

# The Philadelphia Water Department's Cogeneration Project: Transforming Biogas to Energy

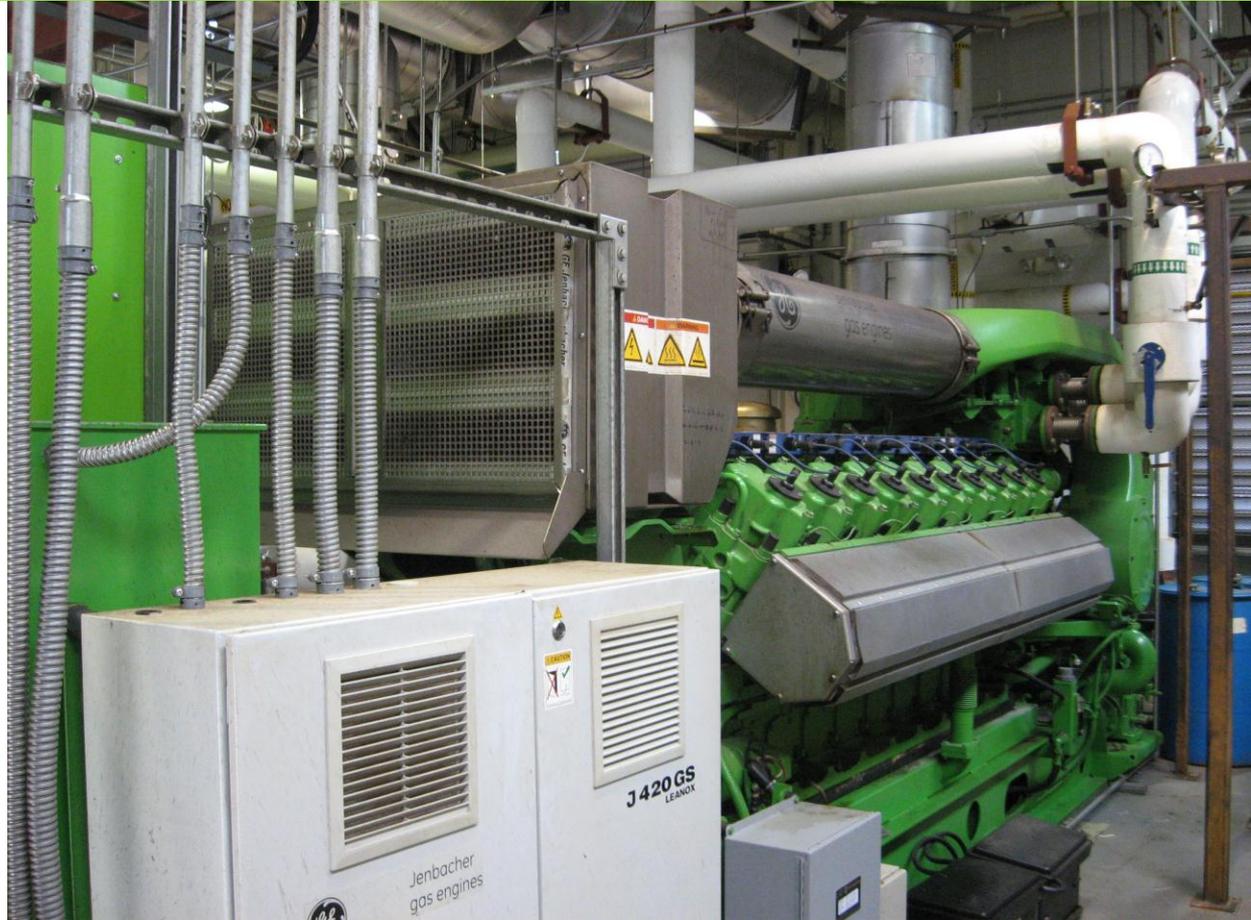
WATER RESOURCES ASSOCIATION OF THE DELAWARE RIVER BASIN



**AECOM**

# Presentation Overview

- Project Goals and Objectives
- Biogas Beneficial Use Options
- PWD Cogeneration Facility
- Project Implementation



# Project Goal



***Maximize the energy potential of the biosolids process by harnessing the untapped biogas waste stream. Reduce Energy Consumption, Greenhouse Gas Emissions, increase sustainability, and enhance environmental stewardship***

# Project Objectives

- Reduce Flaring
- Maximize the Energy Potential of Biogas Source
- Demonstrate Long-term Economic Benefit
- Affordable Project Delivery

