Sustainable solution for organic waste handling

SWANA Solid Waste Student Design Competition, 2023
Sustainable Environmental Solutions

Aiswarya Acharath Mohanakrishnan, Doreen Ntiamoah-Asare, Hussain Ali

Objective & Background

To consider the 3 tiers of Sustainability to determine the best organic waste management option as shown below, for a county with a strong agricultural industry in the northwest region of US having a population of 600,000 people.

- Landfill the organics, set up LFG collection system and an RNG facility, or
- Divert the organics by implementing source separated organic collection program to compost the organics.

Scenarios Explored

Scenarios	• Cases
1. RNG powerplant without organic waste diversion	• 1.a: Using LandGEM Output • 1.b: Using IPCC Output
2. RNG powerplant with organic waste diversion	• 2.a: Using LandGEM Output • 2.b: Using IPCC Output
3. Composting	• 3.a: Windrow • 3.b: Covered Aerated Static Pile
4. Anaerobic Digestors	• 4.a:Existing AD • 4.b: New AD

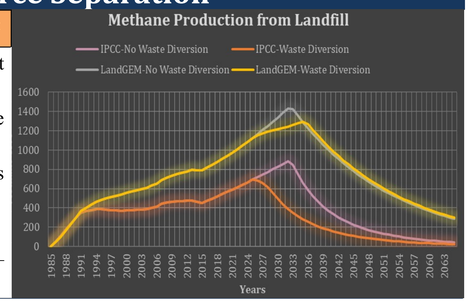
Methods and Tools

Methane estimation	Economic analysis	Environmental & Social analysis
EPA's LandGem	LFG Cost-Web Landfill Gas Energy Cost Model	UTA's POWER tool
IPCC Model	Current Industrial Cost Ranges	Rating and weighing tables

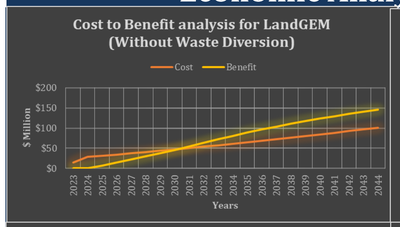
Source Separation

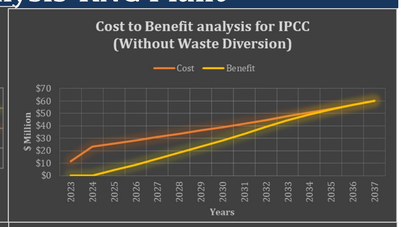
Proposal on Drop-off-to Credit concept

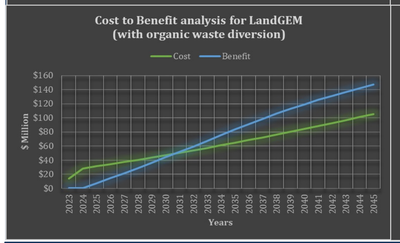
- Install collection kiosks at appropriate locations.
- Organics drop off at these collection kiosks by community.
- Credits/voucher/display stickers as rewards(incentives)for drop offs.
- No tipping fee (incentive).
- Funds from surcharging 0.5 – 1.5% on biodegradable foods.

