Methane Generation Using Food Waste

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Problem Statement:

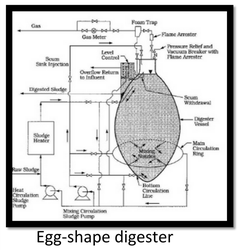
Food waste is a goldmine for energy production. It is estimated by the Food and Agricultural Organization that a third of all food produced for human consumption is lost or wasted globally[1]. In developing economies it is at the production stages while in developed nations it is from retail and consumer waste. The focus of the study is to capture waste from large food production establishments and convert it into methane. These establishments can be cafeterias, universities, army bases and any other place where a large amount of food waste is generated.

Goal: Design a cost effective solution that can be implemented across the country to reduce the amount of food waste going to landfills and to generate positive returns for the stakeholders.

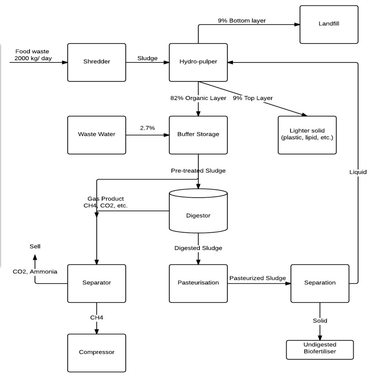
Design objectives:

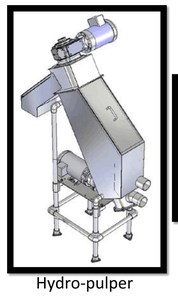
- Develop a cost effective and environmental-friendly solution to process food waste into biogas
- Separation and purification process of gas product into methane, carbon dioxide and other trace gases
- Determine the initial capital investment and annual cost over a period of 10 years with 12% interest rate

Final Design:



Egg-shape digester





Hydro-pulper

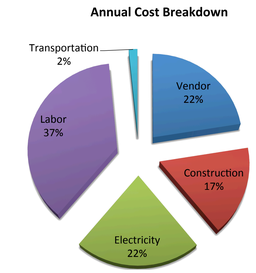
Industrial Shredder

	Operation	Price ($)
Screening	Four-shaft shredder	40,000
Organics Separation	5000 lb/hr Hydro-pulper	35,000
Digestion	150 m^3 Egg-shape digester	290,500
Pasteurization	0.625 m^3/hr Milk pasteurizer	2,000
Gas Separation	Amine absorption [3]	1,750,000
Pumping/Piping System	6 Positive Displacement Pumps 1334 ft stainless steel 4 in pipes	51,554
Gas packaging	Compressor	100,000

Economic Analysis:

Our economic analysis concluded that selling methane and ammonia generated from the food waste is far more profitable than producing our own electricity for sale. The yearly production of methane and ammonia reach **177946.5 MMBtu** and **501.9 tons** respectively, which leads to the **total revenue of $2,08,605.**

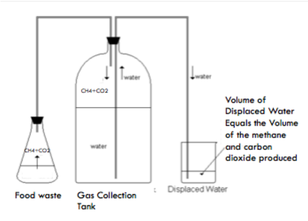
Summary	
Total Annual Revenue	$2,080,605
Total Annual Cost	$1,788,943
Net annual Revenue	$291,662



Annual Cost	Dollar per year
Vendor	$401,827
Construction	$297,333 [4]
Electricity	$394,641
Labor	$666,480
Transportation	$28,662
Total	**$1,788,943**

Experimental Design:

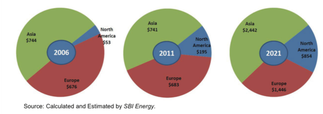
The theoretical small-scale experiment can be conducted using the experimental apparatus shown below. However, laboratory difficulty such as the complete elimination of oxygen in the apparatus makes conducting the experiment unfeasible. The theoretical production of natural gas from 1 kg of food waste is 0.2045L.



Societal impact:

- Reduce waste to landfill sites
- Generate methane and reduce dependence on fossil fuels
- Create awareness for recycling

Global Impact:



With the growth of interest in conserving natural resources globally, the development of anaerobic digesters is rapidly expanding.

Background:

- Natural gas contains approximately **61.6% methane** and **37.4% of carbon dioxide** and **1% of ammonia** in this project.
- The food waste produced on the Purdue campus is about **2000 kg per day**, which is sufficient in producing over **189465 m^3** natural gas per day
- Price of natural gas can rang from **$2/MMBtu to $35/MMBtu** depending on region and season.
- Price of ammonia is **$600/ton**.
- There is an extensive **2.1 million** mile underground natural gas delivery system.

Strength	Opportunities
• Global anaerobic digester markets are expected to show solid growth, for 2011 through 2021. [2] • Environmentally friendly way of dealing with waste • Food waste is constantly generated, so the input is always guaranteed	• Public-private partnerships and municipal bond issuance to raise money • Developing similar systems in multiple high density areas
Weakness	**Threats**
• Presence of halogens in gas when combusted creates dioxins and furans • High initial cost of equipment • Tuning bacteria mixture to handle waste	• Over production of methane from traditional sources • Lack of support from EPA and other environmental watchdogs

Alternative solutions:

Digester Design:
- Taped digester with floating gas holder
- Floating gas holder with water seal
- Two-chamber digester
- Oil-drum digester
- Jar digester with separate gas holder
- Fixed dome digester with separate gas holder

Gas separation:
- Membrane selection
- Solvent separation
- Cryogenic distillation

Product Use:
- Flare
- Electricity generator
- Boiler

Waste Treatment:
- UV treatment
- Ozone

Reference:
[1] Venkat, K. (2012). The Climate Change and Economic Impacts of Food Waste in the United States. *International Journal on Food System Dynamics, 2*, 431-431.
[2] Thermal and Digestion Waste-to-Energy Technologies Worldwide. (2011). *SBI Energy,* 111-112.
[3] Peters, L., Hussain, A., Follmann, M., Melin, T., & Hägg, M. (2011). CO2 removal from natural gas by employing amine absorption and membrane technology—A technical and economical analysis. Chemical Engineering Journal, 952-960.
[4] Wastewater treatment plant cost. (n.d.). Retrieved April 15, 2015, from http://www.costwater.com/wastewatertreatment.htm

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