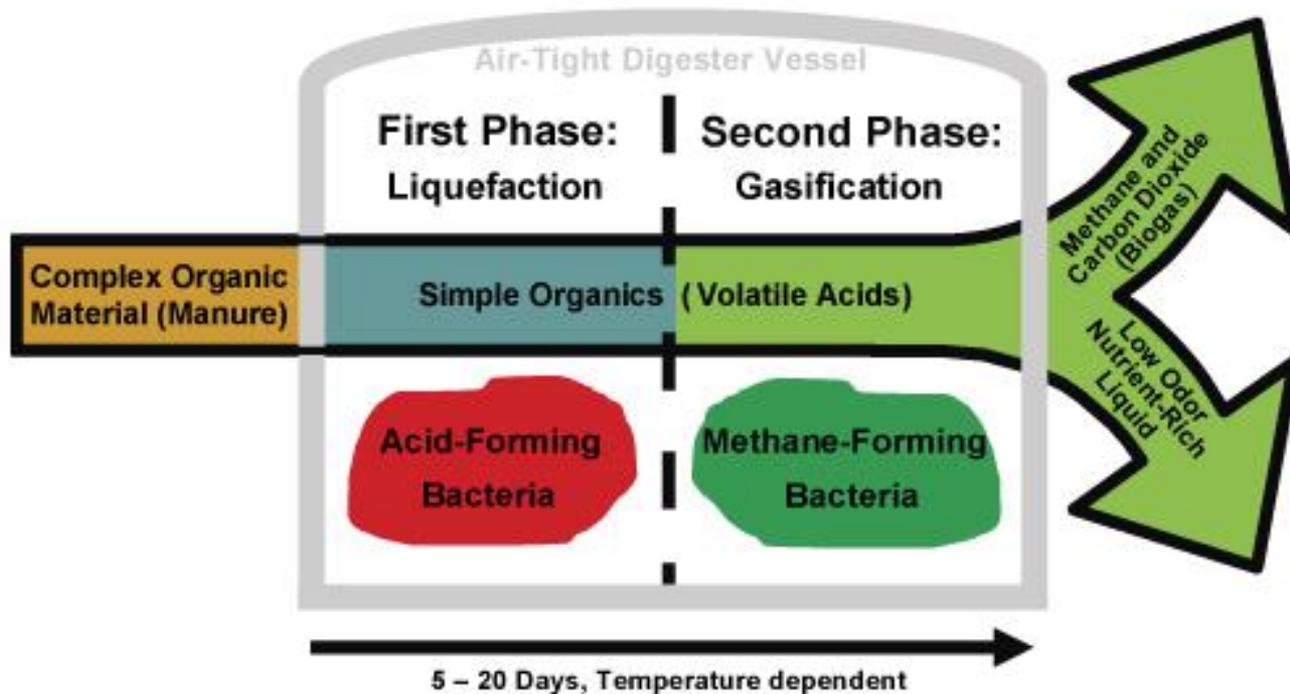


# Project Team

- Philadelphia Water Department Planning, Engineering, and Operations
- AECOM in association with Princeton Energy Systems (Feasibility Study)
- Specialty Design Subcontractors: Hunt Engineering and J. Blanco Associates
- Ameresco Energy (Project Implementation)

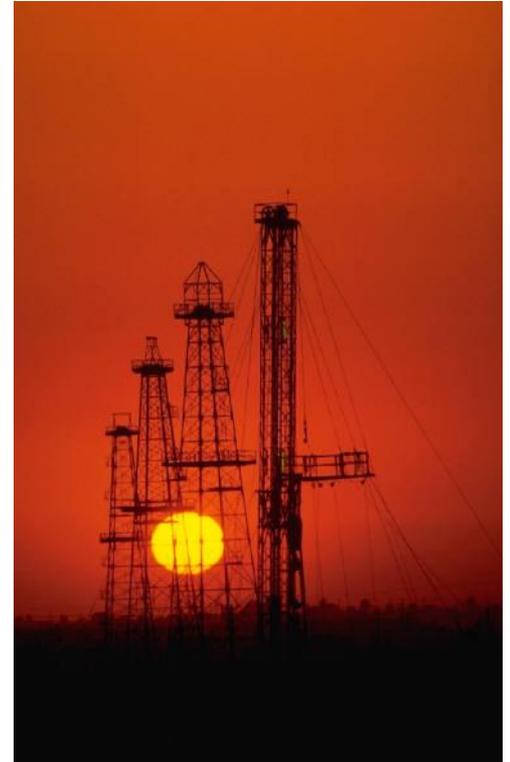
# Biogas Production Overview

## How it works...



# Beneficial Use Options Considered

- Purify Biogas to Pipeline Quality
- Combust Biogas to Produce Energy/Heat



# NEWPCP Biogas Quantity

- 1.5 MMscf/day avg production as byproduct of anaerobic digestion process
- 2.5 MMscf/day with anticipated future increase in production
- 43% currently consumed for process heating at boilers (57% wasted to flares)

# NEWPCP Biogas Quality

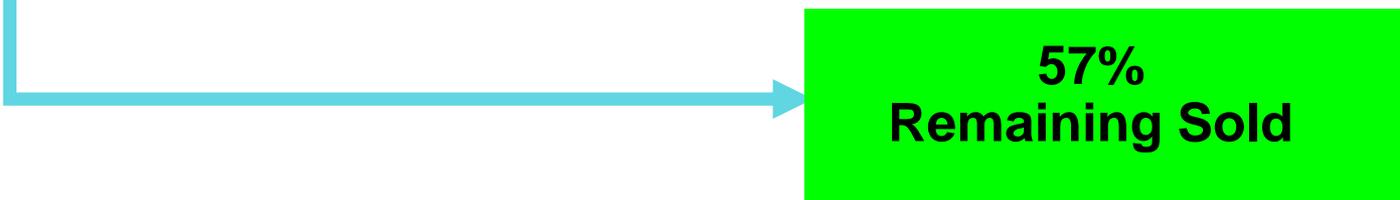
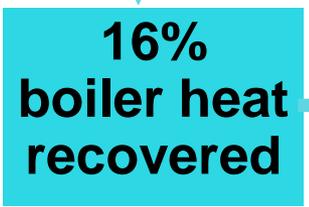
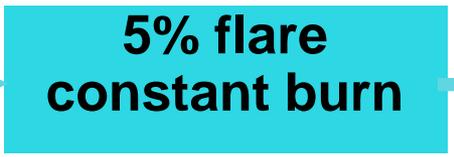
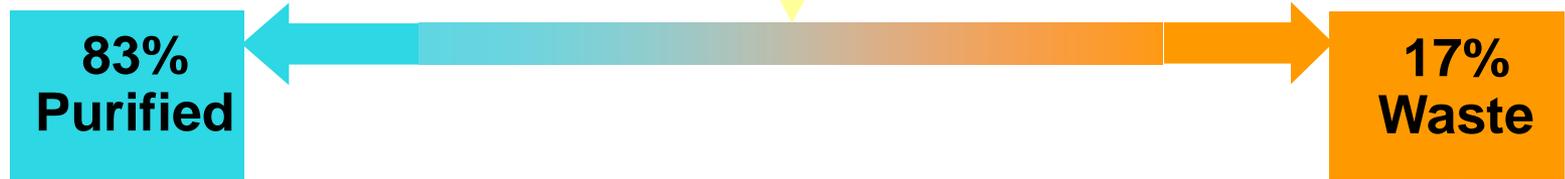
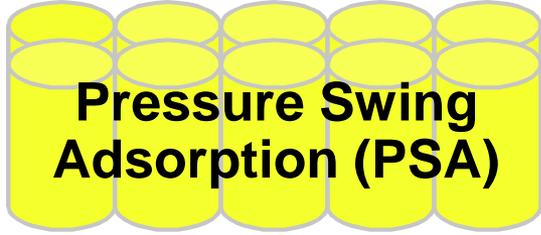
- Inherent biogas characteristics at Municipal WWTPs:
  - High corrosivity ( $H_2S$ )
  - Saturated (water vapor)
  - Siloxanes compounds and other impurities

