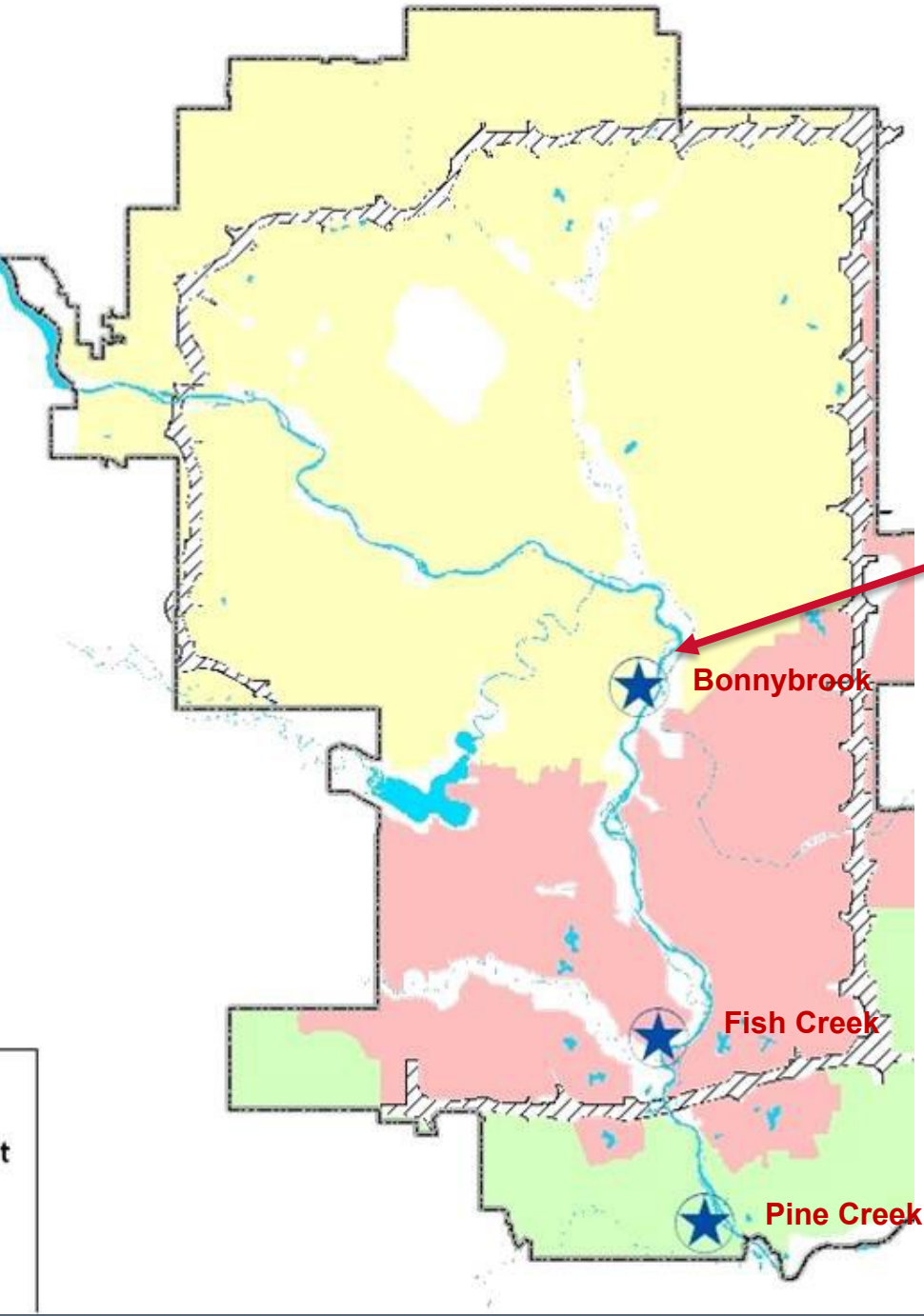
Calgary

For: 2024 NWWC
By: Jifan Liu P.Eng
2024-11-5

Cogeneration Expansion Project
Bonnybrook Wastewater Treatment Plant

Calgary, Alberta, Canada



Bonnybrook WWTP

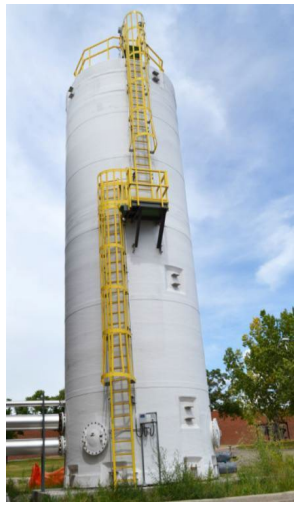
- Largest one of the three WWTPs
- Serving 1.17 M population
- Average flow treated: 360 MLD

Power Generation and Heating Facility (PGH)

- Plant process & space heating
- Plant normal & standby power

Simplified Biogas Flow

Digester → Biogas Conditioning → Co-gen → Power & Heat



Project description

- Adding a new 5 MW co-generation plant to existing Power Generation and Heat (PGH) facility

- Utilizing biogas to generate electricity and steam

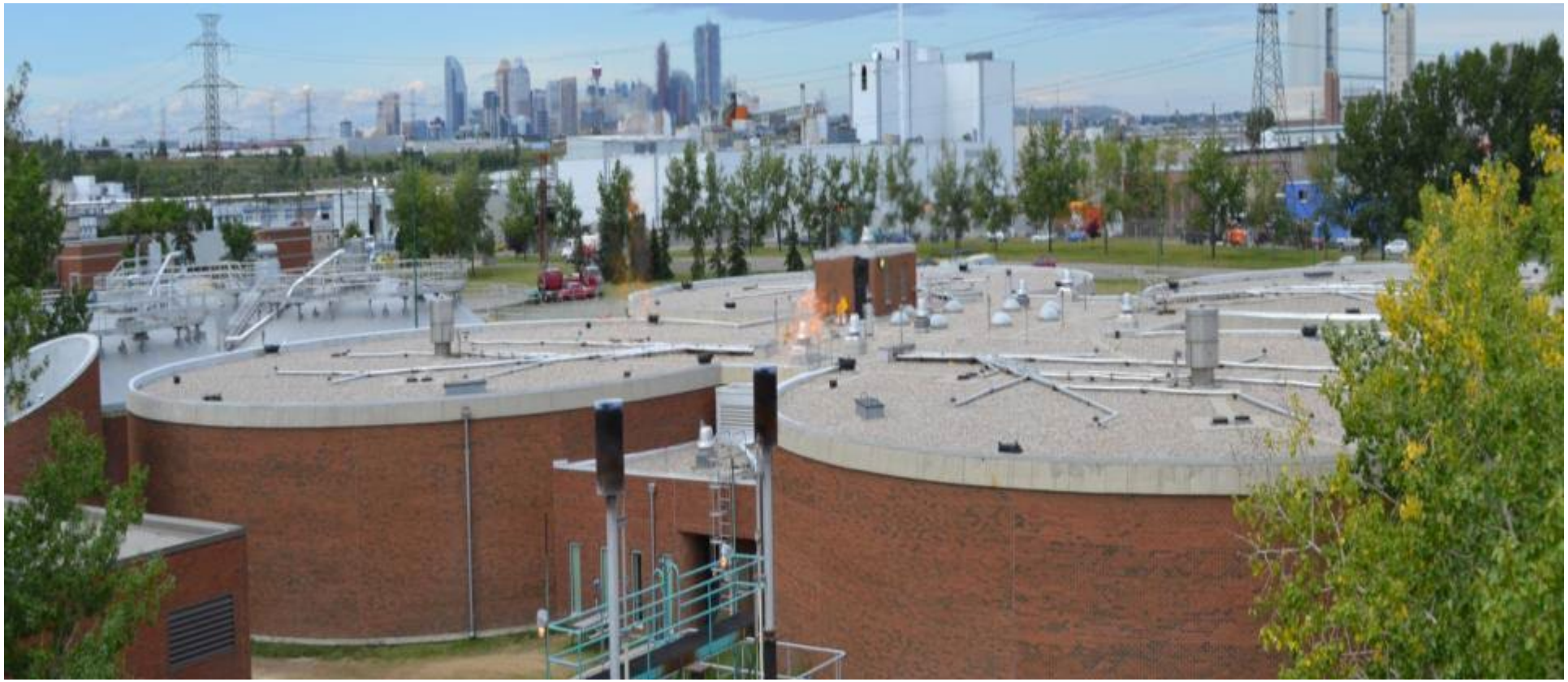
Project Objectives

- Fully utilize freely available biogas
- Double the plant onsite energy production – Cost savings
- Effort to achieve electrical energy self-sufficiency
- Produce steam for future thermal hydrolysis process (THP)
- Improve electrical system availability and reliability

