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Renewable Natural Gas (RNG) Design Standard

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Renewable Natural Gas (RNG) Design Standard

October, 2019

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Agenda

Focused Strategy

RNG Sources

Design Guideline for RNG Facilities

Focused strategy

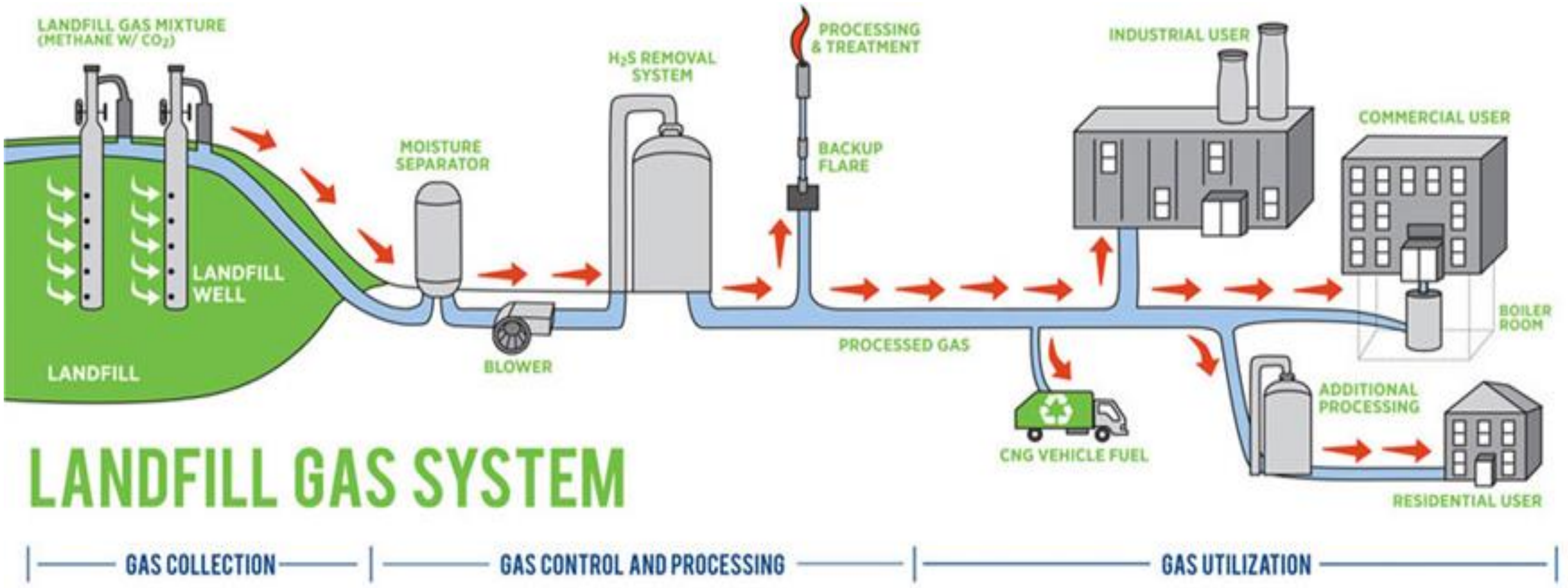
Company strategic priority

- Extend natural gas transmission and distribution to renewable gas opportunities.