# Purification Gas Quality Comparison

Constituent	Raw Biogas at Northeast WPCP	Pipeline Gas Requirements
Methane	61%	97% min
CO <sub>2</sub>	39%	1% max
Nitrogen	0.35%	2% max
Water	Saturated	7 lbs/MMcf max
H <sub>2</sub> S	Up to 14 ppmv	4ppmv

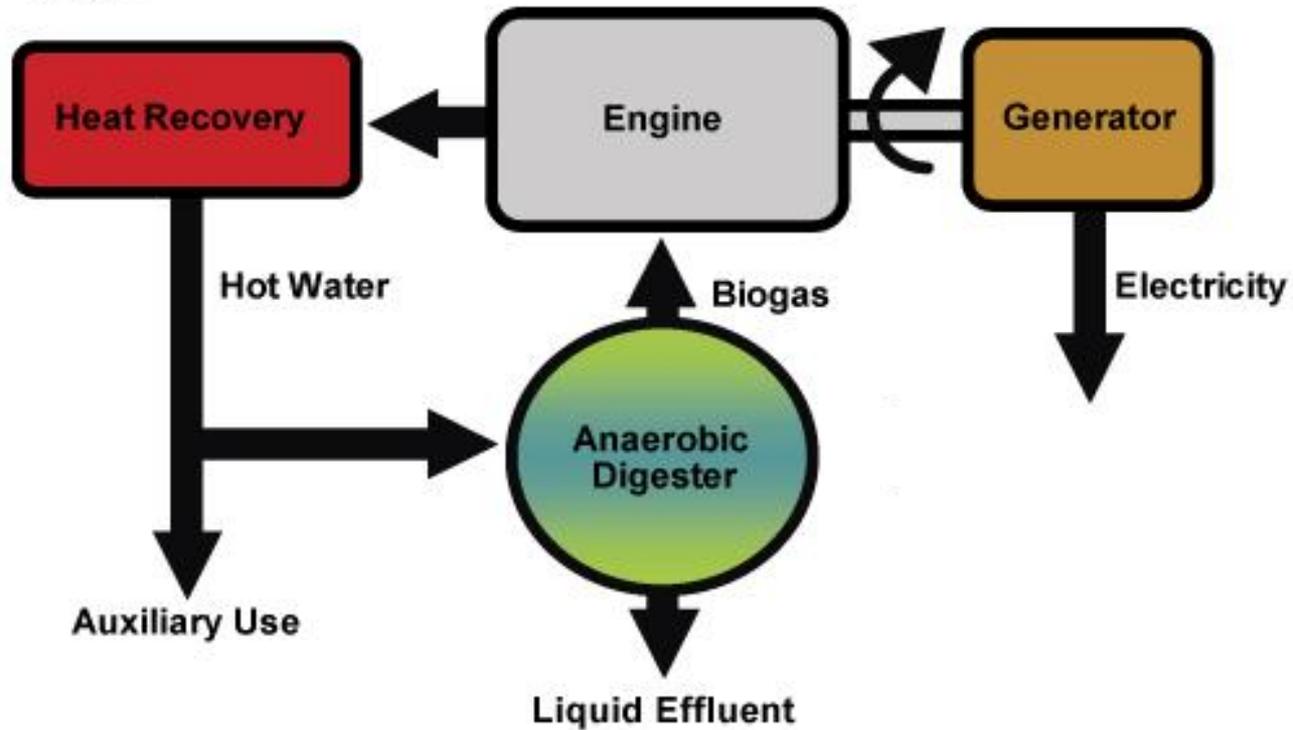


# Pipeline Quality Gas Recovery Schematic



# Combined Heat and Power

**How it's used...**



# Beneficial Use Selection

- **Economic Analysis**

- Construction/Operational Costs
- Energy Off-set/Savings (Co-gen Option)
- Gas Sales (Purification Option)
- Net Present Worth Analysis
- Return on Investment (Payback)

- **Other Considerations**

- Operation and Maintenance
- Control of Assets
- Contractual Arrangements

***COGENERATION OPTION SELECTED***

# Economic Benefits

- 20 Year Life Cycle Cost Analysis
  - \$28.5 M Capital Cost
  - \$24M Net Present Value
  - 11% Return Rate
  - \$4.3M offset in electricity costs annually
  - Including O&M costs (5% of capital)
  - Does not include additional incentives
  - \$0.07/kWh



