The City College of New York

Improving Wards Island WRRF Energy Recovery Through Coupled Thermal Hydrolysis and Cogeneration Systems

David Cham, Janet Acquah, David Ip, & Julie Yaish

Agenda

Background
- Goals and Objective
  - Net-Zero Carbon goal of 2050
- Wards Island WRRF
- General THP

No-Build
- Diagram
- Graph of energy generation (gas flared, sent to energy, purchased fuel)
- ADG status

THP
- Diagram of Modifications
- Energy Demands

Comparison
- Energy Balance
- Cost Estimates

Background

Design Problem

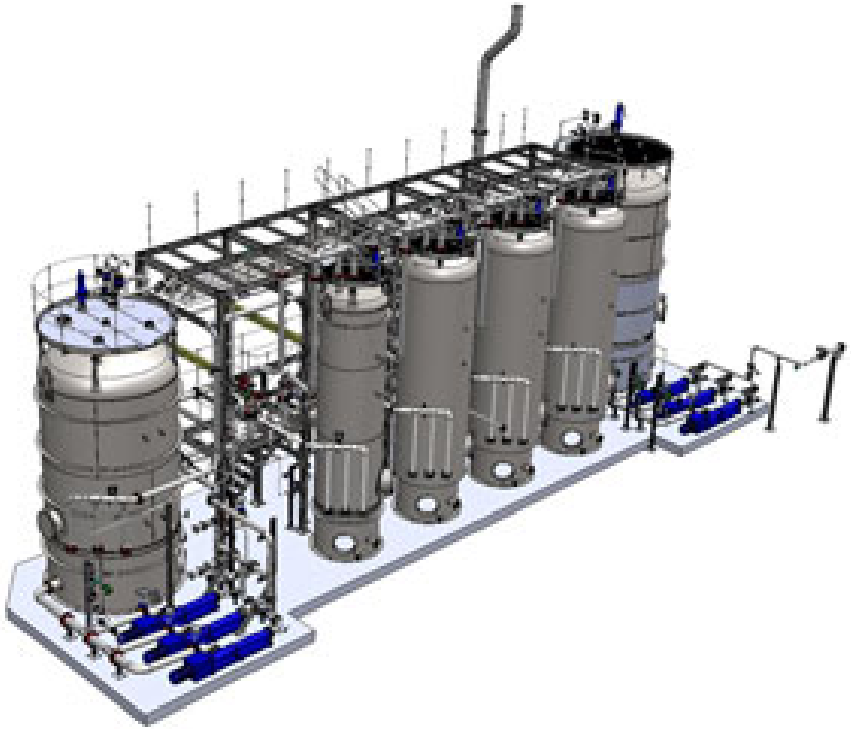
- Net-zero carbon emission
- WWRF at the Forefront of advancements
- Design

- NYC operates 14 WRRF
- 1. 3 billion Gallons per day collectively

Wards Island

- Located on Randall’s and Wards Island
- Serves over one million people
- 275 MGD flow capacity