- Minimize or eliminate flaring of biogas
- Reduce GHG emissions

Co-gen options

- Reciprocating engine
- Gas turbine



Digester gas / biogas

- Biogas – a byproduct from sludge digestion
- Biogas production- 1700 SM3/H
- Biogas - 2/3 of the heating value of Natural gas

Bonnybrook raw biogas and typical natural gas composition

Constituent	Quantity
Methane	62%
H2S	3000 ppm
Siloxane	70 mg/m³
Carbon Dioxide	38%
Fuel Heating Value (LHV)	621 btu/scf

Constituent	Volume %
Methane	92.79 %
Ethane	4.16 %
Propane	0.84 %
N-Butane	0.18 %
N-Pentane	0.04 %
Nitrogen	1.51 %
Carbon Dioxide	0.44 %
Fuel Heating Value (LHV)	983 btu/scf

Old PGH

- IC Engines
- Hot water Boilers
- Flares

Existing Internal combustion engines

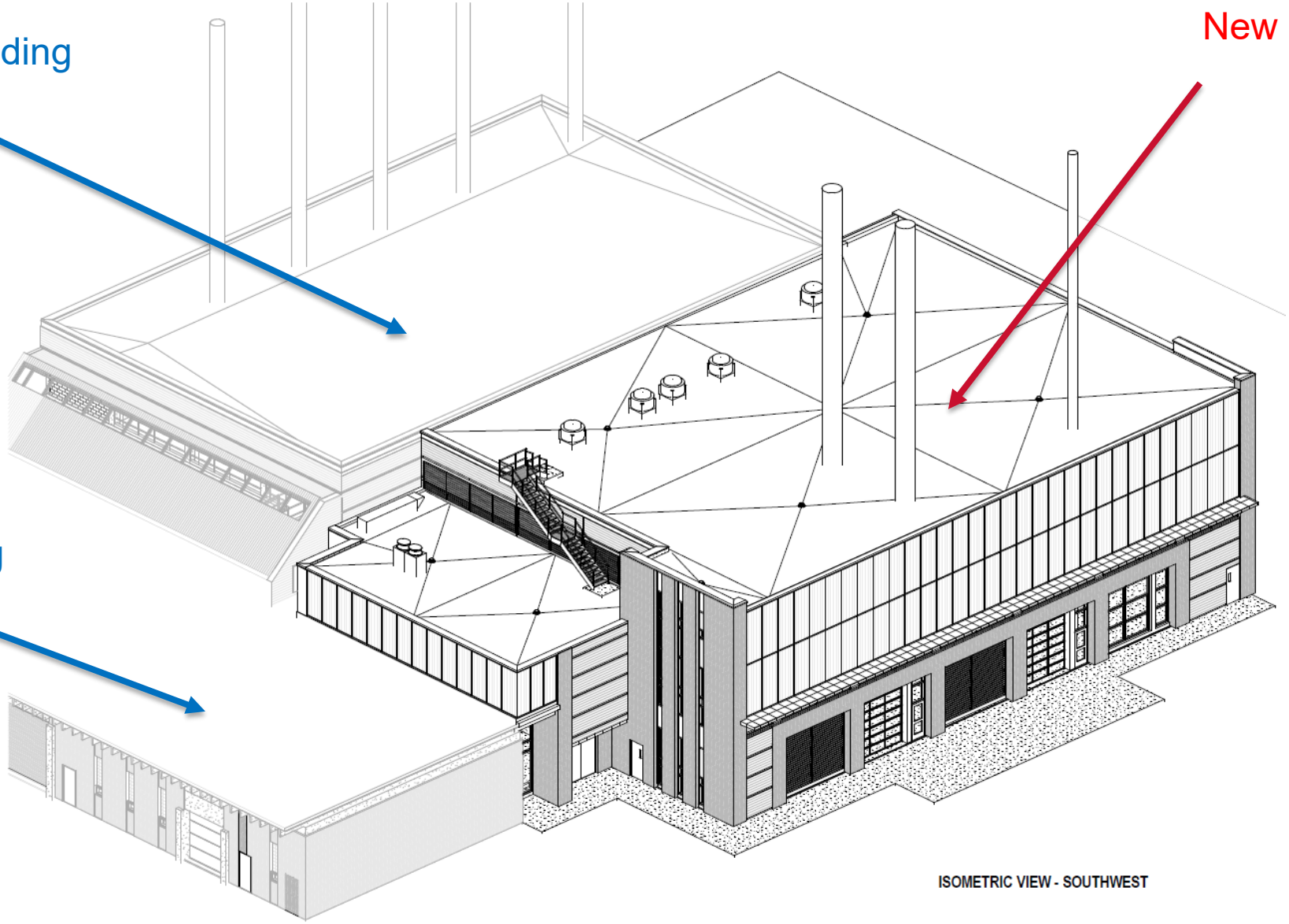
- CAT G3520C
- 3 x 1.6 MW

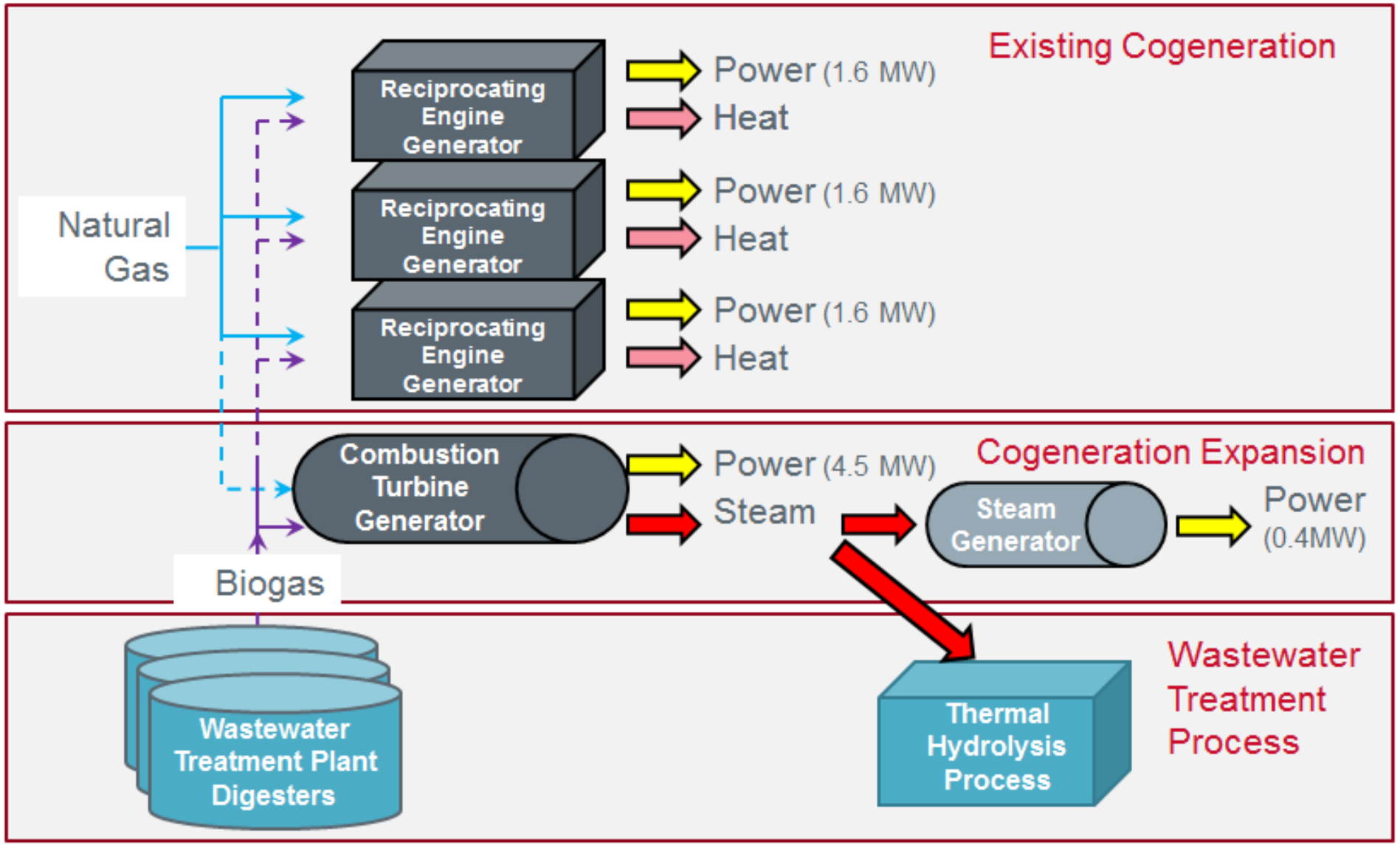
Existing & New

Existing IC engine building

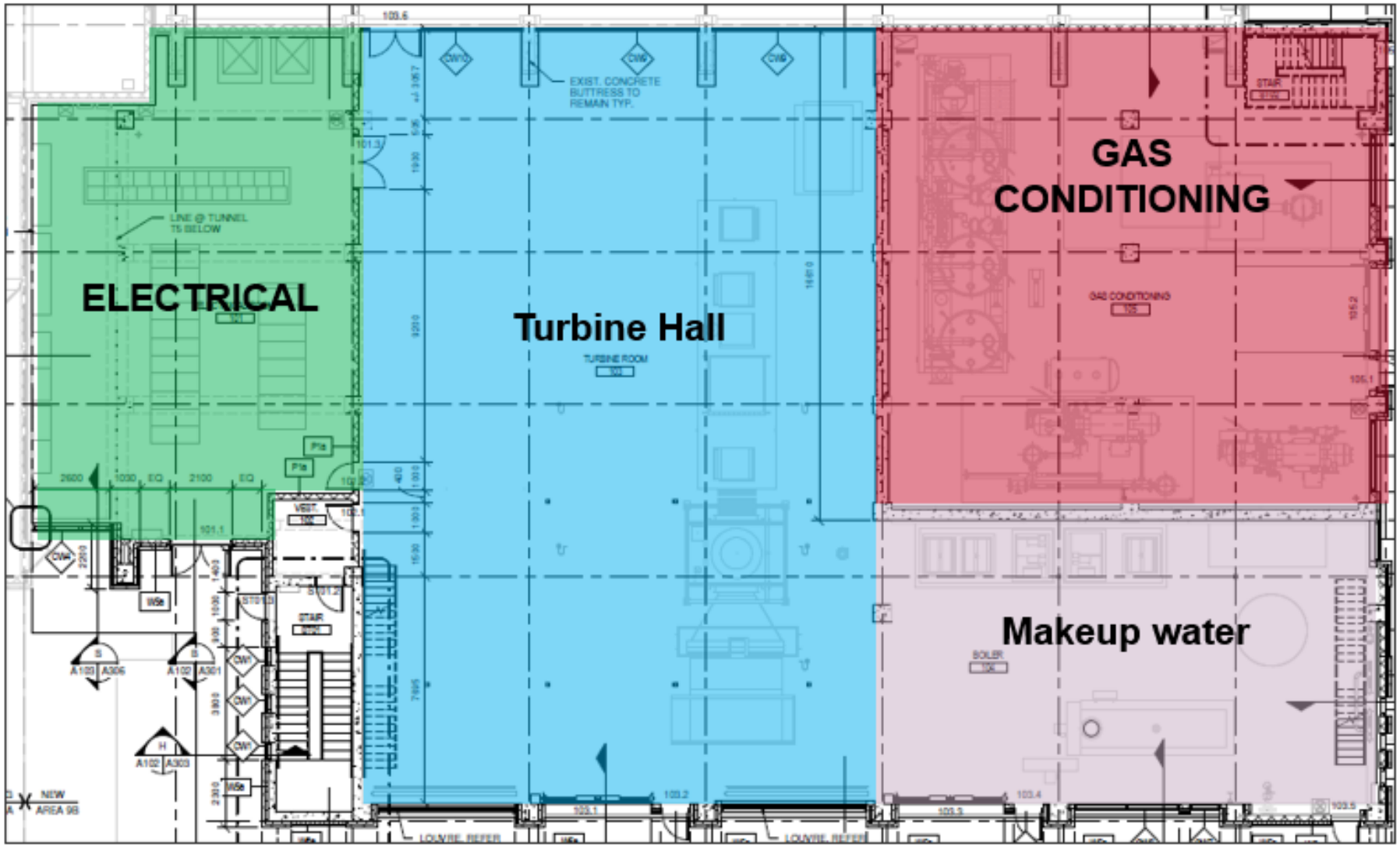
New Co-gen plant

Existing boiler building

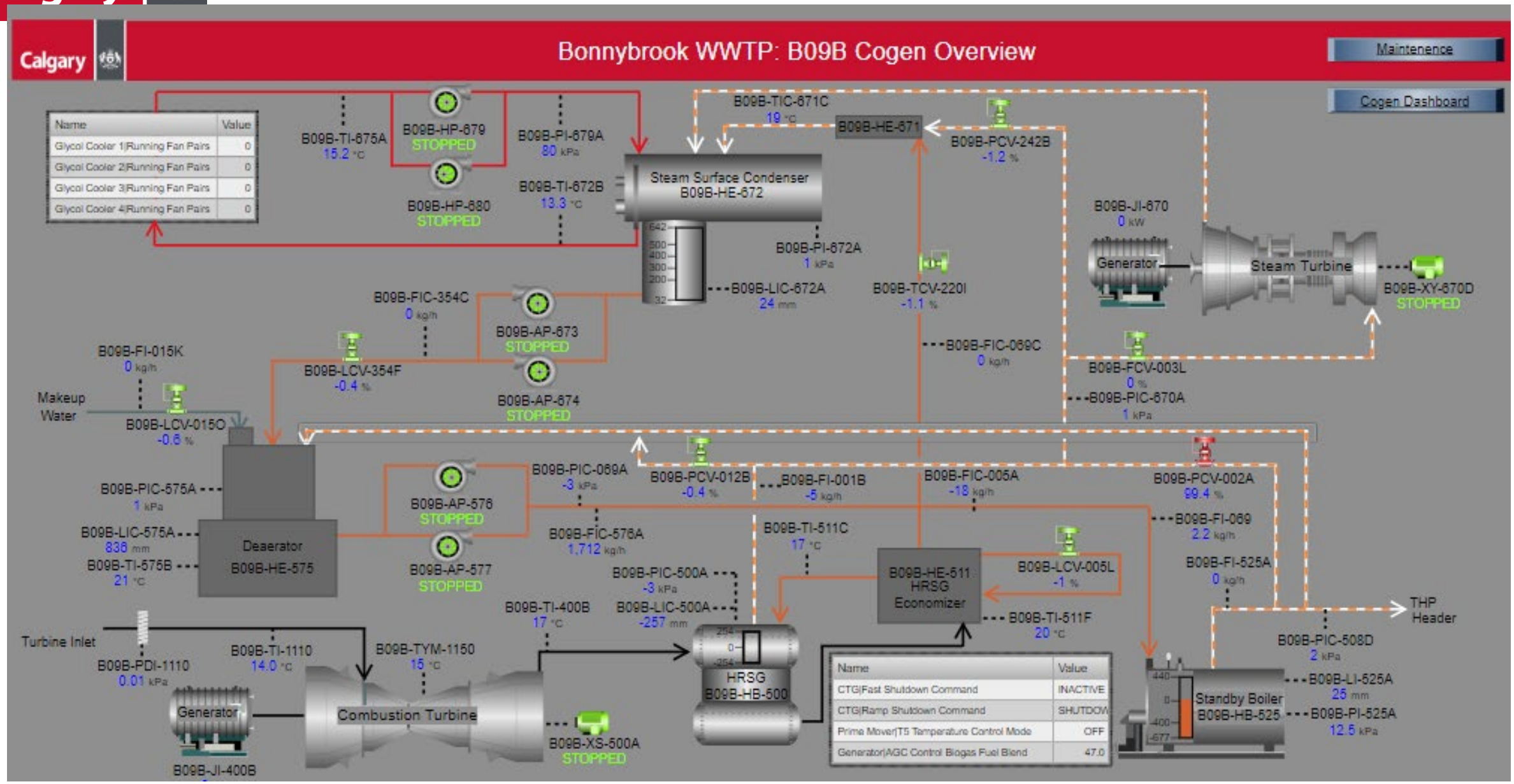



Existing Cogeneration
Natural Gas
Reciprocating Engine Generator
Power (1.6 MW)
Heat
Reciprocating Engine Generator
Power (1.6 MW)
Heat
Reciprocating Engine Generator
Power (1.6 MW)
Heat
Cogeneration Expansion
Combustion Turbine Generator
Power (4.5 MW)
Steam
Steam Generator
Power (0.4MW)
Biogas
Wastewater Treatment Plant Digesters
Thermal Hydrolysis Process
Wastewater Treatment Process

