Staged Combustion System for NOx Control & Power Generation at the San Bernardino Water Reclamation Plant's 704 kWe Biogas Engine

[aka Hydrogen Assisted Lean Operation (HALO) and Staged Combustion with Partial Oxidation Gas Turbine]

Project Update

SCAQMD Biogas Technology Advisory Committee Meeting

October 29, 2014

John A. Claus

City of San Bernardino Municipal Water Department

Background

- **SBMWD operates a 33 MGD activated sludge secondary treatment facility and the Rapid Infiltration and Extraction (RIX) tertiary treatment facility**
- **SBMWD operates 6 Internal Combustion Engines (ICEs)s on digester gas:**
  - 2 225 HP driving pumps
  - 2 750 HP driving blowers
  - 2 999 HP driving generators
- **Not only generate electricity, or power equipment to offset our electrical demand, but we also recover heat from the 4 larger engines to heat our anaerobic digesters and further reduce overall energy demands**

Background

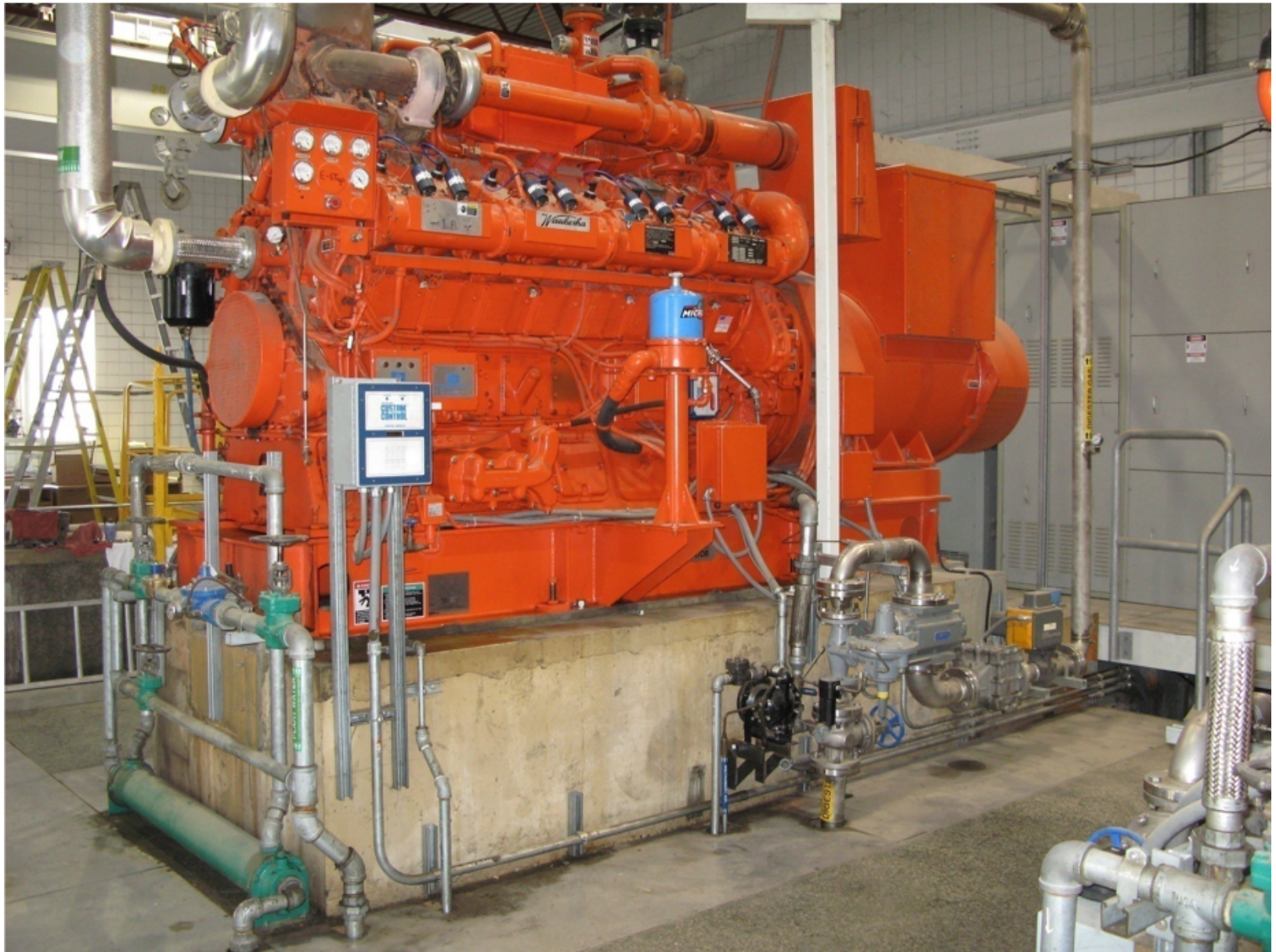
- **Obstacles (to catalytic systems & biogas treatment):**
  - estimated capital cost of >$6M
  - excessive engine exhaust back pressure
  - piping conflicts
  - excessive O&M costs
  - bankruptcy filing
- **Possible solution: HALO**
- http://www.casaweb.org/documents/2013/07-san_bernardino_mwd_-_claus.pdf

