MIDWEST BIOSOLIDS ASSOCIATION

MBA Annual Conference Keynote Address

Anaerobic Co-digestion on Department of War Installations: Increasing Energy Security?

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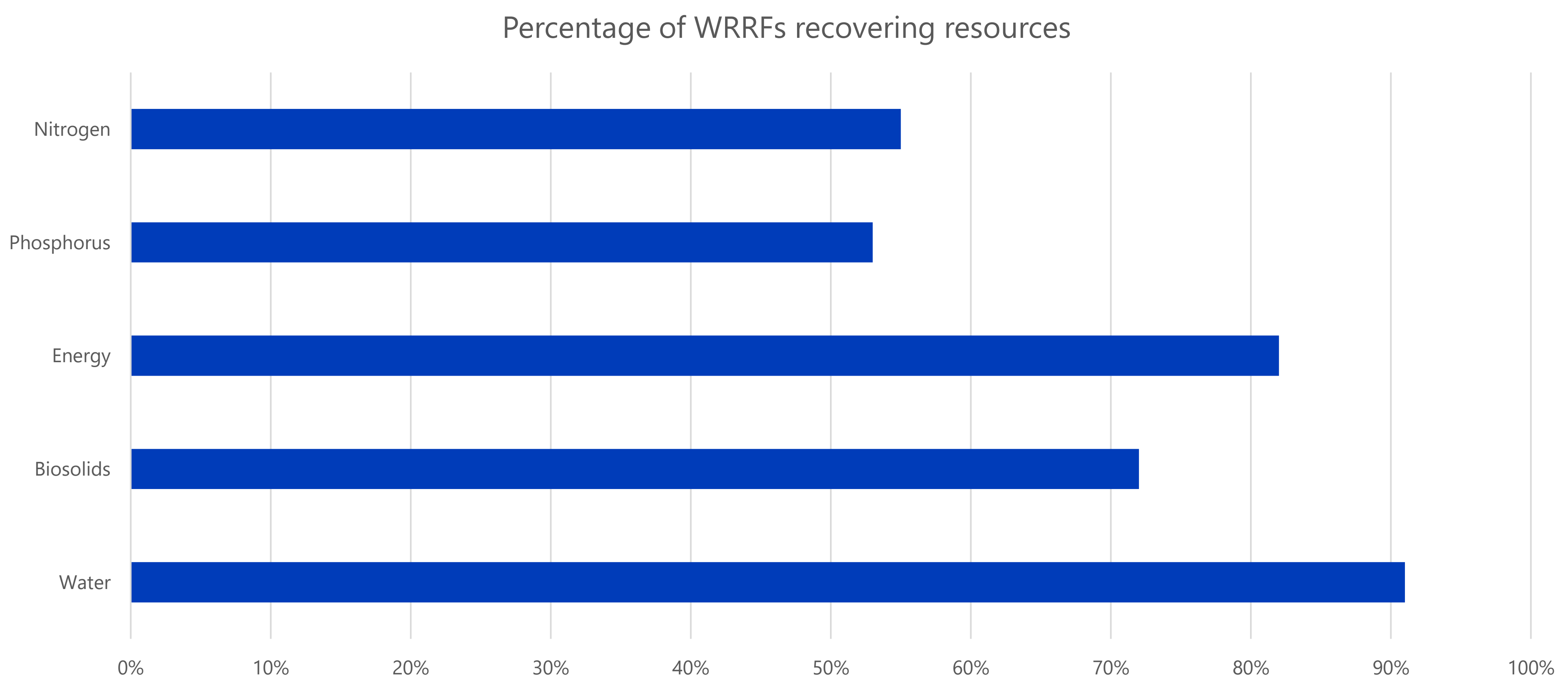
June 9th, 2026

carollo

Pollution is nothing but the resources we are not harvesting. We allow them to disperse because we've been ignorant of their value.