New co-gen building



Co-gen expansion


Calgary
Bonnybrook WWTP: B09B Cogen Overview
Maintenance
Cogen Dashboard
Name
Value
Glycol Cooler 1|Running Fan Pairs
0
Glycol Cooler 2|Running Fan Pairs
0
Glycol Cooler 3|Running Fan Pairs
0
Glycol Cooler 4|Running Fan Pairs
0
B09B-TI-675A
15.2 °C
B09B-HP-679
STOPPED
B09B-HP-680
STOPPED
B09B-PI-679A
80 kPa
B09B-TI-672B
13.3 °C
B09B-TIC-671C
19 °C
B09B-HE-671
B09B-PCV-242B
-1.2 %
Steam Surface Condenser
B09B-HE-672
B09B-PI-672A
1 kPa
B09B-LIC-672A
24 mm
B09B-TCV-220I
-1.1 %
B09B-JI-670
0 kW
Generator
Steam Turbine
B09B-XY-670D
STOPPED
B09B-FIC-354C
0 kg/h
B09B-AP-673
STOPPED
B09B-LCV-354F
-0.4 %
B09B-AP-674
STOPPED
B09B-FIC-069C
0 kg/h
B09B-FCV-003L
0 %
B09B-PIC-670A
1 kPa
B09B-FI-015K
0 kg/h
Makeup Water
B09B-LCV-015O
-0.6 %
B09B-PIC-575A
1 kPa
B09B-LIC-575A
836 mm
B09B-TI-575B
21 °C
Deaerator
B09B-HE-575
B09B-AP-576
STOPPED
B09B-AP-577
STOPPED
B09B-PIC-069A
-3 kPa
B09B-FIC-576A
1,712 kg/h
B09B-PCV-012B
-0.4 %
B09B-FI-001B
-5 kg/h
B09B-FIC-005A
-18 kg/h
B09B-PCV-002A
99.4 %
B09B-FI-069
2.2 kg/h
B09B-TI-511C
17 °C
B09B-HE-511
HRSG
Economizer
B09B-LCV-005L
-1 %
B09B-FI-525A
0 kg/h
B09B-PIC-500A
-3 kPa
B09B-LIC-500A
-257 mm
B09B-TI-400B
17 °C
B09B-TI-511F
20 °C
THP Header
Turbine Inlet
B09B-PDI-1110
0.01 kPa
B09B-TI-1110
14.0 °C
B09B-TYM-1150
15 °C
Generator
Combustion Turbine
B09B-JI-400B
B09B-XS-500A
STOPPED
HRSG
B09B-HB-500
Name
Value
CTG|Fast Shutdown Command
INACTIVE
CTG|Ramp Shutdown Command
SHUTDOV
Prime Mover|T5 Temperature Control Mode
OFF
Generator|AGC Control Biogas Fuel Blend
47.0
Standby Boiler
B09B-HB-525
B09B-PIC-508D
2 kPa
B09B-LI-525A
25 mm
B09B-PI-525A
12.5 kPa

A Complex Integration of Many Packages

Biogas → Turbine → Electricity and Steam

- **Biogas Conditioning**
  - Siloxane removal
  - gas compression
  - Filtration
  - Dehydration
  - Mixing

- **Generators**
  - Gas turbine
  - Steam turbine

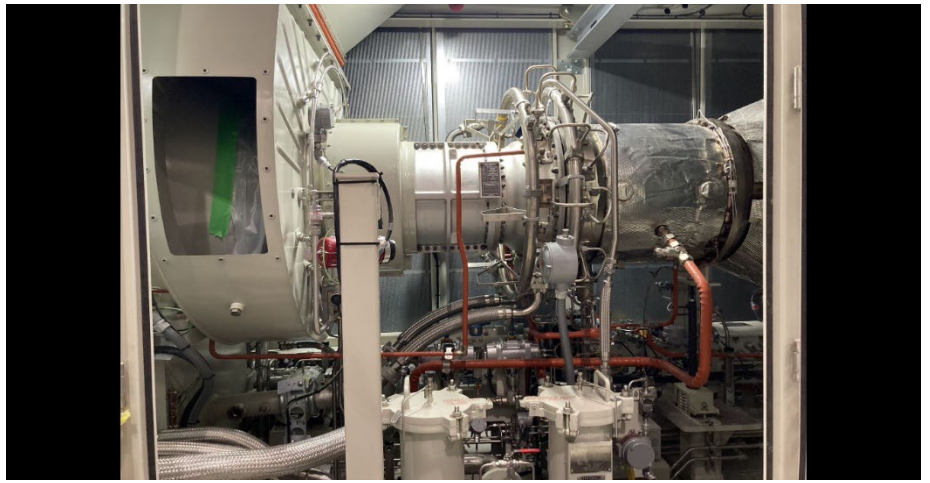
- **Electrical Distribution System**
  - Medium Voltage Switchgear
  - 600V Switchgear
  - 600V Motor Control Centre
  - Power Management Control System

- **Distributed Control System**
  - **Delta V**

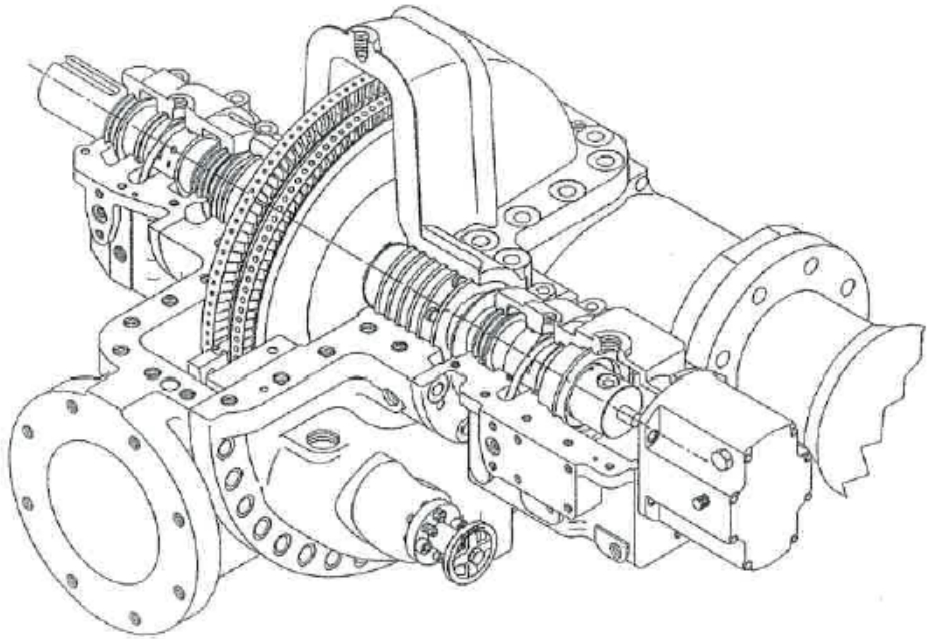
- **Steam System**
  - HRSG
  - STG
  - Standby steam boiler
  - Steam surface condenser
  - Cooling system

- **Water Treatment**
  - De-chlorination
  - Water Softener
  - Multimedia Filter
  - Reverse Osmosis
  - Electro De Ionization
  - Deaerator
  - Chemical Dosing

