Next Generation Resource Recovery

Co-Digestion to Renewable Natural Gas (RNG) Pipeline Injection

Dustin Craig, PE

January 30, 2019

CDM Smith

NEWEA – 2019 Annual Conference & Exhibit

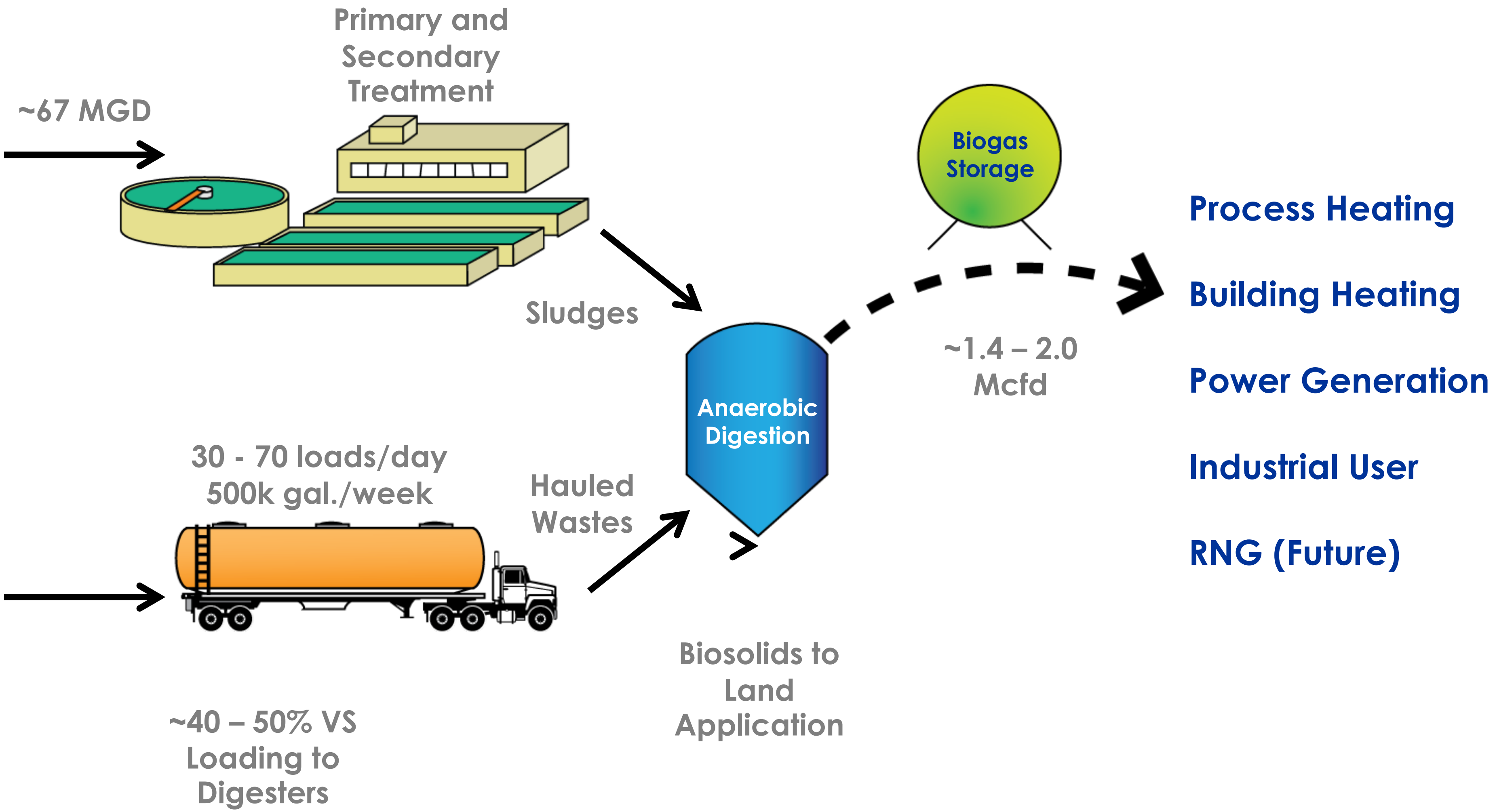
NEWEA
WORKING FOR WATER QUALITY

WRA

Des Moines Wastewater Reclamation Authority (WRA)

- WRA Serves 17 member agencies in three counties
- City of Des Moines is the contract operator of the WRA's wastewater reclamation facility (WRF)
- Average dry-weather flows of ~67 million gallons per day (MGD)
- Serves ~500,000 residents in greater metro Des Moines area
- Mission Statement - Preferred hauled waste facility for Iowa and surrounding areas
- Completed $20M Anaerobic Digestion Improvements Project in Spring 2014

Des Moines WRF Flow Schematic




Des Moines
SE 30th St
Granger Ave
Vandalia Rd
Des Moines
Vandalia Rd

A Wastewater and Hauled Organic Waste Treatment Center


1
2
3
4
5
6
©Makeeff
West view of Digestor Complex

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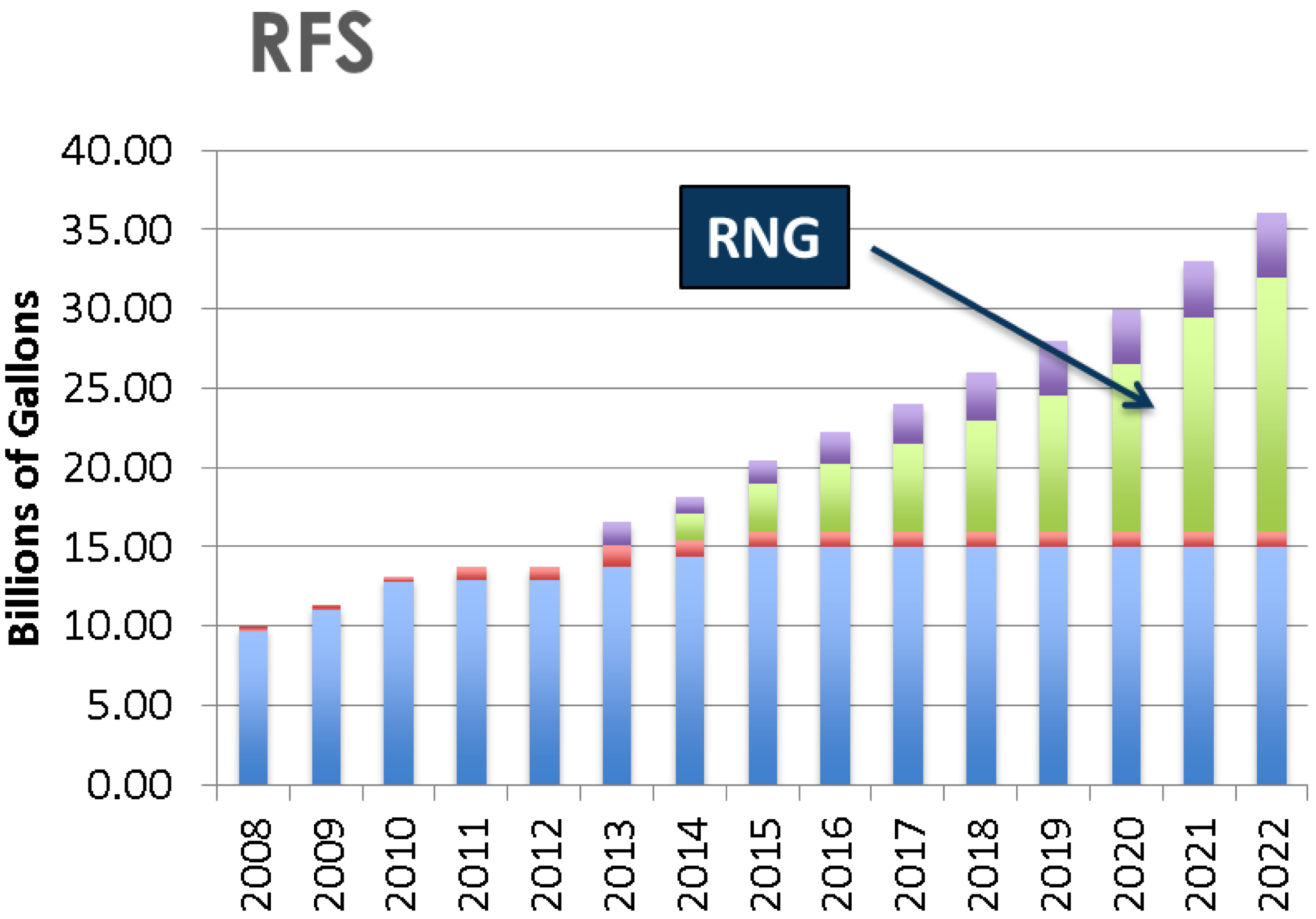
Project Drivers