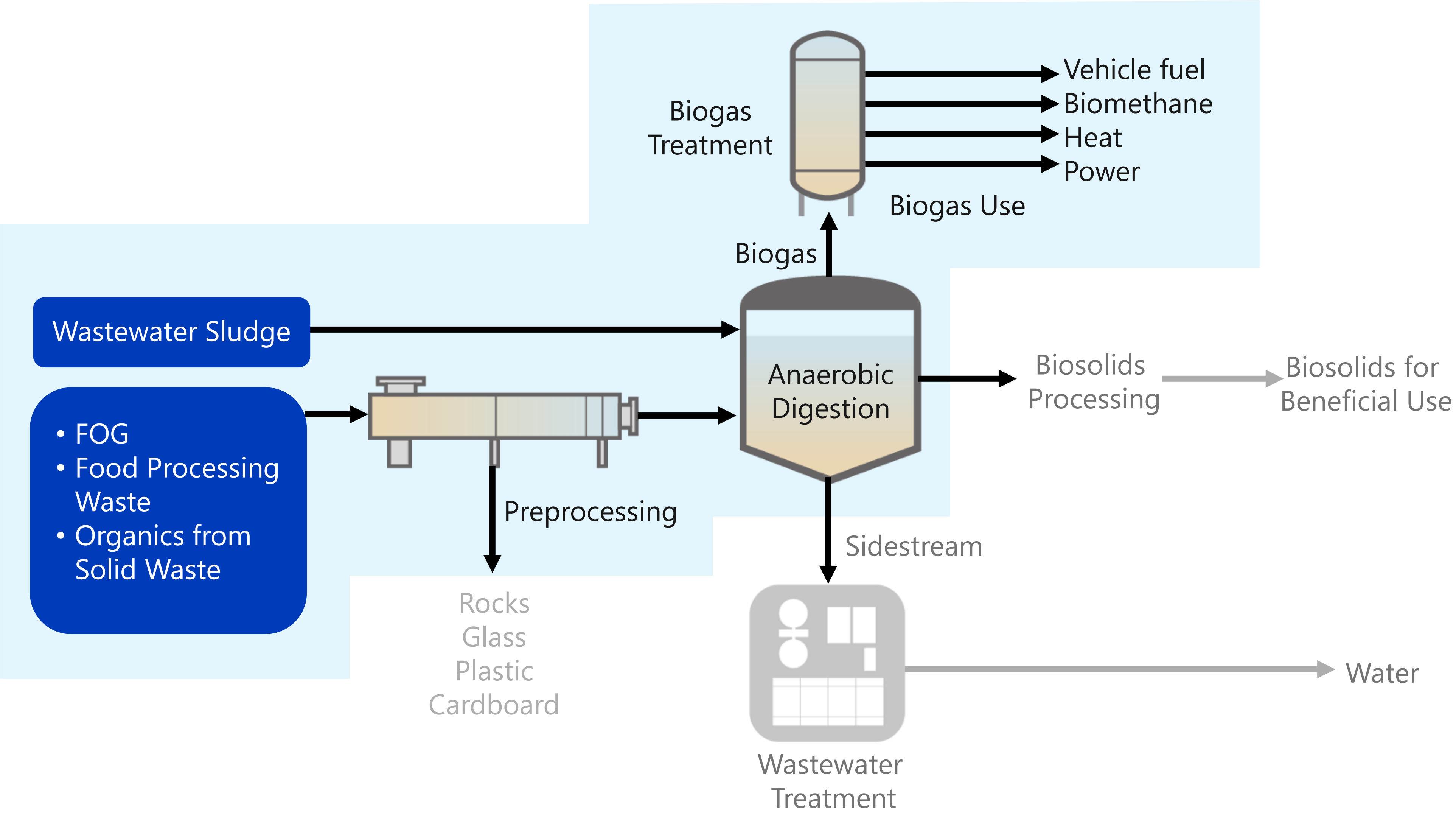
R. Buckminster Fuller

According to WEF survey, the majority of WRRFs claim significant resource recovery



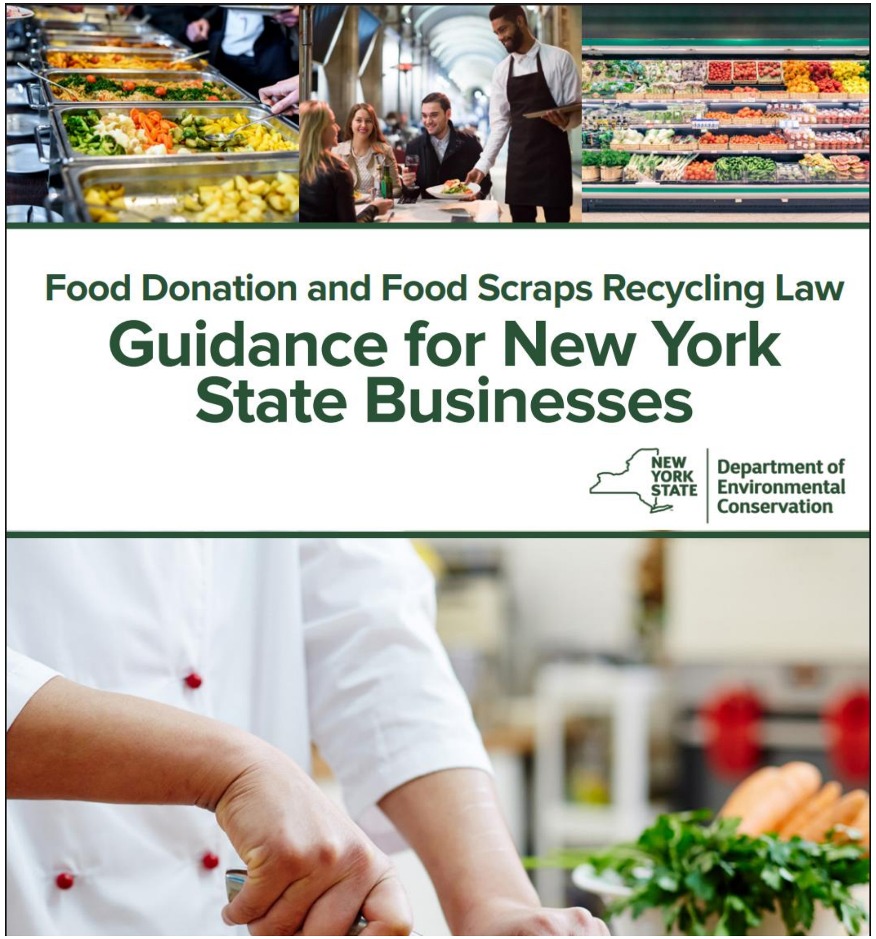
Baseline Data to Establish The Current Amount of Resource Recovery from WRRFs, WEF, 2018

Co-digestion can turn organic waste into energy



Co-digestion may be driven by regulations to divert food waste from landfills

Source: State Water Board, Carollo, Co-digestion Capacity in California, June 2019