Fuel-Flexible, Hybrid CHP Project

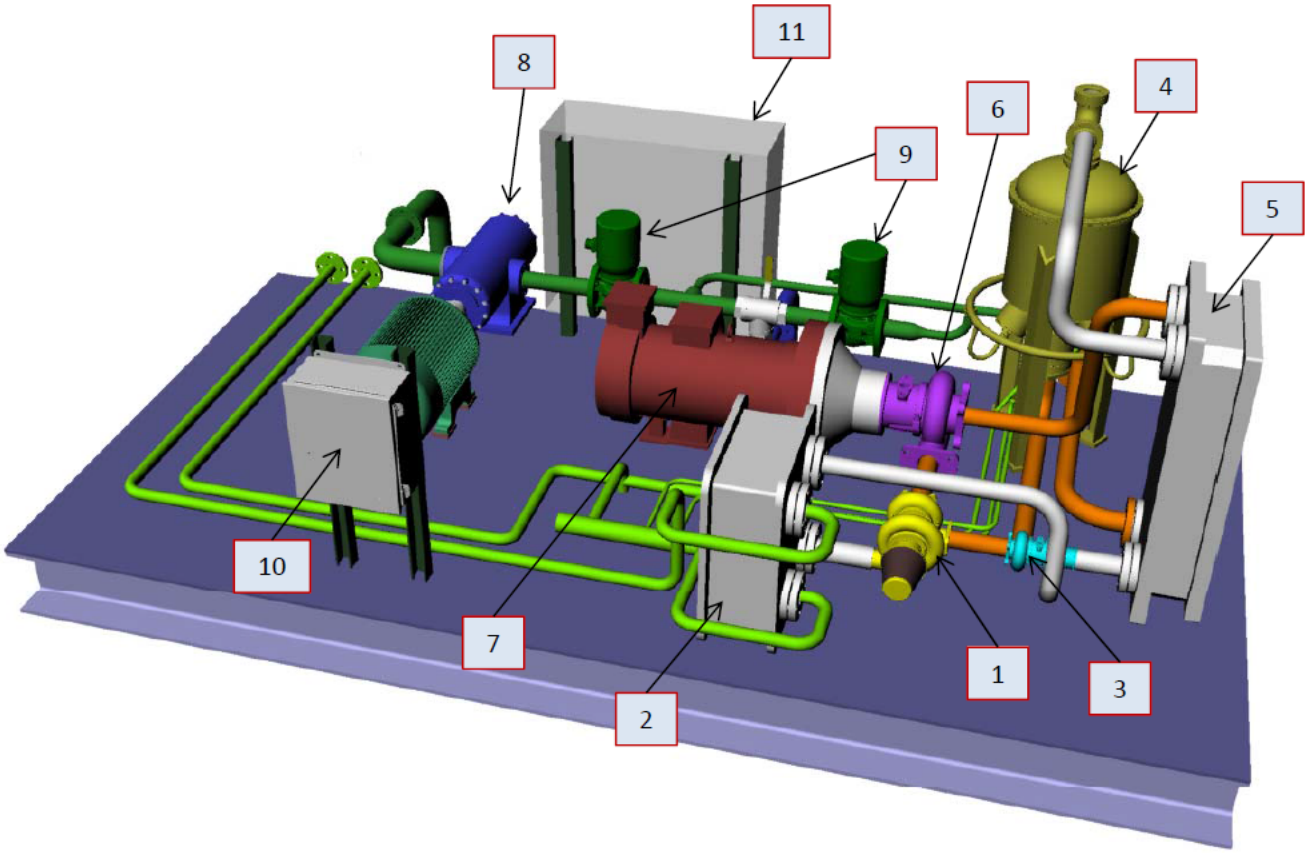
Staged Reheat Combustion System (SRCS) Based Upon POGT Integrated w/ICE

- **In general, the SRCS consists of three stages connected in series:**
  - 1st Stage: Substoichiometric combustion at flame temperature 1900-2100°F
  - 2nd Stage: Heat removal from fuel gas produced in stage 1 using an expander and a recuperator
  - 3rd Stage: Complete combustion at moderate flame temperature (with power generation in this application)
- **GTI developed and patented the concept of integrating a POGT with an ICE and is the prime contractor for the work that will be described in this presentation**
- **GTI has teamed with Alturdyne Power Systems (El Cajon, CA) to build a POGT for integration with the 704 kWe IC engine at SBWRP**
- **Vronay Engineering Services of La Jolla, CA is responsible for design, installation and integration of the POGT with the engine**
- **The project is being funded by CEC, Southern California Gas, SCAQMD, and San Bernardino Municipal Water Department.**

Existing Equipment – Generator-Drive Engines



Project Models – POGT Skid

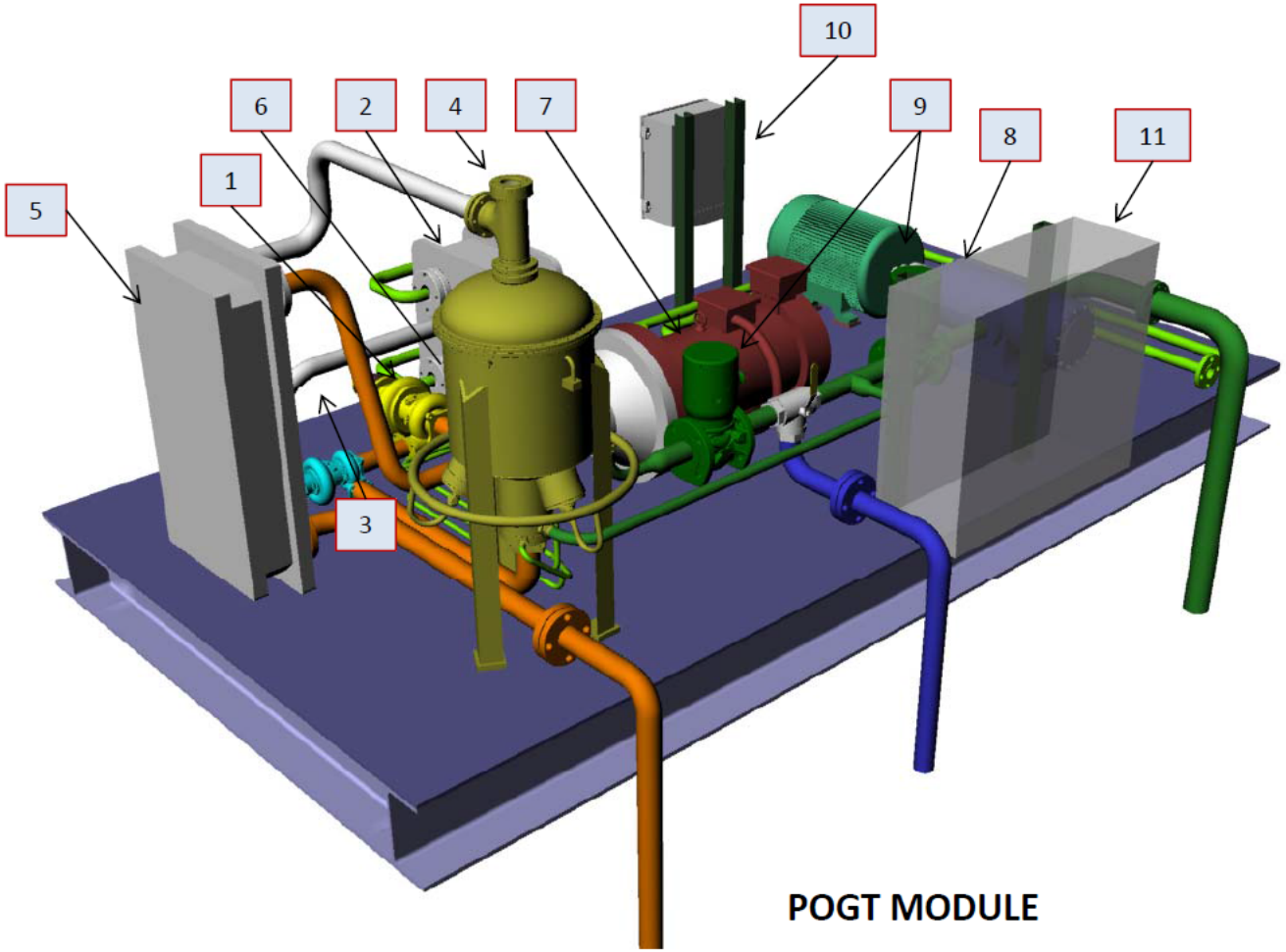


1. IP Turbocharger
2. Turbo Intercooler
3. HP Turbocharger
4. POR
5. Air Recuperator
6. LP Turbocharger
7. Generator (100kW)
8. Gas Compressor
9. Gas Valves (ECV-5)
10. ECV-5 Controls
11. Control Panel