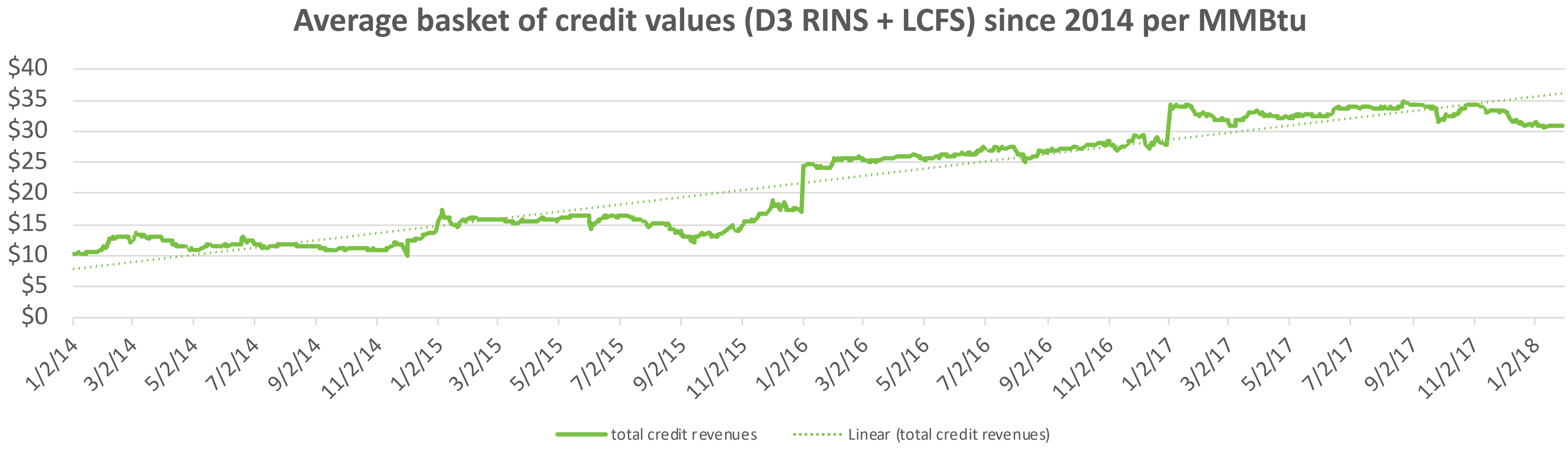
- WRA is producing a significant amount of renewable fuel in digesters
- Capacity to increase biogas production with more hauled waste
- Changes in federal legislation are establishing renewable fuel standards, particularly for use in transportation fuels
- Environmental impacts of biogas
  - RNG production is carbon-neutral (does not add to greenhouse gas emissions)
  - Reduces consumption of natural gas, thus lowering CO_2 emissions
- Supports sustainability initiatives and goals of City of Des Moines and WRA

RFS Program Opportunities

- Renewable Fuel Standards (RFS) program
- Renewable transportation fuels
- Renewable Identification Numbers (RINs)
- Low Carbon Fuel Standard (LCFS) credits



Renewable Identification Numbers (RINs)



- RINs and renewable fuel credits
- RIN classifications by fuel type (“D”-codes)
- D3 RINs (municipal wastewater)= High Value
- D5 RINs (organic waste) = Low Value

Development of Bioenergy Model

Financial Inputs

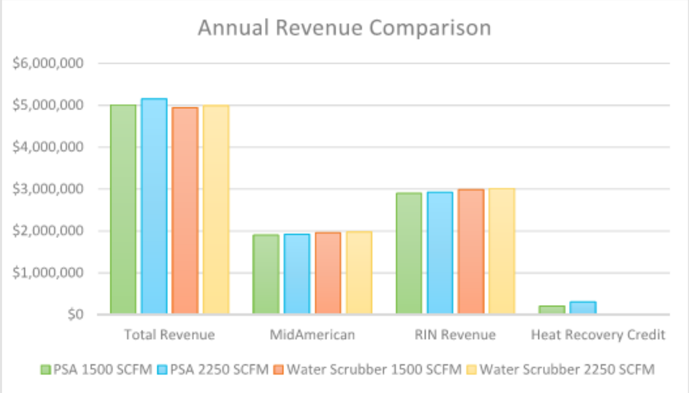
Electricity Cost, $/kwh	$0.0616
Natural Gas Purchased, $/MMBtu	$6.86
Labor, $/hr	$60
Water, $/100 gal	$0.40
Lube Oil, $/gal	$15
Polymer, $/5 gal	$700
Air Emissions Fee, $/ton	$56
Discount Factor	5%
RIN Inflation, %/yr	5%
Utilities Inflation, %/yr	5%
Labor Inflation, %/yr	5%
Maintenance Inflation, %/yr	5%
MidAmerican Tariff Inflation, %/yr	5%
Air Emissions Fee Inflation, %/yr	5%

Process Information

	PSA 1500	PSA 2250	WS 1500	WS 2250
% Recovery	95%	95%	98%	98%
Sales Gas %CH_4	97%	97%	96.2%	96.2%
Sales Gas HHV, BTU/cf	980	980	970	970
Water, gpm	0	0	2.7	4.4
Connected Load, hp	948	1294	842.9	1216.3
Natural Gas, MMBtu/day	48	72	0	0
Polymer, gal/yr	0	0	5	7.5
Compressor Heat Recovery, MMBtu/hr	0	0	0.0	0.0
Tail Gas Heat Recovery, MMBtu/hr	3.4	5.1	0.0	0
Lube Oil, gpd	Included below		4	6.5
Preventative Maintenance, $/yr	$72,000	$91,260	$50,500	$50,500
Labor, hr/yr	0	0	0.0	0.0
Downtime, hr/yr	0	0	0	0

20-Year Economics, Present Value

	PSA 1500	PSA 2250	WS 1500	WS 2250
Capital	$9,855,000	$11,921,000	$9,475,000	$12,086,000
Total Annual Costs	$36,304,000	$52,772,000	$33,288,000	$36,665,000
Total Annual Revenue	$100,162,000	$103,050,000	$98,914,000	$99,784,000
20 Year Overall Revenue	$54,003,000	$38,357,000	$56,151,000	$51,033,000
Payback Period, months	37	57	35	46



Raw Gas Data

Raw Gas, %CH_4	65%
Raw Gas, H2S ppmv	4000
Raw Gas Flow Growth, %	0%

Initial Investment

	PSA 1500	PSA 2250	WS 1500	WS 2250
Equipment Capital, $	$2,350,000	$3,042,000	$2,556,000	#########
Thermal Oxidizer, $	$497,000	$643,351	$350,055	$477,696

See "Capital" tab for more details

Sales Gas Economics

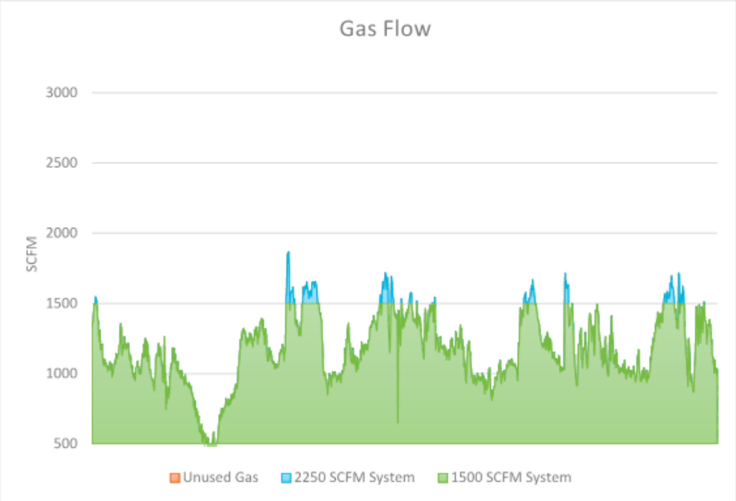
Renewable Gas Sold, $/MMBtu	$5.00
Monthly Customer Charge, $/month	$1,315
Commodity Charge, $/therm transported	$0.00495
Demand Charge, $/MDR therm/month	$0.52886