Design Scope - Thermal Hydrolysis/Cogeneration

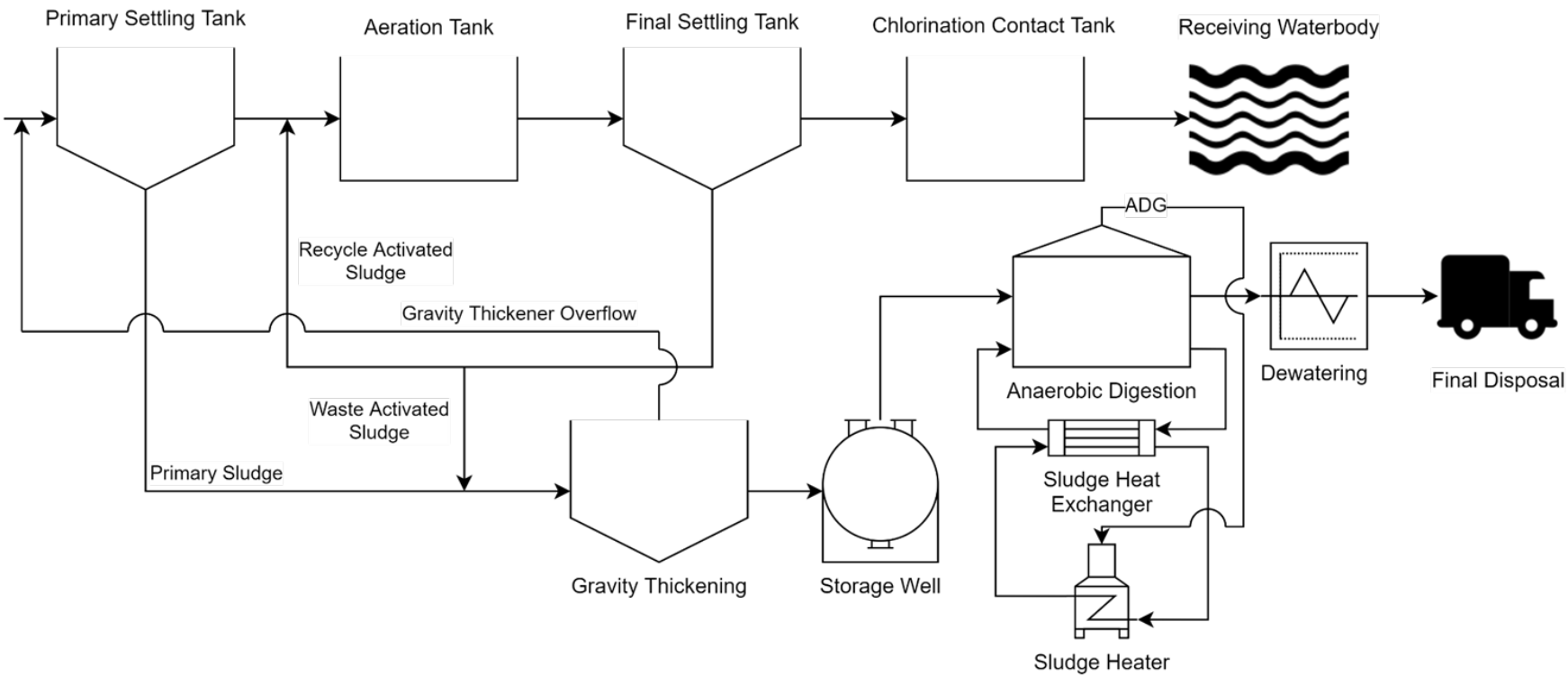


- Increase solids Distraction
- Increase Anaerobic Digester gas production
- Increase Anaerobic Digester capacity
- Net –Zero Energy Demand