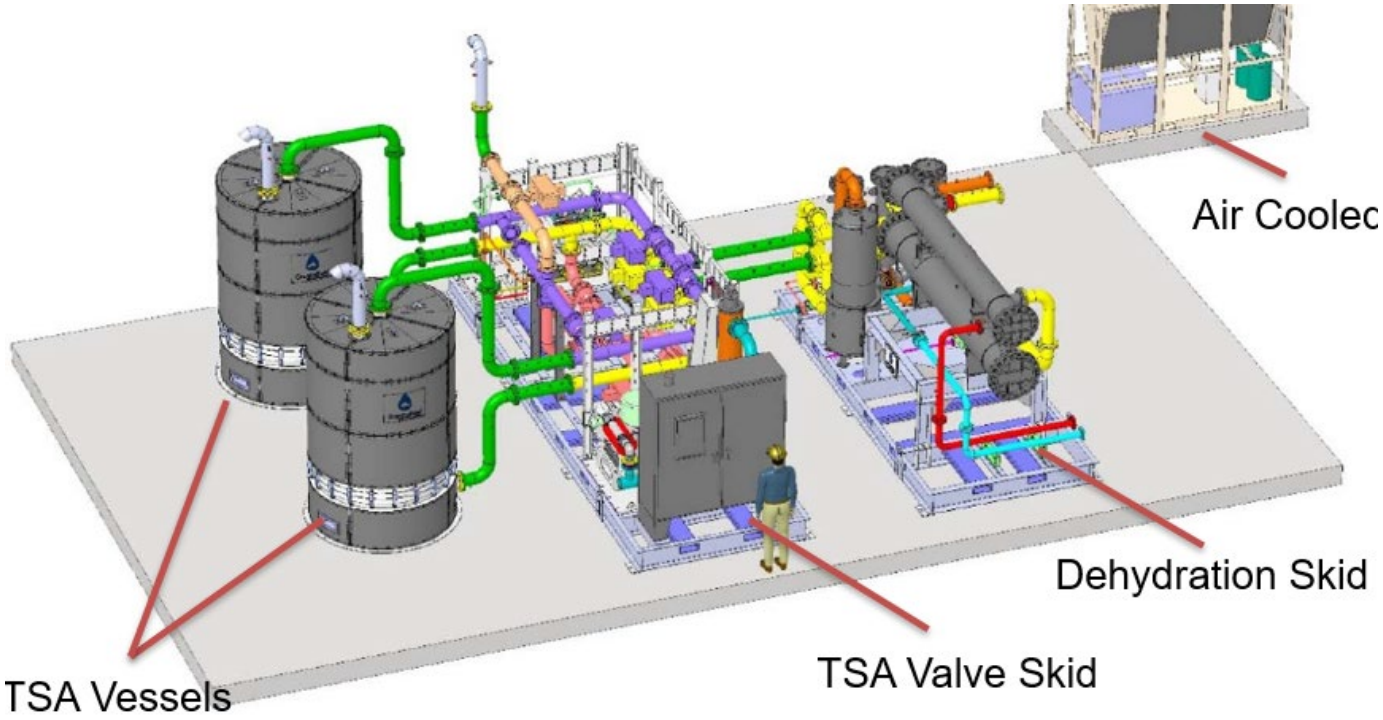
Gas turbine (CTG) - 4.5MW



Steam Turbine Generator (STG)- 0.5MW



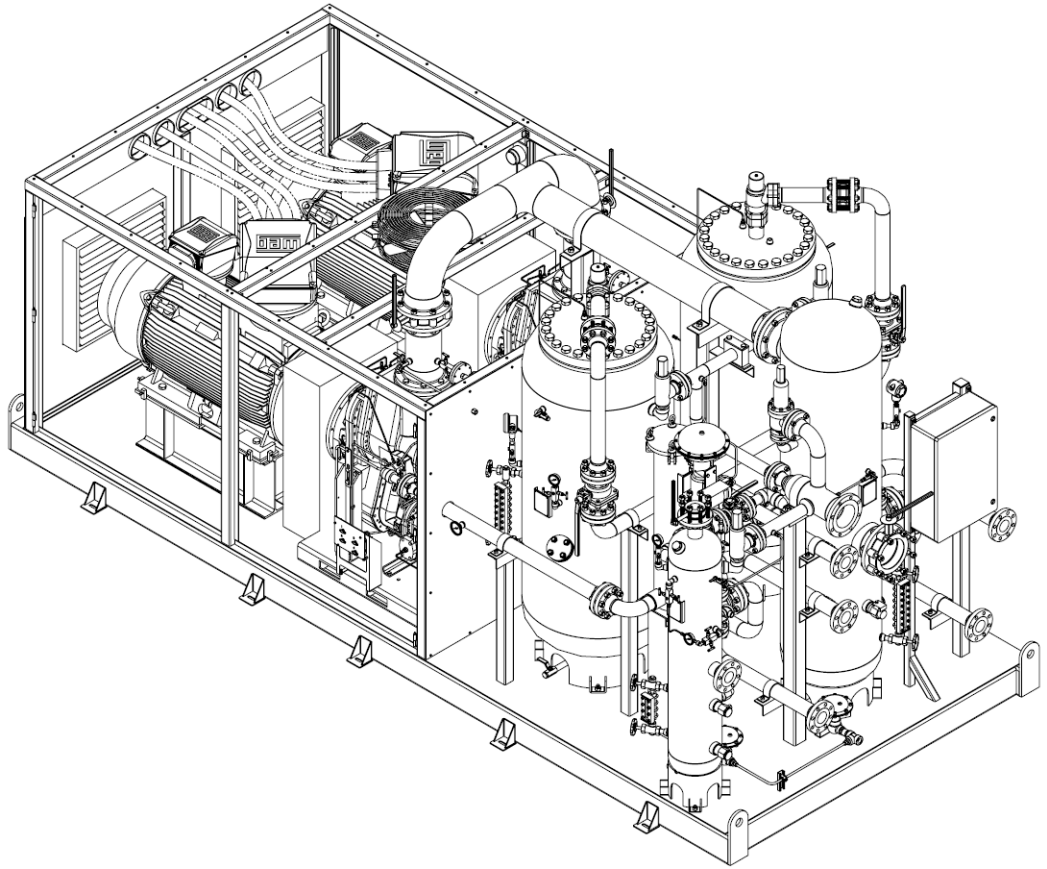
Siloxane removal



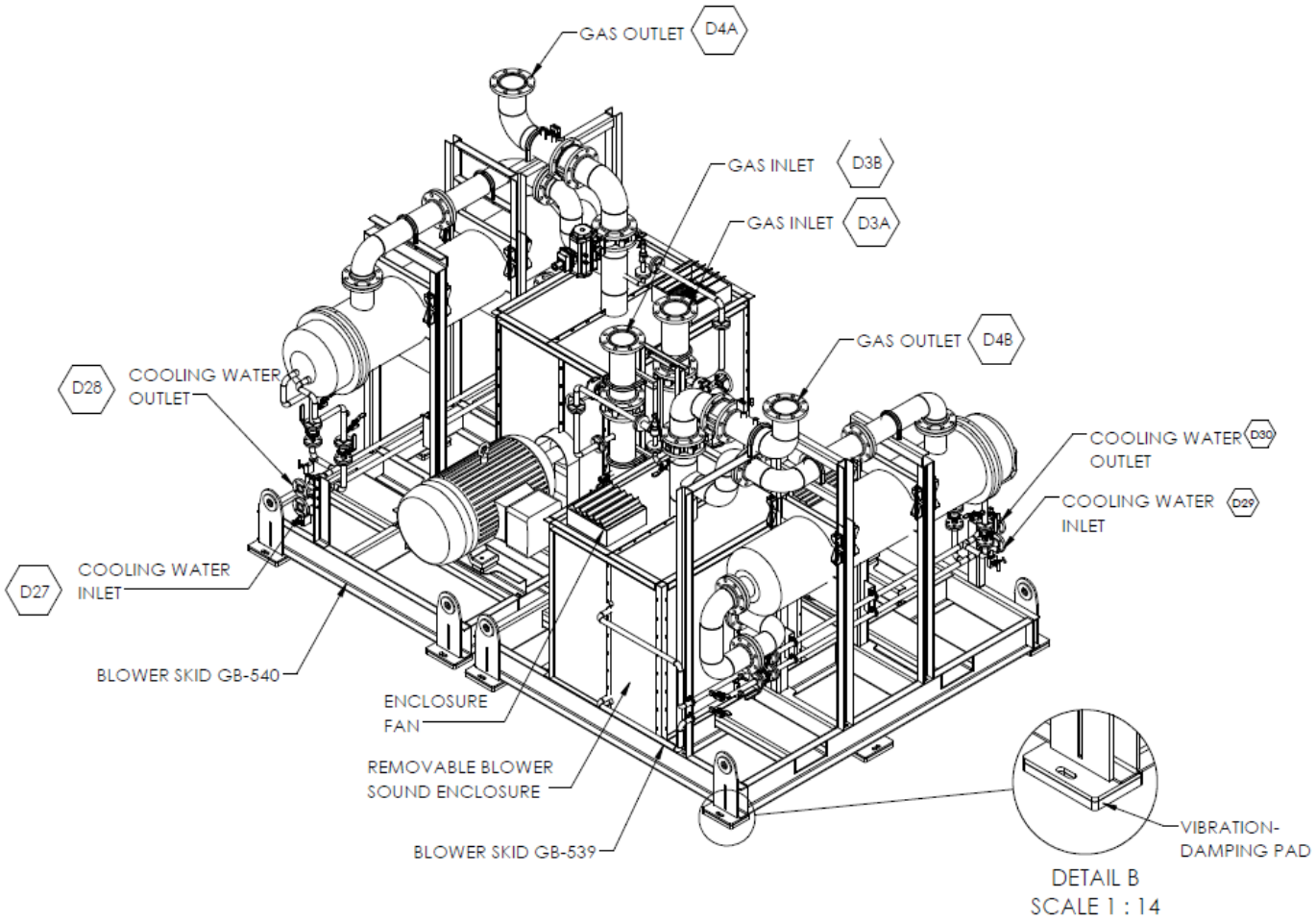
Ref No. Sample ID/Description	Beginning of Cycle		Ending of Cycle	
	23121908 RDG3sru1 1213231510	23121804 TDG3sru1-1 1213231510	23121909 RDG4sru1 1215231250	23121806 TDG4sru1-48 1215231252
Total Silicon Equivalent (mg/m3)	21.098	0.340	26.077	0.448
Removal Efficiency	98.4%		98.3%	