RNG design guideline objectives

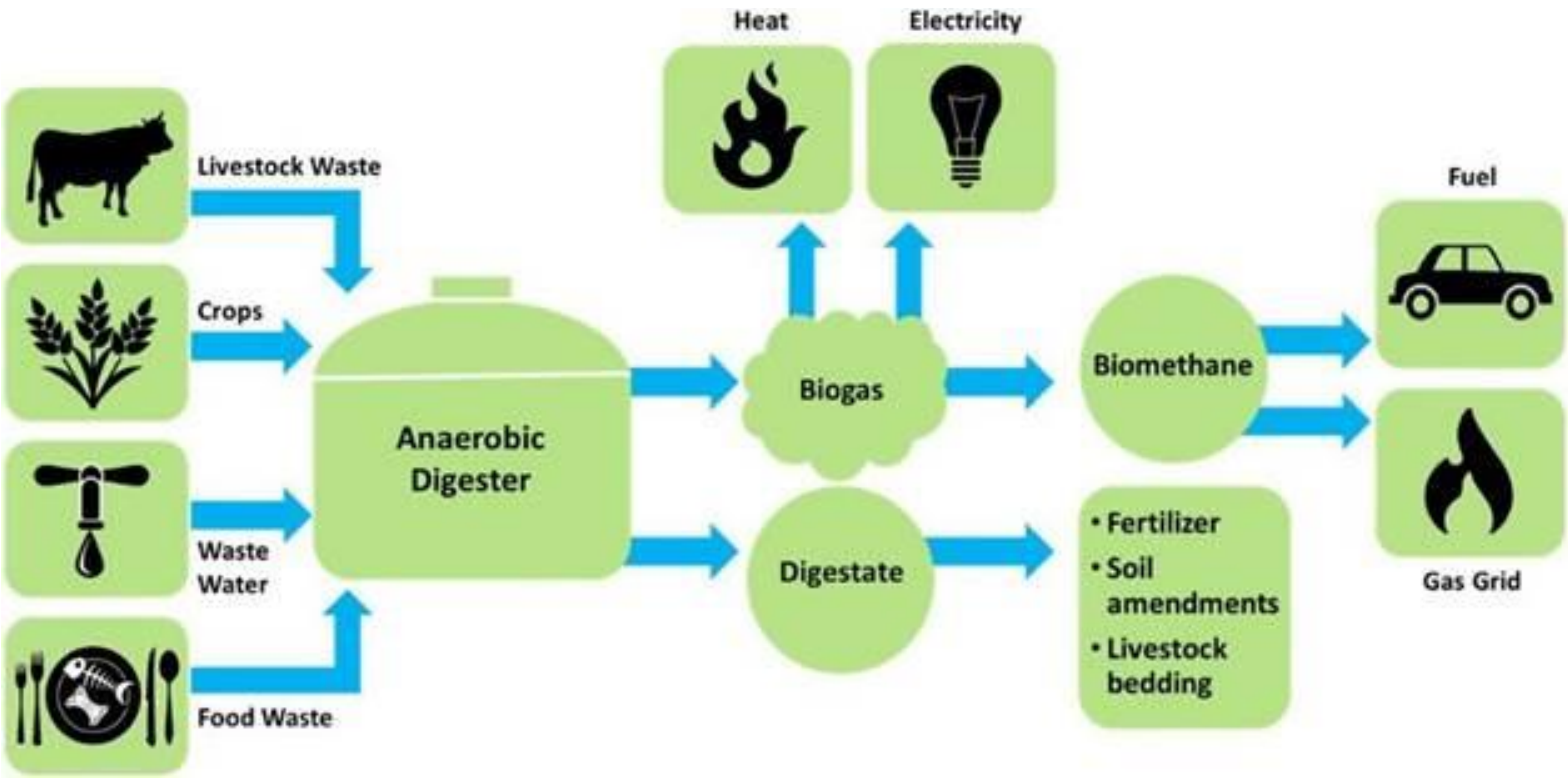
- Deliver a safe, reliable, feasible and cost effective renewable natural gas station design guideline that considers relevant risk tolerance factors and applicable codes and standards.
- The guideline sets principles for network design, gas quality, injection station design, as well as purification and compression package selection.