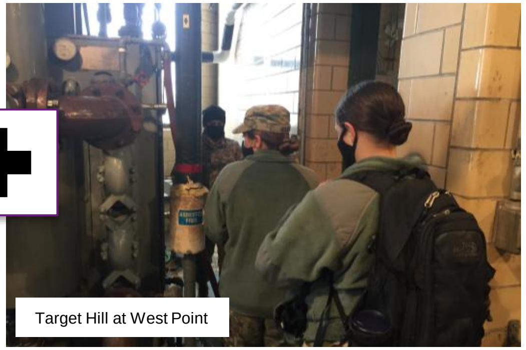
Source: NY State Department of Environmental Conservation, 2025

For DoW…Energy Security Opportunity

Acute Stressors

External Grid Reliance

Aging Infrastructure



Policy for Energy Security

SECRETARY OF THE ARMY
WASHINGTON

3 1 MAR 2020

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Army Directive 2020-03 (Installation Energy and Water Resilience Policy)

Opportunity: Co-digestion of Food, FOG, Sludge

For Onsite Electrical and Heat Energy Generation

DOD installations require improved solutions to meet energy security objectives. Onsite energy production through co-digestion of organic wastes can enhance energy security.

Project Team

AMERICAN WATER

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Environmental Eng.

Post-Doc

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West Point Collaborators

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Respirometry Kinetics Modeling

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Other Teammates

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Dr. Enoch Nagelli – Energy Storage

Former Teammates

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MAJ Chelsea Linvill – Wastewater
MAJ Alex Pytlar – Resilient Systems
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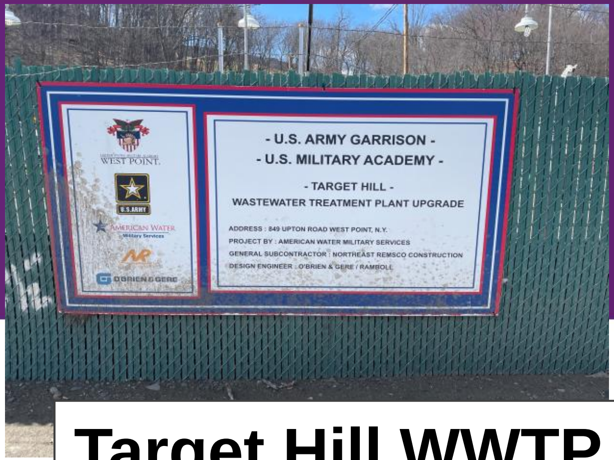
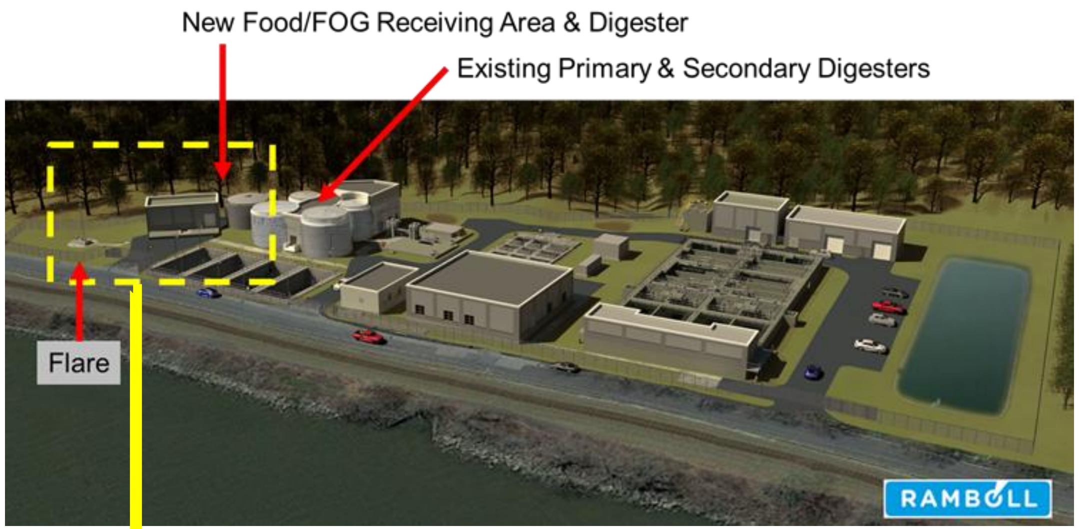
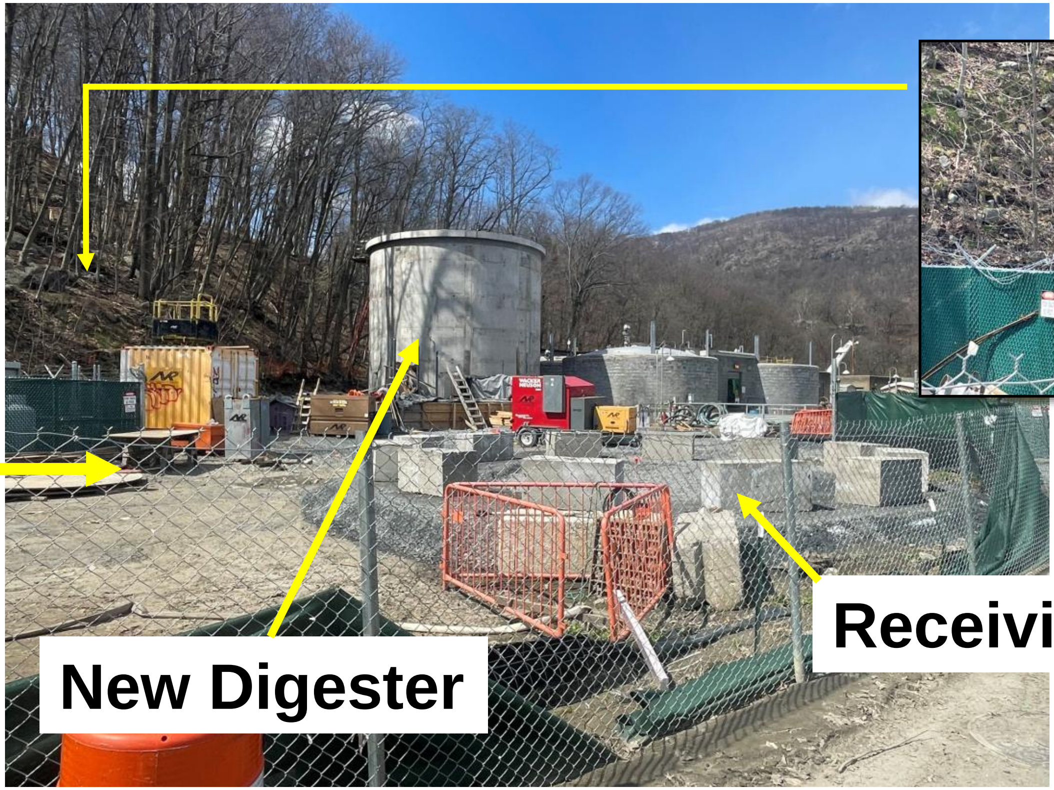
ESTCP

