FOOD WASTE DIVERSION FOR RENEWABLE ENERGY PRODUCTION

"According the UN – 30% or more of America's food production ends up as waste!"

EXECUTIVE SUMMARY

According to the United Nations Food and Agriculture Organization (UNFAO), 30%-40% of all food manufactured in the United States ends up in landfills or incinerators as waste. Vanguard Renewables was formed to divert and process organic food waste and agricultural farm waste into renewable energy. The process for converting food waste to bio-gas is known as Anaerobic Digestion (ADAD is commonplace in Europe, but relatively unknown in America. Food waste is collected from any generator and shipped to our farm digesters to be converted into renewable natural gas and organic fertilizer. AD has become an important renewable energy source as it is available to the grid as baseload 24/7 power. As importantly, because of the sequestration of Methane, which is a 25 times worse greenhouse gas than CO2, AD has a dramatically better GHG reduction profile than solar or wind per megawatt.

Farm Powered Anaerobic Digester at Bar-Way Farm in Deerfield, MA

HOW IT WORKS

Vanguard Renewables' AD systems take organic wastes and convert those inputs into renewable biogas. Our AD systems combine a mixture of organic wastes (i.e. food manufacturing, restaurant and hotel waste, expired products, and animal manure) in large oxygen-deprived tanks, and then capture the methane rich gas produced through the process. Then the gas is either used to generate Renewable Natural Gas or Renewable electricity. The byproducts of the AD system (heat, organic fertilizer, bedding solids) are given to our farm partners to reduce their operating costs and carbon footprint.

FARM POWERED

AD creates an amazing carbon reduction pathway for any of the participants in this closed loop energy system. Whether acting as a food waste contributor, energy off-taker or both, the benefits that accrue are significant. As seen in the table below, the GHG reduction is 10 times more beneficial per megawatt than solar or wind, and requires no onsite equipment installation. Vanguard will assist any participant in quantifying their GHG and carbon footprint reduction on a monthly and annual basis. Vanguard also works with our partners on enhancing brand visibility with a no-cost licensing of the FARM POWERED™ logo and associated marketing attributes.

For a 1 MW anaerobic digestion (AD) unit running at full capacity:

	Units produced or consumed (per year)	CO_2 produced per unit (lb)	Total CO_2 savings (tons)
Manure	9,125 tons	1,380	4,550
Food waste	36,500 tons	357.5	6,524
Electricity	8,760 MWh	1,550	8,303
Heat	31,005 MMBTU	22.4	3,383
Fertilizer	74 tons	20.46	1,514
		Total tons CO_2 savings:	24,274

This 24,274 tons is the equivalent of[i]:

- Powering 2,000 homes for a year
- Removing 5,000 passenger vehicles from the roads for one year
- The carbon sequestration potential of planting 560,000 tree seedlings

IN DETAIL:

For a 1 MW AD unit running efficiently and at full capacity, the following assumptions about greenhouse gas emission reductions can be made:

- Methane from manure
  - 25 tons manure per day (TPD) = 9,125 tons manure per year (TPY)
  - 1 lb manure = 1 cu ft biogas[ii]; biogas is 65% CH_4
    - 9,125 TPY yields 6,319 tons CO_2[iii] so 1 ton manure yields 1,380 lb CO_2[iv]
  - AD system reduces CH_4 emissions 72%[v] so expected CO_2 emissions total 1,769 tons
- Emissions from food waste
  - Assuming the following scenario for food waste: 100 TPD = 36,500 TPY
    - 5 TPD each of beef, poultry, grains
    - 10 TPD fruits & veggies, 15 TPD bread
    - 25 TPD dairy products, 35 TPD food waste (mixed, institutional)
  - Assume 1 ton food waste = 14.3 lb CH_4[vi]
    - 36,500 TPY yields 261 tons CH_4 which yields 6,524 tons CO_2[vii]
- Electricity production emissions
  - The AD system will generate 8,760 MWh of electricity each year[viii]. For a utility to provide this same amount of electricity to the farm, 9,319 MWh/year would need to be produced[ix]. Producing electricity on-site will avoid 8,303 TPY CO_2[x].
- Heat production emissions
  - CHP engine unit will produce 31,005 MMBTU/year[xi].
    - All heat will be used to heat homes, barns, other structures and processes on site[xii]
    - To produce this quantity by burning heating oil, 263,367[xiii] gallons would need to be burned; heating oil produces 22.4 lb CO_2 per gallon[xiv], resulting in 3,383 TPY of avoided CO_2 emissions[xv]
- Fertilizer emissions
  - Per-pound GHG emissions for fertilizer production are 20.46 lb CO_2 per 1 lb product[xvi]:
    - 7.92 lb during production of fertilizer
    - 0.22 lb during transportation to market/consumers
    - 12.32 lb during application (some lost to air)
  - This system produces 33 TPY N, 15 TPY P_2O_5, and 26 TPY K_2O, totaling 74 TPY of fertilizer products[xvii]. Using this 74 TPY value total GHG emissions needed to produce this same quantity of commercial fertilizer is 1,514 tons CO_2[xviii].