Renewable natural gas sources
Landfill



Renewable natural gas sources

Anaerobic digestion



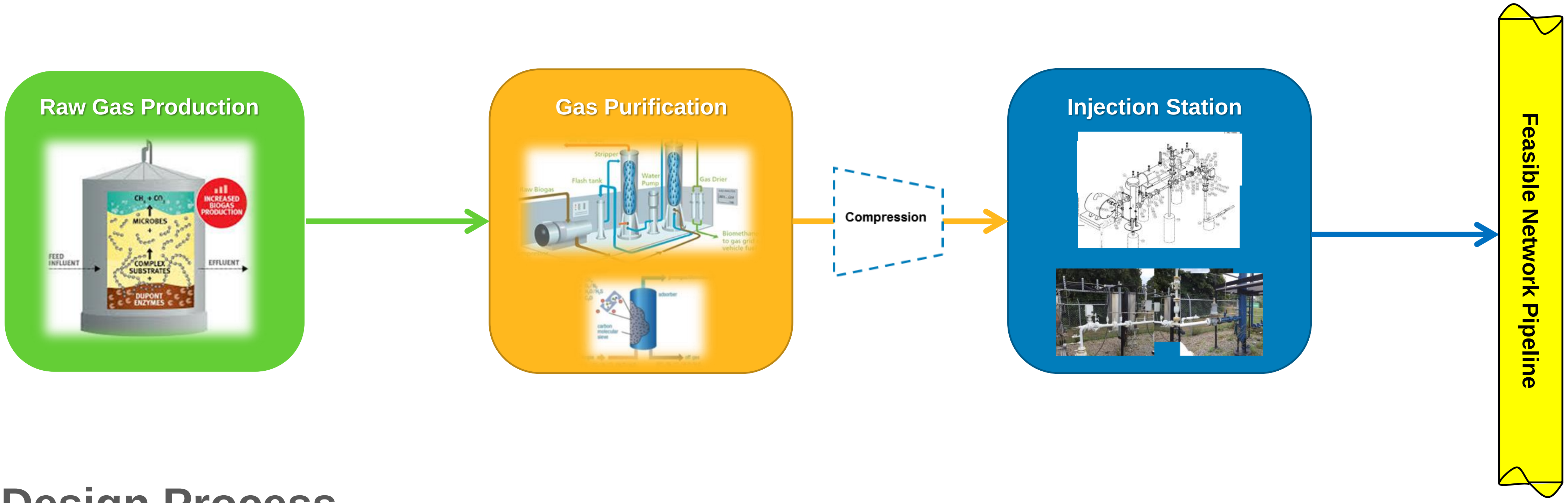
Biogas and landfill gas vs. natural gas

Component	Biogas Range (%)	Landfill Gas Range	Natural Gas Range
Methane	50-75	40-60	87.0 - 97.0
Nitrogen	0-10	2-5	0.2 - 5.5
Carbon Dioxide	25-50	40-60	0.05 - 1.0
Oxygen	0-1	0-1	trace - 0.1
Hydrogen	0-1	0-1	trace - 0.02
Hydrogen Sulphide	0-3*	0-2	0.57 - 0.62

**High hydrogen sulphide levels typically result from upset conditions*

RNG is purified biogas/landfill gas that meets pipeline gas injection specifications

Renewable natural gas process flow



Design Process

- Gas Network Evaluation
- Purification Technology Selection & Design
- Compression Sizing and Design
- Injection Station Sizing and Design
- Determine Gas Quality Measurement

Gas Network Analysis Evaluation

Gas distribution network design

- Each project must include a determination of market availability
  - Using the lowest flow condition (non-peak hour).