Design Solution

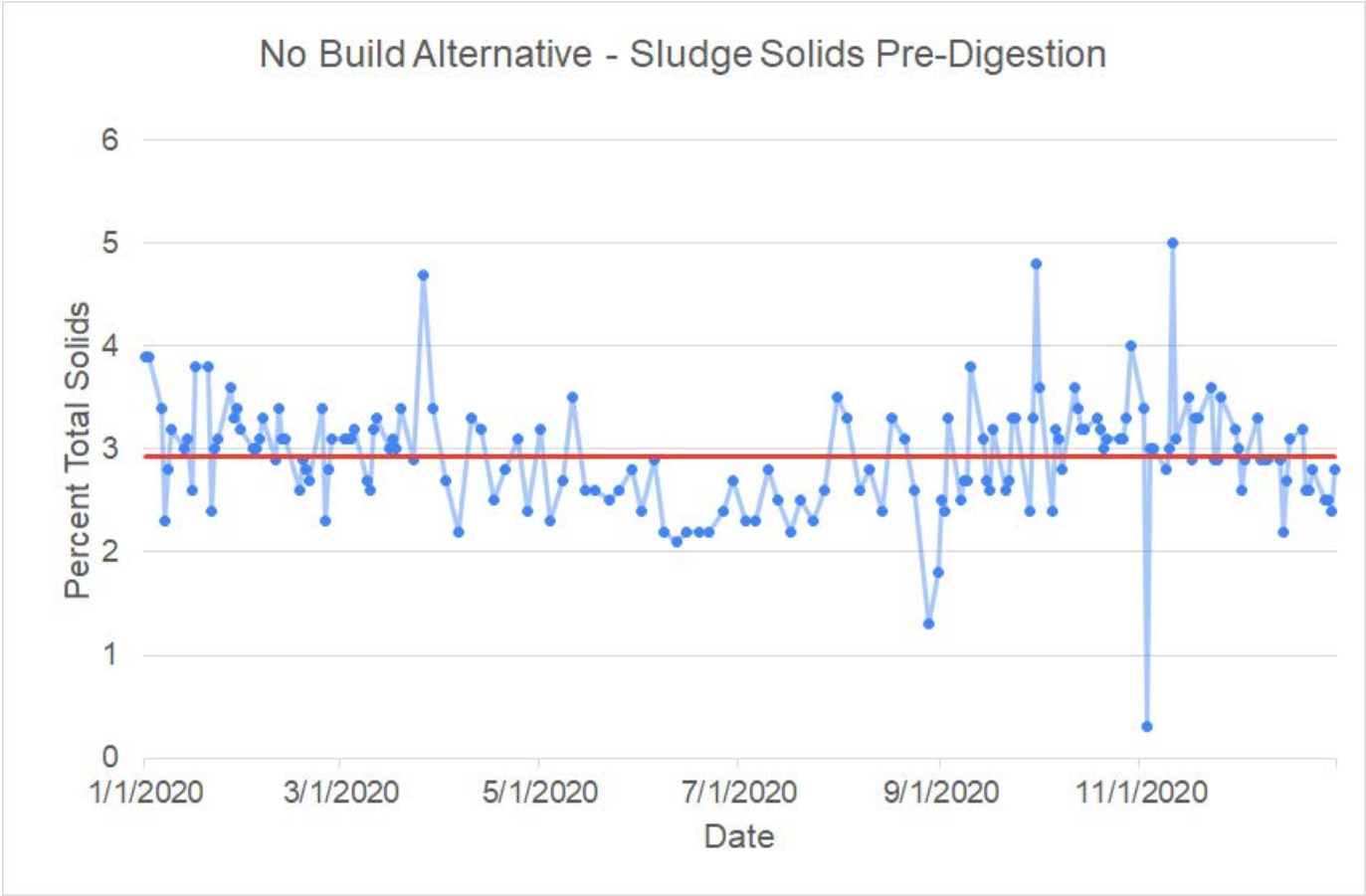
Alternative #1 - No Build

Existing Process -No-Build



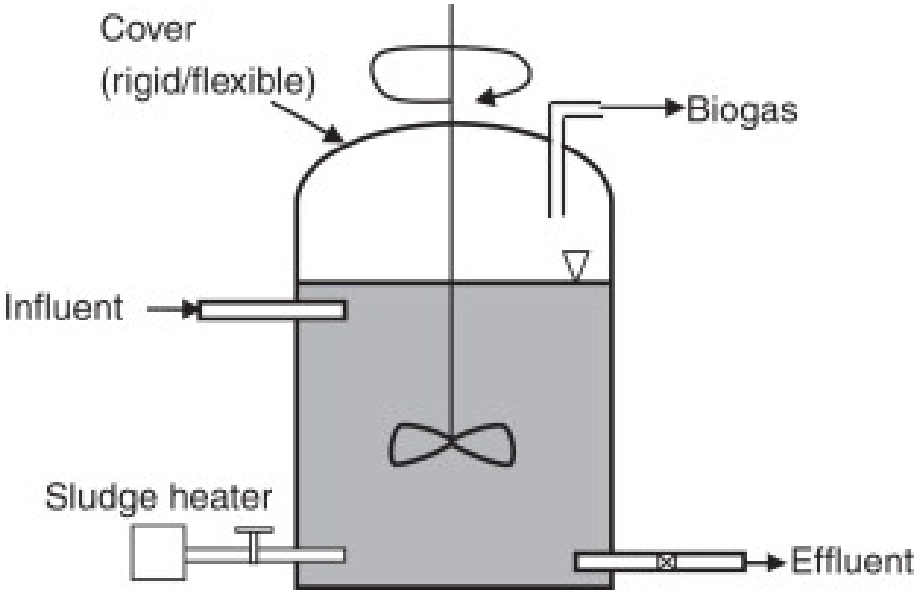
Thickening

- Current gravity thickeners result in sludge ranging from 0.3 to 5% solids
- Average thickness is 2.94% with standard deviation of 0.55%



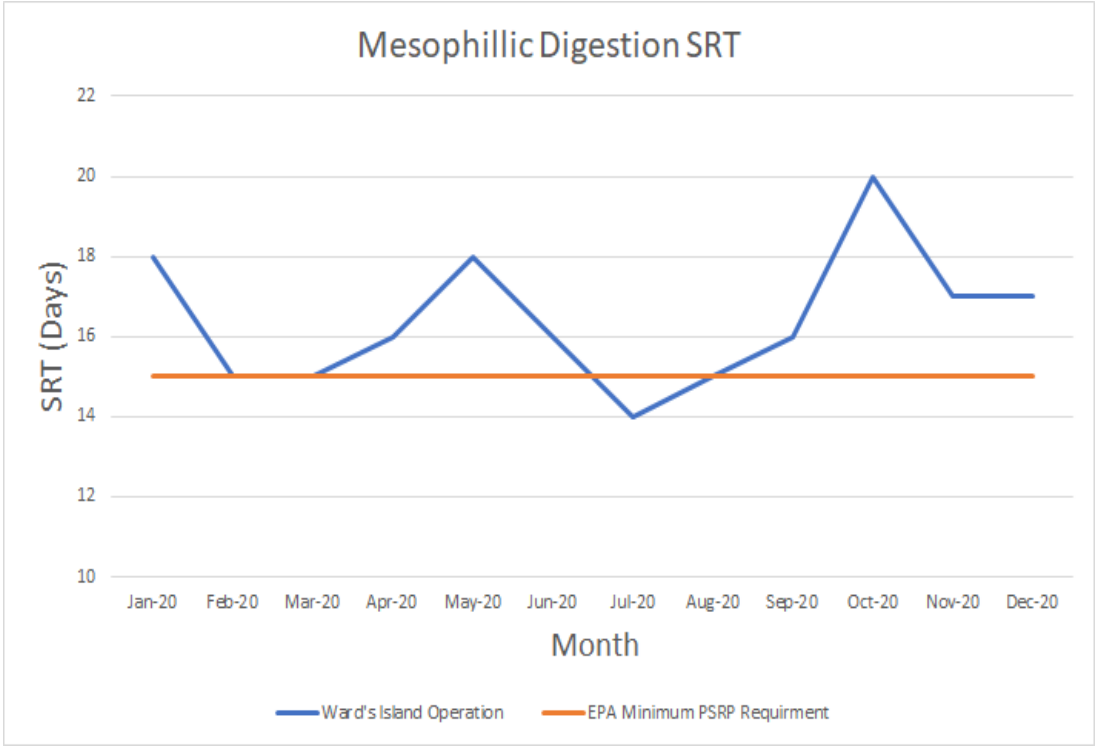
Anaerobic Digestion

- Sludge is placed in an oxygen deprived, cylindrical chamber
- Temperatures are raised to encourage bacteria activity
- Specialized bacteria and archaea break down biodegradable material in the absence of oxygen
- Biogas and digested sludge are the effluents