Site Description



Target Hill WWTP, West Point, NY





Status:

- New aeration basins
- Digesters construction
- New site engineer

Food & FOG Generation Rates

	Generation Rates (kg/week)	
Generator	**Food Waste**	**FOG Waste**
Bowling Alley	25	16
Hotel	188	44
Golf Course/Ski Lodge Snack Bar	48	14
Grocery Store	1,500	NA
Fast Food Restaurant	171	44
Child Development Center	27	NA
Collegiate Sports Complex	207	44
Student Café	108	22
Student Dining Hall	13,870	562
Community Club and Restaurant	119	18
Student Bar and Grill	29	11
Large Theater Complex	30	14
Sandwich Shop / Coffee Shop	79	11
Elementary School	54	9
Hospital	48	40
Preparatory School Dining Hall	629	29
Residential Areas	1,987	NA
Total	***19,119***	***875***

- In-depth survey used to determine rates
- Need to validate reported rates over time
- **72.5%** of food and **64.2%** of FOG from cadet mess hall

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Modeled Methane Production

Scenario 1 = sludge only

Scenario 2 = expected organic waste input

Scenario 3 = needed to power WWTP

	Sludge	Food	FOG
Scenario 1	100%	0%	0%
Scenario 2	67%	30%	3%
Scenario 3	24%	70%	6%

Solids Model	Scenario 1	Scenario 2	Scenario 3
Waste Solids (kg TS/d)	1,546	2,291	6,564
Sludge	1,546	1,546	1,546
Food	0	684	4,606
FOG	0	61	412
% CH_4 in biogas	63.0%	62.3%	61.3%
V_{CH4} (m^3/d)	375	605	1,930

bCOD Model	Scenario 1	Scenario 2	Scenario 3
Waste Flowrate (m^3/d)	36	42	74
Primary sludge	20	20	20
Waste activated sludge	16	16	16
Food	0	5.4	37
FOG	0	0.14	0.92
V_{CH4} (m^3/d)	347	605	2,082
% Diff CH_4 from Solids Model	-8%	0%	8%