Cooling Water
Mixed Gas
Natural Gas
H2 Enriched Gas

PARTIAL OXIDATION GAS TURBINE (POGT) MODULE

Project Models – POGT Skid

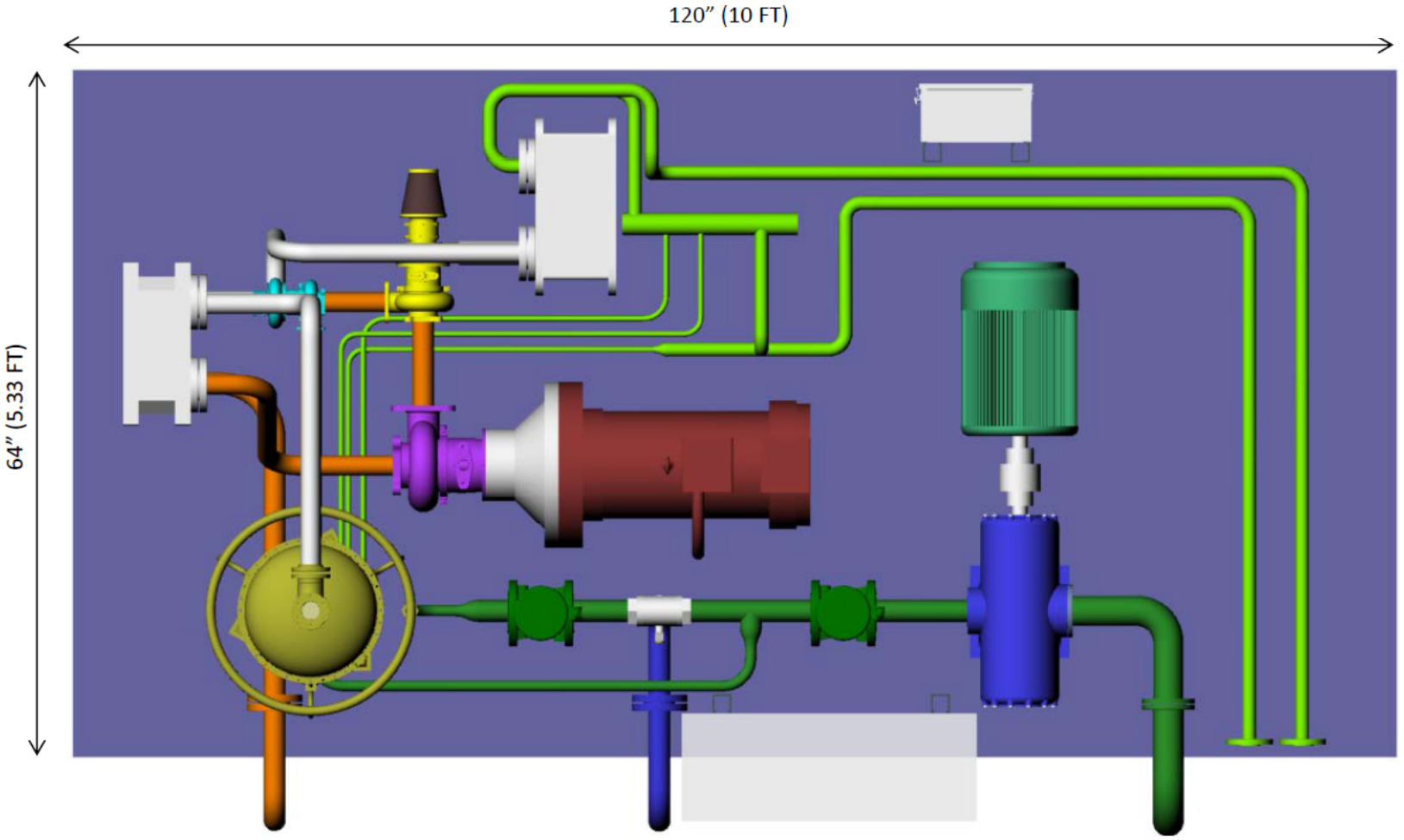


POGT MODULE

1. IP Turbocharger
2. Turbo Intercooler
3. HP Turbocharger
4. POR
5. Air Recuperator
6. LP Turbocharger
7. Generator (100kW)
8. Gas Compressor
9. Gas Valves (ECV-5)
10. ECV-5 Controls
11. Control Panel