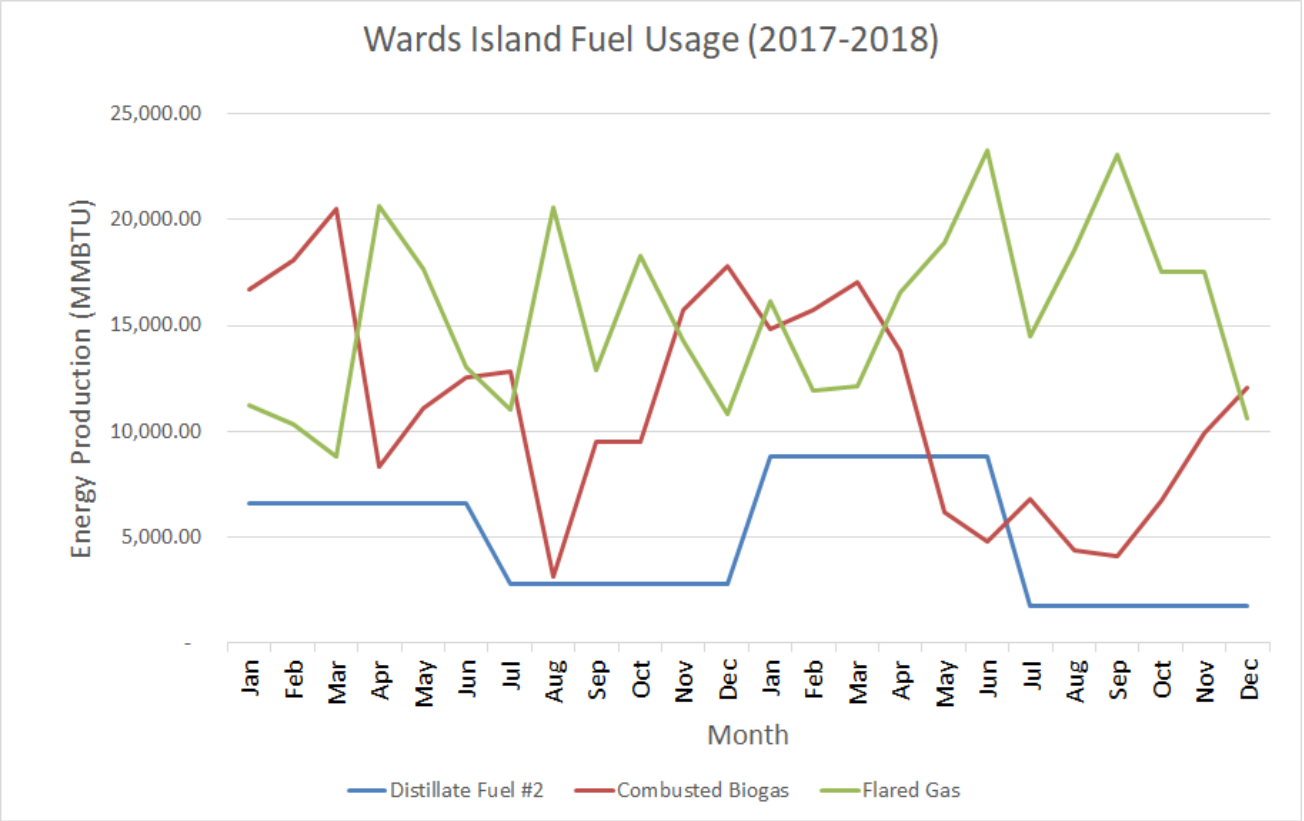


Mesophilic Anaerobic Digestion at Ward's Island

- Mesophilic digestion reduces sludge stream
  - Improves dewaterability
  - Minimizes shipping costs
- EPA requires a 15 day SRT to significantly reduce the pathogen content of sludge



- Average monthly biogas flared: 15,434 MMBTU
- Average monthly Distillate Fuel Purchased: 4,969 MMBTU
- Average monthly Biogas beneficially used: 11,345 MMBTU
- 41.7% of Biogas is beneficially used monthly
- Monthly Average Energy Potential: 108,024 MMBTU



Biogas Use

Current Usage

- Sent to Boilers to be burned for heating Facilities
- There is a surplus of Biogas that can be used

Potential Usage

- Boiler Usage with New Storage
- Cogeneration
- Direct Fueling to Vehicles
- Direct Injection into Fuel Pipeline
- Modifying Anaerobic Digestion (Biorefinery)
- Thermal Hydrolysis Pretreatment with Cogeneration
- Thermal Hydrolysis Pretreatment without Cogeneration