# Northeast Water Pollution Control Plant

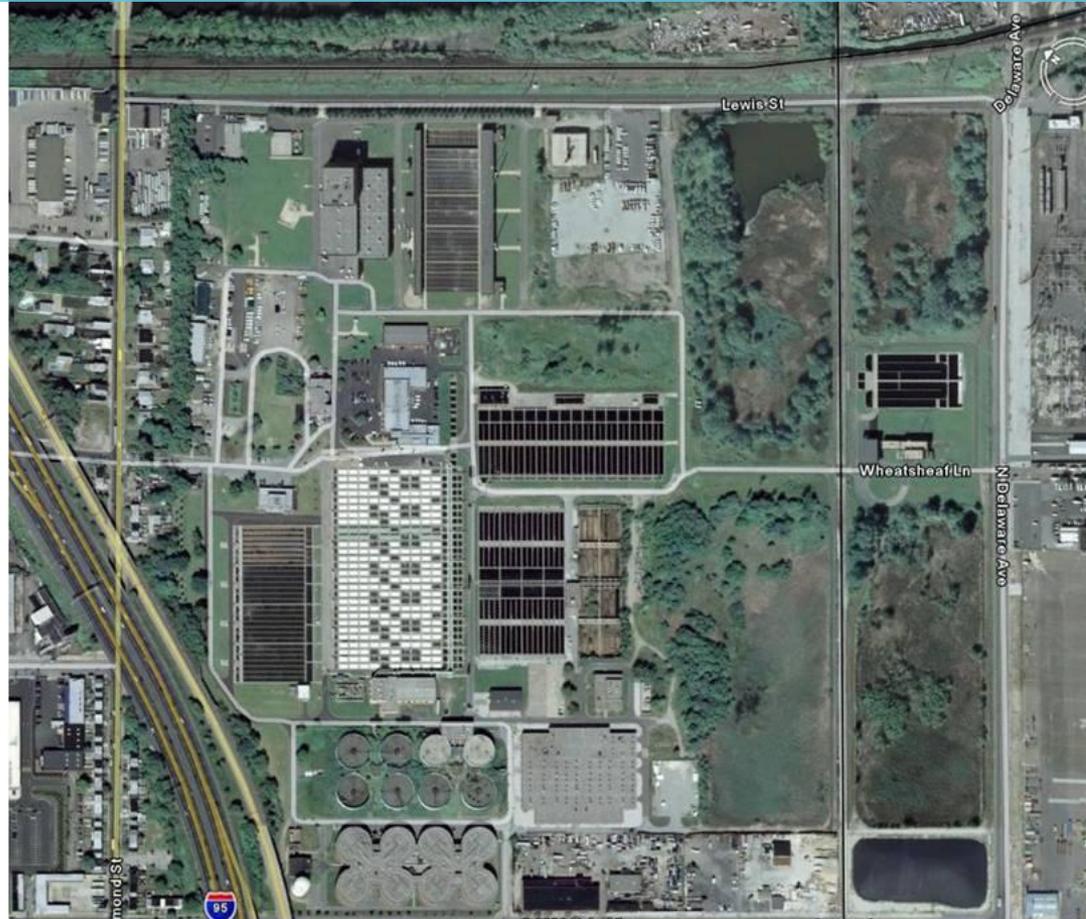
Online Since 1923

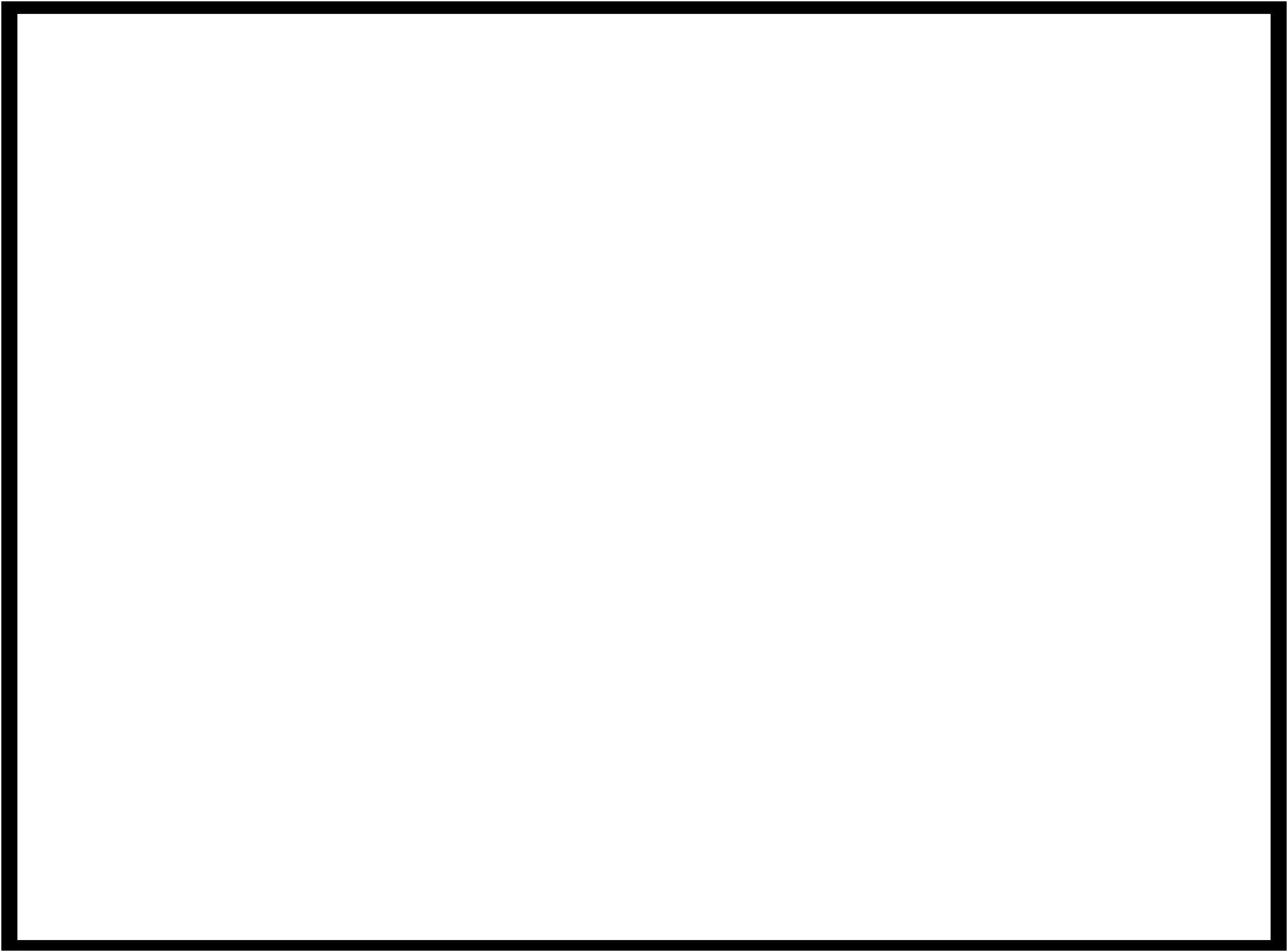
Capacity of 190 MGD

Anaerobic Digestion

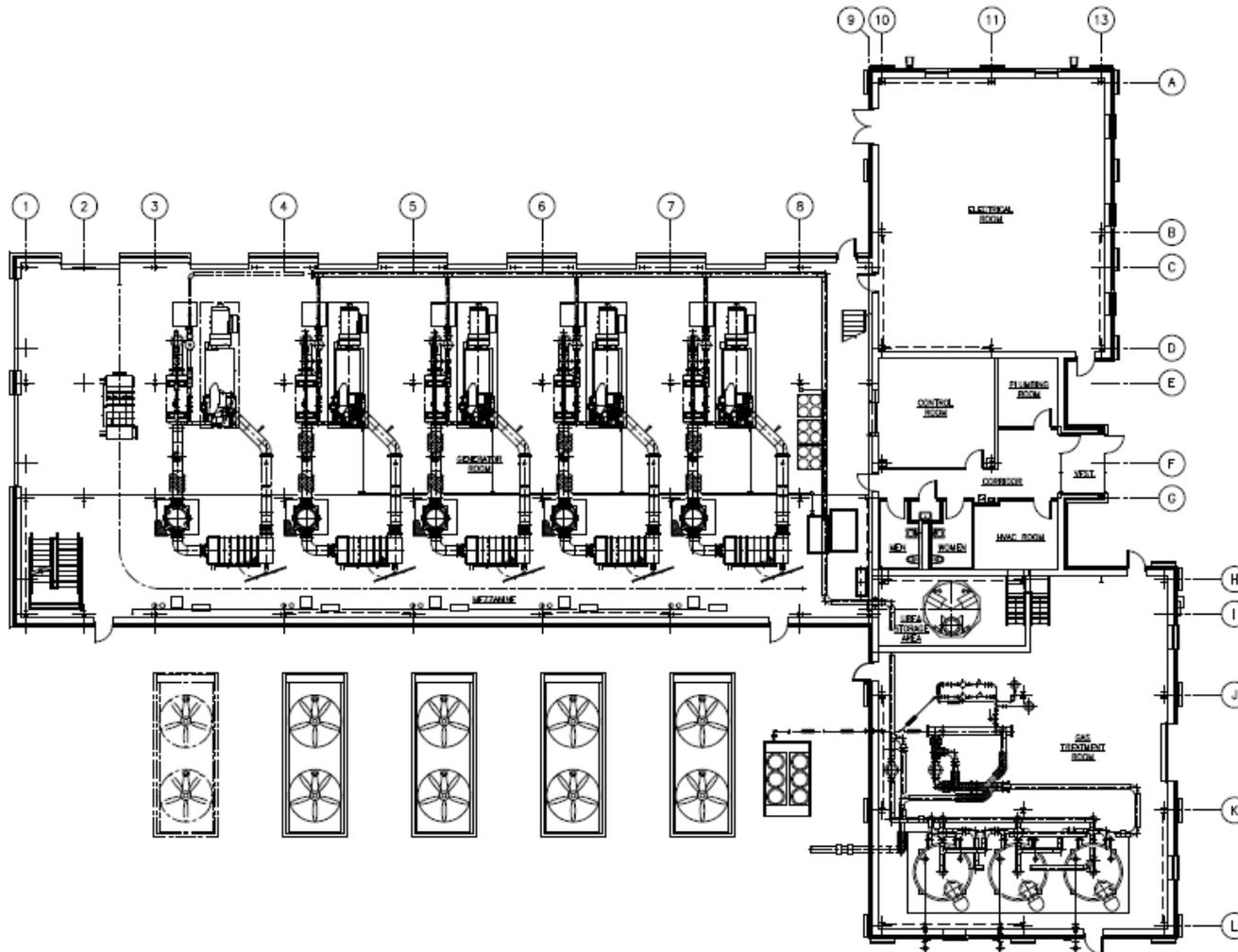
1.5 MMcfd Digester Gas

~57% Flared to Waste