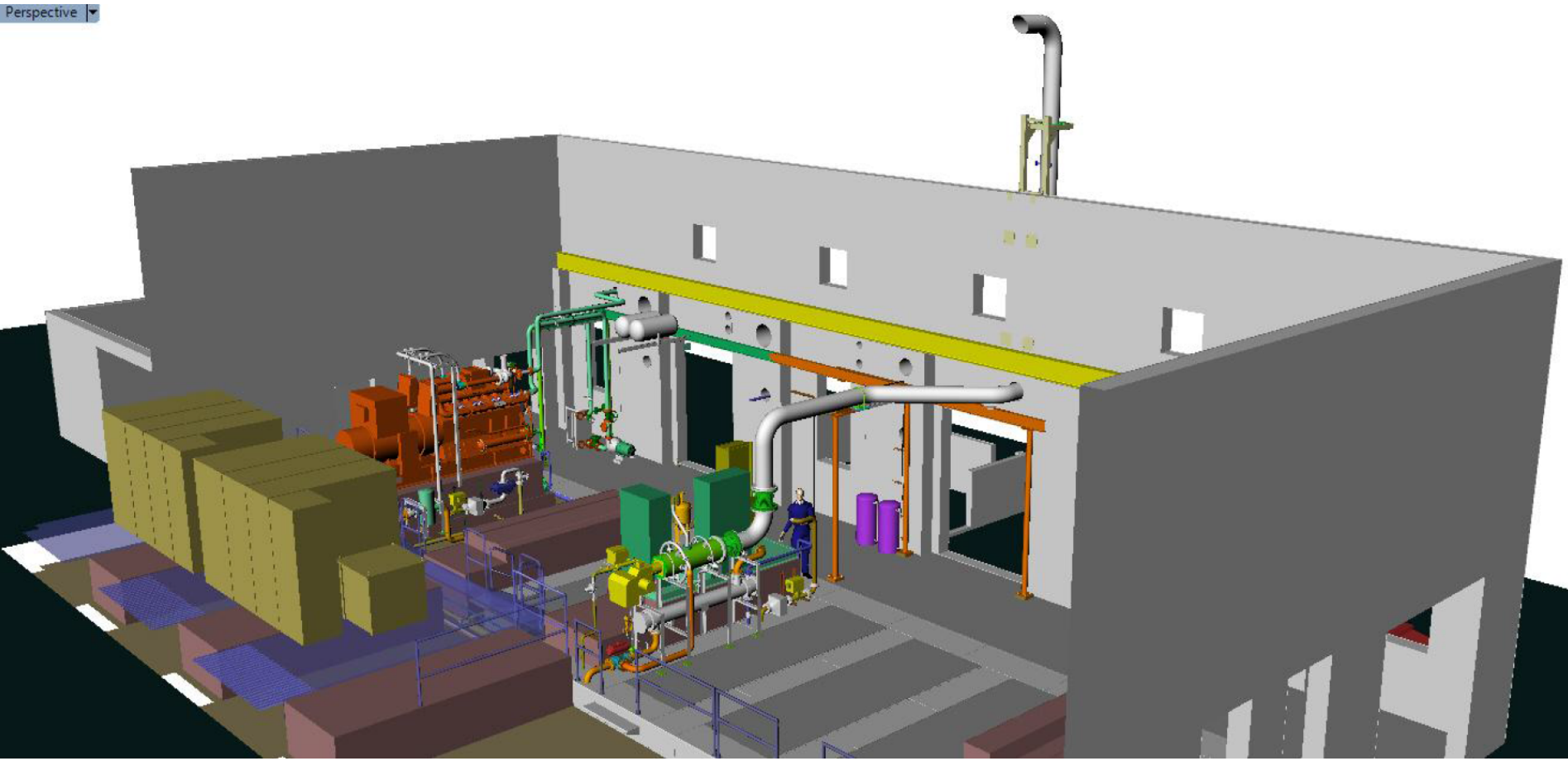
Cooling Water
Mixed Gas
Natural Gas
H2 Enriched Gas