Alternative 2 - Thermal Hydrolysis

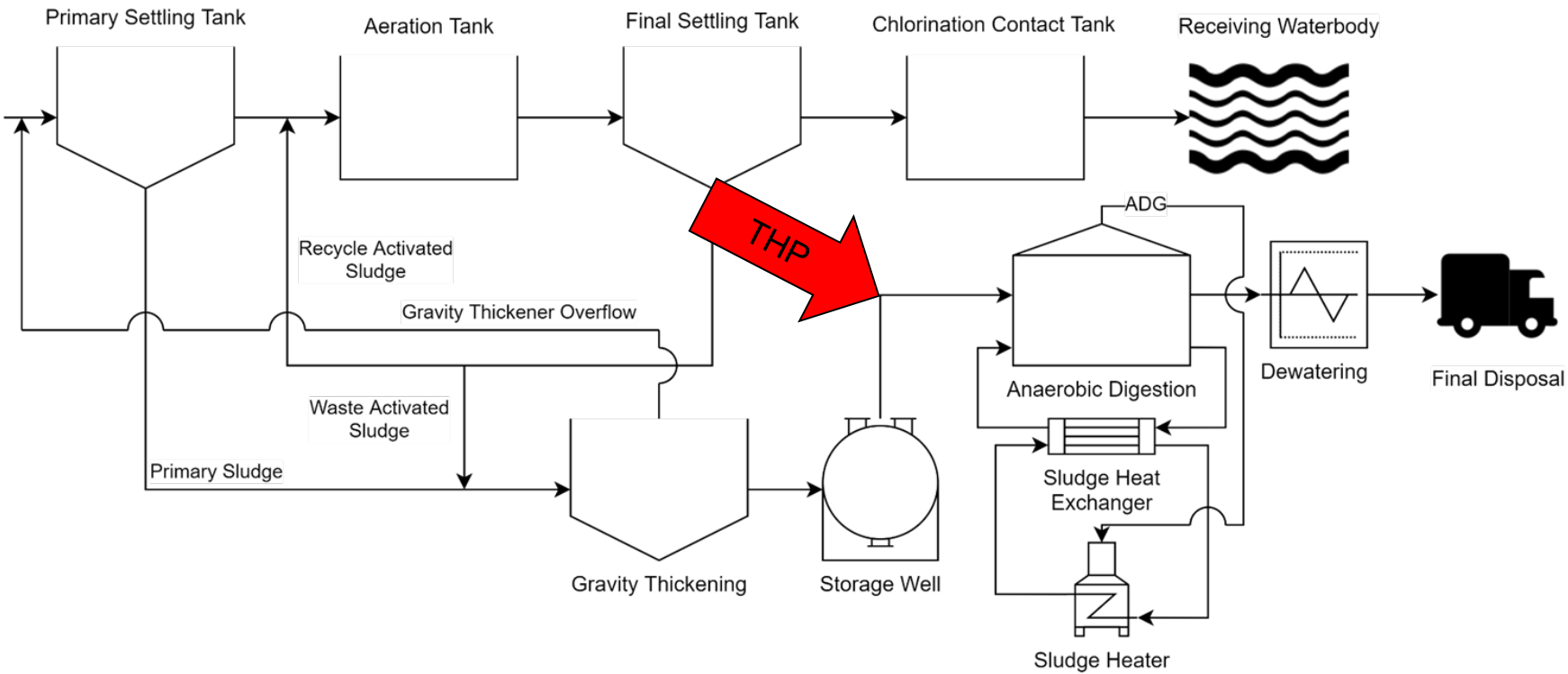
Thermal Hydrolysis (THP)

- THP process - heating sludge to high temperatures at high pressures

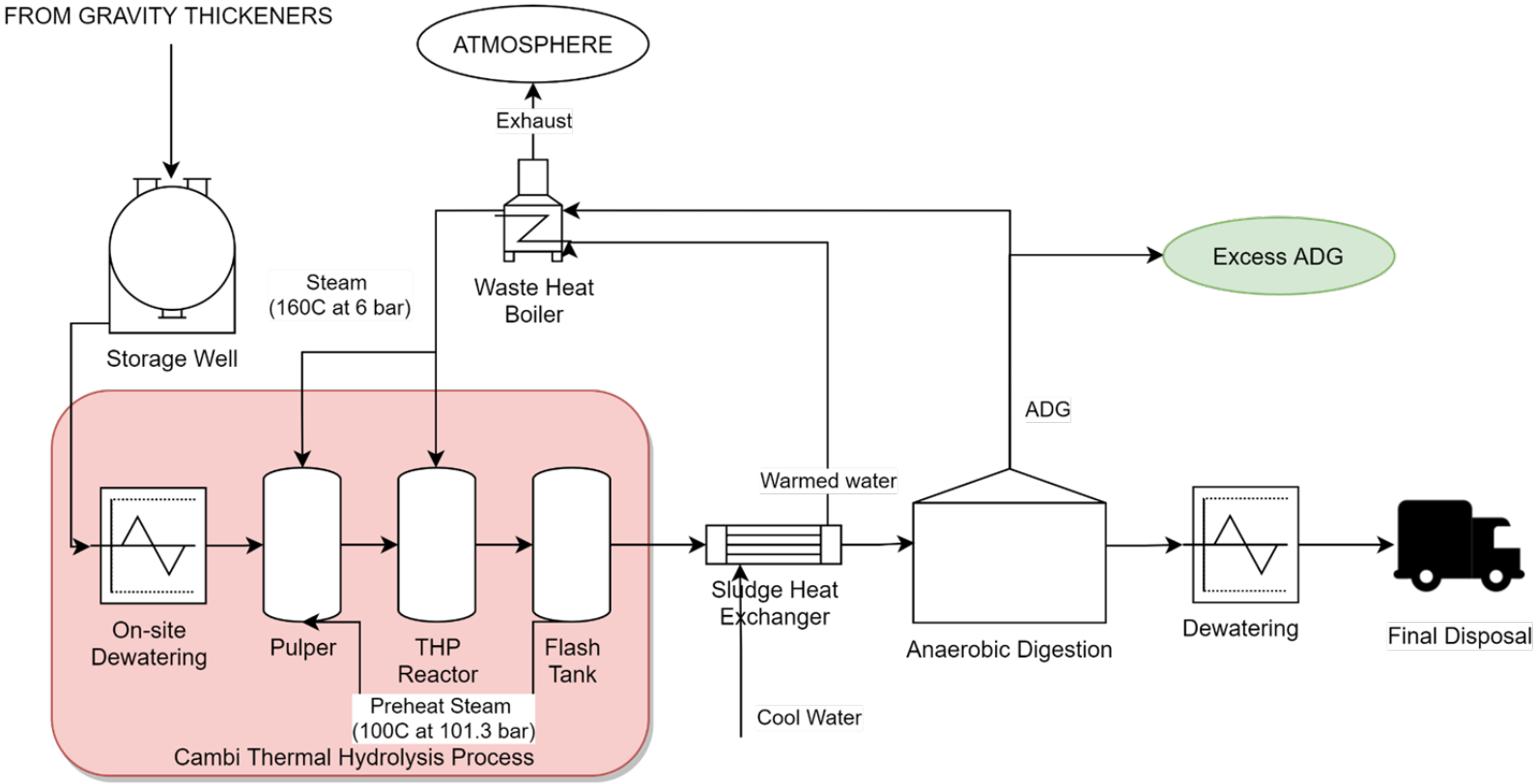
- Consists of three phases:
  - Sludge Preheat
  - Thermal Hydrolysis
  - Steam Explosion and Cooling

