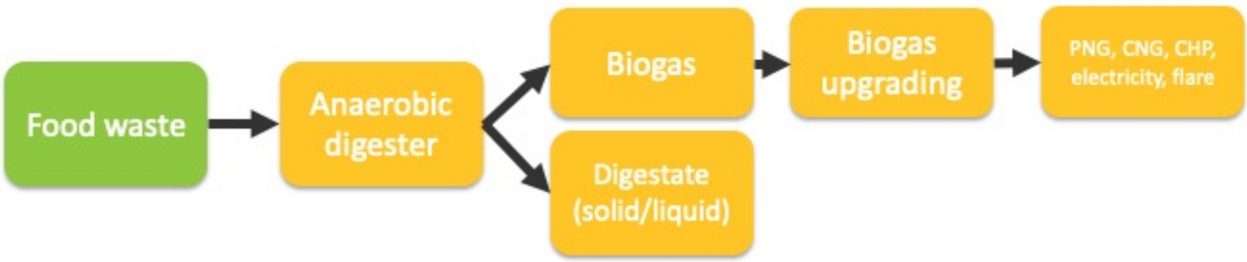
Waste-to-energy Technical Assistance Results: Hartford, CT

Alex Badgett, Jacqueline Streur, Anelia Milbrandt
September 28, 2021

Objective

- This work is intended to provide a high-level screening/feasibility analysis of food waste pathways and does not replace the need for a detailed, site-specific analysis conducted by an industry provider.



PNG: pipeline natural gas
CNG: compressed natural gas
CHP: combined heat and power

Materials and Methods

- Costs to construct, operate, and maintain facility processing food waste are estimated from NREL models
- Regional economic parameters are incorporated into cost estimates (Table 1)
- Scale of different systems is based on nonresidential food waste in the following counties:
  - Hartford
  - Middlesex
  - Tolland

Table 1: Key Input Parameters

Variable	Value	Units
Industrial electricity price	0.134	\$/kWh
CNG price	2.19	\$/GGE
Compost market price	25.79	\$/yd^3
D3 RIN market price	2.75	\$/RIN
D5 RIN market price	1.4	\$/RIN
Dry AD tipping fee	59.00	\$/t
Diesel price	3.21	\$/gallon
LCFS credit	185	\$/t CO_2
Labor rate	32.31	\$/h
AD CNG carbon intensity	-50.00	g CO_2/MJ
RECs for electricity	0.039	\$/kWh
RECs for CHP	0.0095	\$/kWh

This work assumes that CNG pathways have access to LCFS markets and associated revenue streams. LCFS prices and pathway carbon intensities are shown in Table 1. While LCFS credits can provide notable revenue streams, they do require that CNG is used in California as a transportation fuel. Depending on the intended end use for CNG, LCFS revenues may or may not apply. Depending on the end use for CNG, it may not be possible to claim LCFS credits, and the revenue streams shown in these results may not apply. Additionally, the carbon intensity for a given pathway varies depending on the LCFS certification.