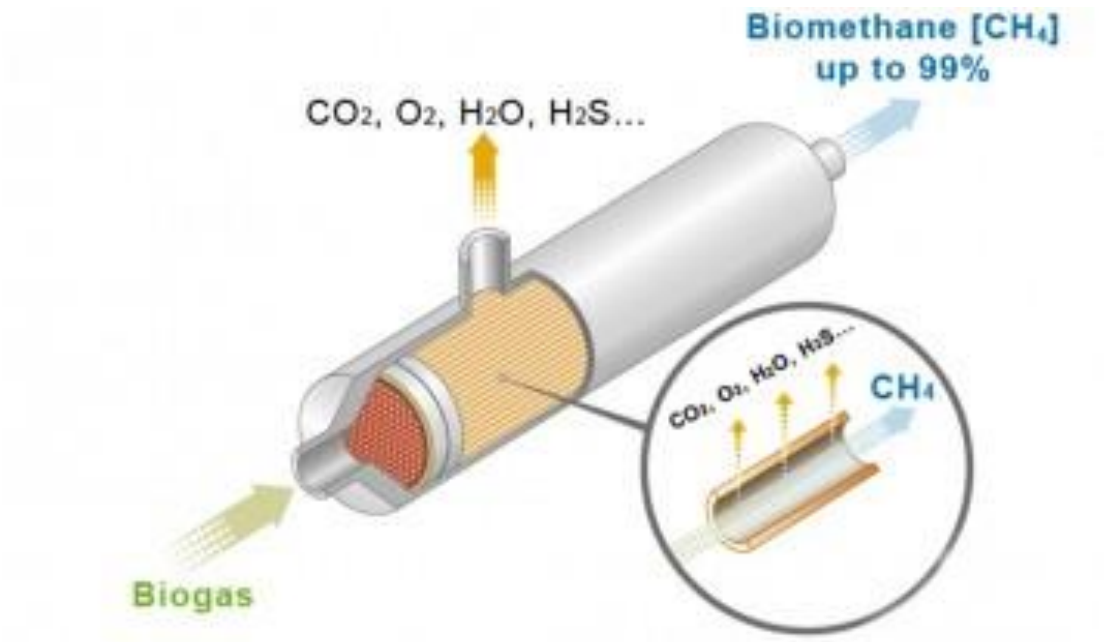
- Each project must include documentation of system specific risks and overall confidence on ability to accept RNG.

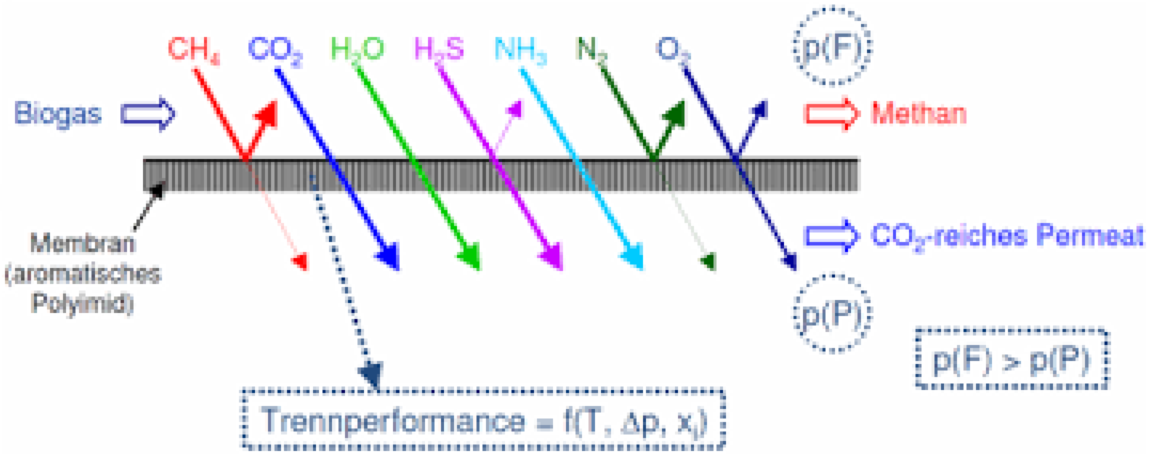
- For the protection of downstream reliability, no system shall be designed in a manner that the loss of RNG supply would result in the loss of ability to continually feed customers in the affected system.

- Manipulation of the natural gas system is acceptable to allow the injection of RNG:
  - Consider automated controls for frequent adjustments.
  - No MOP (Maximum Operating Pressure) downgrades allowed.