- THP seeks to improve quality of digested sludge and increase ADG production

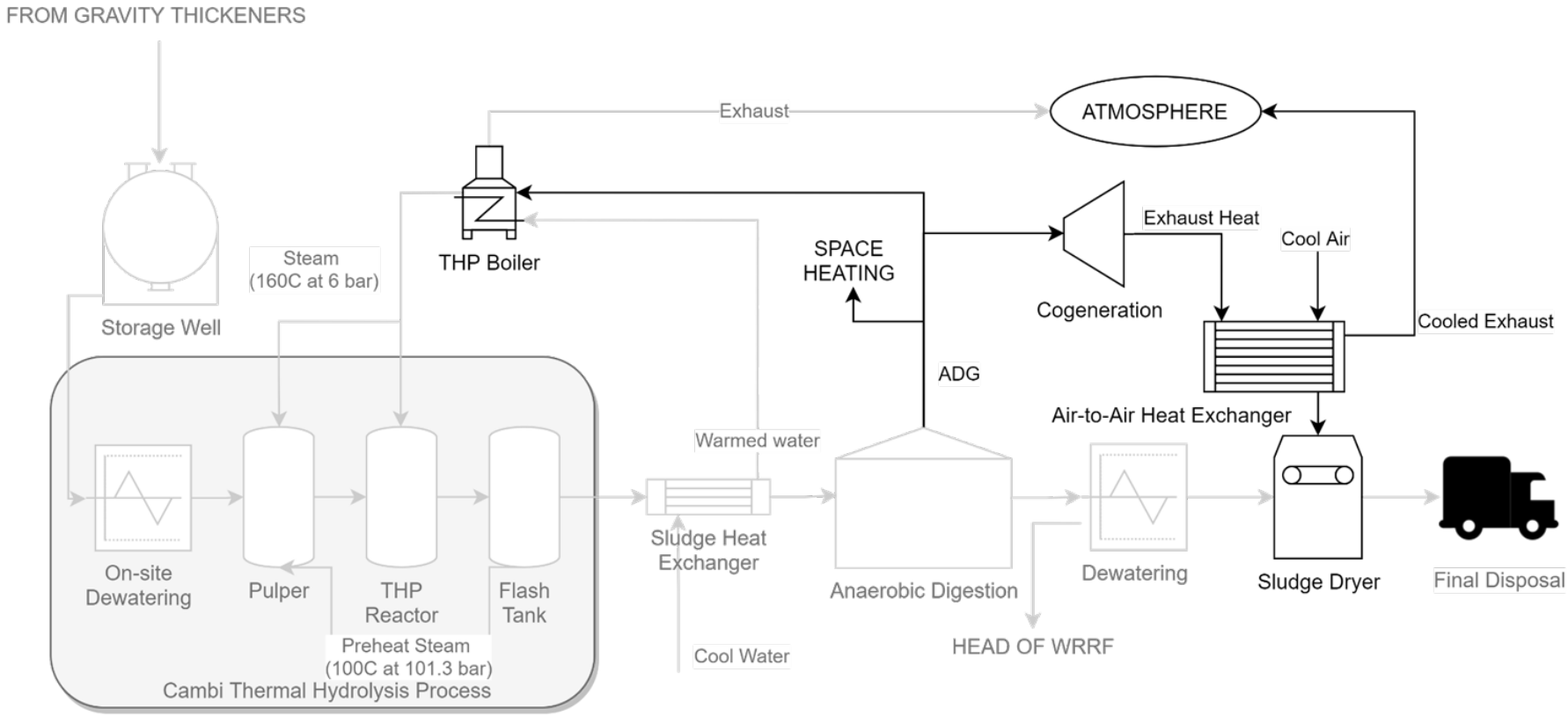
No-Build Alternative



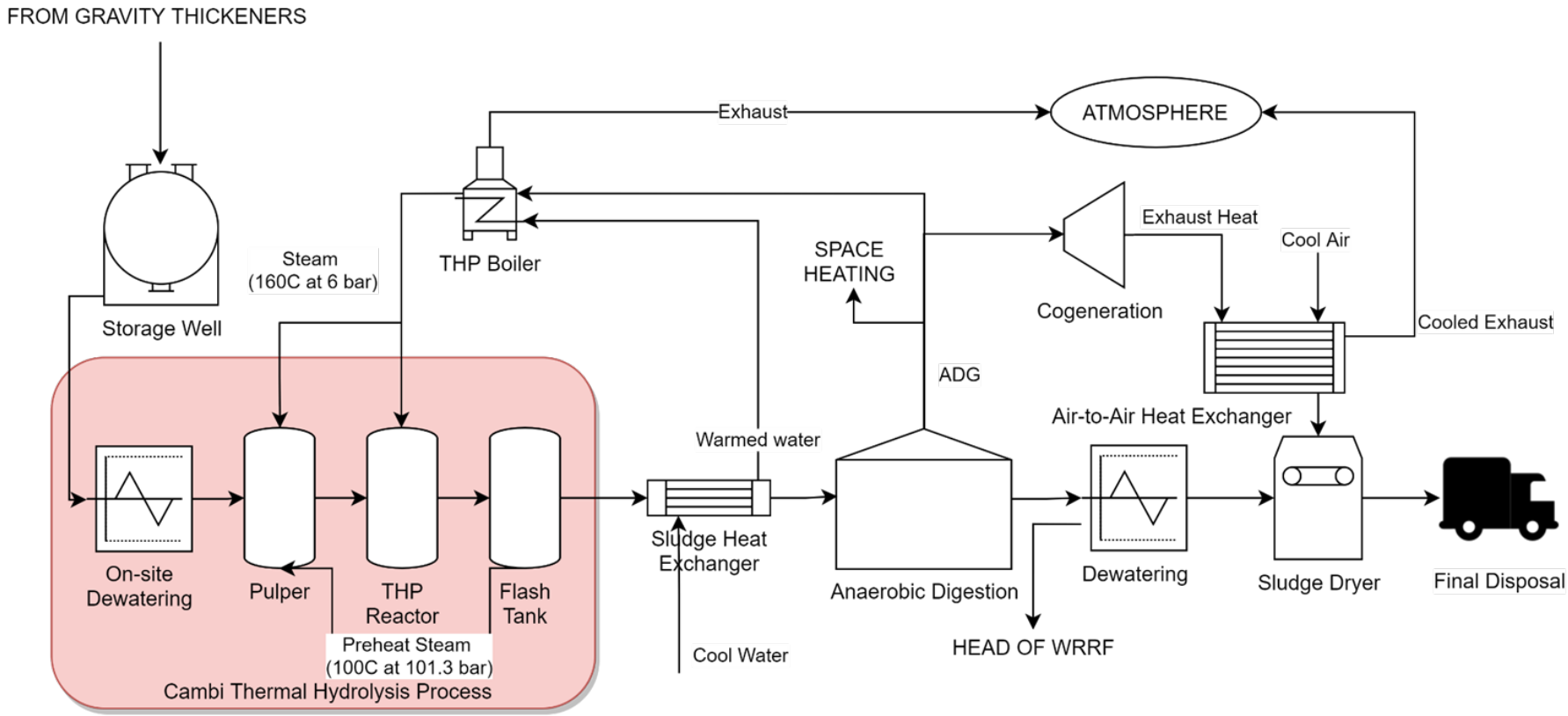
No-Build Alternative with THP



ADG Allocation in THP



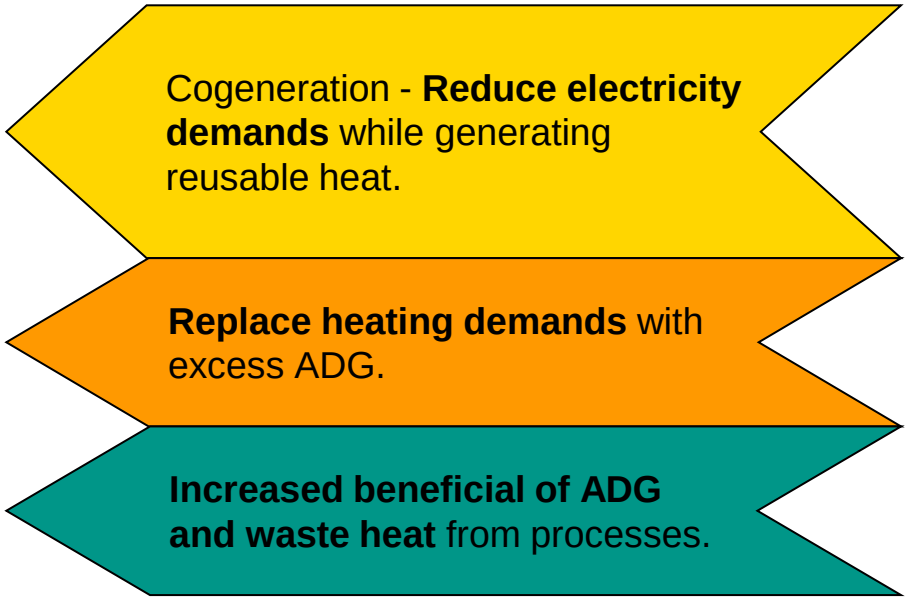
ADG Allocation in THP



Energy Balance Analysis

No-Build Alternative - Energy Balance

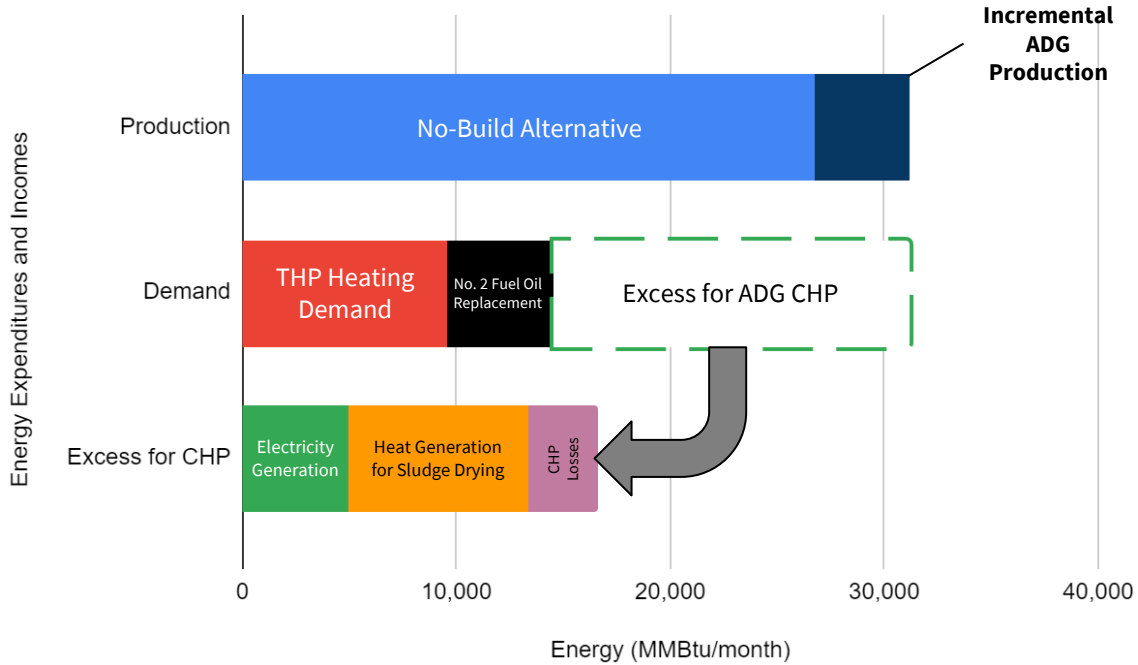
1. Electricity - 8 million kWh/month (27,300 MMBtu/month)
    a. Powering office space
    b. Operating machinery
        i. Aeration blowers
        ii. Pump motors
2. No. 2 Fuel Oil - 5,000 MMBtu/month
    a. Heating space
    b. Water heating
3. ADG Recovery - 27,000 MMBtu/month
    a. Digester heating
    b. Flared



THP System - Energy Balance

Changes to No-Build:

1. Replaces digester heating with THP waste heat
2. Replaces No. 2 Fuel Oil heating demand
3. Generates 18% of Wards Island WRRF's electricity demand
4. Introduces sludge drying with CHP waste heat



Cost Analysis

Current Operational Costs

- Digester maintenance and employee costs are assumed to remain the same
- Consists of the cost of No.2 Fuel Oil and sludge disposal