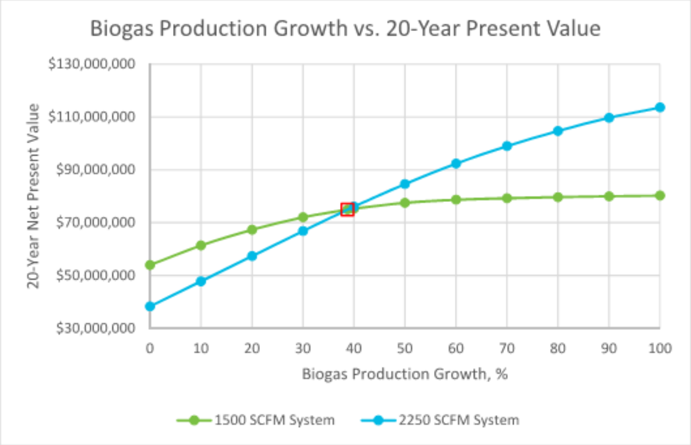
Environmental Attributes

RIN Value, $/RIN	$0.65
RIN Conversion, RIN/MMBtu	11.727
RIN Value, $/MMBtu	$7.62

Percent of Gas Accepted

1500 SCFM System	99.1%
2250 SCFM System	100.0%





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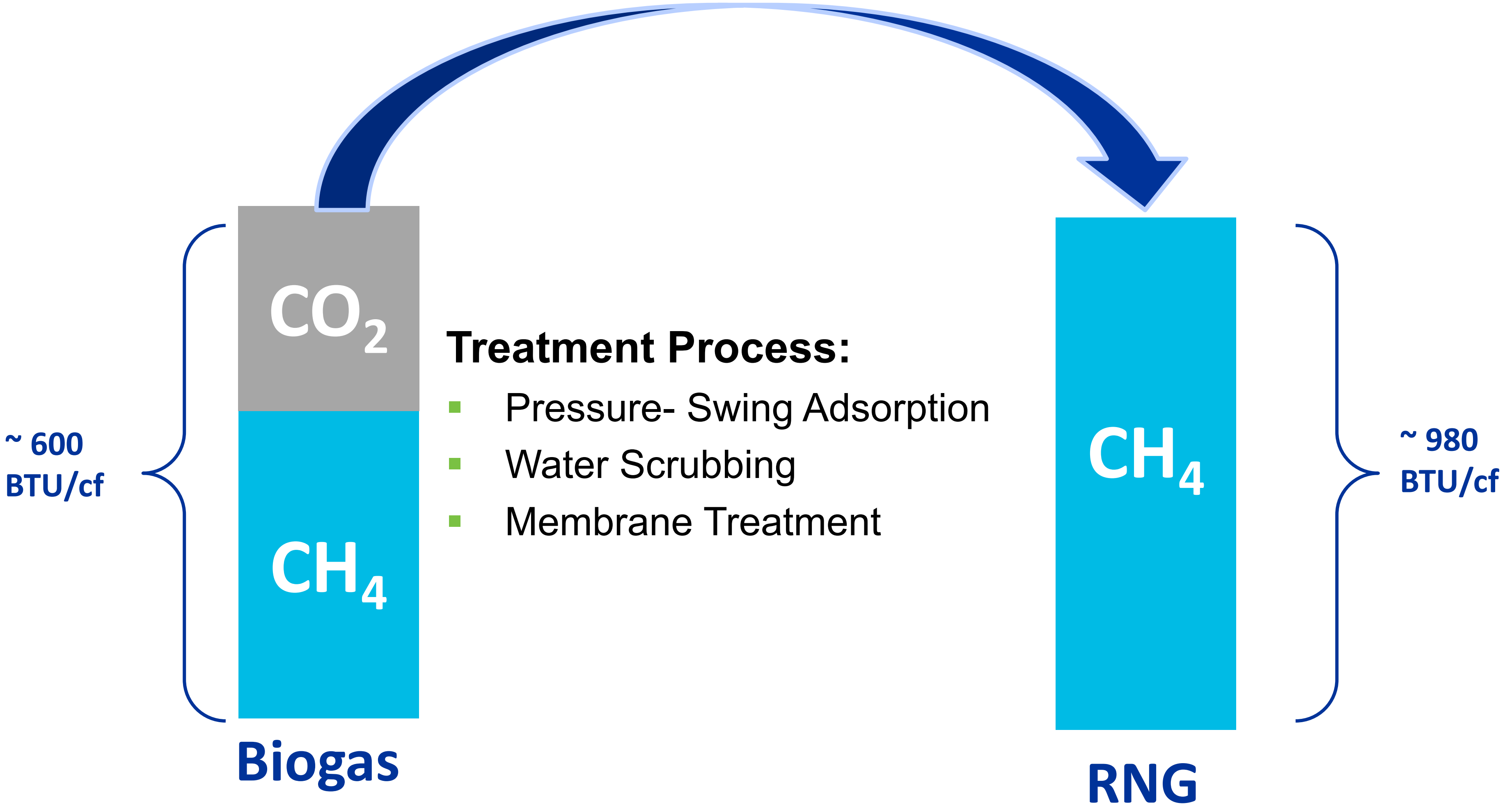
System Design Criteria

- Inlet Biogas Flow: 2250 SCFM

Component	Digester Gas	Pipeline Specification
BTU Content	~660 BTU/scf	> 970 BTU/scf
Carbon dioxide	35%	< 3% by volume
Nitrogen	0.7%	< 4% by volume
Total Inerts (N_2 + CO_2)	~36%	< 5% by volume
Oxygen	<0.2%	< 0.3% by volume
Water	Saturated	< 5 lb/mmscf
Hydrogen sulfide	Actual: 50-600 ppm Design: 6,000 ppm	< 0.25 grain/Ccf
Total Sulfur	N/A	< 20 grain/Ccf
Volatile Organic Compounds	10-30 ppm	0 ppm

RNG System - Technology Comparison

Biogas → Renewable Natural Gas (RNG)



Treatment Process:

- Pressure- Swing Adsorption
- Water Scrubbing
- Membrane Treatment

Membrane Scrubbing System

- **System Description**
  - Utilizes physical diffusion process through membranes which use a thin polymer film.
  - Membrane selectively retains CH_4 and some N_2 (~20%) and O_2 (~50%)
  - Generates very high quality CO_2 outlet stream with approximately 1-2% CH_4
- **Typical Components**
  - Compressor
  - Gas Heat Exchanger / Moisture Removal
  - Air Chiller
  - H_2S Scrubbing System
  - Siloxane Carbon Filters (if necessary)
  - Final Polishing Filters
  - Separation Membranes

Membrane Scrubbing System

- **Manufacturers**
  - Air Liquide Advanced Separations – Newport DE
  - Utilize Evonik Membranes: DMT Environmental Solutions (Joure, Netherlands), Unison Solutions (Dubuque, Iowa), Greenlane (New Zealand, USA), Hitachi Zozen, Brightbiomethane, Envitec
- **Advantages**
  - High CH_4 recovery (97-99.5%)
    - Depending on the number of stages
  - High level of turndown (~10%)
  - Can remove some O_2 (~50%) and N_2 (~20%)
  - Dry process
  - Modular Process
- **Disadvantages**
  - Limited (but growing) US Installation History
  - H_2S and siloxane pretreatment required (depending on supplier)
  - Limited data on membrane life and fouling

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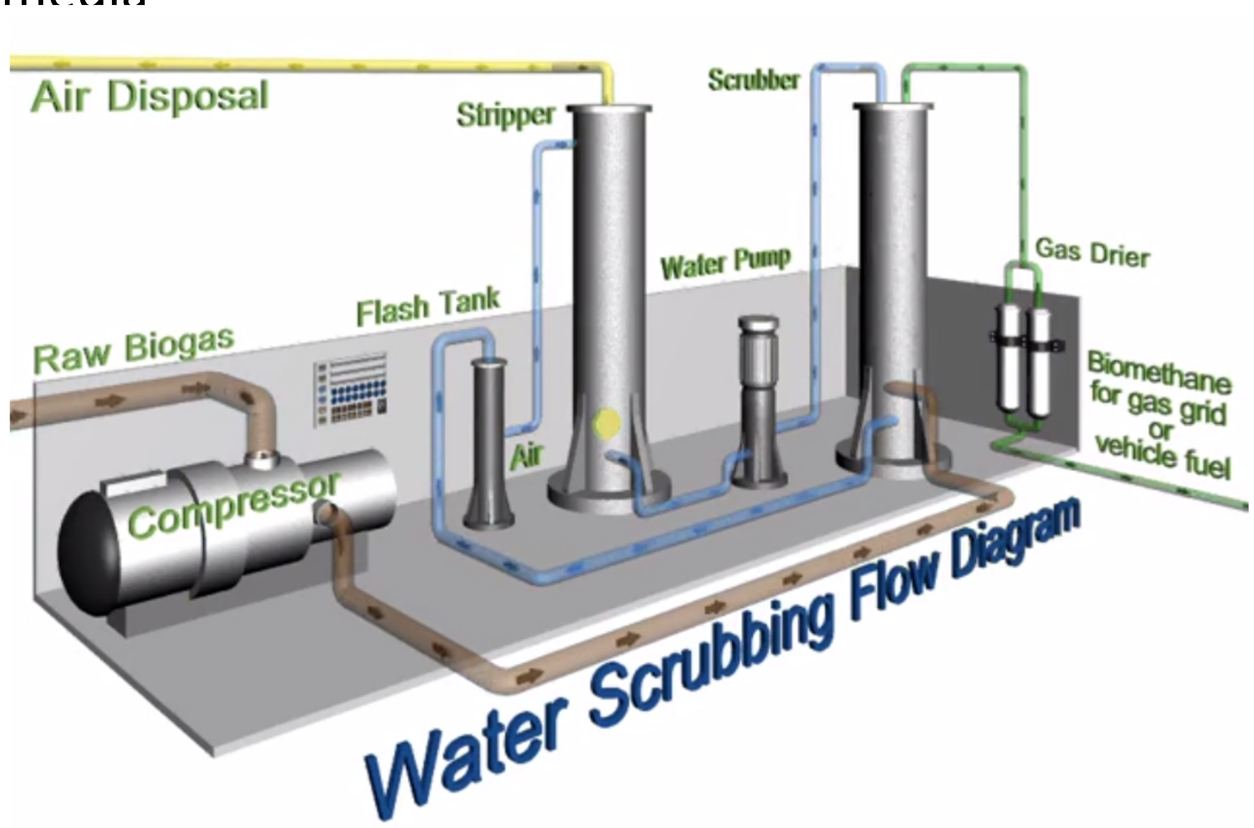
Water Scrubber System

