips, energy has been utilized since the beginning of humankind for applications such as heating and lighting (Guo). In the environmental context, biomaterials refer to materials sourced from living organisms that can be used in place of traditional materials. Biomaterials are a renewable energy source, and their use can reduce environmental impacts.

Humans have been using fossil fuels for thousands of years, but their use was expanded during the Industrial Revolution, primarily starting with coal. The large growth in fossil fuels has led the globe to be dependent on fossil fuels, with energy use by the entire world being generated from 80% fossil fuels (US Energy Information Administration). Associated with fossil fuels are huge environmental and social issues including pollution, deforestation, emissions, acid rain, and health and public concerns. Global warming has also been attributed to the use of fossil fuels, calling for a change in where society gets its energy from.

With the emergence of renewable energies as an alternative to fossil fuel driven energy, the question for me became, *what role can my college campus play into the fight for climate change?* This project looks at California Polytechnic Humboldt’s current use of biomaterials on campus including compost and tree trimmings, and where it goes and is repurposed for. Through chemical processes such as gasification or pyrolysis, biomass can be converted into biofuels, which can then be used to replace liquid fossil fuels such as gasoline or diesel. Biofuels have always been a contender in fighting climate change, however, growing biomaterials just for fuel has caused land change use problems, limiting applications of biomass. Using food scraps could solve this issue.

This project aims to develop a sustainable plan to convert biomass from the Cal Poly Humboldt’s campus- specifically compost and tree scraps/trimmings- into renewable energy sources, such as biofuel and biogas. Additionally does this project hope to promote waste reduction and encourage compost education. The deliverables of this project include creating a map and a project report on how the Cal Poly Humboldt’s campus can efficiently collect and process biomass and then use it to produce renewable energy. In addition to this will there be a composting educational component to get more composting sources. This project will include a cost analysis and an environmental impact report.

## Methods

### Biomass Data Collection and Analysis (Methods)

In the 2023-2024 fiscal year, Cal Poly Humboldt generated the following biomass materials (Department of Sustainability, Cal Poly Humboldt):

1. **Greenwaste:**

A total of **304,400 pounds** (152.2 tons) of greenwaste, which includes tree trimmings, grass clippings, and other landscaping waste were generated.

1. **Pallets:**

A total of **1,840 pounds** (0.92 tons) of wooden pallets were generated.

1. **Food Waste:**

A total of **158,220 pounds** (79.11 tons) of food waste was generated.

1. **Grease Trap Waste:**

A total of **12.48 tons** of grease trap waste was generated.

1. **Used Vegetable Oil:**

A total of **7.1 tons** of used vegetable oil was generated.

### Biomass Conversion to Biofuels (Methods)

The biomass materials generated on campus have significant potential for conversion into biofuels such as biogas and biodiesel. Based on the collected data for this project, the campus biomass (including green waste, pallets, food waste, grease trap waste, and used vegetable oil) offers a strong resource for energy generation.

***Table 1:*** Biomass Conversion to Biofuels***.*** This table uses conversion rates found from various sources to find the energy output of each biomaterial CPH has.

|  |  |  |  |
| --- | --- | --- | --- |
| **Conversion Technology** | **Material** | **Conversion Rate** | **Energy Output** |
| **Biodiesel Production** | Used Vegetable Oil | 1 ton vegetable oil= 0.8 tons biodiesel -through transesterification (U.S. Department of Energy) | 1 gallon of biodiesel=**120,000 BTU** |
|  |  |  | From 7.1 tons of used vegetable oil and 12.48 tons of grease trap waste: |
|  |  |  | Could generate up to 1,958 gallons of biodiesel = **234,960,000 BTUs** |
| **Biogas Production** | Food Waste | 1 ton of food waste= average of 376 cubic meters of biogas | 1 cubic meter of biogas= 6kWh, but only 2kWh is usable |
|  |  |  | From 79.11 tons of food waste: |
|  |  |  | Could generate **59,490 kWh** of electricity |
| **Biogas Production** | Greenwaste | 1 ton of greenwaste= average 15kWh- through anaerobic digestion (U.S. Department of Energy) | 152.2 tons of greenwaste could generate **2,283 kWh** |
| **Total Potential Energy** | Biomass Materials (Waste oils, food waste, and greenwaste) |  | **61,773 kWh** of electricity from biogas (food waste and greenwaste) |
|  |  |  | **234,960,000 BTUs** from biodiesel (used vegetable oil and grease trap waste) |
|  |  |  |  |
| **Campus Electricity Consumption** | Total Annual Electricity Consumption (2023-2024) | 13,100,000 kWh of electricity for the fiscal year (Cal Poly Humboldt) | Biomass systems could meet about 1% of the campus’s total energy consumption |