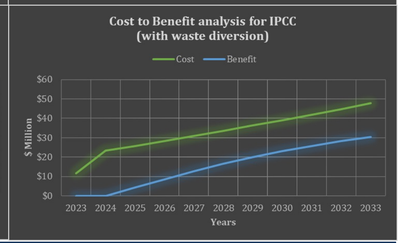


Economic Analysis-RNG Plant

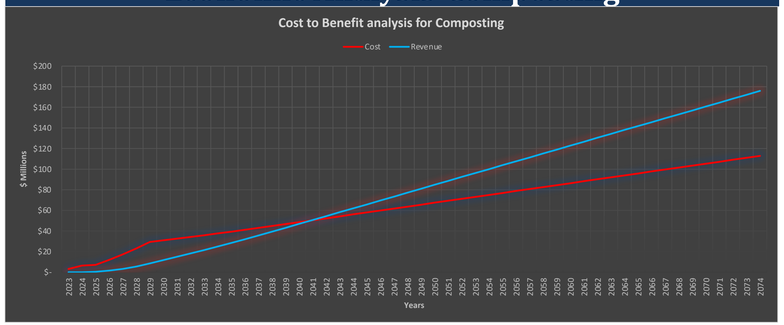




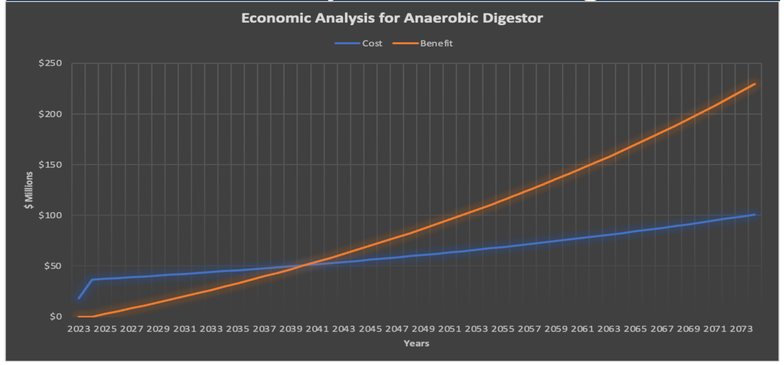




Economic Analysis-Composting



Economic Analysis-Anaerobic Digester



Environmental Analysis

Total Emissions (Kg/yr)	VOCs	NO_x	PM_{10}	$PM_{2.5}$	N_2O	CO_2	CH4
Landfill	905	-939	-169	89	191,295	34,050,585	60,447,315
Composting	81	643	26	20	3	8,377,736	829
A.D	182	-1,541	-83	-97	32	-1,573,604	6,073

Social Analysis

Life cycle phase	Number of points		
	Landfill with RNG Plant	Compost	AD
Manufacturing/construction	132	111	130
Use Phase	498	549	597
End-of-life	162	90	90
Total Scores	**792**	**750**	**817**

Discussion

	Break-even	Capital cost $	Ops & Maintenance $
Economics			
RNG-LandGEM	7 years (2031)(with & without organic waste diversion)	23,265,000-28,149,000	2,500,000-3,000,000
RNG-IPCC	10 years(2034)without organic waste diversion; Does not break-even with organic diversion		
Composting	17 years (in 2041)	$20,550,000	$807,525
Anaerobic Digestor	18 years (in 2042)	$36,614,199	$759,156
Environmental	**Landfill:** Overall highest emissions of CO2, CH4, N2O, VOCs, NOx, PM2.5 and PM10. **Composting:** Relatively high in NOx, PM2.5, PM10 and CO2, and relatively low in VOCs, N2O and CH4 compared to Anaerobic Digestion. **Anaerobic Digestion:** Relatively high in VOCs, N2O and CH4 and relatively low in NOx, PM2.5, PM10 and CO2 compared to Composting.		
Social	Upon social analysis of Life-cycle phases, AD scored the highest, followed by Landfill (with RNG plant) while composting scored the least.		

Conclusion

- Anaerobic digestion and composting were found to be relatively favorable over installing an RNG plant on a landfill.
- Both composting and anaerobic digestion were relatively cheaper and emitted lower levels of pollutants.
- Proposing a pilot study on both (composting & AD) and installing a hybrid system where food waste can be diverted to AD whereas green waste and AD digestate to composting.

References:

USA EPA Landfill Methane Outreach Program (LMOP); Landfill Gas Control Measures, Agency for Toxic Substances and Disease Registry, Atlanta GA; Landfill Gas Collection and Control, SCS Engineers; South Wake County Landfill Gas Collection and Control System, NC; Landfill Gas Generation & Collection, Geo Engineer, April, 2021; Understanding the basics of landfill gas collection system (GCCS) maintenance. Bruce Clark, Dan Cooper, Gregory Hansen and Ken Guilbeault of SCS Engineers, August, 2011; Landfill Gas Collection and Treatment Systems, U.S. Army Corps of Engineers Washington DC, April 2013; Solid Waste Association of North America, 2017; EPA "Anaerobic Digestion Facilities Processing Food Waste in the United States (2017 and 2018)", January 2021; Composting Facility List, US and Territories, 2020, Region 9; Bhatt, A., Tao, L. "Economic Perspectives of Biogas Production via Anaerobic Digestion". Bioengineering. 2020, 7(3), 74; Vermont Agency of Natural Resource, Department of Environmental Consideration, Sight Identification Design; Klemeš, J.J, Liew, P.Y, Ho, W.S., Shiun. J., Cost Benefit Analysis of Composting and Anaerobic Digestion in a Community: A Review. 2017.