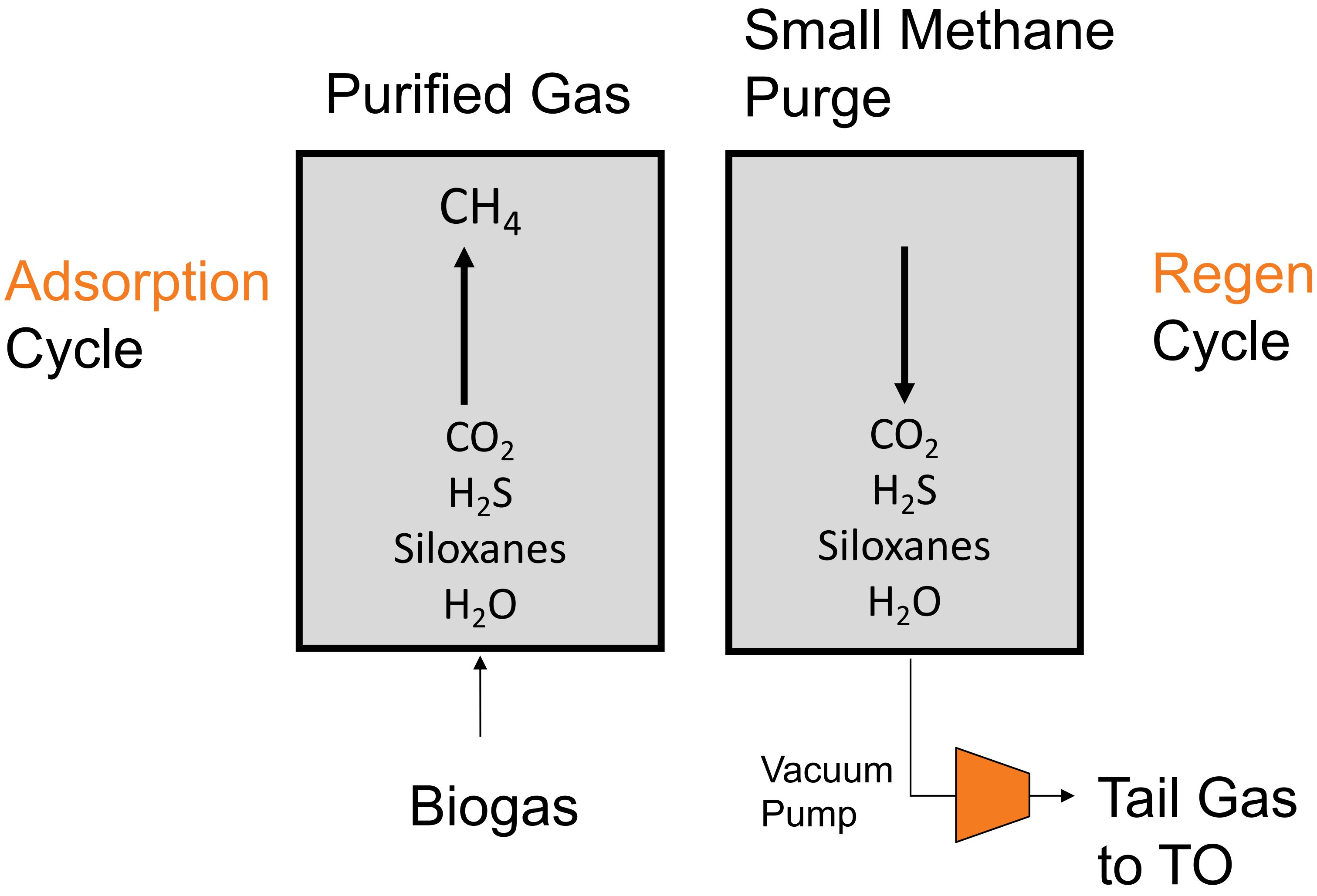
- **System Description**
  - Separation by physical adsorption in scrubber
  - Water is transfer solvent; performance follows Henry's Law-CO_2 is more soluble in water than CH_4
  - Upflow packed towers with polypropylene media
  - Solvent regenerates in stripping tower
- **Typical Components**
  - Compressor
  - Scrubber Vessel
  - Flashing Vessel
  - Stripping Vessel
  - Compressor Radiator Skid
  - PSA/TSA Adsorber (gas drier)
  - Process Water Chiller



Water Scrubber System

- **Manufacturers**
  - Greenlane (New Zealand, USA)
  - DMT (Netherlands, USA)
  - Malmberg (Sweden)
- **Advantages**
  - Proven technology Non-toxic solvent (water)
  - Also removes H_2S in inlet biogas
  - Moderate CH_4 losses (~2% slip)
- **Disadvantages**
  - Increases / Concentrates H_2O, O_2, and N_2
  - Tail gas treatment is typically required
  - Very tall outdoor vessels

Pressure Swing Absorption (PSA) Flow Schematic



Pressure Swing Adsorption (PSA)

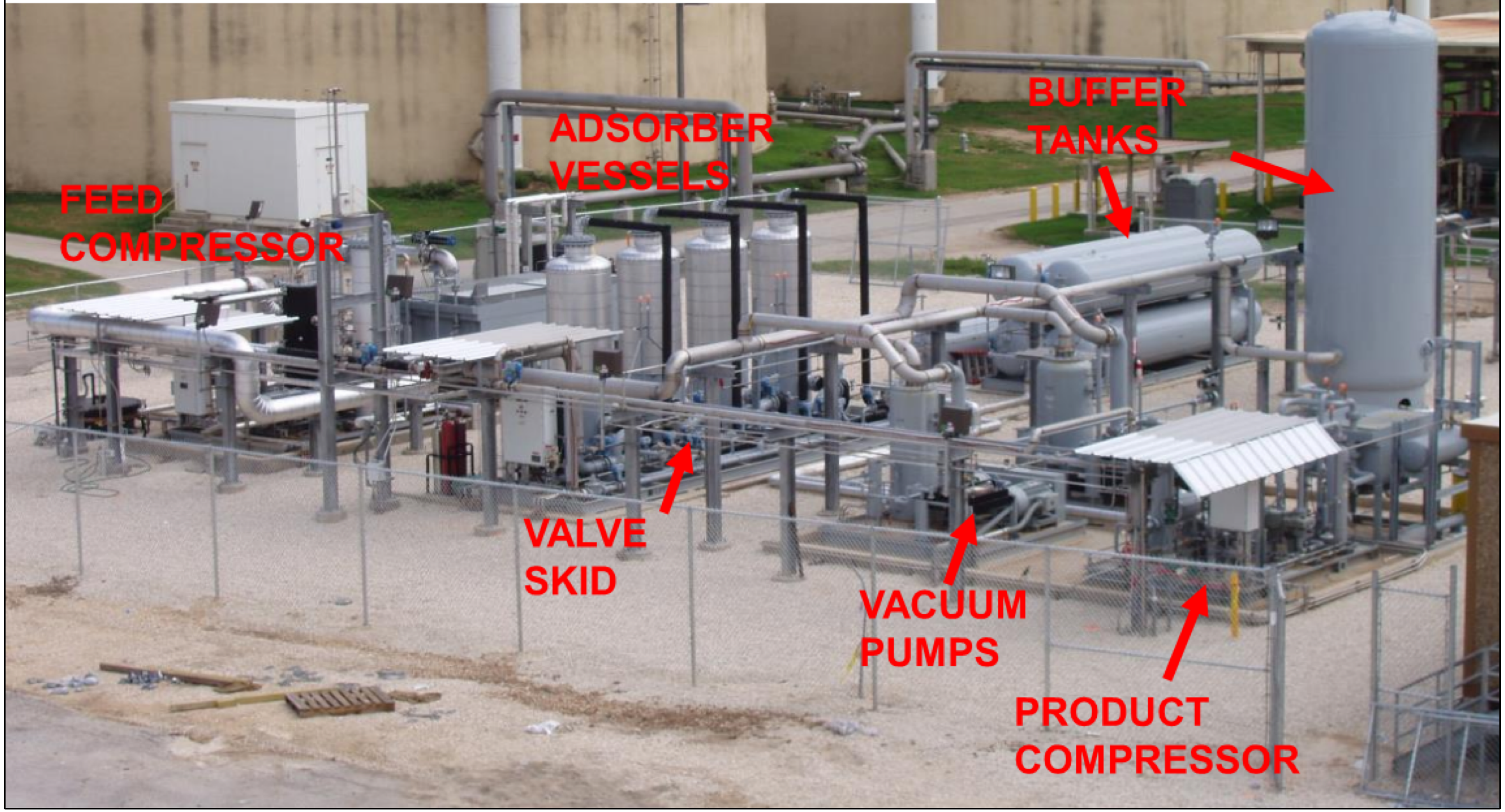
- **System Description**
  - Biogas is pressurized to flow up through the adsorption vessels
  - Contaminants are trapped by media designed to not capture CH_4
  - Vacuum is applied to depressurize (i.e.; pressure swing) after adsorption to purge contaminants from vessel in tail gas stream
  - Process is batch but use of multiple vessels and rotary valve allow continuous flow
- **Typical Components**
  - Compressor
  - Water Separator
  - Air Fan Cooler
  - Adsorber Vessels and Valve Skid
  - Vacuum Pumps
  - Buffer Tanks