### Cost Analysis (Methods)

***Table 2:*** *Cost Analysis*

|  |  |  |
| --- | --- | --- |
| **System** | **Cost Range** | **Details** |
| **Biodigester System** (Biogas from food waste and greenwaste) | Average- $950/ton of waste (SKS Development) | The cost of a biogas facility can be between $400-$1500/ton of material processed; includes all costs;  With 250 tons, approximately $237,500 |
| **Biodiesel Conversion System (**From used vegetable oil and grease trap waste) | Average- $18,835 (Tennessee State University) | Includes biodiesel processor, oil press unit, methanol recovery system and installation for processor that can convert 2,000 gallons annually |
| **Annual Energy Savings** | Average electricity rate in California is 32c/kWh (Energy Sage); save $41,600 annually | These savings come from the energy generated by converting campus biomass into biogas and biodiesel, which could offset some of the university’s electricity consumption |
| **Investment Tax Credit (ITC)** | 30% credit for qualified expenditures (Novogradac) | Could get 30% credit off initial investment, reducing price. |
| **Clean Energy Investment Grant: U.S. Department of Agriculture (USDA)- Rural Energy for America Program (REAP)** | Grants on average range from $25,000-$500,000 for small renewable energy systems (USDA) | Grants could override initial costs and lead to eventual profit from saving money. |
| **Carbon Credits** | Average price per credit was $6.97/ton Co2 reduced in 2023 (Gold Standard) | The university could offset carbon emissions and receive carbon credits; if the project reduces 10,000 tons of CO2 annually, $69,700 could be generated through carbon credits |
| **Annual Revenue** | $111,300 | CPH could potentially break even within 1 year based on the annual revenue from energy savings and carbon credits, given grants and incentives. |

## Environmental Impact Report

There are many environmental benefits associated with the proposed project of converting campus biomaterial to biofuel and biogas. By diverting food waste, greenwaste, and used oils to energy production instead of landfills, Cal Poly Humboldt could significantly reduce its carbon footprint, as organic waste in landfills can generate methane. Additionally, converting campus biomass into biogas and biodiesel provides a renewable energy source that reduces reliance on fossil fuels. The energy generated can power campus facilities and reduce the environmental impact of energy consumption. Lastly, the composting of greenwaste and food waste can produce nutrient-rich compost, promoting soil health.

If not properly managed, anaerobic digester and biodiesel processing facilities may emit odors. Odor control and strategic plans to minimize the impacts could be effective. Biofuel production systems may require a lot of water for processing (Tidwell).

### Educational Outreach

To promote this project, educational outreach is essential. Composting workshops should be organized frequently, especially in the beginning steps of this project, to educate students, faculty, and staff on proper composting techniques, and how composting can directly contribute to biofuel production. Additionally, informational materials such as flyers, posters, and digital content should be created to raise awareness on the importance of campus waste diversion and the role of composting in renewable energy production.

## Conclusion and Results

## In conclusion, this project explores a promising strategy for Cal Poly Humboldt to contribute to sustainability efforts by utilizing campus biomass to generate renewable energy. By converting food waste, greenwaste, and used oils into biogas and biodiesel, the university can both reduce its environmental footprint while also providing a renewable source of energy for campus operations. The analysis of biomass generation on campus shows potential for energy production, which could meet approximately 1% of the university’s total annual electricity consumption. The cost analysis indicates that with proper investment in biodigesters and biodiesel systems, Cal Poly Humboldt could achieve a return on investment within a year, and additionally benefit from grants, tax credits, and possibly carbon credits.

Beyond the technical and financial aspects, the project also includes an educational component to engage the campus community in composting and waste diversion. By raising awareness through workshops and informational materials, the university can create a culture of sustainability and encourage participation. The environmental benefits, including waste reduction, energy generation, and soil enrichment, demonstrate the potential for this project to make a meaningful impact on the campus and beyond. With continued investment and outreach, Cal Poly Humboldt can become a model for utilizing biomass for renewable energy, contributing to broader climate change mitigation efforts while enhancing campus sustainability.

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