- Operational Costs: **$14.5 million dollars/year**
  - Assumptions:
    - Sludge Disposal - $130/wet ton of sludge

Thermal Hydrolysis & Cogeneration

- Approximately the cost of thermal hydrolysis can be difficult due to lack of implementation across the world
- Costs comprise of completing a thermal hydrolysis and cogeneration facility
- Upfront Costs -> **$104.5 million dollars**
  - Cost of THP Plant (GBP) = $6*10^6*(Q^{0.5509})$ (Barber, 2016)
  - Assumptions
    - Electrical Capacity - 2000 kW
    - Capital Cost Rate - 2240 $/kW
- Operational Cost Savings -> **$7.7 million dollars/year**
  - Assumptions
    - Sludge reduction - 30%

	No-Build	THP + Cogeneration
Upfront Costs	$0	$104.5 million
Operational Costs	$14.5 million/year	$7.7 million/year

About a 13.6 year return on investment (ROI)

Conclusions

Conclusions

- Thermal hydrolysis improves the quality and decreases the quantity of digested sludge
- Thermal hydrolysis at Wards Island WRRF can improve ADG production from 30% - 50%
- Cogeneration can reduce electricity demands of the WRRF

References

CAMBI. (n.d.). *How does thermal hydrolysis work?* Thermal Hydrolysis. https://www.cambi.com/what-we-do/thermal-hydrolysis/how-does-thermal-hydrolysis-work/

Barber, B. (2016, October 19). Cambi Thermal Hydrolysis Theory, market and the future. In *Cambi, Recycling Energy*. Retrieved July 30, 2021, from https://www.wef.org/globalassets/assets-wef/3---resources/online-education/eshowcases/handouts/presentation-handouts---cambi-eshowcase-2.pdf

DEP. (n.d.). *Wastewater Treatment Process*. New York City Department of Environmental Protection. https://www1.nyc.gov/site/dep/water/wastewater-treatment-process.page

Legal Information Institute. (n.d.). *40 CFR § 503.15 - Operational standards - pathogens and vector attraction reduction*. Cornell Law School. Retrieved June 10, 2021, from https://www.law.cornell.edu/cfr/text/40/503.15

Metcalf and Eddy, AECOM. (2014). *Wastewater Engineering, Treatment and Resource Recovery* (Fifth ed.). McGraw Hill Education.

Water Technology. (2011, May 01). *Wards Island Water Pollution Control Plant.* Retrieved June 10, 2021, from https://www.water-technology.net/projects/wards-island

Acknowledgments

Krish Ramalingam

Michael Bobker

Alex Rosenthal

Thank You!