Food Waste Generation Rates

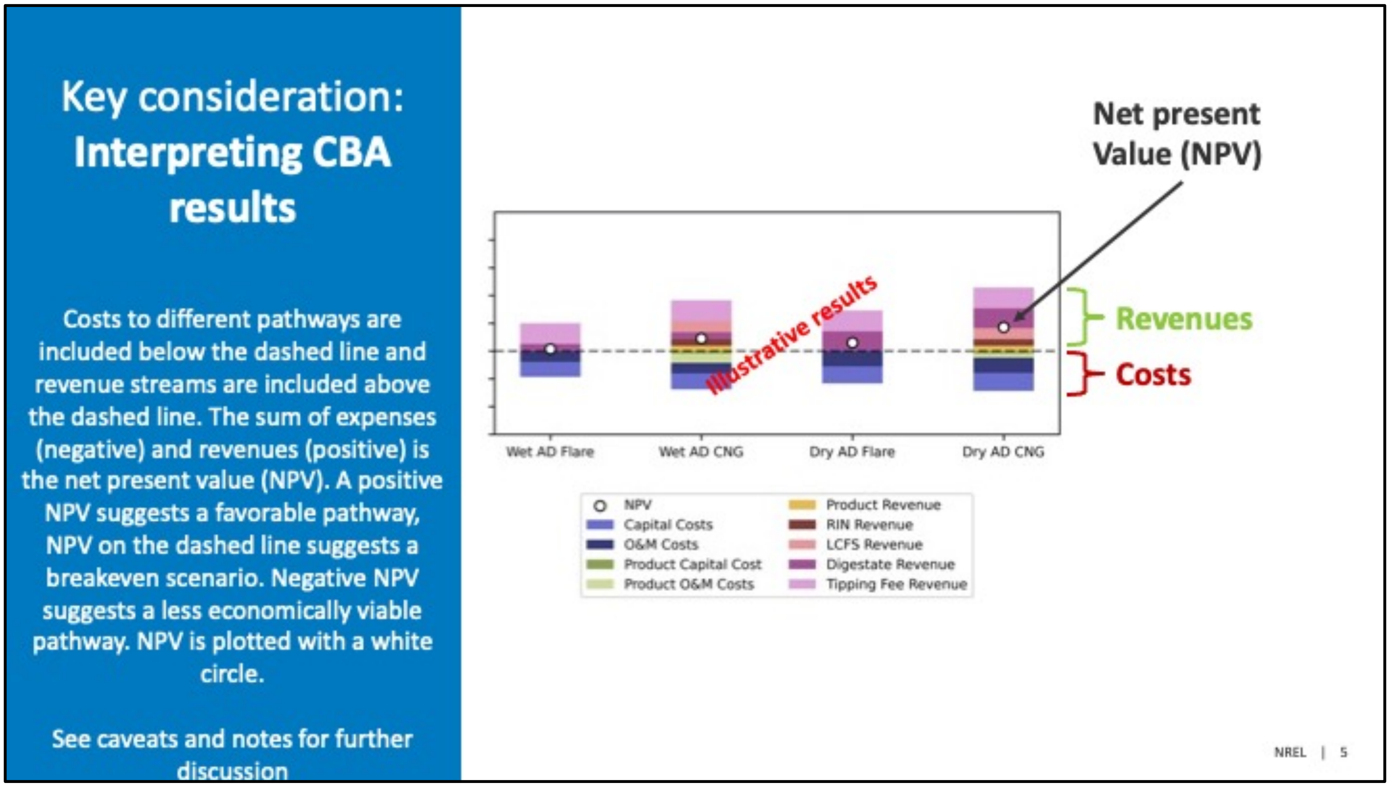
- CBA models are run for only non-residential food waste
- Waste generation including surrounding counties are also included
- Cost of waste collection and pre-processing is not included