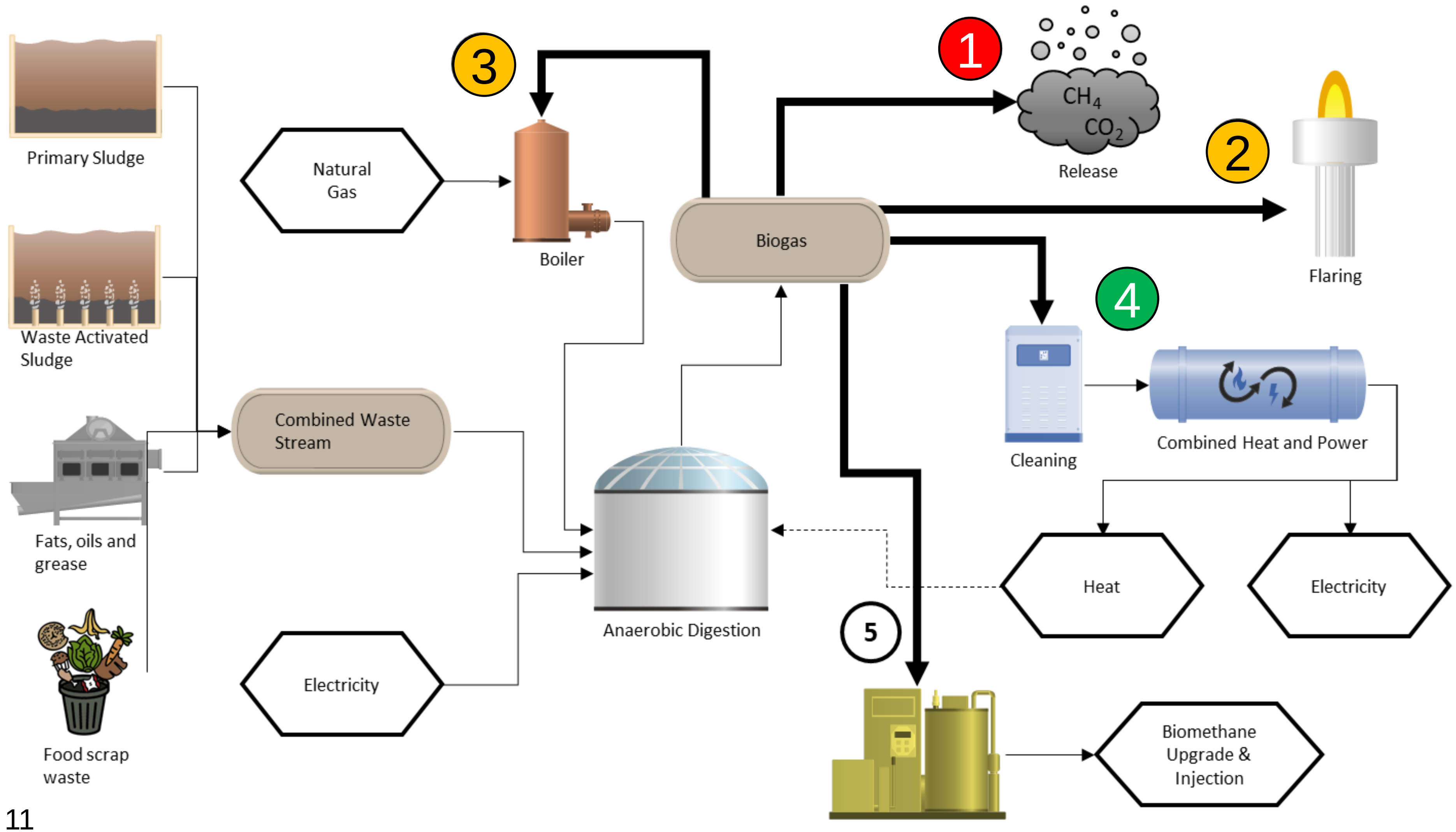
Energy Production

Solids Model	kg CH_4/d	MJ/d	kWh/d
Scenario 1	238	11,884	990
Scenario 2	384	19,207	1,601
Scenario 3	1,224	61,216	5,102

bCOD Model	kg CH_4/d	MJ/d	kWh/d
Scenario 1	220	11,017	919
Scenario 2	384	19,186	1,600
Scenario 3	1,321	66,047	5,509

Biogas Use Options

- Baseline (red)
- Planned (yellow)
- Aspirational (green)



1. Uncontrolled release
2. Flaring
3. Boiler (heat energy)
4. CHP (heat & electrical energy)
5. Natural gas pipeline injection