Purification Package Selection Criteria

Purification
Membrane



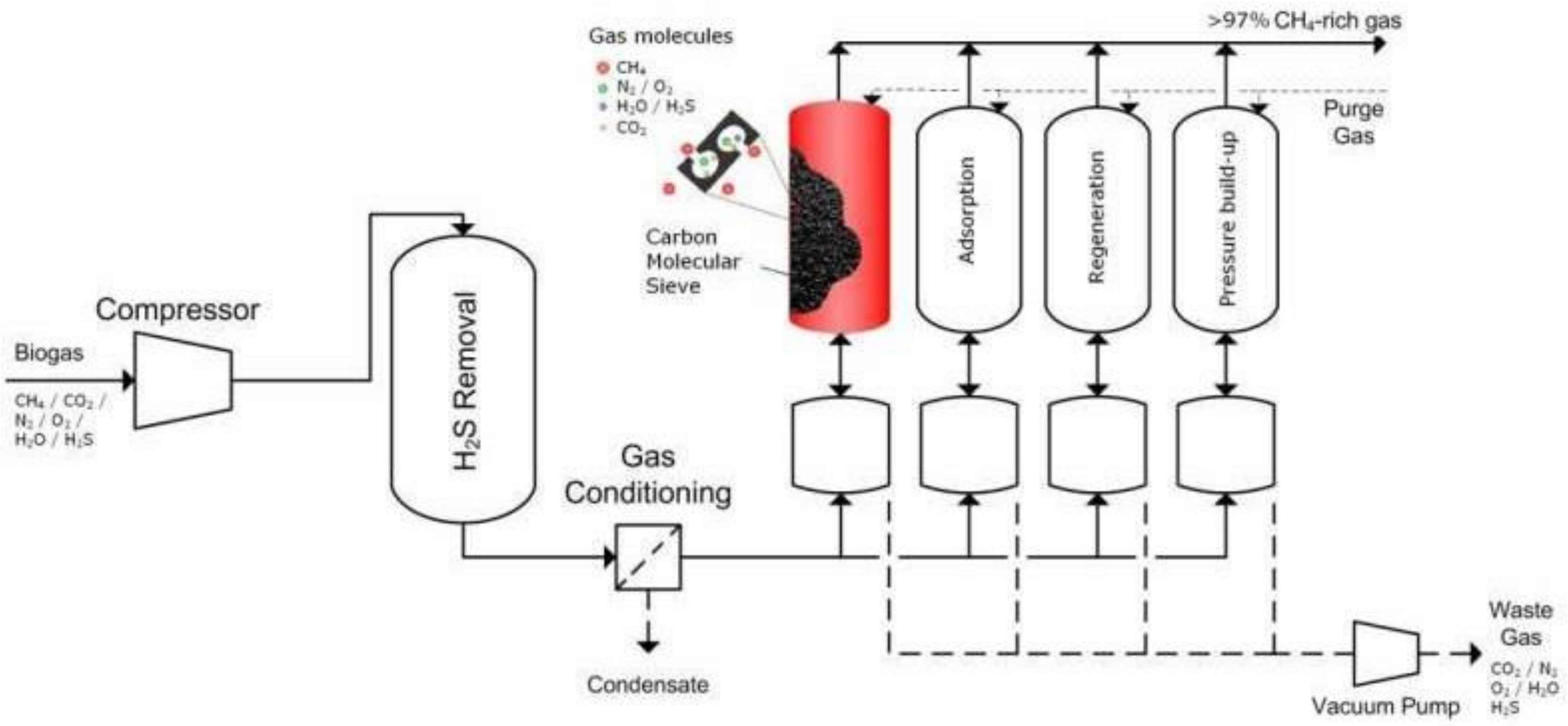


Air Liquid Advance Business & Technologies, Biogas Clean Energy Solutions, 2018, Natural Energy Solutions, p.3

Comparative Assessment of Technology Options for Biogas Clean-up, California Biogas Collaborative, University of California, Davis, 2014