Project Models – POGT Skid

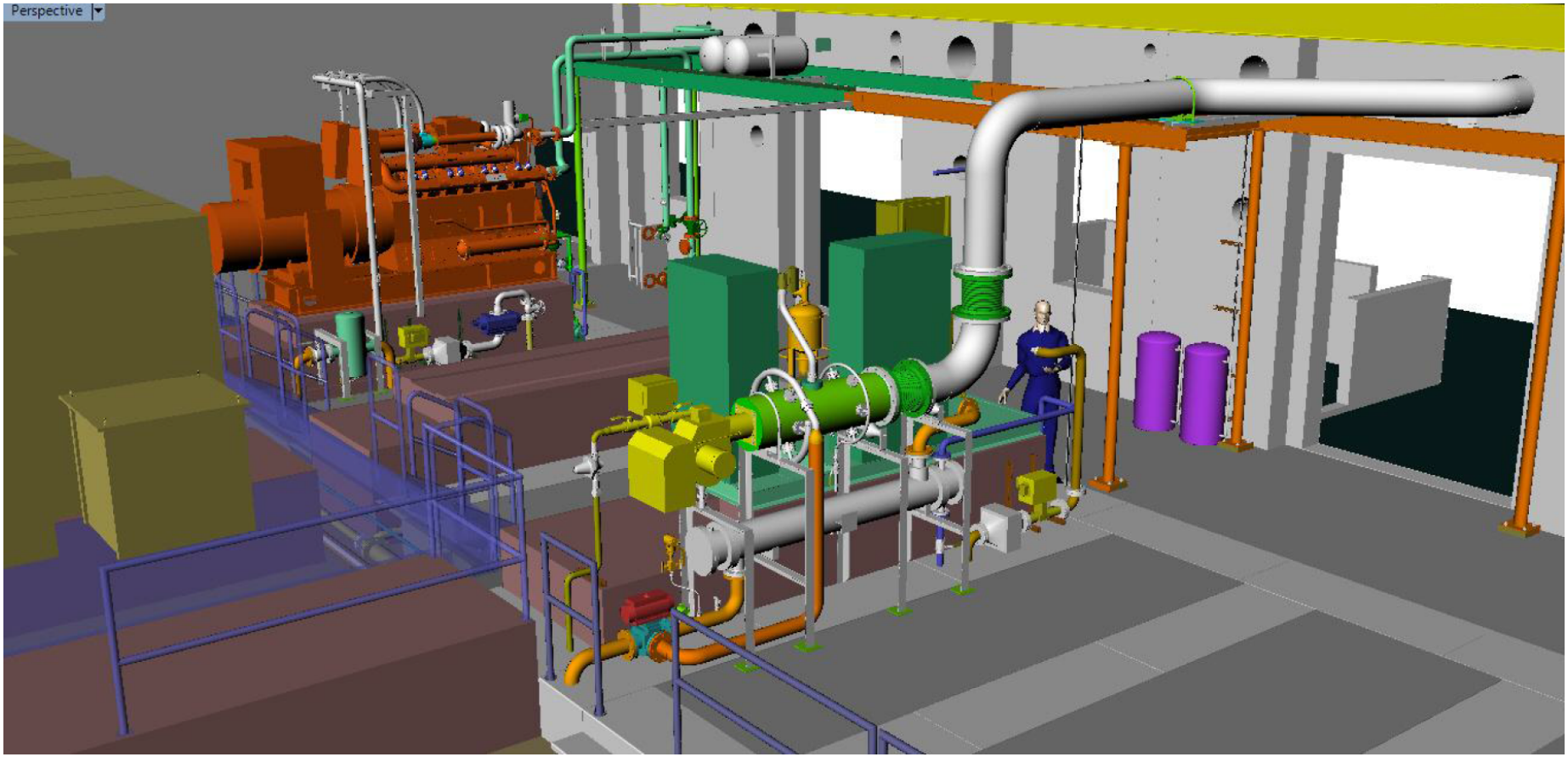


POGT MODULE

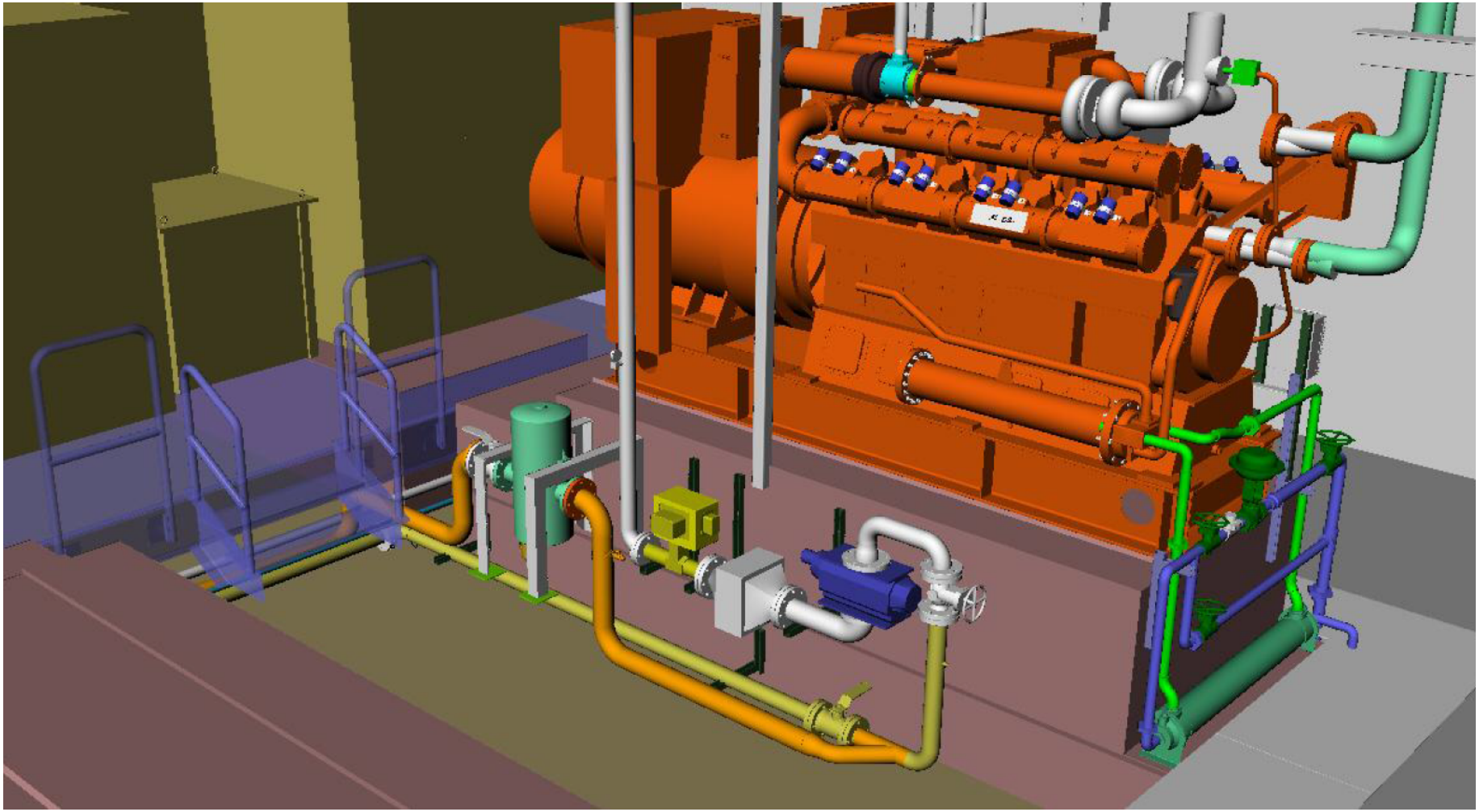
Project Models



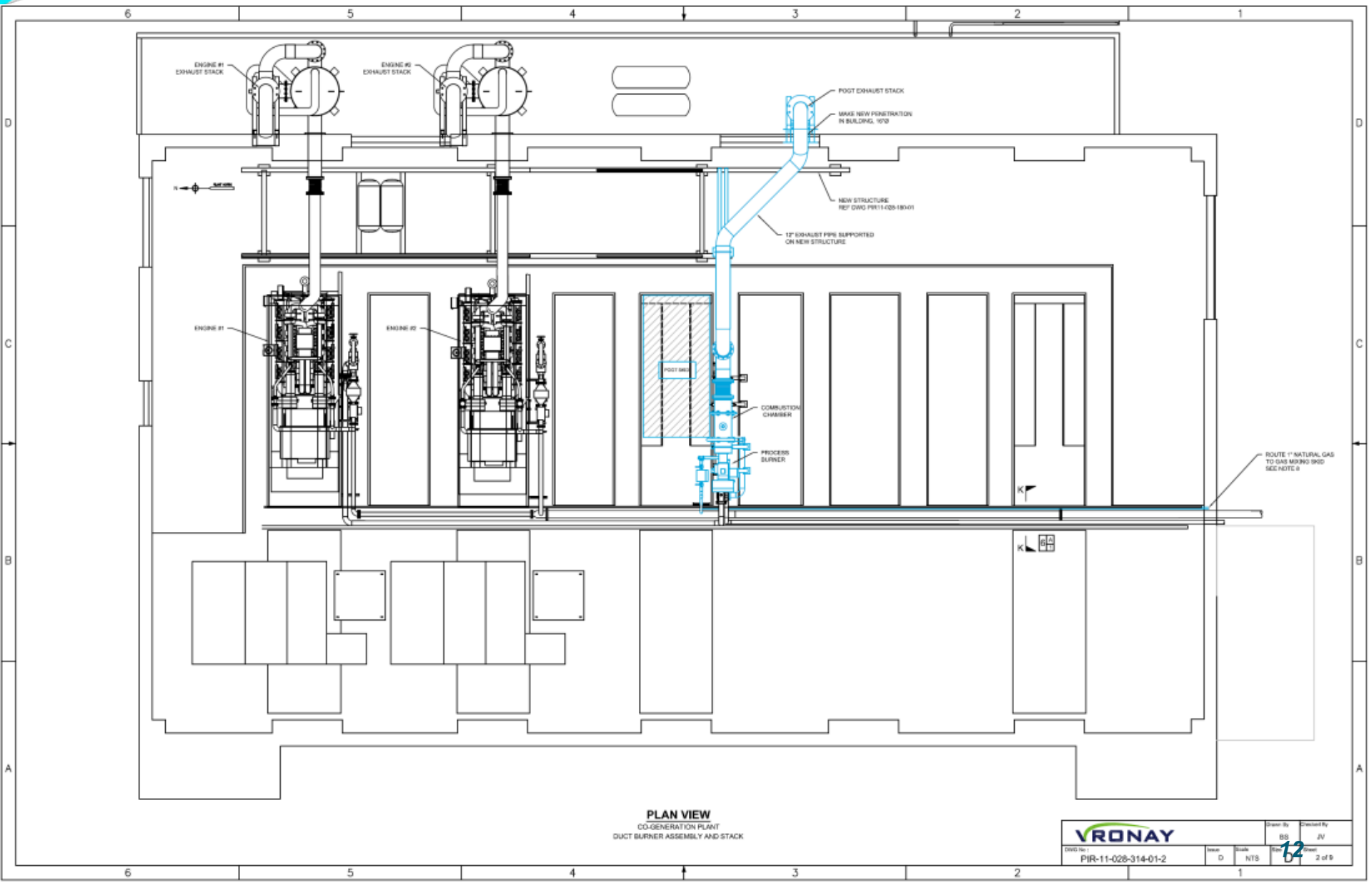