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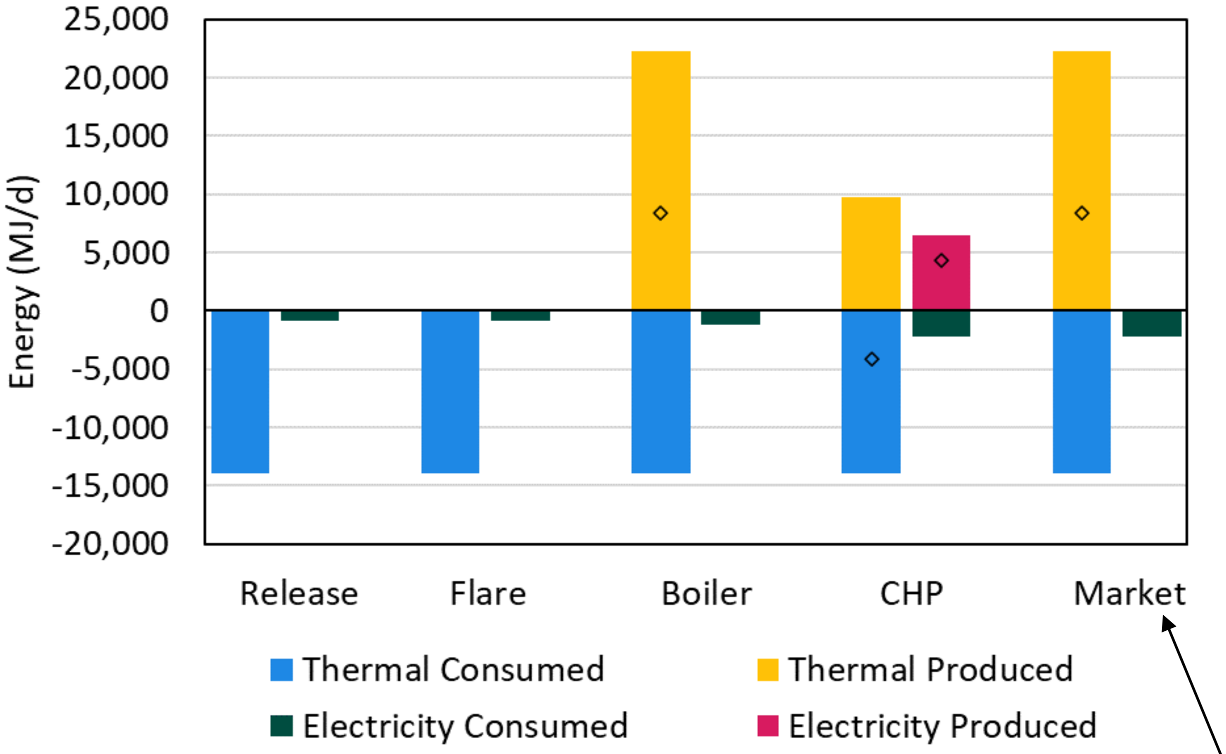
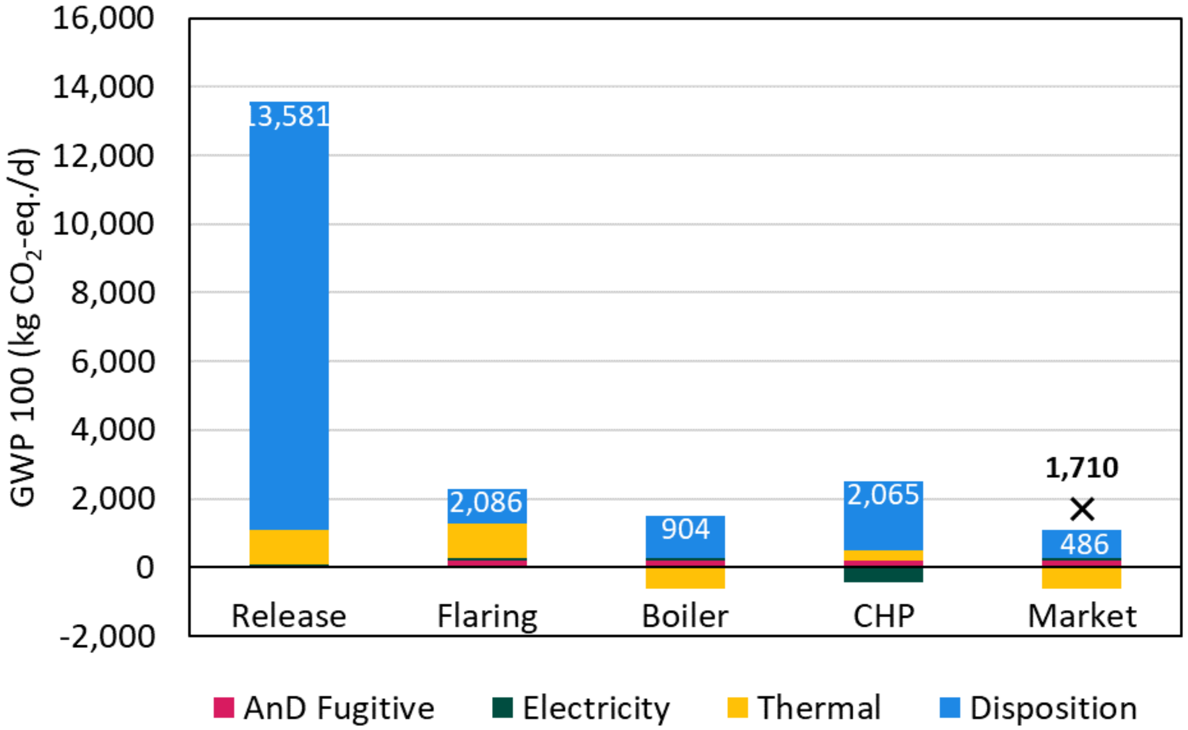
Energy Production & Carbon Emission Modeling (Monte Carlo Simulation Outputs)