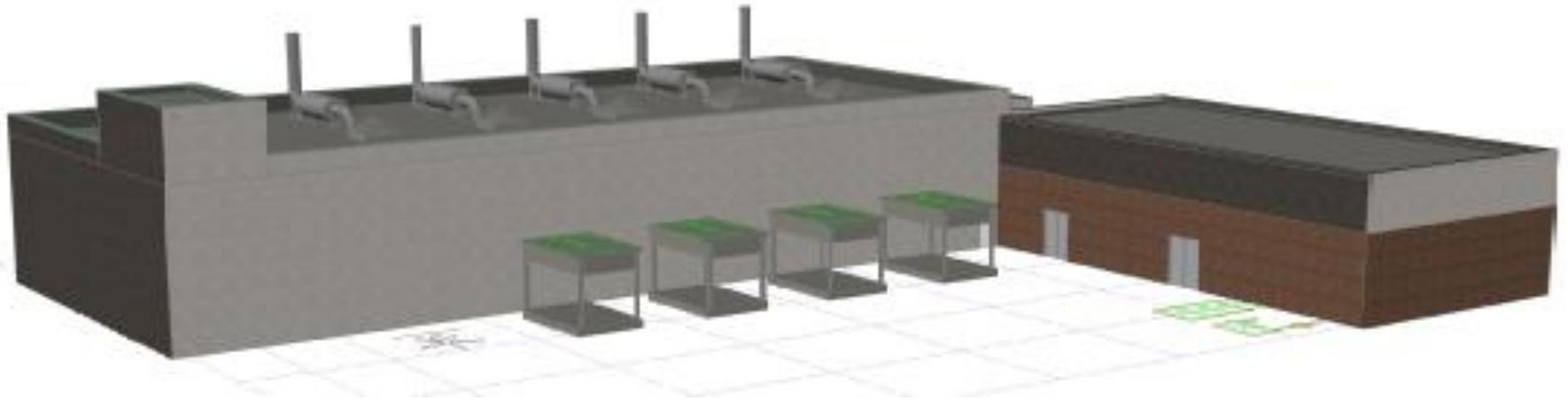




# Cogeneration Facility Layout



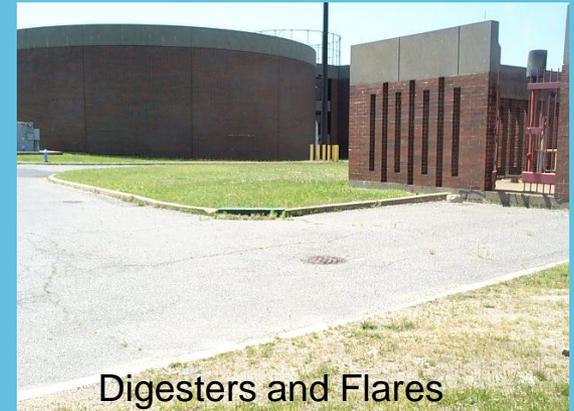
# Cogeneration Building Renderings





# Digester Gas

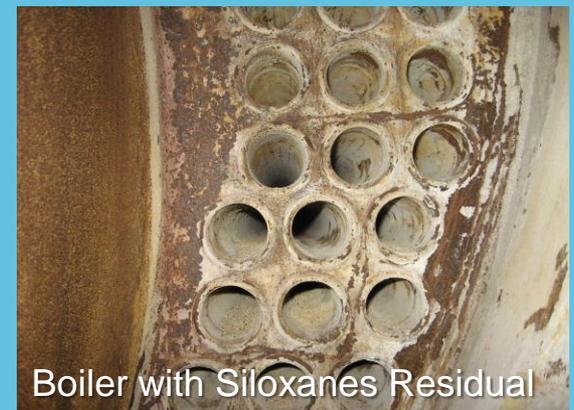
- Variable Seasonal Flows
- Supplemental Fuel Blending
- H<sub>2</sub>S, Siloxanes, and Moisture Removal



Digesters and Flares



Dual-Fuel Blending Train



Boiler with Siloxanes Residual

# Digester Gas Pretreatment

- Moisture Removal: Multiple Locations
- Siloxanes Removal: Carbon-based Media
- H<sub>2</sub>S Removal: Iron oxide-based Media