Table 2: Food Waste Generation Estimates

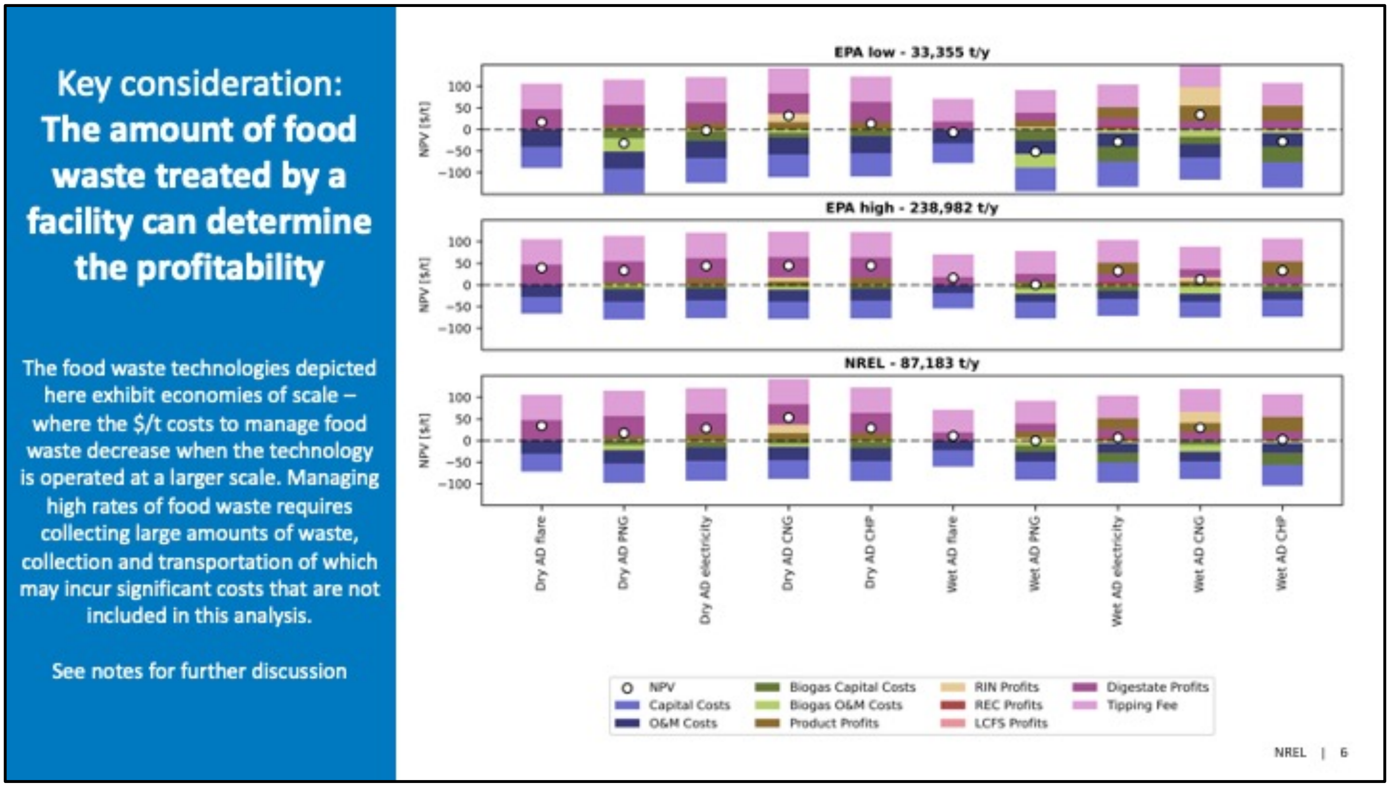
County	NREL Nonresidential	EPA Nonresidential Low	EPA Nonresidential High	Units
Hartford	67,104	27,729	189,354	t/y
Middlesex	10,194	3,166	28,860	t/y
Tolland	9,884	2,458	20,767	t/y

See the following for methodology on NREL waste generation estimates:

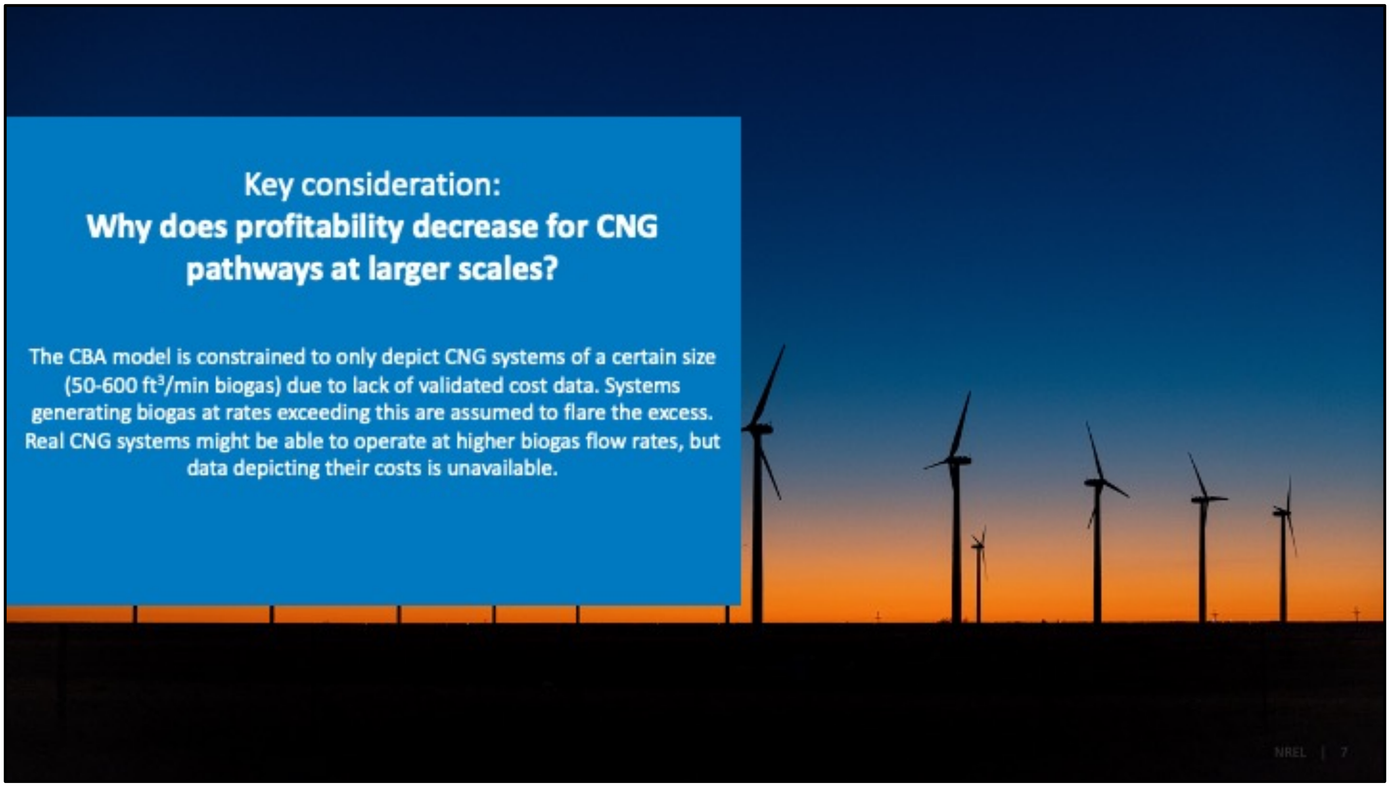
Milbrandt, A., Seiple, T., Heimiller, D., Skaggs, R. & Coleman, A. Wet waste-to-energy resources in the United States. *Resour. Conserv. Recycl.* **137**, 32–47 (2018).



Waste management systems are conventionally operated without revenue streams from biogas, landfill gas, etc. These systems historically rely upon tipping fees to ensure that the revenue equals expenses. In this analysis tipping fees are held constant regardless of facility costs; however, a waste management pathway would likely adjust the tipping fee it charges to ensure that the NPV is equal to or greater than zero. An exhaustive understanding of possible facility costs and ranges of acceptable tipping fees is important to understanding the economics of a particular waste management pathway. While this work provides and initial screening analysis of relevant cost and revenue streams for various pathways, it should not be used as a basis for investment without further analysis and site-specific characterization.