Project Models



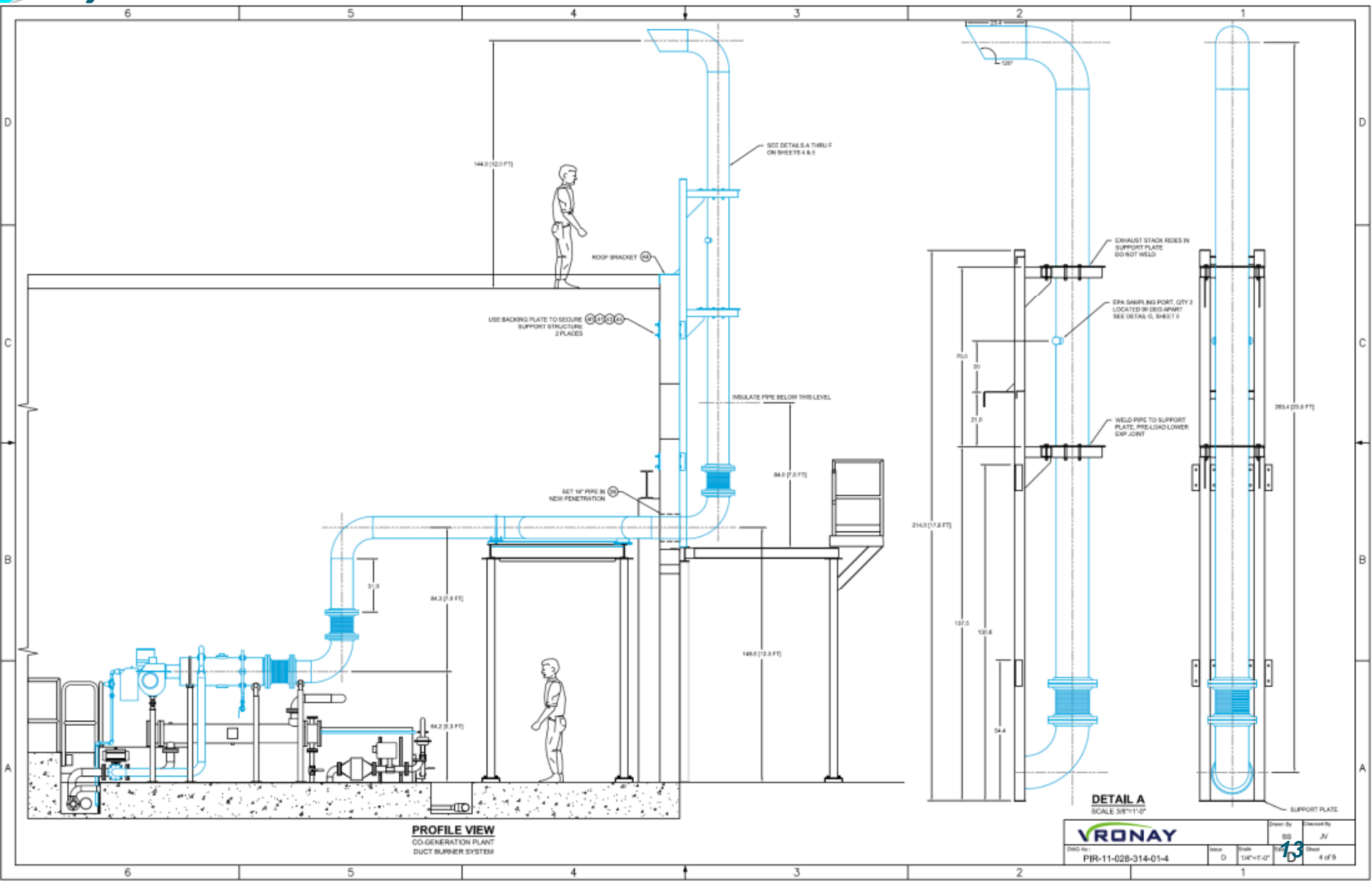
Project Models



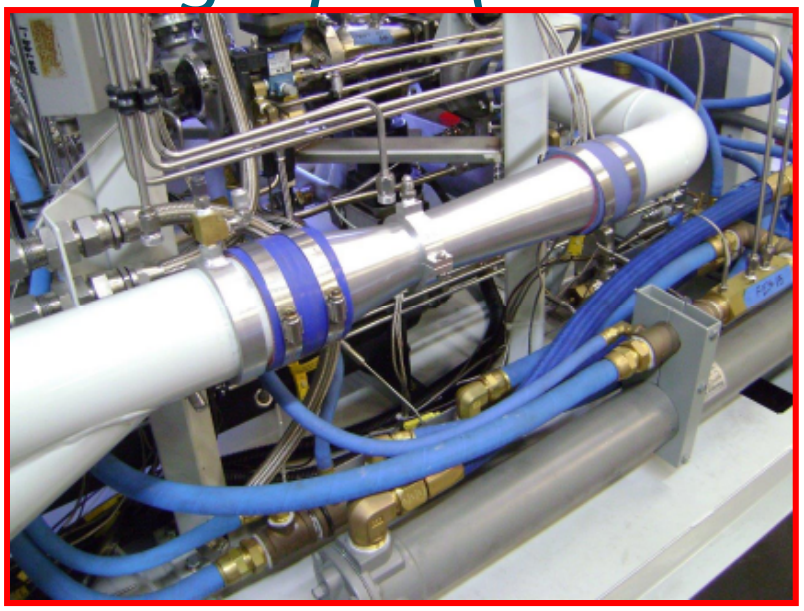
Layout – Plan View

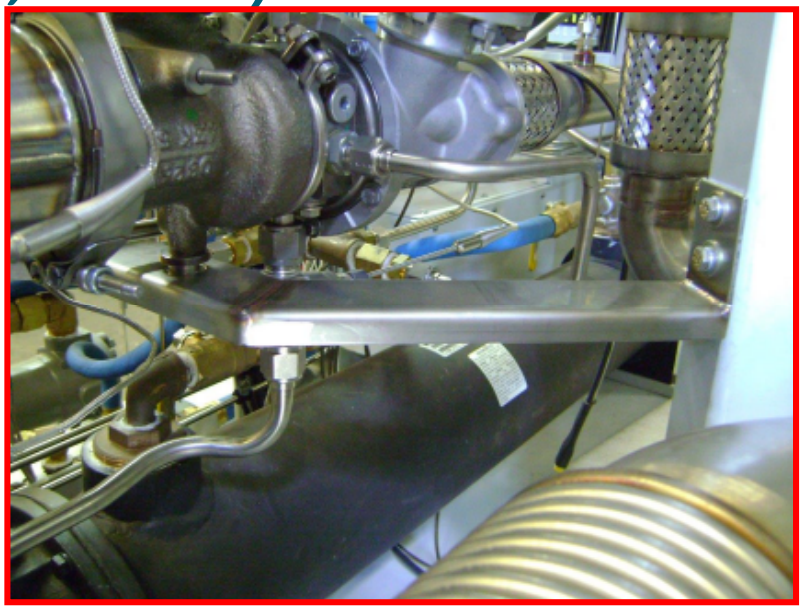


