Demonstrating Pathogen-Free Thermal Treatment Solutions Towards ISO/PC 318 Energy Neutrality Requirements

EDGARD NGABOYAMAHINA edgard.ngaboyamahina@duke.edu

Edgard Ngaboyamahina, August Frechette, Taylor Myers, Lars Schoebitz

BIOMASS CONTROLS

Center for WaSH-AID
WATER, SANITATION, HYGIENE AND INFECTIOUS DISEASE

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Outline

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- Thermal Treatment and the Biogenic Refinery
- ISO/PC 318
- Energy Available in Fecal Sludge
- Methods
- Results
- Discussion

Introduction

Thermal treatment and the Biogenic Refinery

- Need for community scale FSTUs
- Emerging standard for off-grid ISO/PC 318
- The Biogenic Refinery

What is needed to comply?

Key criteria for compliance with the standard include:

- Achievement of pathogen threshold requirements
- Energy independence in steady-state

Energy Available in Fecal Sludge

Is there enough energy in fecal sludge to power the Biogenic Refinery (BR)?

Mean calorific value of fecal sludge

SOURCE	CALORIFIC VALUE (MJ/kg)
Gold, Moritz, et al.[1]	10.9, 13.4
Muspratt, Ashley, et al.[2]	16.6, 16.2, 19.1
Myers, Taylor, et al.[3]	19.6, 22.3
Rose et al.[4]	AVG. 17.2, MEAN 19.1

1. Gold, Moritz, et al. "Faecal Sludge as a Solid Industrial Fuel: a Pilot-Scale Study." *Journal of Water, Sanitation and Hygiene for Development*, vol. 7, no. 2, 2017, pp. 243–251.
2. Muspratt, Ashley, et al. "Fuel Potential of Faecal Sludge: Calorific Value Results from Uganda, Ghana and Senegal." *Journal of Water, Sanitation and Hygiene for Development*, vol. 4, no. 2, 2014, pp. 223–230.
3. Rose C, Parker A, Jefferson B, Cartmell E. "The Characterization of Feces and Urine: A Review of the Literature to Inform Advanced Treatment Technology." *Crit Rev Environ Sci Technol.* 2015;45(17):1827-1879.
4. Myers T, Miller, G, Piascik J, Hallowell J, Stoner B. A thermal analysis of the pyrolysis and combustion of real and simulated human feces. *Fuel.* Paper in preparation.