Existing H_2S Scrubber

Gas Compression



Gas Compression



Gas filtration

Gas dehydration

Gas dehydration and oil removal

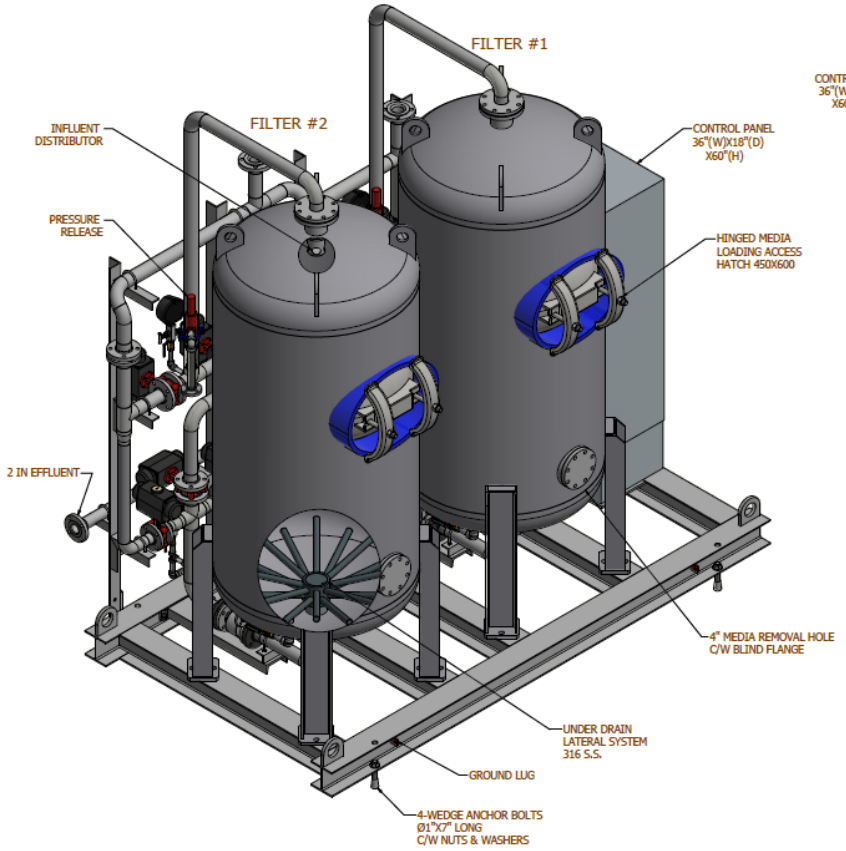
Gas blending

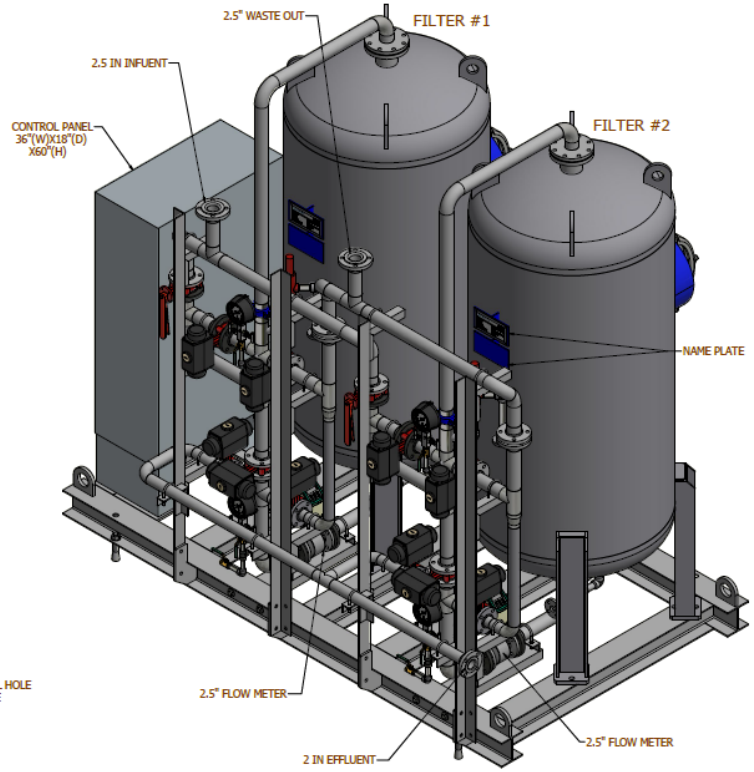
Standby steam boiler

HRSG-Economizer

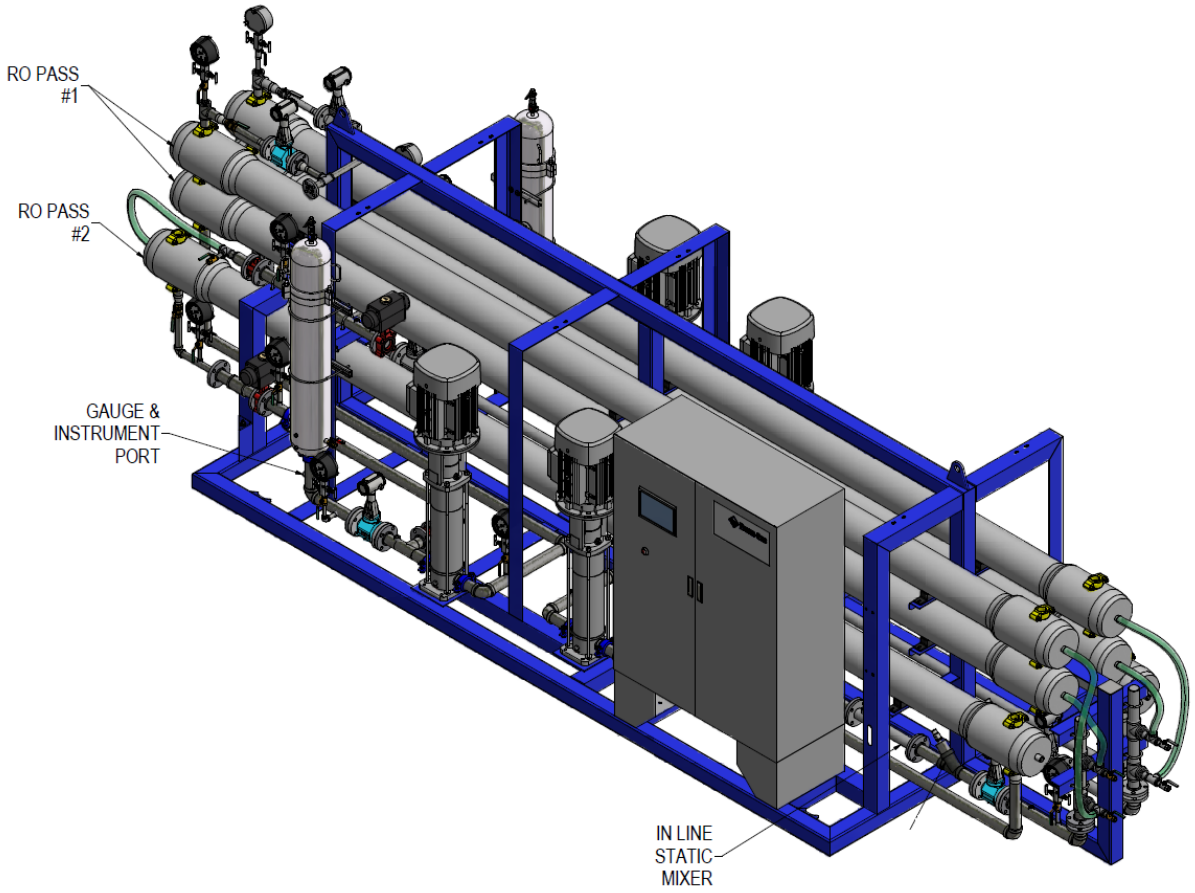
Electrical system

Water treatment- Multimedia filter

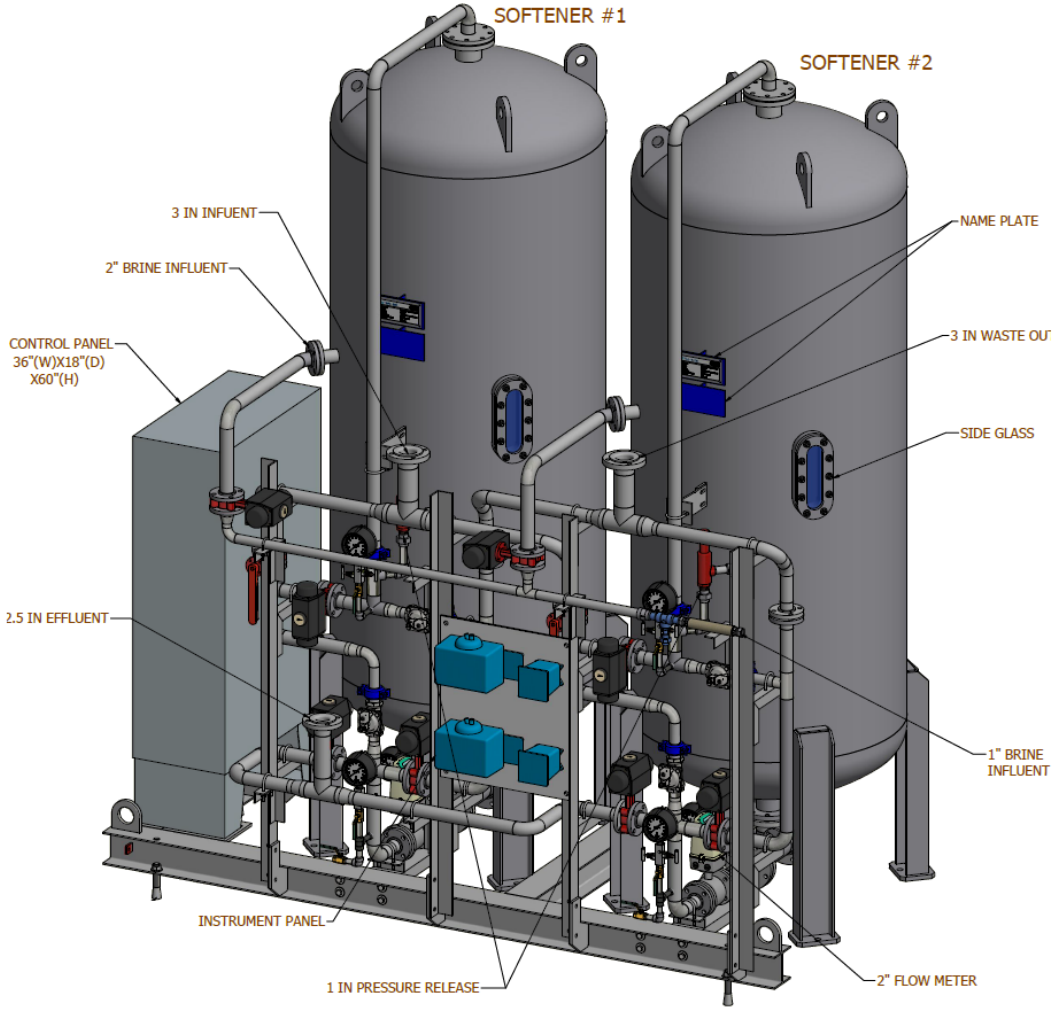