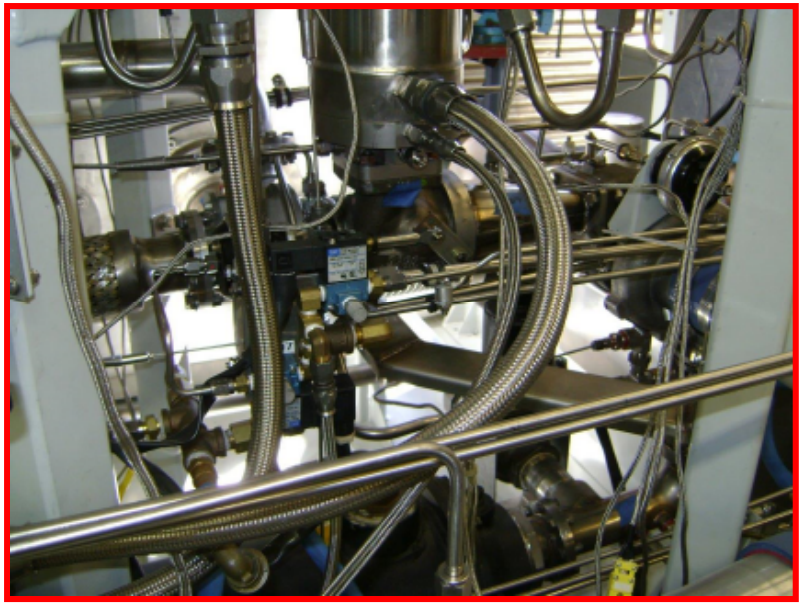
Layout – Profile View

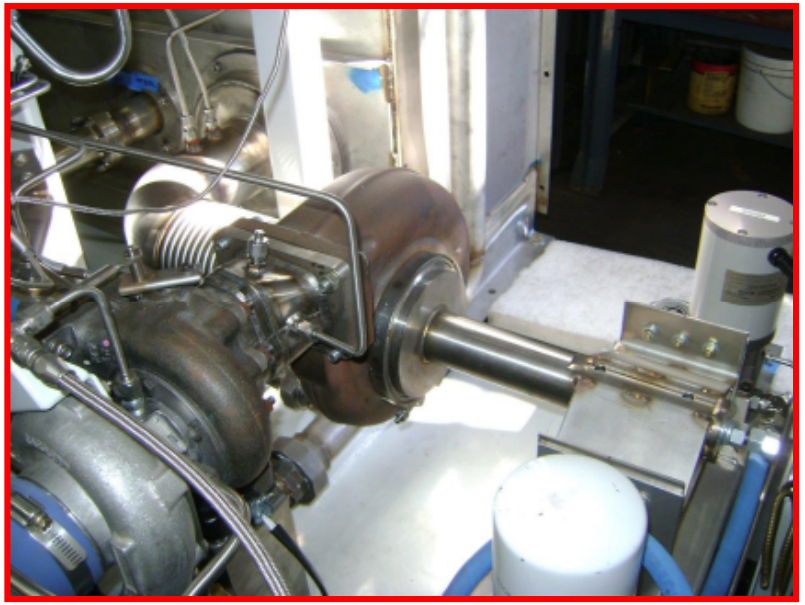


Photographs (October 9, 2014)









Photographs (October 9, 2014)