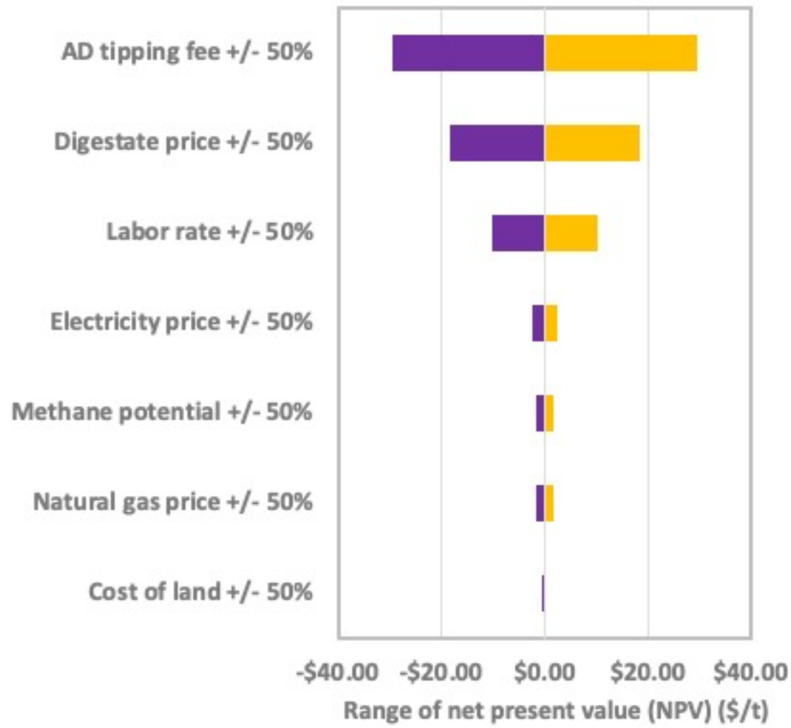


The figure on this slide shows CBA results for three different sizes of waste management facility, which include nonresidential food waste only. With conventional waste management facilities, the capital and operating and maintenance costs are lowest on a $/t basis when the facility is large. These effects can be seen in the AD flaring pathways. Adding bioenergy systems increases new costs and revenue streams to the facilities. In some cases these added investments can reduce the NPV if the revenue stream from the bioenergy system is not enough to offset the costs. Other pathways exist where the bioenergy revenue generated is greater than the bioenergy system added cost, suggesting that such an investment could be economically favorable. Additional policy-driven revenue streams can help economics of bioenergy pathways, as shown in the CNG pathways shown here. These pathways leverage revenue streams from the California low carbon fuel standard (LCFS) and EPA renewable fuel standard (RINs).