Water treatment – reverse osmosis



Water treatment - softener



Water treatment –chemical dosing/Electro Deionization

Water treatment – de-aerator

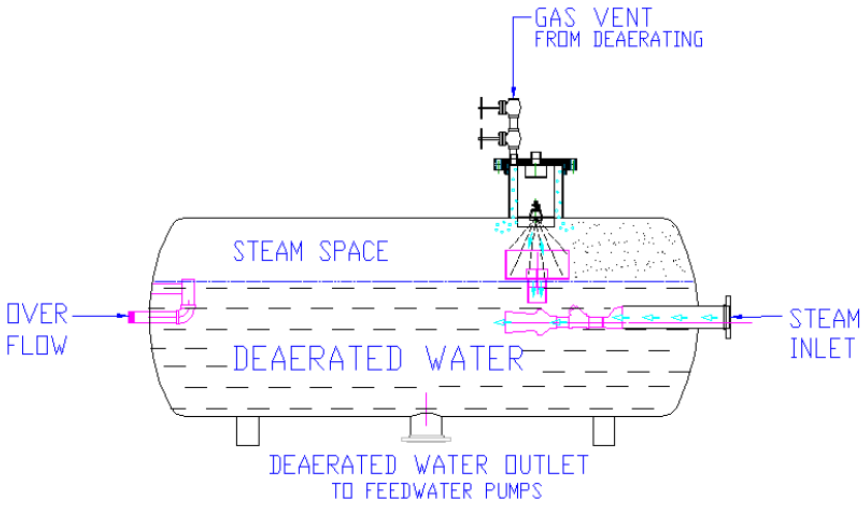
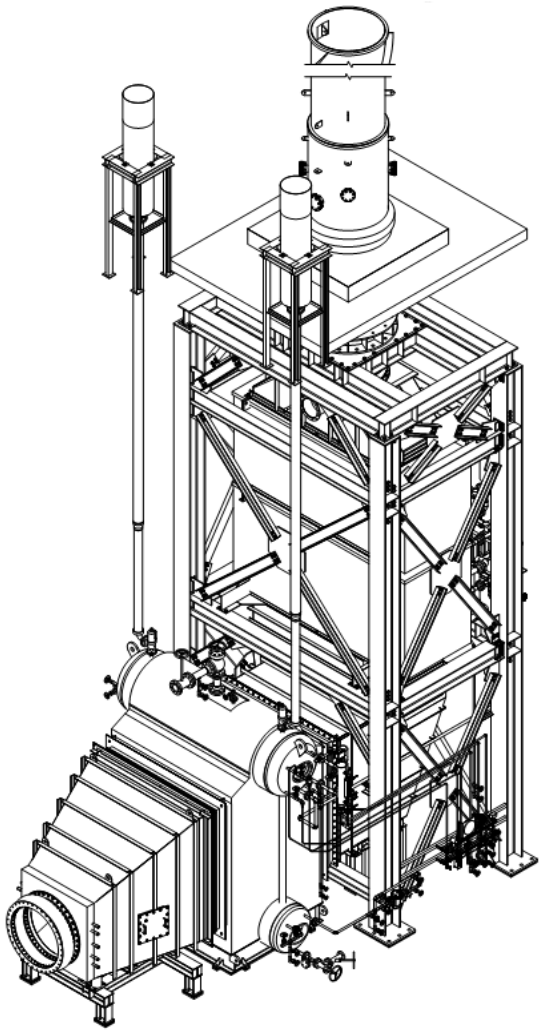
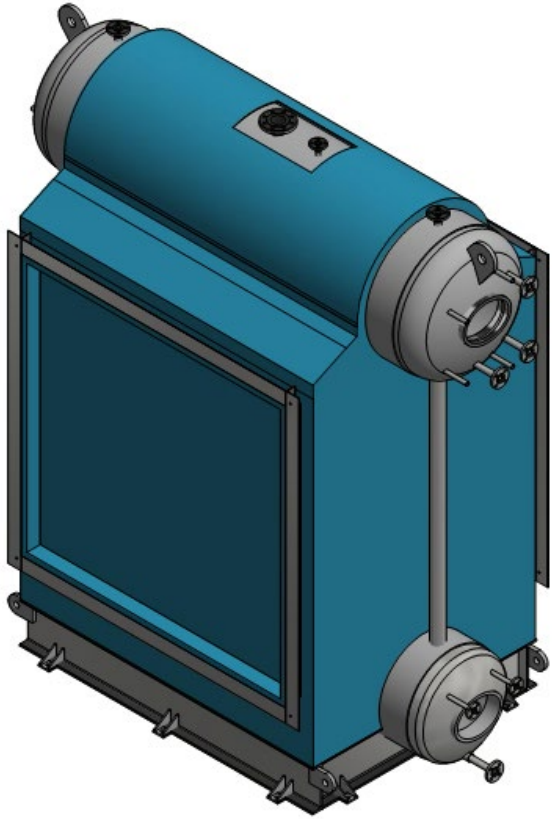


Fig.1C: Operating Principle - Typical Arrangement
Deaerator size 30 000 lb/hr or less (13 T/hr or less)