Zeolite Media

Pressure Swing Adsorption

- **Manufacturers**
  - Guild Associates Inc. (Dublin, Ohio)
  - Xebec Adsorption Inc. (Quebec, Canada)
- **Advantages**
  - No H_2S pretreatment required for <6,000 ppm (Guild only)
  - Simple, one step, dry process that is proven technology
  - Media is regenerative
  - Spare parts are generic. Can be serviced by plant operators or local mechanic
- **Disadvantages**
  - Methane recovery is lower (92-95%)
  - Additional PSA vessels required for O_2/N_2 removal if air is in the biogas
  - Tail gas treatment is required

Guild Molecular Gate PSA System
San Antonio, TX (through Ameresco)
Digester (Waste Water Plant)
1300 SCFM (2100 nm3/hr) Feed
Product to Pipeline Quality (98% Methane)

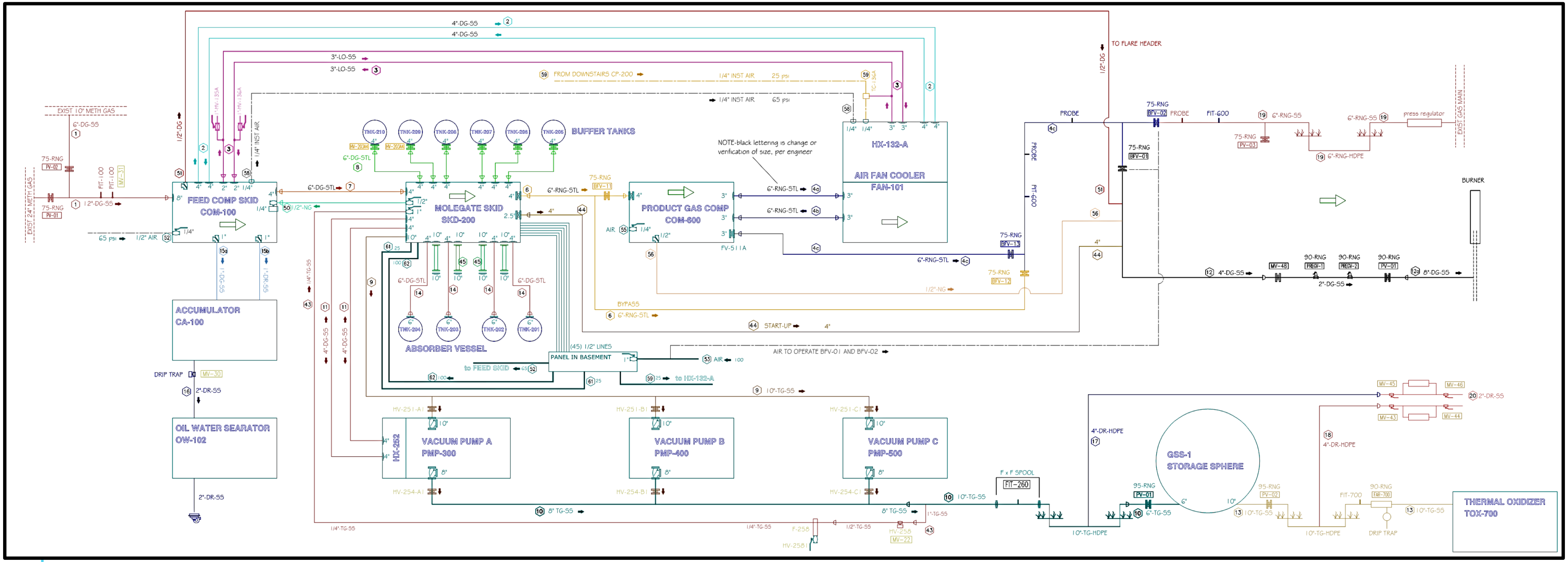


Technology Comparison & Selection

- **Hydrogen Sulfide Considerations**
  - Membranes: typically pre-treatment required
  - Water Scrubber: maximum inlet ~2,500 ppm H_2S
    - Tail gas treatment required (biofilter or RTO)
  - PSA: maximum inlet ~ 6,000 ppm H_2S
    - Tail gas treatment required (TO)
- **System Recovery Performance**
  - Membranes: high methane recovery
  - Water scrubber: high methane recovery, increases oxygen
  - PSA: lower methane recovery
- **Technology Selection:**
  - PSA System
  - Capacity of 2,250 scfm inlet biogas flows
  - Thermal Oxidizer with heat recovery