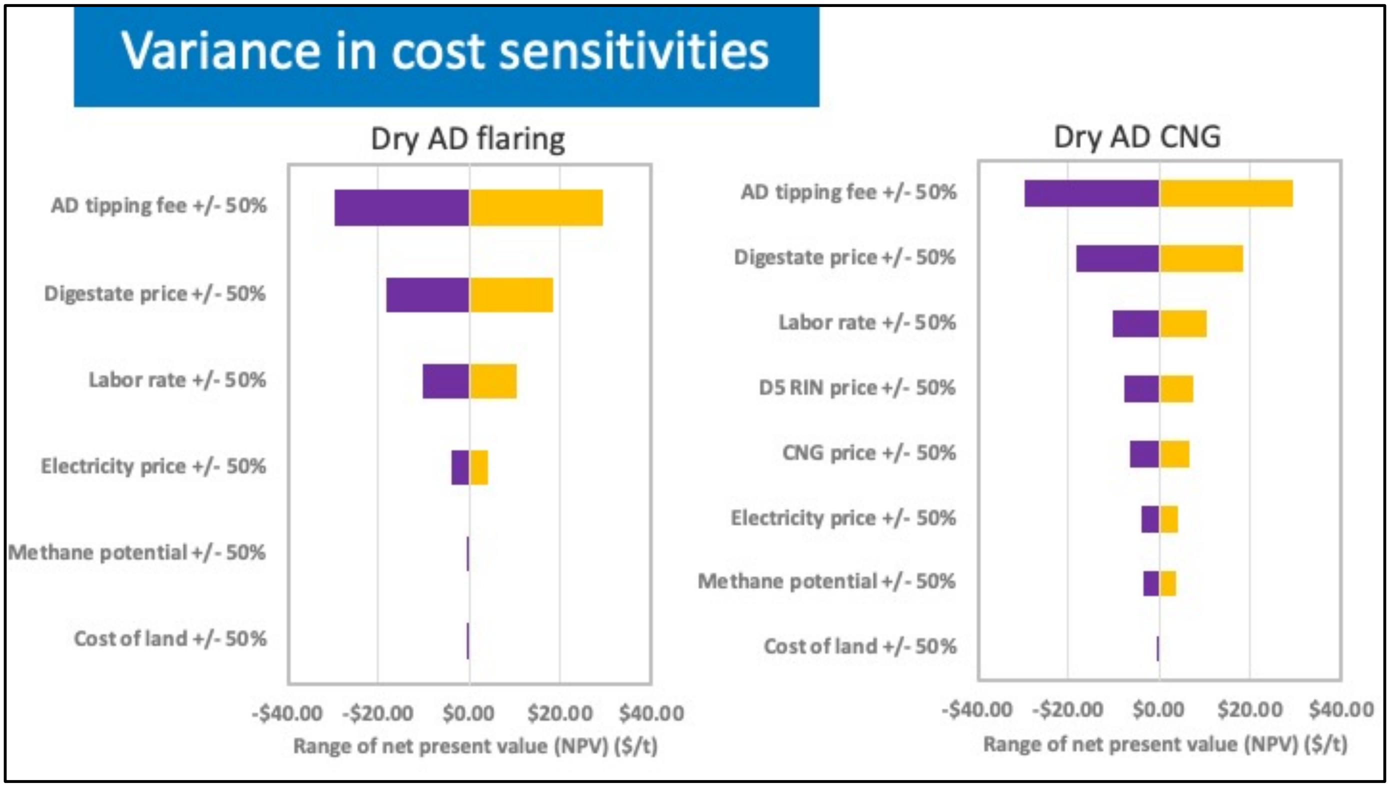

Key consideration:
Why does profitability decrease for CNG pathways at larger scales?
The CBA model is constrained to only depict CNG systems of a certain size (50-600 ft^3/min biogas) due to lack of validated cost data. Systems generating biogas at rates exceeding this are assumed to flare the excess. Real CNG systems might be able to operate at higher biogas flow rates, but data depicting their costs is unavailable.
NREL | 7

Sensitivity analysis: AD CHP

- Tipping fees are the largest driver of economics, but digestate and electricity prices revenue streams are also important
- Labor rates are drivers of operating costs



For AD CHP systems the key cost driver is the tipping fee and price of digestate sold from the digester. Since the system produces electricity and heat energy, the prices of electricity and natural gas price are also cost drivers, albeit small ones.

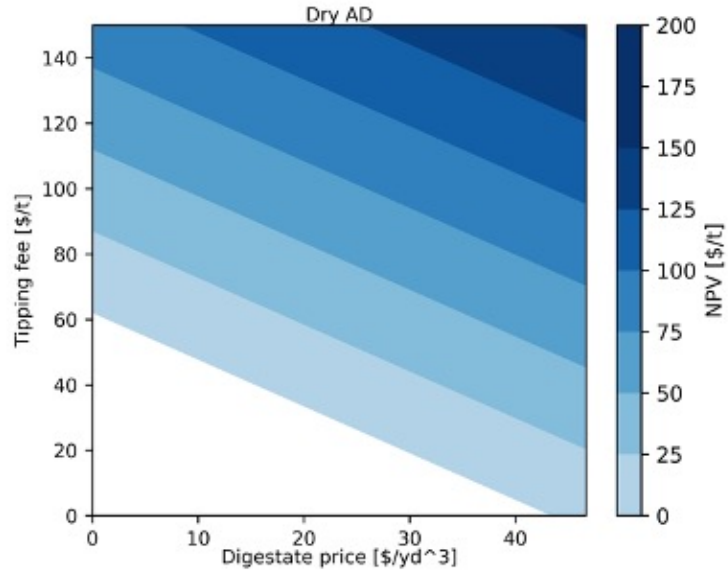


If an AD biogas energy system is developed, the economics of a waste management pathway become dependent on the methane generated from food waste in the pathway. As evidenced in the AD with gas flaring and AD with CNG shown on this slide, the D5 RIN prices and CNG prices become stronger cost drivers because multiple facility revenue streams are determined by them, including: LCFS revenue, CNG revenue, and RIN revenue. In contrast, AD pathway with flaring flaring primarily depends on the tipping fee.