Estimates prior to testing

POWER AVAILABLE

BR throughput: 20 kg/hr
Energy content: 19 MJ/kg
Thermal power: 106 kW

POWER NEEDED

All BR components: 3 kWe

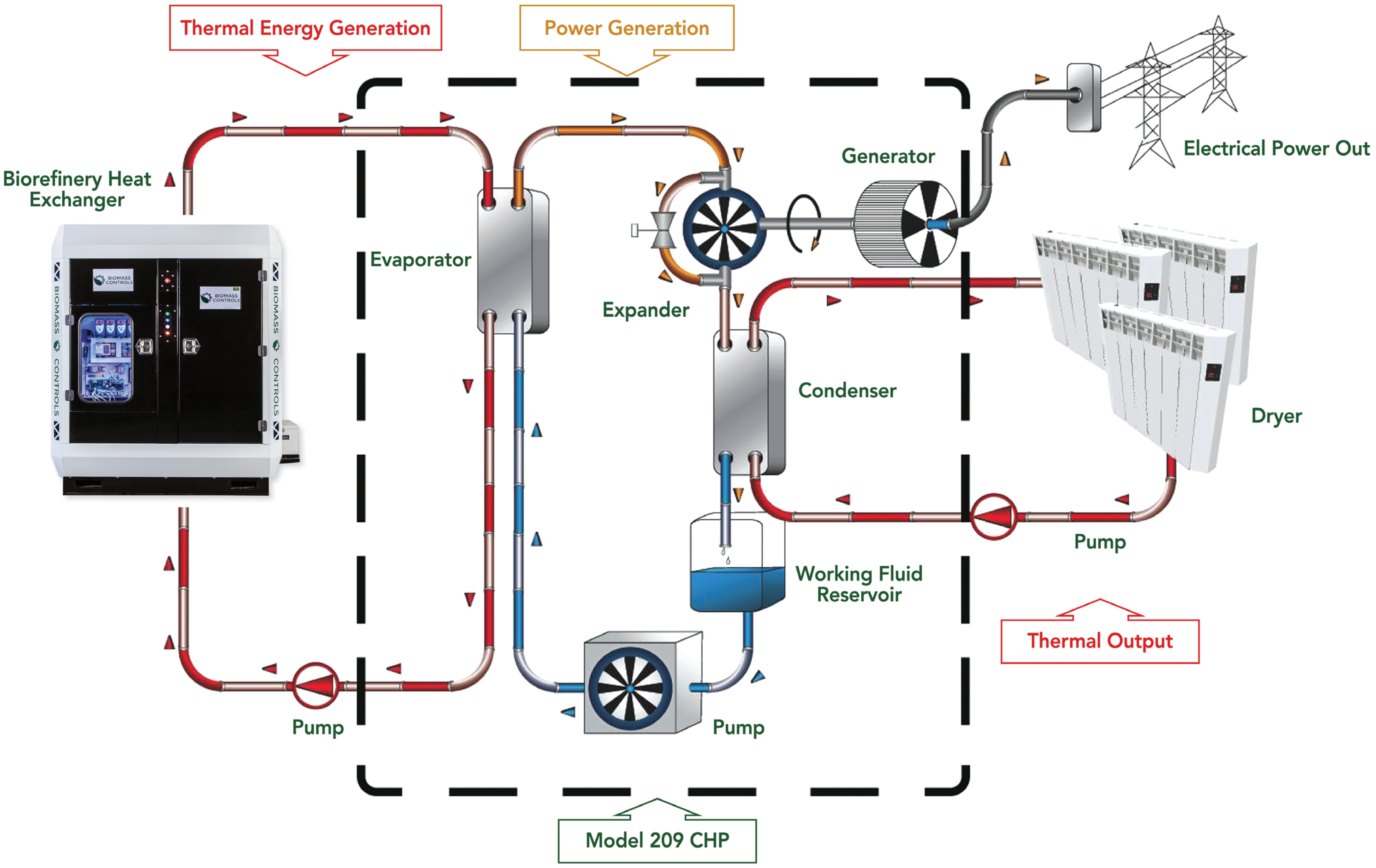
kWth to kWe efficiency required: 4%

Objectives

What was the goal of the exercise?

- Document energy flow in a thermal treatment unit
- Demonstrate the availability of thermal power in a thermal treatment unit
- Demonstrate the ability to generate an excess of electrical power with a Biogenic Refinery CHP unit