Energy Production by Biogas Use Option

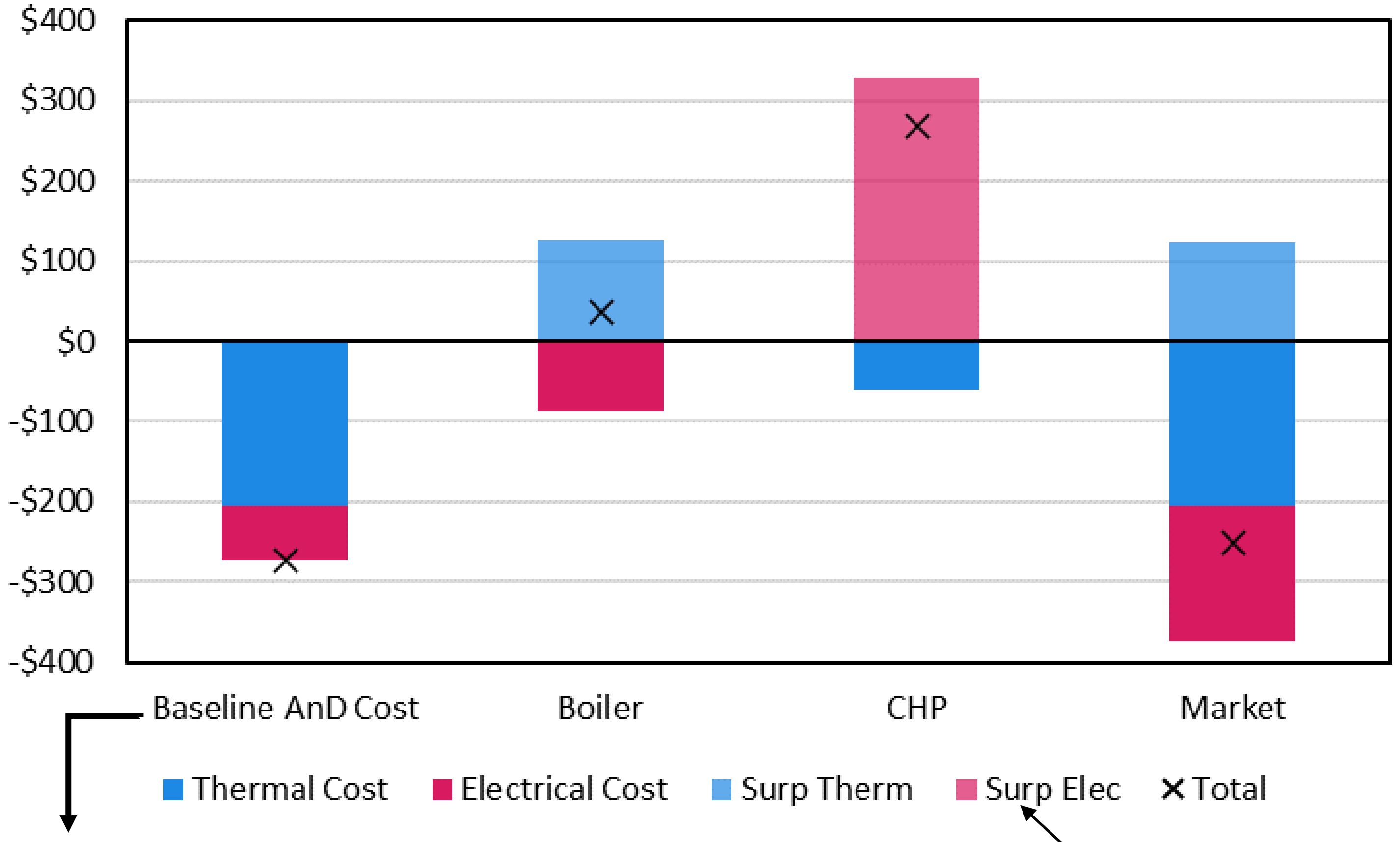


GWP (Carbon Emissions by Biogas Use Option)



RNG, Energy used offsite

Cost Comparison of Biogas Use Options ($/day)



Costs per day with no energy recovery

Surp = surplus

- **Boiler and CHP** are cost savers through production of energy onsite (cheaper than buying from grid).
- **CHP** has the highest cost saving potential.
- **Upgrading to natural gas** for pipeline injection carries a large financial overhead

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Technoeconomic Analysis of CHP + other renewable tech to achieve net energy production

Baseline (Boiler)	Scenario 1 (CHP)	Scenario 2 (CHP + PV)	Scenario 3 (CHP + PV + Pyrolysis)
• 85% thermal efficiency • No electricity generation	• 2 x microturbines • 23.9% & 48.2% electric & thermal efficiency	• Nameplate: 1,234 kW DC • Requires natural gas supplement in Jan-Mar	• Solids → Py-char, py-gas, and py-oil • High solids disposal savings
Thermal Positive Only	Partial Energy Offset Only	Net-Energy Positive	Net-Energy Negative
NPV: -$11.3 M Annual O&M: $0.61 M	NPV: -$13.8 M Annual O&M: $0.74 M	NPV: -$10.7 M Annual O&M: $0.43 M	NPV: -$12.3 M Annual O&M: $0.42 M

Anaerobic co-digestion of sewage sludge, food and FOG

Trade offs: Capital vs. O&M vs. Energy

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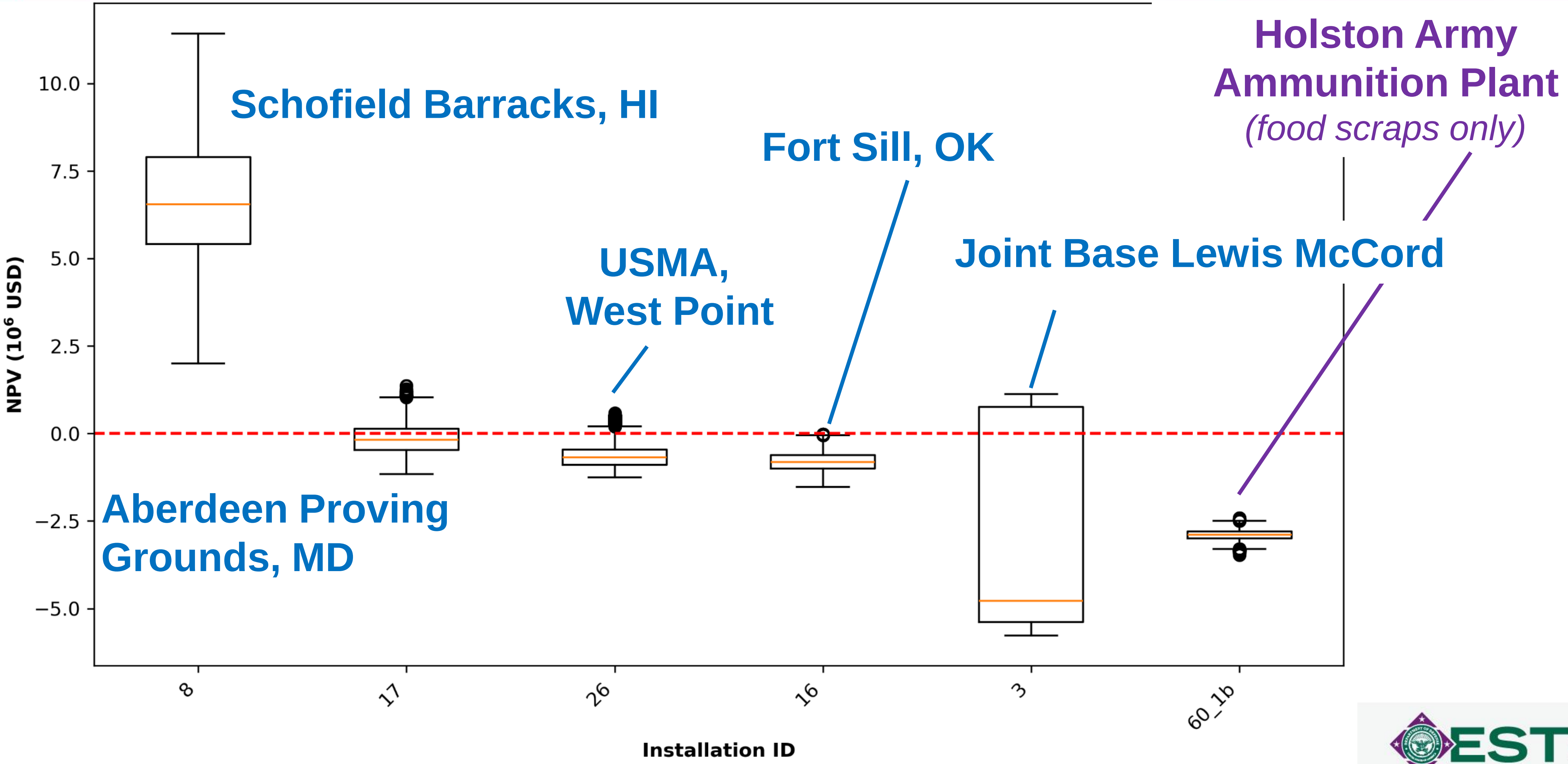
Significant Results for West Point