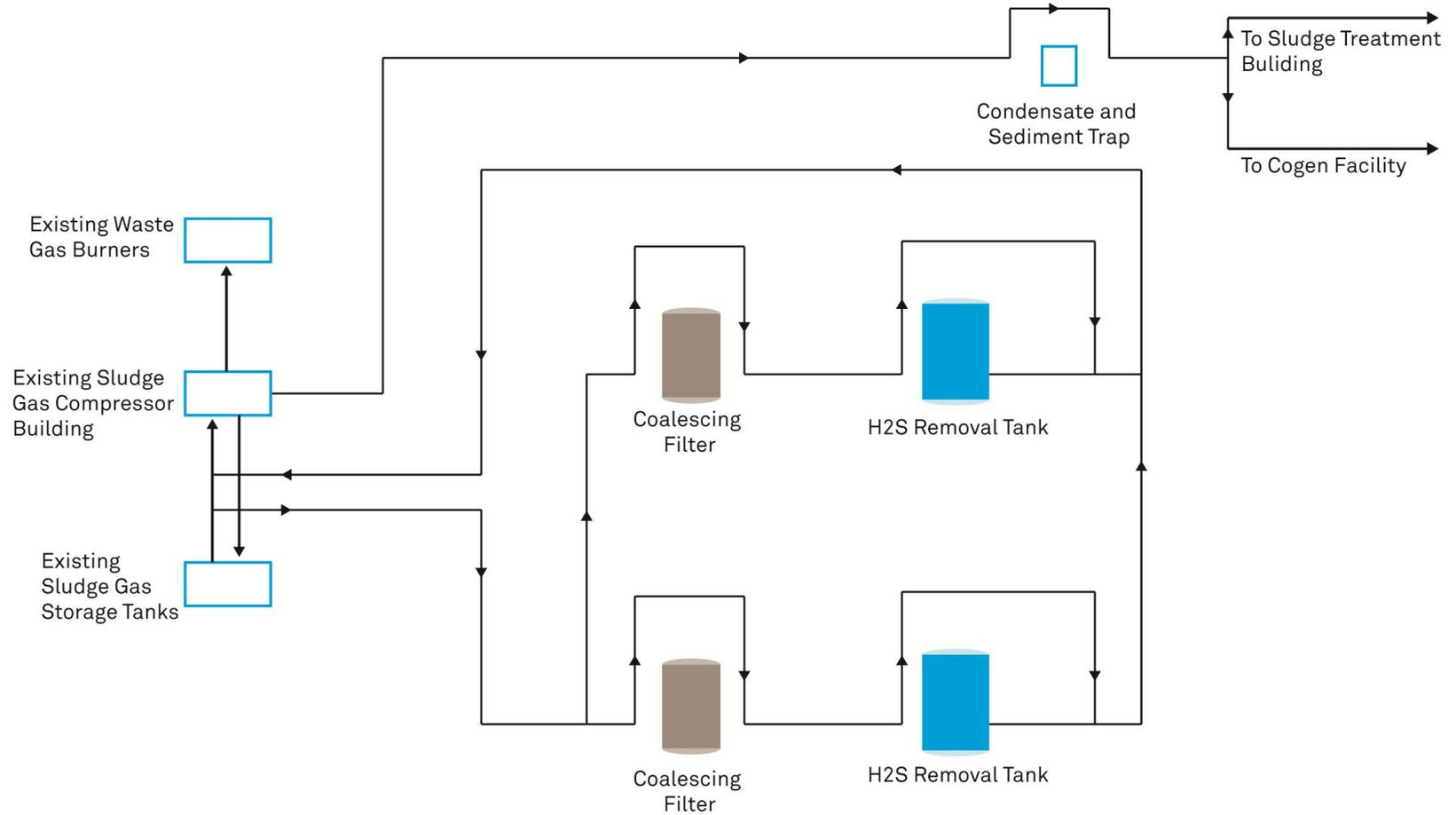
## Siloxanes Removal System



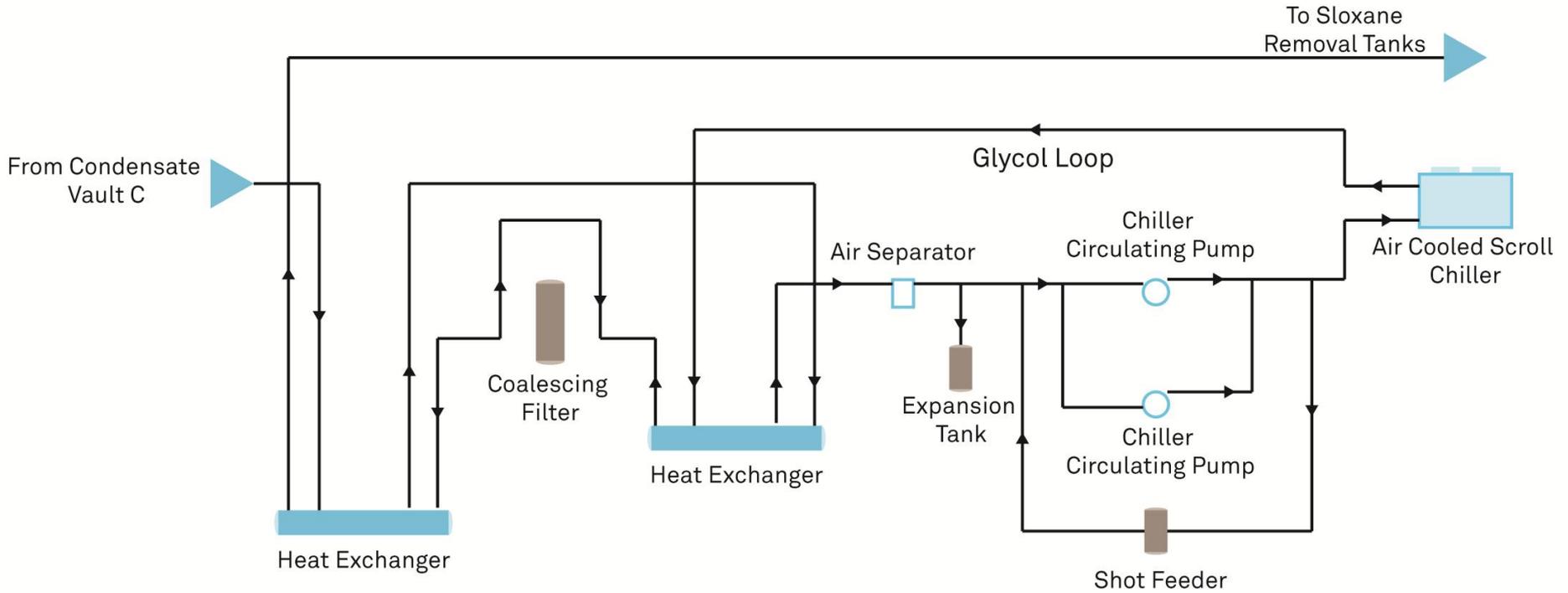
## H<sub>2</sub>S Removal System



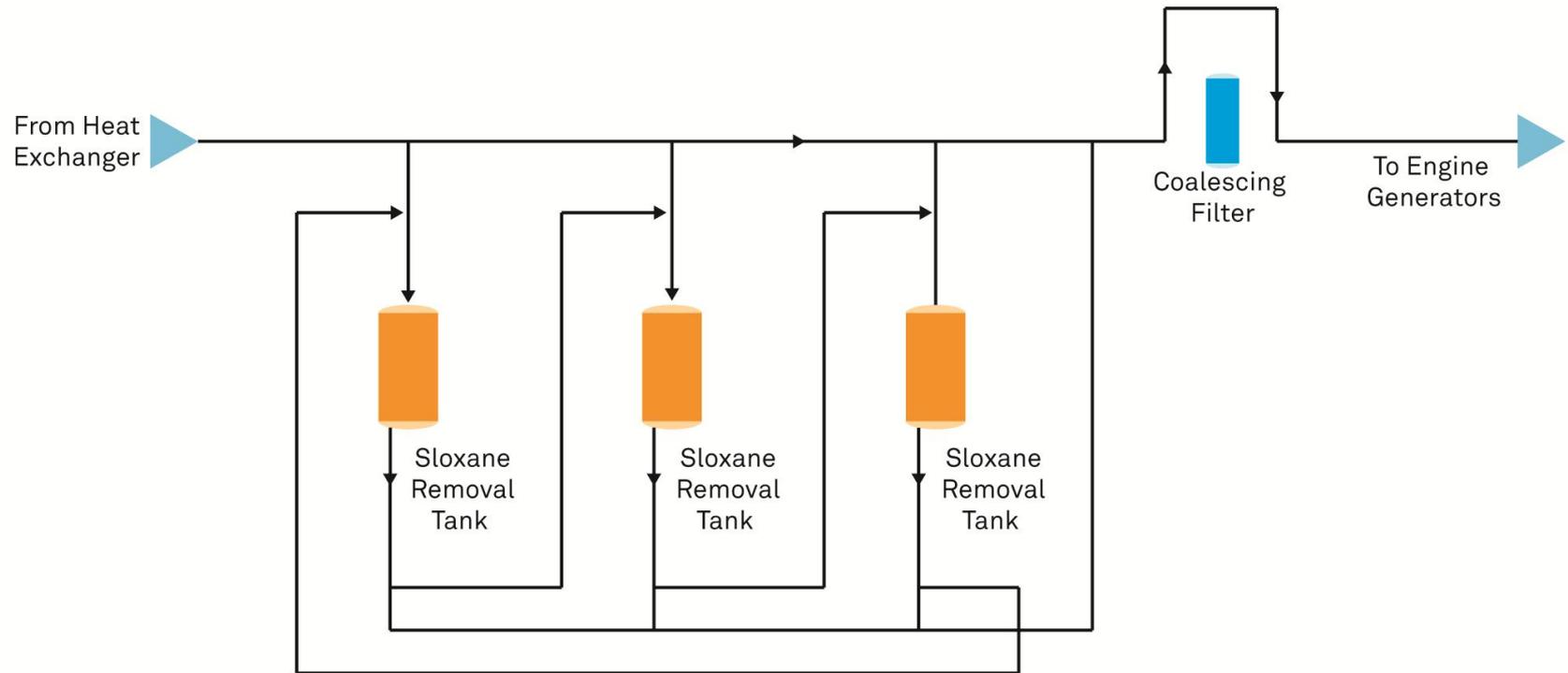
# Pretreatment Process



# Pretreatment Process



# Pretreatment Process







# Air Emissions

- Current Plant Emissions Regulated
- Primary air pollutants from IC engines: NO<sub>x</sub> and CO
- Potential to emit (lean-burn engines):
  - NO<sub>x</sub>: < 0.6 grams (as NO<sub>2</sub>) per bhp-hr (or 250 mg/Nm<sup>3</sup>)
  - CO: < 3.3 grams per bhp-hr (or 1,375 mg/Nm<sup>3</sup>)
- Estimated Emission from the Proposed Cogeneration Facility



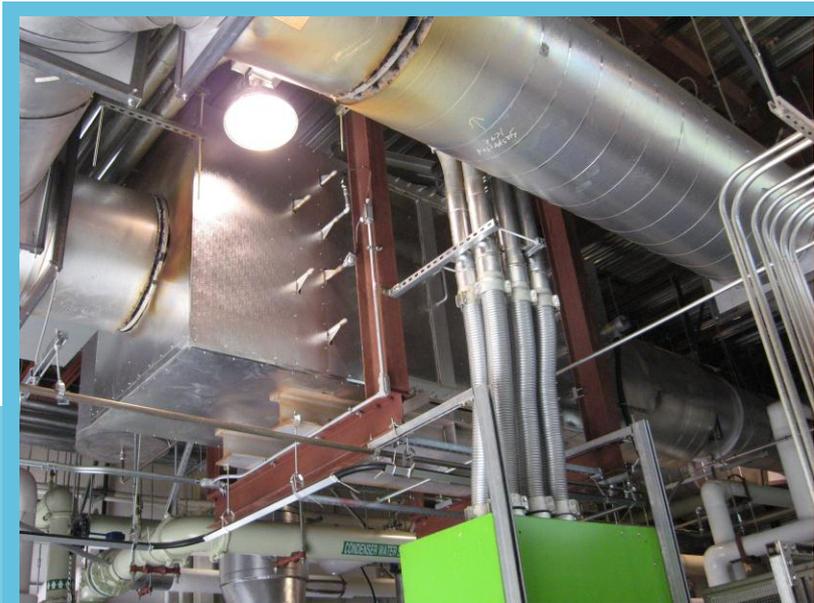
Criteria Pollutant	Annual PTE
NO <sub>x</sub> (as NO <sub>2</sub> )	~ 41 tons/yr
CO	~ 226 tons/yr

\* Based on four 1,426 kW engines operating at 90% capacity 24/7, 365 days

- **Selective Catalytic Reduction (SCR) Systems:** installed at engine exhaust for NO<sub>x</sub> reduction of 75%, CO reduction of 83%

# Selective Catalytic Reduction (SCR)

- Reduction of CO, NO<sub>x</sub>, VOC, and PM
- Urea Solution Injection
- Precious Metal-based Catalyst
- Driver for Pre-treatment Requirements



# Project Implementation/Construction

- Design-Build-Maintain Implementation
- Public-private partnership (P<sup>3</sup>) between Ameresco and the City
- General Contractor: AP Construction
- 16 Year Contract
- ARRA funding made possible through P<sup>3</sup>



# Construction Phase



# Construction Phase



# Construction Phase



# Construction Phase



# Construction Phase



# Project Benefits

- 90% of average electrical demand for plant
- 26,500 barrels of oil (foreign or other) annually saved
- Reduce CO<sub>2</sub> emission by  
~ 22,000 tons/year
- 4,833 cars removed from the roadways
- 5,390 Acres of Pine Forest planting



# ACKNOWLEDGMENTS

A photograph of a wind turbine tower and nacelle against a blue sky with white clouds. The tower is a tall, white, cylindrical structure. The nacelle is a large, white, curved structure with a ribbed texture. The sky is a vibrant blue with scattered white clouds. The overall scene is bright and clear.

Thank You

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