Project Design

System Flow Schematic



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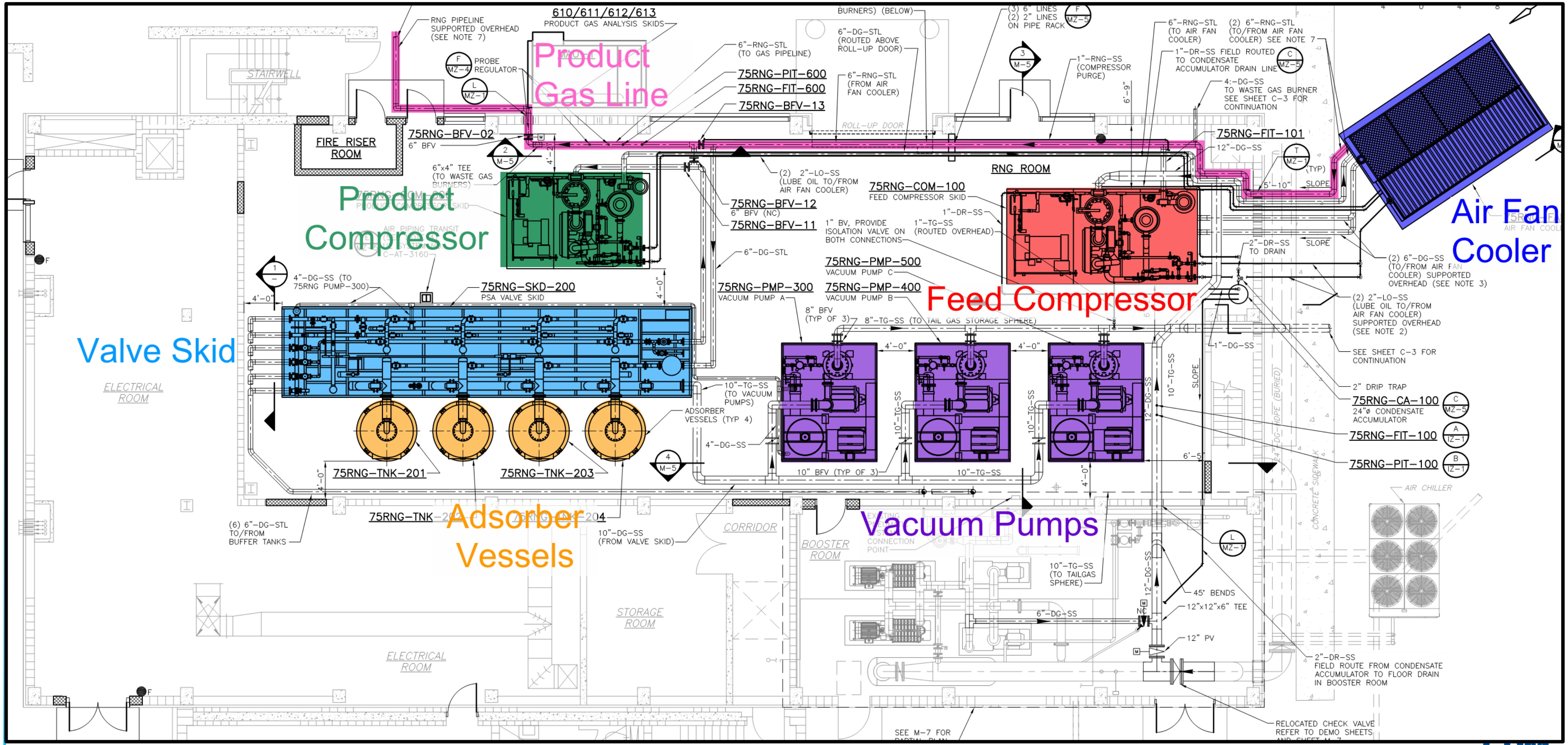
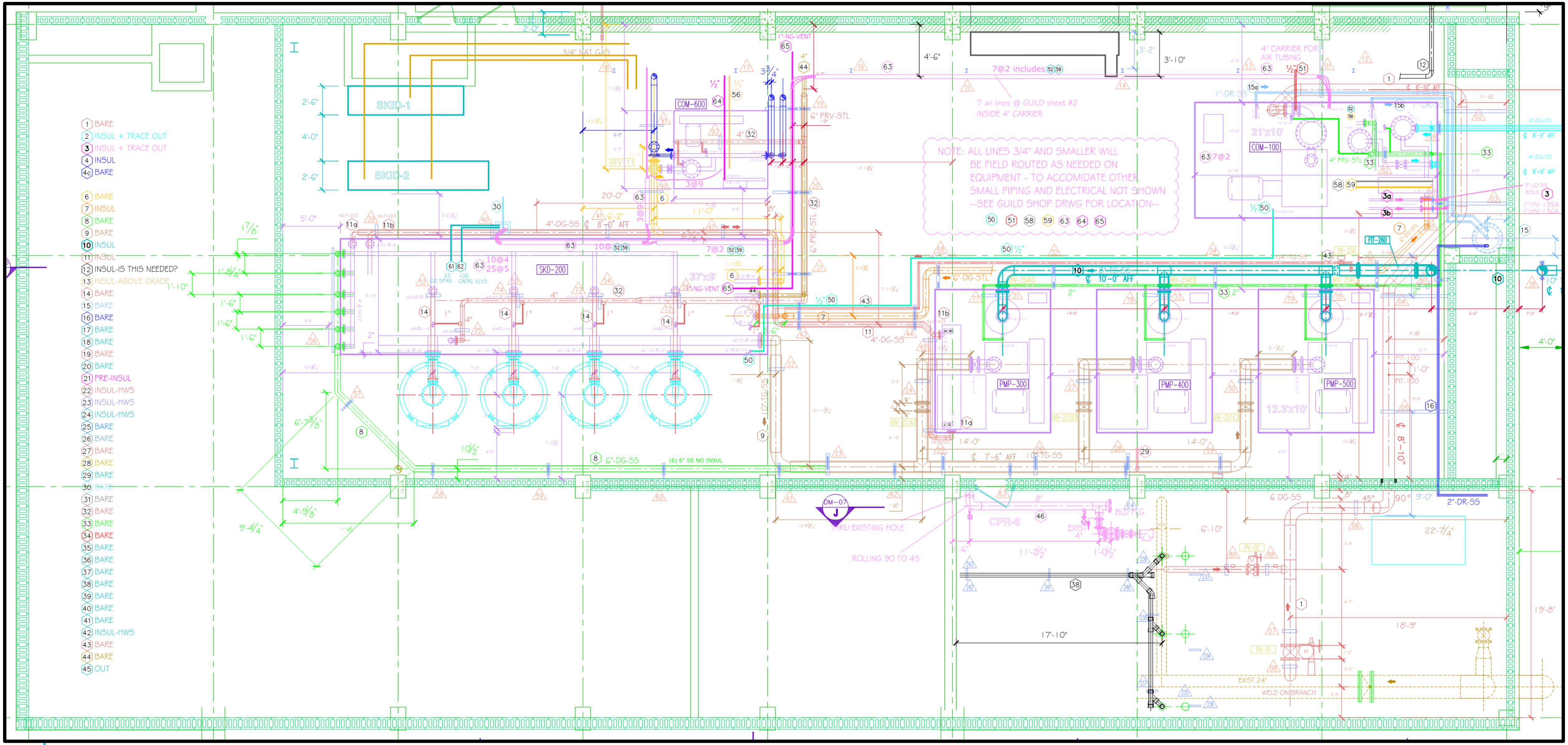
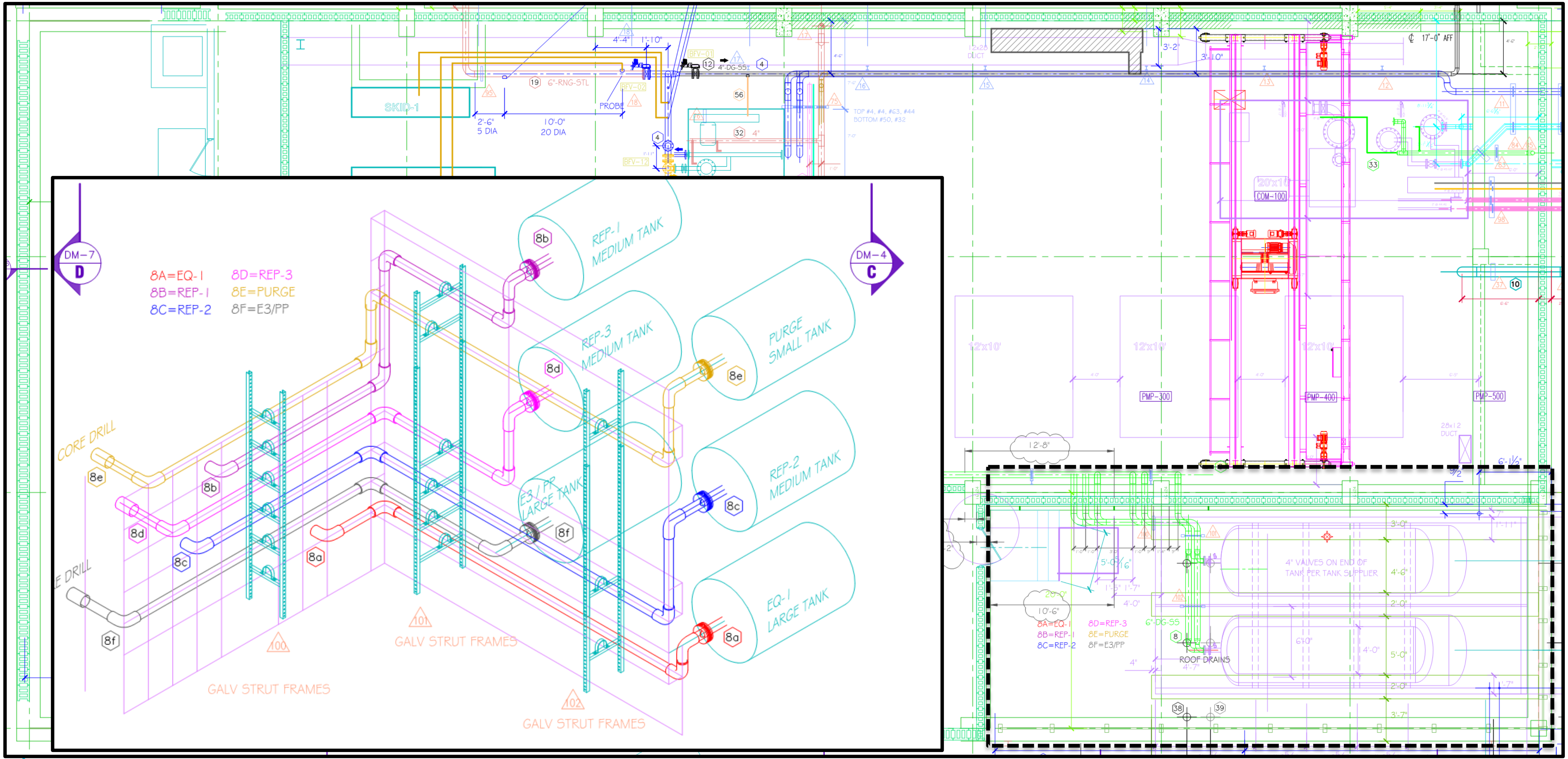
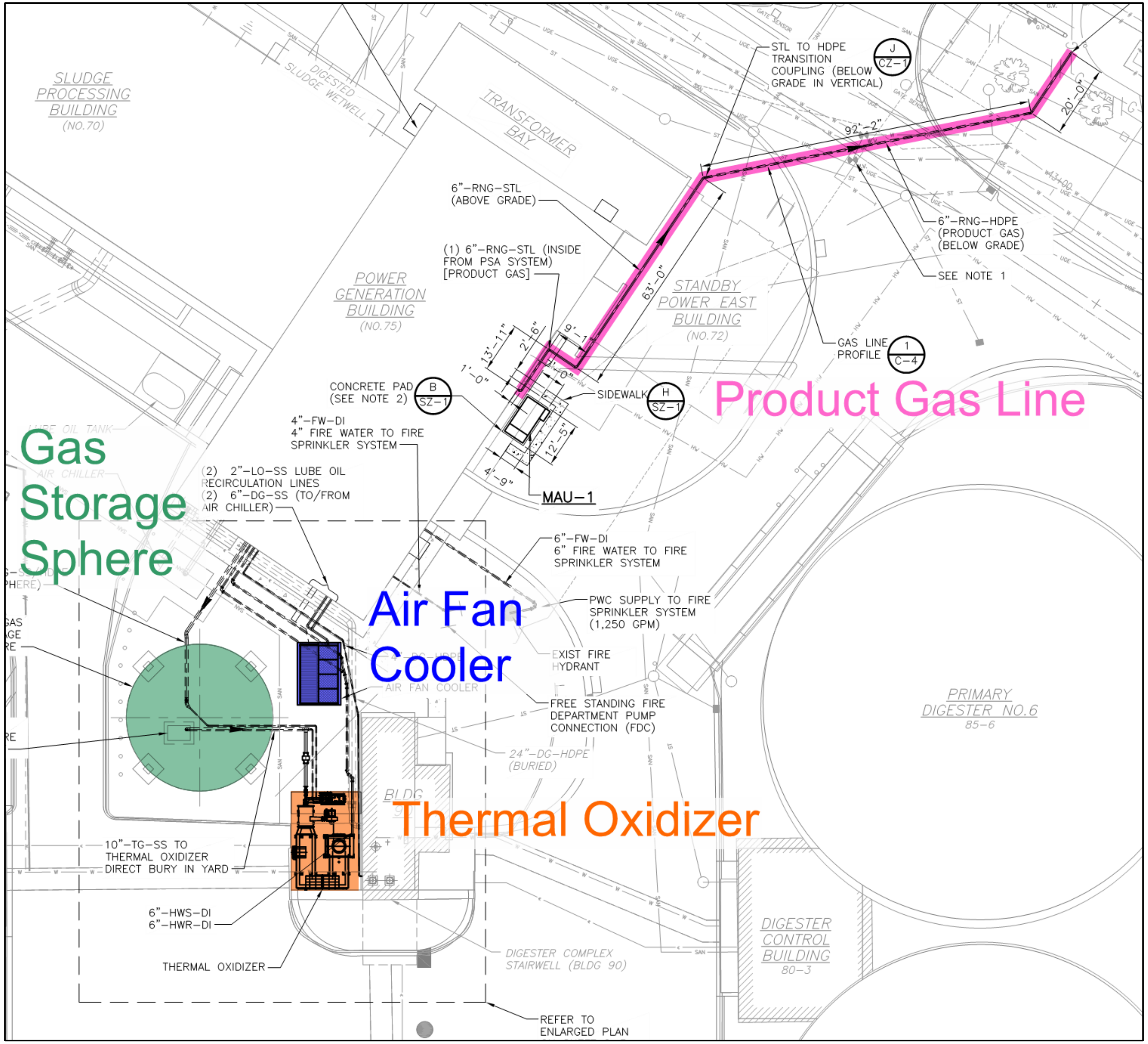
System Layout