- West Point produces > ~19,000 kg/week of food scraps and ~875 kg/week FOG. Most comes from the Cadet Mess Hall.
- Co-digestion produces ~600 m^3 CH_4/day
- Energy potential in produced CH_4 is > 19,200 MJ/d or 1,600 kWh/d
- C65 microturbine can offset 33-64% of WWTP energy needs. (Best case = 86%)
- Available organic wastes cannot power the entire WWTP. Need ~115,000 kg/wk organics to become net energy producing from organics alone.
- Tradeoffs between boiler and microturbine concerning energy production and carbon emissions. (Boiler = more heat energy, less emissions; CHP = electricity produced)
- Microturbines + solar are the best option to achieve net on-site energy production

Screening Study of Army Installations



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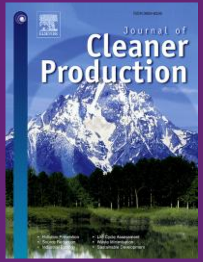
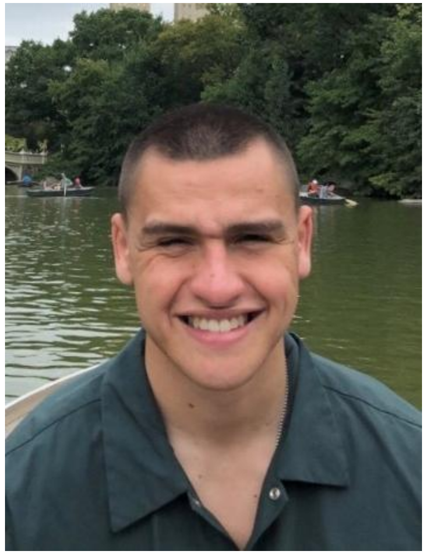
Publications



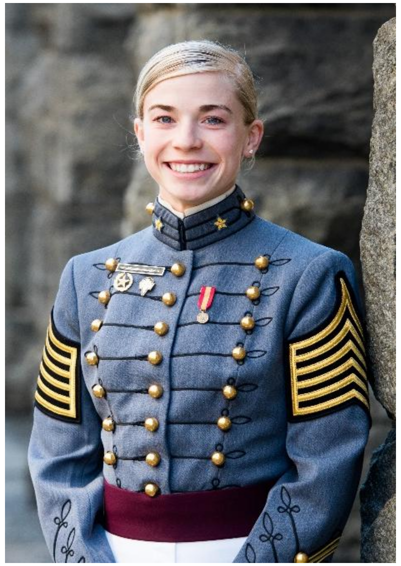
- J. L. Callahan, T. Douthwaite, D. Esqueda, K. Newhart, and A. Pfluger, Technoeconomic analysis of energy-producing small-scale wastewater resource recovery facility using anaerobic co-digestion and renewable energy technologies, *ACS ES&T Engineering*, 2025.
- P. Schmedeman and A. Pfluger, Evaluating Anaerobic Co-digestion and Biogas Production Potential for Energy Security on Military Installations, *Journal of Cleaner Production*, 2025.
- J. L. Callahan and A. Pfluger, Comparison of energy production and carbon emissions from varying biogas dispositions from anaerobic co-digestion at a small-scale wastewater treatment plant, *Environment Systems and Decisions*, 2025.
- J. L. Callahan, C. A. Robbins, T. Douthwaite and A. Pfluger, Toward Net Energy-Positive Wastewater Treatment via Anaerobic Codigestion of Organic Wastes at Small Scale, *Environmental Engineering Science*, 2025.
- B. Krueger, A. Shetty, D. Esqueda, L. Bentley, J. Hooper, A. Zumbuhl, M. Butkus, and A. Pfluger, Measuring Biomethane Potential of Food Scrap Waste Anaerobically Co-Digested with Waste-Activated Sludge Using Respirometry. *Journal of Visualized Experiments*, 2024.

LT Annesley Black
Fulbright Scholar

LT Marley Wait
Marshall Scholar



LT Ian Morris
GEM, Stanford



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Thank you!

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