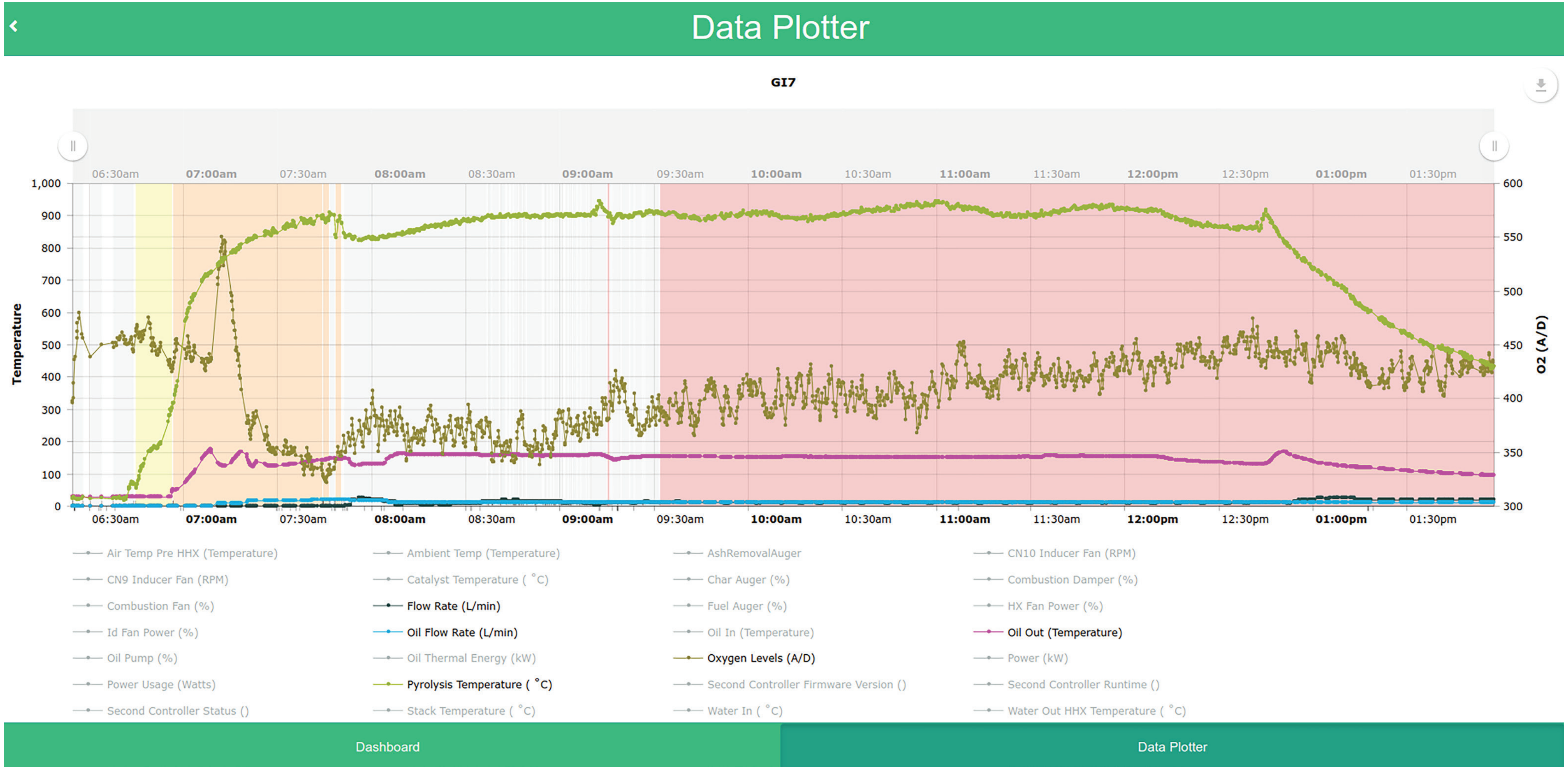
Methods | BR CHP



Methods | Test Protocol

- Run with wood pellets equivalent to fecal sludge energy
- Monitor thermal power of BR in steady state
- Monitor electrical power through ORC
- Data recorded with kelv°n

Methods | Test Protocol



How much energy was entered into the system?

Wood pellets

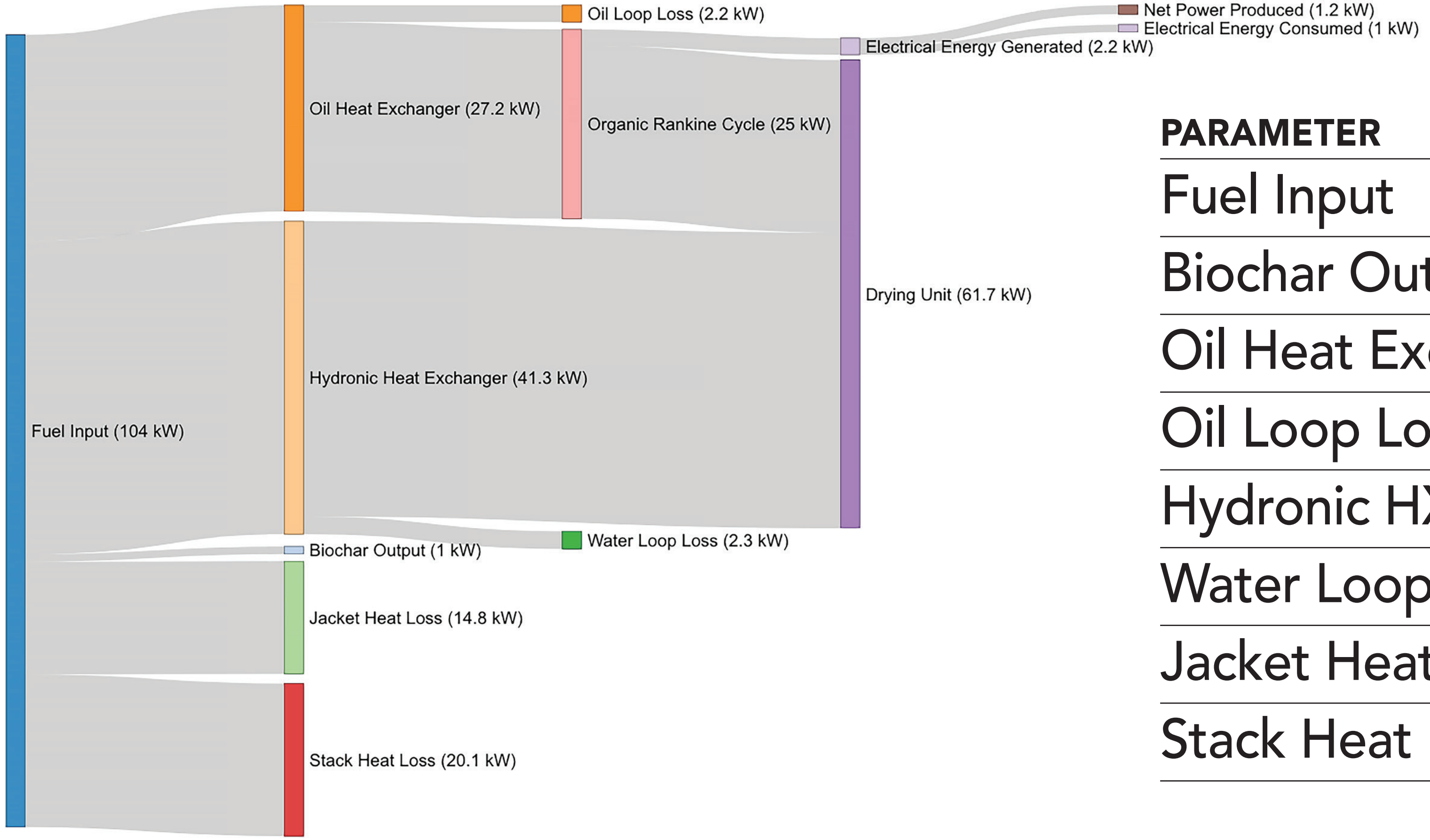
- 19.2 MJ/kg
- 35% MC
- 21.1 kg/hr (dry basis)