1 BARE
2 INSUL + TRACE OUT
3 INSUL + TRACE OUT
4 INSUL
4c BARE
6 BARE
7 INSUL
8 BARE
9 BARE
10 INSUL
11 INSUL
12 INSUL-IS THIS NEEDED?
13 INSUL-ABOVE GRADE
14 BARE
15 BARE
16 BARE
17 BARE
18 BARE
19 BARE
20 BARE
21 PRE-INSUL
22 INSUL-HWS
23 INSUL-HWS
24 INSUL-HWS
25 BARE
26 BARE
27 BARE
28 BARE
29 BARE
30 BARE
31 BARE
32 BARE
33 BARE
34 BARE
35 BARE
36 BARE
37 BARE
38 BARE
39 BARE
40 BARE
41 BARE
42 INSUL-HWS
43 BARE
44 BARE
45 OUT
SKID-1
SKID-2
SKD-200
COM-600
COM-100
PMP-300
PMP-400
PMP-500
CPR-6
NOTE: ALL LINES 3/4" AND SMALLER WILL BE FIELD ROUTED AS NEEDED ON EQUIPMENT - TO ACCOMIDATE OTHER SMALL PIPING AND ELECTRICAL NOT SHOWN --SEE GUILD SHOP DRWG FOR LOCATION--
7 air lines @ GUILD sheet #2 INSIDE 4" CARRIER
4" CARRIER FOR AIR TUBING
3/4" NAT GAS
THRU EXISTING HOLE
ROLLING 90 TO 45
EXIST 24"
WELD ON BRANCH
(6) 6" SS NO INSUL


SKID-1
6"-RNG-STL
PROBE
2'-6"
5 DIA
10'-0"
20 DIA
4"-DG-SS
TOP #4, #4, #63, #44
BOTTOM #50, #32
17'-0" AFF
COM-100
12'x10'
PMP-300
PMP-400
PMP-500
12'-8"
10'-6"
DM-7
D
DM-4
C
8A=EQ-1
8B=REP-1
8C=REP-2
8D=REP-3
8E=PURGE
8F=E3/PP
REP-1
MEDIUM TANK
REP-3
MEDIUM TANK
PURGE
SMALL TANK
REP-2
MEDIUM TANK
EQ-1
LARGE TANK
E3 / PP
LARGE TANK
CORE DRILL
GALV STRUT FRAMES
GALV STRUT FRAMES
GALV STRUT FRAMES
4" VALVES ON END OF
TANK PER TANK SUPPLIER
6"-DG-SS
ROOF DRAINS

Site Plan



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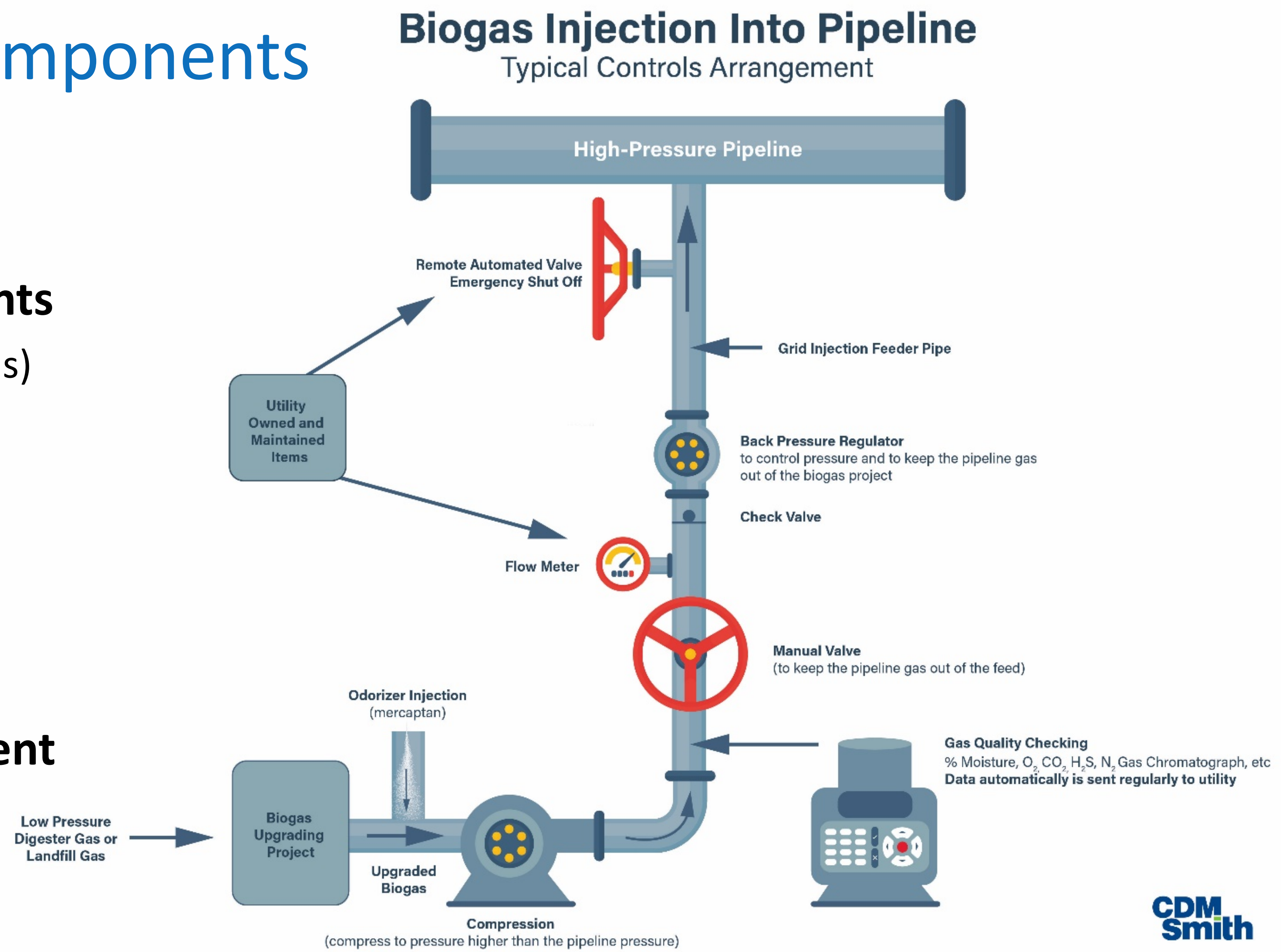
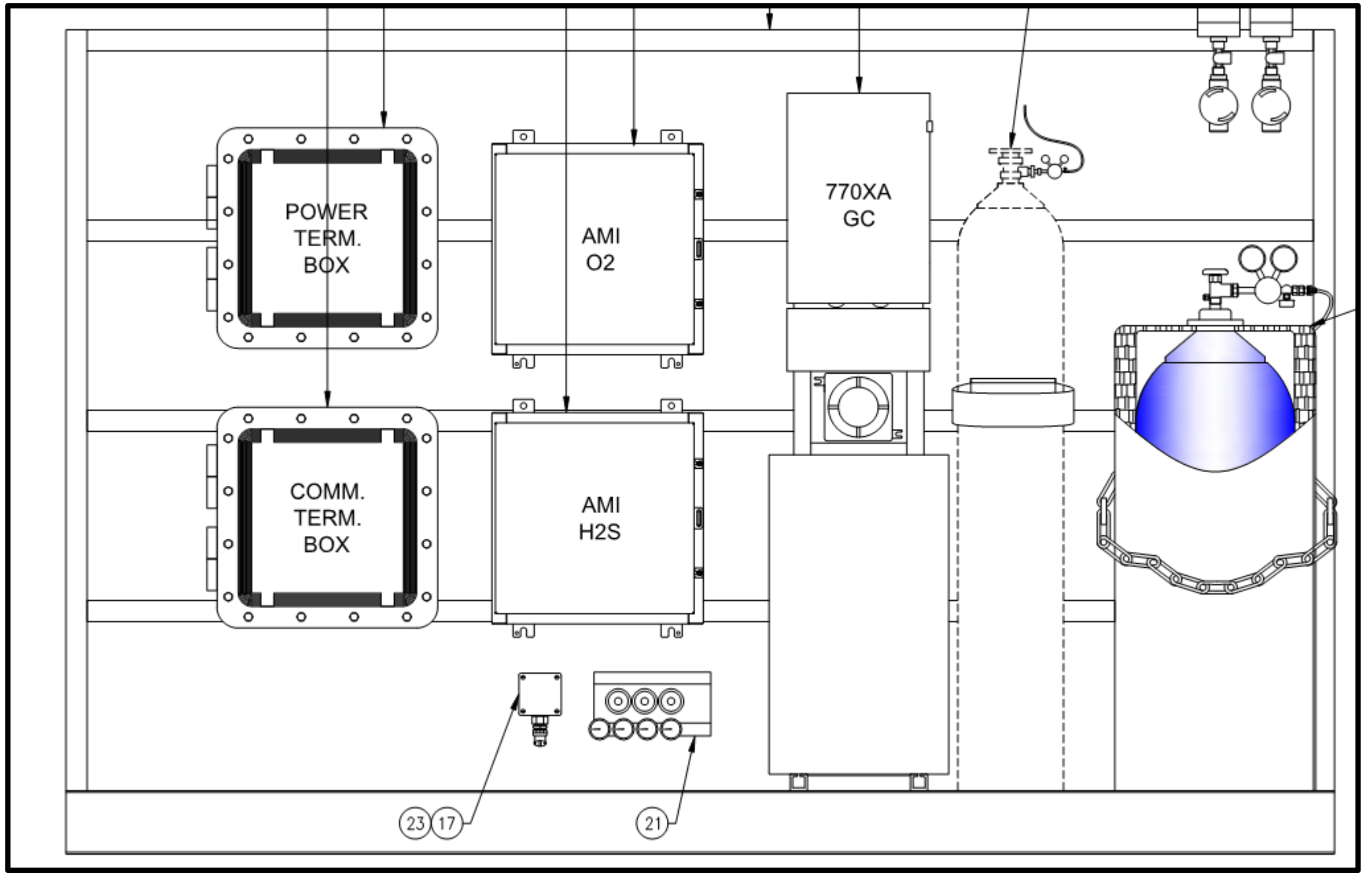
Pipeline Injection Components