Project Status

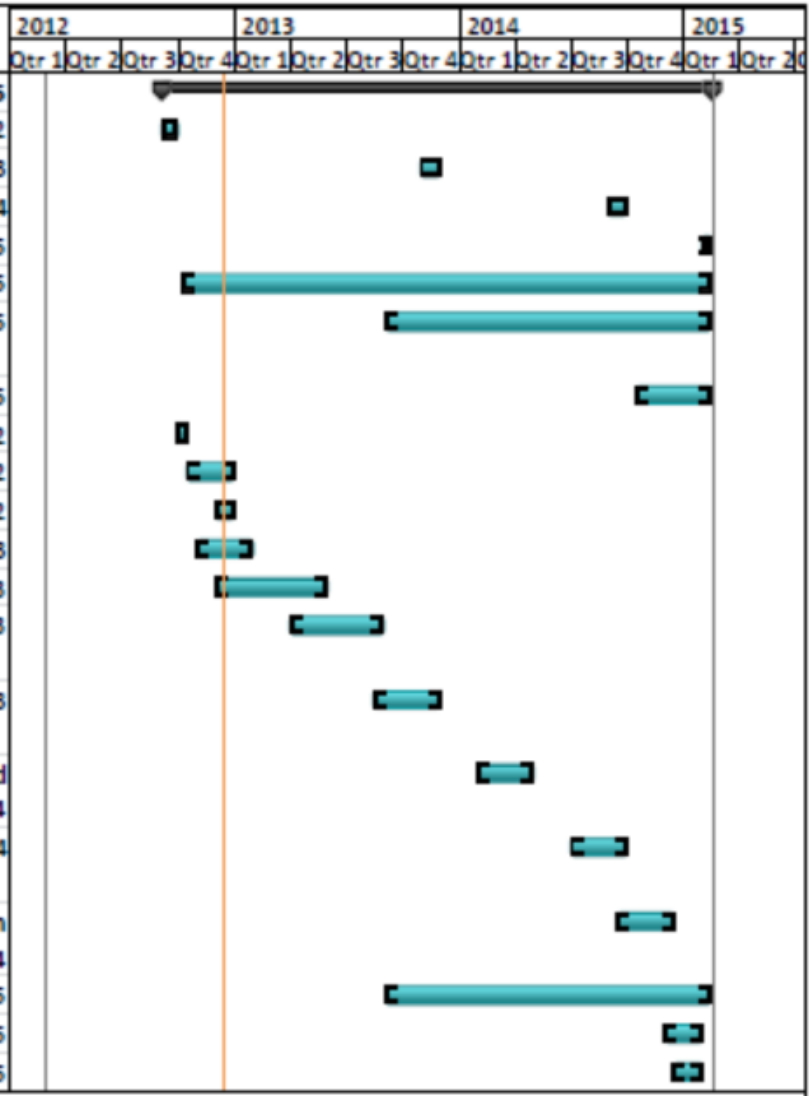
- Amended contracts (additional funding required)
- Completed system upgrades to maximize existing system operability during test phase
- GTI submitted the draft test plan for short-term testing of the ICE-POGT for CHP at SBWRP to SCAQMD, SoCal Gas, & CEC in August, 2014
- Permit to Construct/Operate Experimental Research Operations (Permit No. G33083) issued October 7, 2014
- Mechanical/Electrical contractor is preparing for installation of POGT system at SBWRP
- Alturdyne Power Systems (APS) continues efforts to complete fabrication of the POR.
- APS continues fabrication of the POGT skid; however, POR is a critical item that must be completed to complete the POGT skid fabrication.
- Expect to witness POGT skid validation testing November 19 – 21, 2014

Project Status

- Upon completion of validation testing, skid to immediately ship to GTI for additional testing in partial oxidation configuration (estimated duration of 1 month)
- Anticipate installation of POGT system at SBWRP in January 2015
- Finalize test plan for short term performance evaluation of POGT integrated with ICE at SBWRP
- Secure contract extensions

Fuel-Flexible, Hybrid CHP Project

ID	Text1	Task Name	Start	Finish
1	01	**Administrative**	Wed 9/5/12	Sun 2/15/15
2	01.1	Attend Kick Off meeting	Wed 9/5/12	Sun 9/30/12
3	01.2	CPR Meeting 1	Wed 10/30/13	Sat 11/30/13
4	01.2	CPR Meeting 2	Sat 8/30/14	Tue 9/30/14
5	01.3	Final Meeting	Fri 1/30/15	Sun 2/15/15
6	01.4	Monthly Progress Reports	Wed 10/10/12	Sun 2/15/15
7	01.5	Test Plans, Technical Reports &Interim Deliverables	Tue 9/3/13	Fri 2/13/15
8	01.6	Final Report	Wed 10/15/14	Sun 2/15/15
9	01.7	Identify and Obtain Match Funds	Sun 9/30/12	Mon 10/15/12
10	01.8	Identify and Obtain Required Permits	Mon 10/15/12	Sun 12/30/12
11	01.9	Electronic File Format	Sat 12/1/12	Sun 12/30/12
12	02	Development of Hybrid CHP detailed process diagram	Thu 11/1/12	Wed 1/30/13
13	03	Engineering design, fabrication and testing of POR	Sat 12/1/12	Thu 5/30/13
14	04	Conceptual design, modeling, performance evaluation of POGT	Mon 4/1/13	Fri 8/30/13
15	05	Engineering design, construction, installation and testing of POGT at GTI	Thu 8/15/13	Sat 11/30/13
16	06	Design, installation and integration of POGT-ICE at SB WRP	Sat 2/1/14	Wed 4/30/14
17	07	Performance testing of CHP ICE-POGT unit at SB WRP firing biogas and blended NG	Tue 7/1/14	Tue 9/30/14
18	08	Long-term testing and performance verification of Hybrid ICE-POGT unit at SB WRP	Mon 9/15/14	Mon 12/15/14
19	09	Data processing and analyses	Tue 9/3/13	Fri 2/13/15
20	10	Technology Transfer Activities	Mon 12/1/14	Fri 1/30/15
21	11	Production Readiness Plan	Mon 12/15/14	Fri 1/30/15



Project Status

Description	Start Date		Due Date		Status
	Planned	Actual	Planned	Actual	(% complete)
(Task 2) Report on Development of a Hybrid CHP Detailed Process Diagram and Identification of Performance Specifications for Major Subsystems for the SBWRP	10/1/2012		11/30/2012	11/30/2012	100%
(Task 3) Report on Engineering Design, Fabrication and Testing of a POR	8/1/2012	8/13/2012	11/30/2014		>90%
(Task 4) Report on Conceptual Design, Modeling and Performance Evaluation-Hybrid ICE-POGT	4/1/2013	9/1/2012	1/31/2014	2/7/2014	100%
Report for Critical Project Review 1	7/1/2013		1/20/2015		40%
(Task 5) Report on Engineering Design, Construction, Installation and Performance Testing of POGT-TC	4/1/2013		1/12/2015		50%
(Task 6) Report on Design, Installaiton, and Integration of POGT-ICE at SBVWRP	12/1/2013		2/27/2015		%
(Task 7) Report on Performance Testing of ICE-POGT for CHP at SBWRP	6/1/2014		3/31/2015		%
(Task 8) Report on Long-Term Testing and Performance Verification of the Hybrid ICE-POGT System at SBWRP	8/30/2014		6/30/2015		%
(Task 9) Report on Data Processing and Analyses	6/1/2014	1/15/2013	6/30/2015		%
(Task 10) Technology Transfer Plan	11/15/2014		8/31/2015		%
(Task 11) Production Readiness Plan	11/15/2014		8/31/2015		%
(Task 1.6) Final Report					
Draft	10/15/2014		9/30/2015		%
Final Approved	12/15/2014		9/30/2015		%

Summary

- SBWRP is evaluating the potential for using HALO to comply with new emission limits by integrating a POGT with our IC engine.
- We will soon be able to test the POGT to confirm that it is producing the hydrogen rich fuel gas (from digester gas) that will support HALO with our engine.
- By staging combustion, the POGT integrated with the IC engine is capable of producing additional power while maintaining total emissions below the limits required by Rule 1110.2
- Field results are expected by Feb 2015

John A. Claus
Director of Water Reclamation

John.Claus@sbmwd.org
Office (909) 384-5502
Cell (909) 770-2910
Fax (909) 384-5258