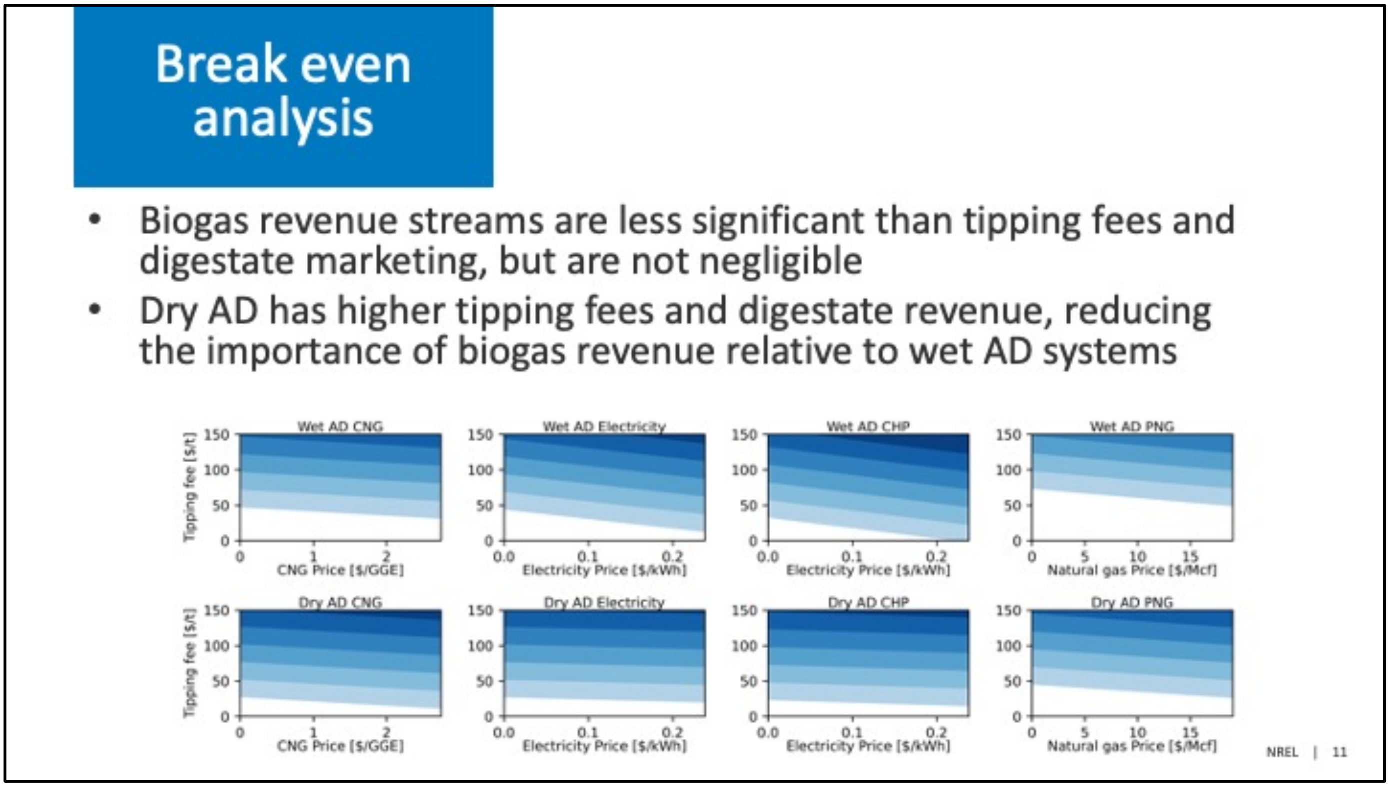
In a general sense, this consideration also hold true for other AD systems that utilize the biogas they generate.

Break even analysis

- Net present value is contoured as a function of tipping fee and digestate price, areas not contoured indicate an NPV less than zero
- Higher tipping fee reduces minimum digestate selling price and vice versa



The plot shown at the right considers different tipping fees and digestate prices and the resulting NPV for the AD pathway, illustrating the relationship between these two parameters. Any NPVs less than zero are not shaded blue. As such, the edge of the white area suggests the break even prices for tipping fees and digestate prices. This analysis was conducted for a dry AD facility at a scale of 87,183.



The figure below shows relationships between wet AD and dry AD systems for those that produce products from biogas. As shown in the figure on slide 10, these shaded areas represent the break-even relationships between tipping fees and prices for the biogas products.

Conclusions

- Multiple possible pathways to managing food waste via AD exist and could be economically viable solutions
- A key consideration of the feasibility of any of these pathways is the amount of food waste that can be treated at the facility and possible economies of scale for the digester
- Waste-to-energy systems and incentives such as RINs and the California LCFS could represent significant revenue streams, but depend on accessing appropriate markets and managing biogas generated from AD

Key Assumptions and Caveats

- This study does not include the cost of collecting and pre-processing (e.g., de-packaging, shredding, mixing) food waste. While economics are better for larger facilities, these may require collecting food waste from more distant sources, driving up collection costs.
- The cost of guaranteeing access to RIN and LCFS markets is not included and should be analyzed in detail to ensure a facility can access these markets.
- A constant feedstock methane content was assumed in this work. In reality, the methane content in food waste varies depending on the source and composition of the waste.
- The facility costs and benefits estimated in this study are taken from academic literature, and real-world costs are likely to vary from those shown here. It is essential to validate the costs estimated here with quotes from developers coupled with further economic analysis prior to any investment.