- **Utility Owned Components**
  - Isolation or Shutout Valve(s)
  - Check Valve
  - Pressure Regulators
  - Flowmeter
  - Odorizer Injection
- **Gas Quality Instruments**
- **Communication Equipment**



Gas Quality Instruments

- **Continuous Measurement**
  - Pressure
  - Flow
  - Gas Chromotgraph
    - CH4, CO2, O2, N2
  - Oxygen
  - Hydrogen Sulfide
  - Moisture
- **Carrier / Calibration Gas Bottles**
- **Fully Redundant Instruments**



- **Demolish (3) 600 Kw Superior Engines**
- **Engines installed 1987**
- **Heat Recovery**
- **Installed within an ‘Unclassified’ Bldg.**

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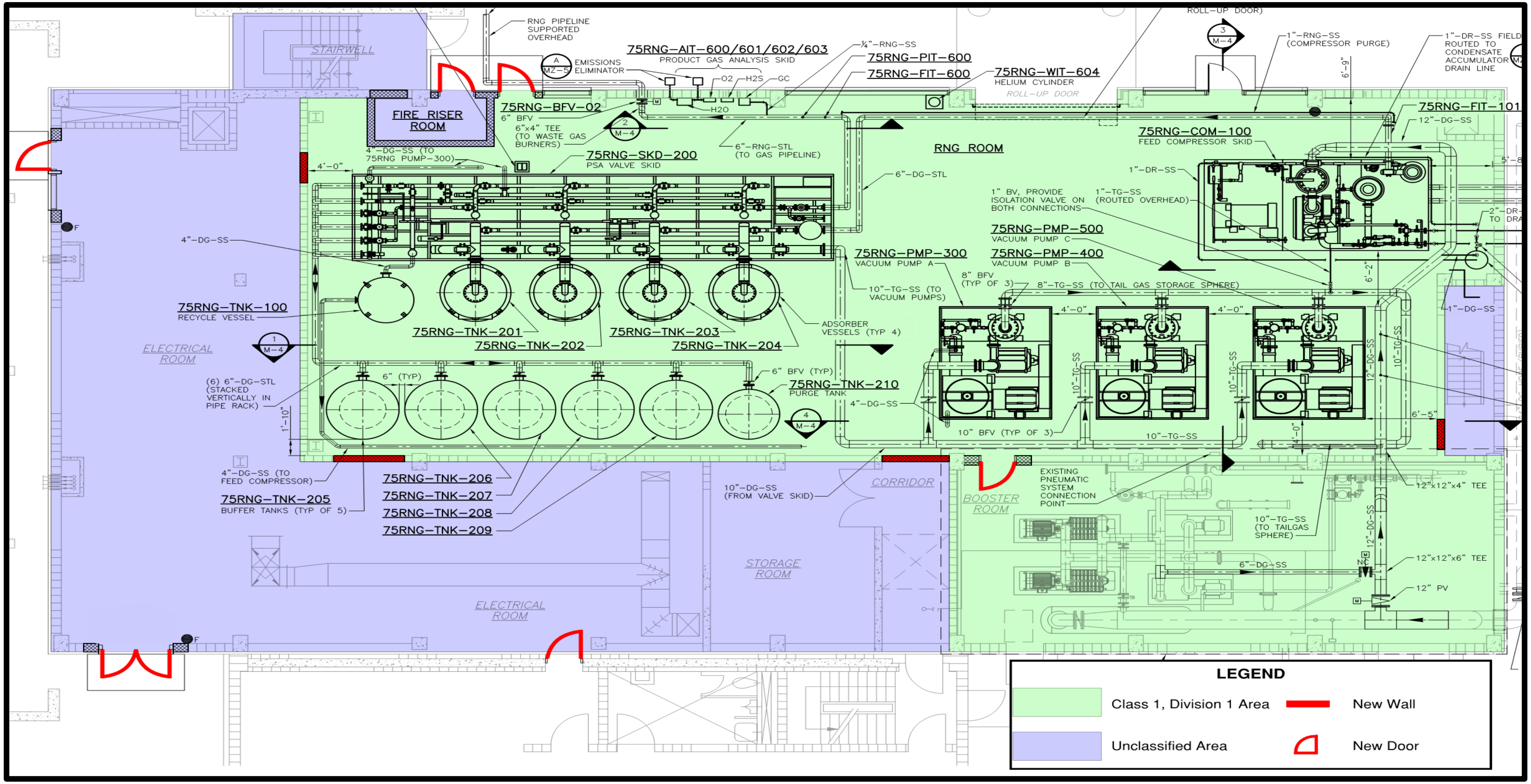
Area Classification & Building Modifications

- NFPA defines requirements of "Digester Gas Processing Rooms" involving biogas compression, handling, and processing equipment

Row	Location and Function	Ventilation Rate	Extent of Classified Area	NEC Area Electrical Classification	Material of Construction & Fire Protection Measures [2]
Row 18a	**DIGESTER GAS PROCESSING ROOMS** (Gas compression, handling, and processing)	No ventilation or ventilated at less than 12 air changes per hours	Entire room	Class 1, Division 1, Group D	NC, CGD, H, FE
Row 18b		Continuously ventilated at 12 air changes per hour	Within 1.5m (5-ft) of equipment	Class 1, Division 1, Group D	NC, LC, CGD, H, FE
Row 18c		Continuously ventilated at 12 air changes per hour	Entire Room	Class 1, Division 2, Group D	NC, LC, CGD, H, FE

NC – Noncombustible Material; LC – Limited-combustible material; CGD – Combustible Gas Detection System;
H – Hydrant Protection; FE – Portable Fire Extinguisher

Building Area Classification Plan – 1st Floor



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Project Status:

- Bid Opening was May 1st, 2018
- Construction Capital Costs ~$14M
- RNG System Arrives Onsite
  - Late Feb. – Mid May
- RNG System Startup: Q4 of 2019
- Anticipated Project Payback of ~4-5yrs
- Currently considering both long and short term RIN contracts

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Questions!

Dustin Craig, PE

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Find more insights through our water partnership
at cdmsmith.com/water and @CDMSmith

Biogas Risk Assessment Methodology

- Conservative, Moderate and Aggressive risk scenarios
- Risk analysis and sensitivity to changes in RIN value

	Conservative	Moderate	Aggressive	Current Conditions
D3 RIN Value, $/RIN	$0.50	$2.50	$3.20	$2.60
D5 RIN Value, $/RIN	$0.25	$0.70	$1.25	$0.75
LCFS – Carbon Trading Price, $/MT	$0	$75	$175	$125