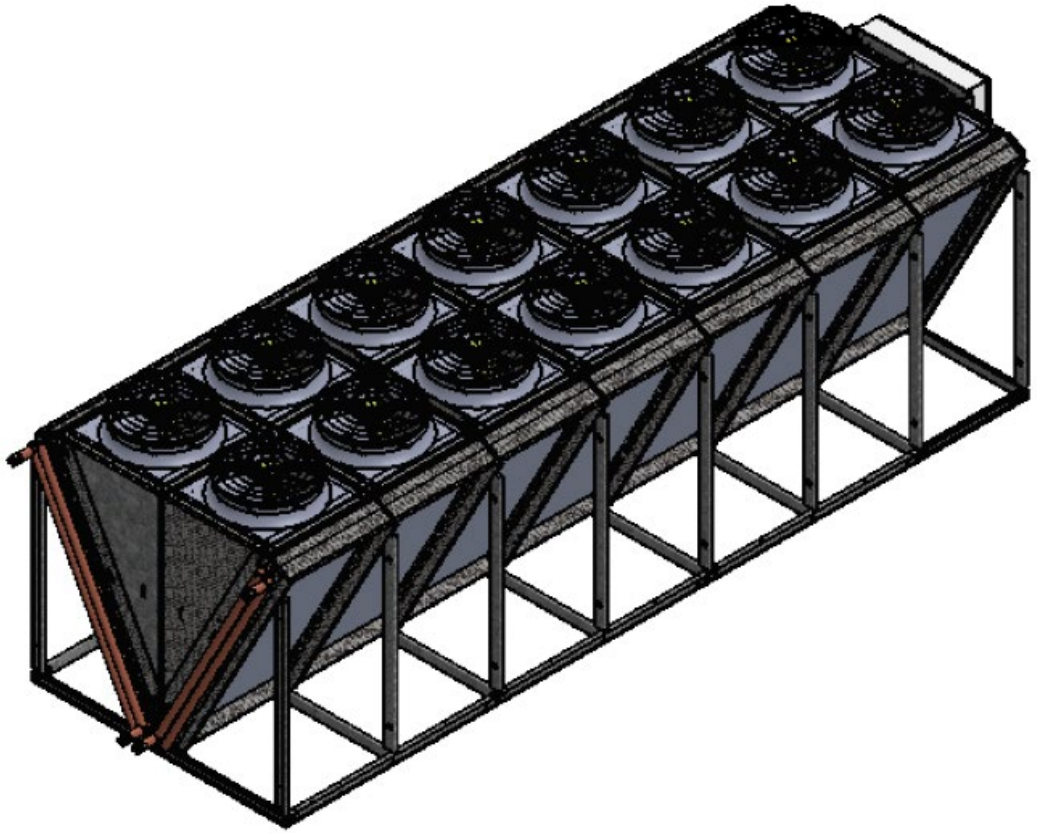
Steam system - HRSG



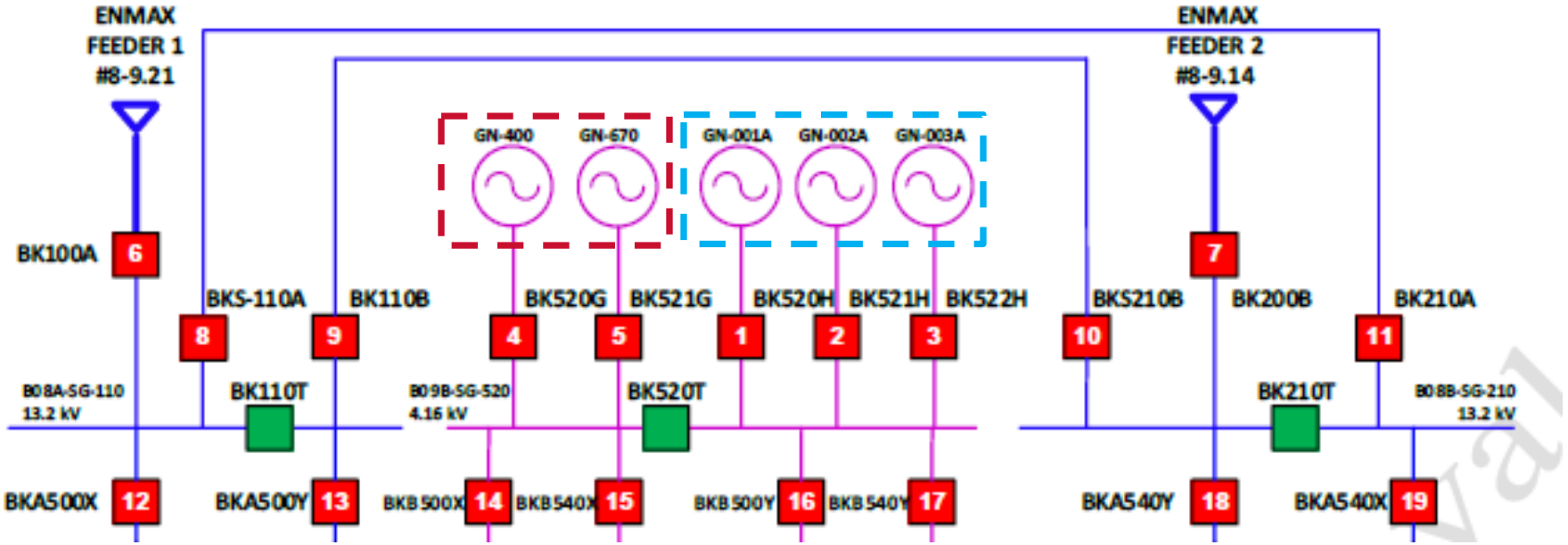


Steam system – steam surface condenser

Steam system – cooling



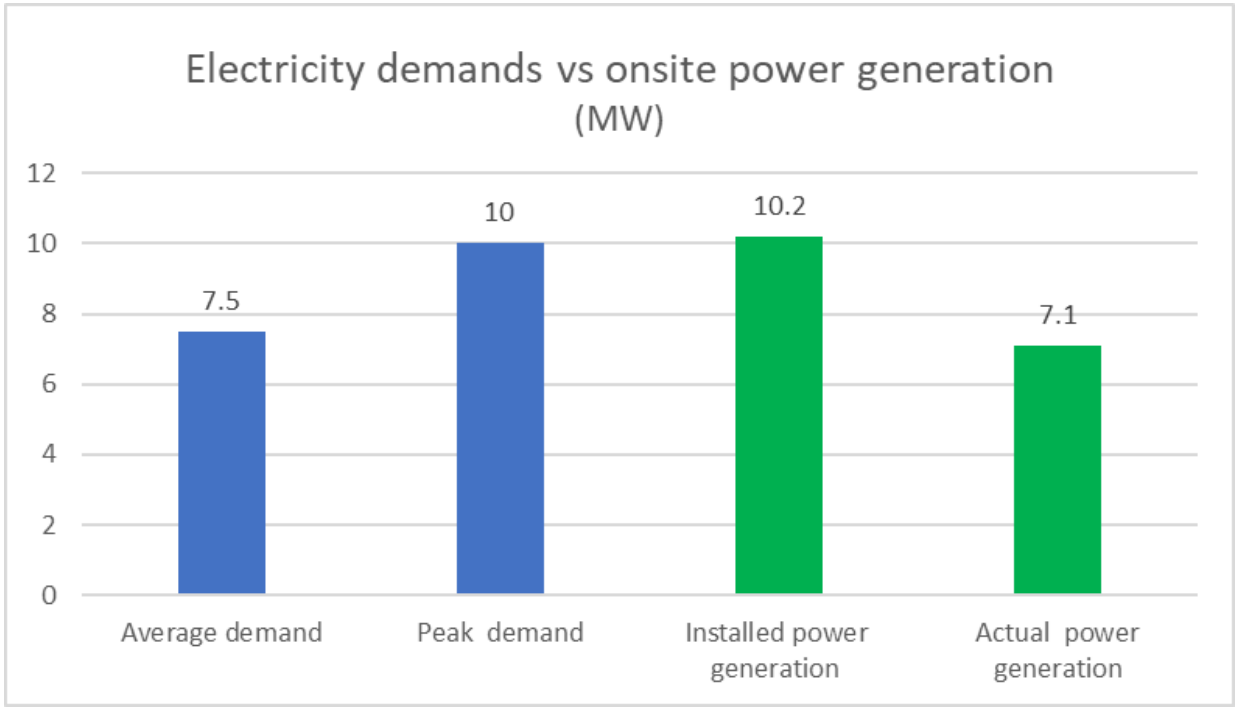
Plant electrical system



- CTG 4.5MW
- STG 0.5MW
- IC Engine 3 X 1.4M

Electricity demands vs onsite power generation (MW)

Average demand	7.5
Peak demand	10
Installed power generation	10.2
Actual power generation	7.1



Lessons learned

- Complications due to STG addition
  - Requiring high-quality feedwater
  - A complicated steam handling system
- Economizer addition to HRSG
  - Stack sulfur buildup
- Steep learning curves for O&M

Five contracts

- Consulting contract
- Three equipment pre-purchase contracts
  - CTG/HRSG
  - Standby Steam boiler
  - Siloxane removal
- Construction contract

Project Schedule

- Design completed in March 2019.
- Construction started in July 2019
- In-service from January 2023
- Substantial Completion in December 2024

Acknowledgement

- Andy Mah P.Eng , the co-author

Questions?