Resources

[i] US Environmental Protection Agency. (2015, October 23). Greenhouse Gas Equivalencies Calculator. Retrieved from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[ii] *(35 ft^3/min biogas)*(60 min/1 hr)*(24 hr/day) = 50,400 ft^3/day/25 TPD = 2,016 ft^3/T = 1 ft^3/lb*

[iii] *Biogas is 65% methane (CH_4): (2016 ft^3/T)*(9125T)*(0.65)=11,957,400 ft^3 of CH_4. Per the US EPA Methane Emissions Reduction Calculator, 11,957,400 ft^3 of CH_4 is equal to 6,319 tons CO_2.* US Environmental Protection Agency. (2014, June). Methane Emissions Reduction Calculator. Retrieved from https://www3.epa.gov/gasstar/tools/calculator.html

[iv] *(6319 tons CO_2)/(9125 tons manure)=(0.69 tons CO_2/ton manure)*(2000 lb/ton)=1,380 lb CO_2/ton*

[v] Artrip, K., Shrestha, D., Coats, E., and D. Keiser. GHG emissions reductions from an anaerobic digester in a dairy farm: theory and practice. *Applied Engineering in Agriculture,* 29(5): 729-737. DOI 10.13031/aea.29.9826

[vi] *Units from article in wet tons. Converted to dry tons byt multiplying by 10% (this is total solids value).* Brown, S. (2013, June 19). Connection: Climate Calculations. *BioCycle Magazine,* 54(6). Retrieved from https://www.biocycle.net/2013/06/19/connection-climate-calculations/

[vii] *(36,500 TPY food waste)*(14.3 lb CH_4/ton) = 521,950 lb CH_4; put into the Methane Emissions Reduction Calculator this yields 261 tons CH_4 = 13,048,750 lb CO_2 = 6,524 tons CO_2*

[viii] *Assumes generator running at 100% capacity for 8,760 hours per year.*

[ix] *Includes transmission and distribution losses*. US Energy Information Administration. (2016, April 6). How much electricity is lost in transmission and distribution in the United States? Retrieved from https://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3
Obtained by multiplying (8,760 MWh)(T&D losses 1/(1-6%))*

[x] *Using U.S average non base-load output emissions rates. Assumes 85% utilization of energy after losses for production and transmission. Obtained by multiplying (9,319.1 MWh/year)*(1,550 lb CO_2/MWh)*(1+ 15% externalities)*(0.0005 ton/ 1 lb).* US Environmental Protection Agency. (2015, October 8). eGRID 2012 subregion GHG output emission rates. Retrieved from https://www.epa.gov/energy/egrid-2012-subregion-ghg-output-emission-rates

[xi] *Using "Heating oil High Heating Value". Assumes generator running at 100% capacity for 8,760 hours per year, and 100% of the heat is recovered and fully used. Based on the manufacturer's specifications the thermal efficiency is 39.4%. Final value obtained by multiplying (6,452 BTU/bhp-hr)*(1,392 bhp)*(39.4% thermal efficiency)*(8760 hours/year)*(1 MMBTU/ 1,000,000 BTU).* U.S Energy Information Administration: Total Energy: Monthly Energy Review: Appendices (heat rates, conversion factors, and more): A1 Petroleum and other liquids. (2016, April 26) Retrieved from: http://www.eia.gov/totalenergy/data/monthly/pdf/sec13_1.pdf

[xii] *Assumes 100% heat recovery rate.*

[xiii] *Obtained by multiplying (31,005 MMBTU/year)/(85% boiler efficiency)/(138,500 BTU/gal)*(1,000,000 MMBTU/1 BTU)*

[xiv] *Assumes 100% combustion.* US Energy Information Administration. (2016, February 2). Carbon Dioxide Emissions Coefficients. Retrieved from https://www.eia.gov/environment/emissions/co2_vol_mass.cfm

[xv] *Assumes 85% utilization of energy after accounting for boiler efficiency and losses in production and transmission.*

[xvi] *Not specific to American fertilizer production. Data taken from infographic produced by a fertilizer manufacturer. Converted from metric using 1 kg = 2.20 pounds.* Yara International ASA. (2012). Carbon Footprint: Climate impact and mitigation potential of plant nutrition. Retrieved from http://yara.com/doc/29465_carbon_footprint_en_0604.pdf

[xvii] *Numbers taken from Due Diligence package prepared for Vanguard Renewables by CHFour Biogas (Haverhill, 7 April 2016).*

[xviii] *Number obtained by multiplying (74 TPY)*(2000 lbs/1 ton)*(20.46 lb CO_2/lb product).*