Energy input

- Gross energy in: 112.5 kWth
- Water evaporation: 8.0 kWth
- Net energy in: 104.5 kWth

Results | Thermal Power Balance

Where did the thermal power go in the BR?



PARAMETER	VALUE	UNIT
Fuel Input	104.5	kWth
Biochar Output	1.0	kWth
Oil Heat Exchanger	25.0	kWth
Oil Loop Loss	2.2	kWth
Hydronic HX	38.9	kWth
Water Loop Loss	2.3	kWth
Jacket Heat Loss	14.8	kWth
Stack Heat Loss	20.1	kWth

How much electrical power was consumed and produced in steady-state?

Electrical power generated

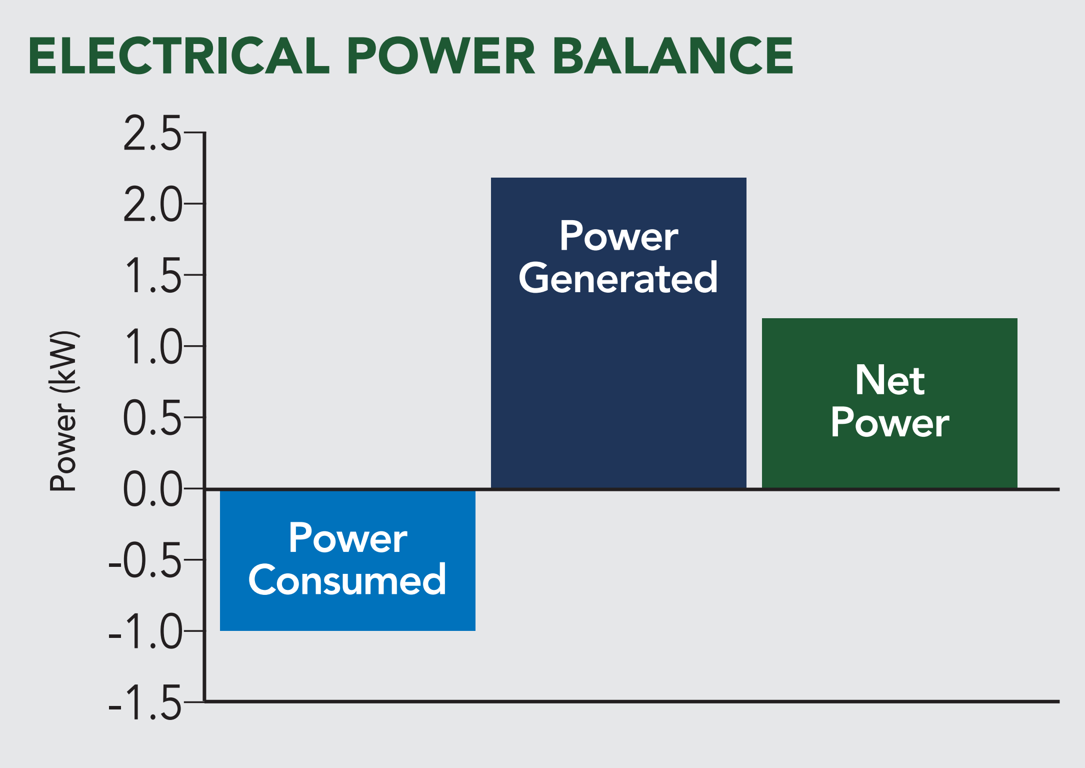
- 25.5 kWth received by ORC
- 2.2 kWe generated

Electrical power consumed

- 1.0 kWe in steady state

Net power generated

- 1.2 kWe



Discussion | Power Balance

What worked?

- More than enough energy in fecal sludge
- Parasitic load in steady state including the ORC was lower than hypothesized
- Even though only 24% of input kWth was sent to the ORC, twice the required electricity was produced

Discussion | Future Work

What remains?

- Energy independence requires off-grid operation, which requires batteries and power management
- Other ISO/PC 318 requirements (safety, etc.)
- Market needs

Thank you!

Contact: **edgard.ngaboyamahina@duke.edu**

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