Purification

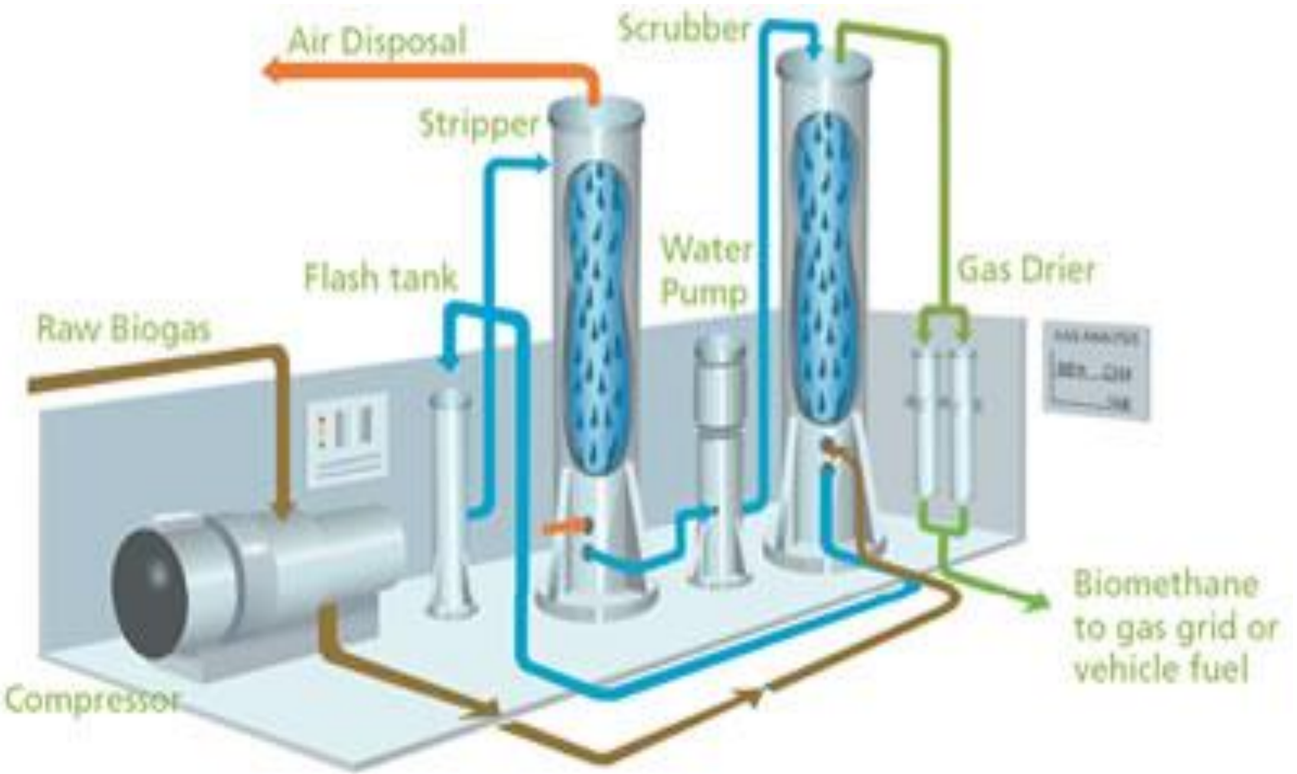
Pressure swing absorption



Purification Technologies for Biogas Generated by Anaerobic Digestion, CSANR Research Report 2010-001 Climate Friendly Farming

Purification

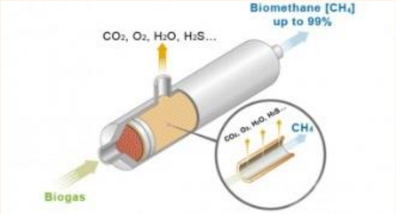
Water wash

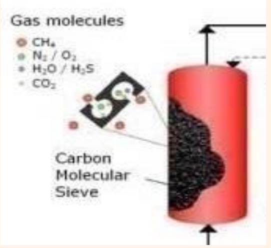


https://www.americanbiogascouncil.org/biogasProcessing/waterWash.html

Purification comparison summary

	MEMBRANE	PRESSURE SWING ADSORPTION	WATER WASH
Operation	Remove H2S and moisture CH4 pushed through membrane	Remove H2S and moisture Compressed within adsorption medium CH4 released	Bio-gas through scrubbing tower CH4 to dryer Contaminants removed in stripping tower
Advantages	Easy to use Simple maintenance Solid filter	Easy to use Simple maintenance	Chemical free Process rate can quickly be increased (decreases recovery rate)
Disadvantages	Membrane swaps Recovery 96% Does not remove oxygen, nitrogen or H2S efficiently Filtration based on molecule size	Medium needs to be swapped Waste may need to be treated Energy losses in swing Medium can become hazardous if wet	Waste water treatment does not remove oxygen or nitrogen





Purification comparison summary

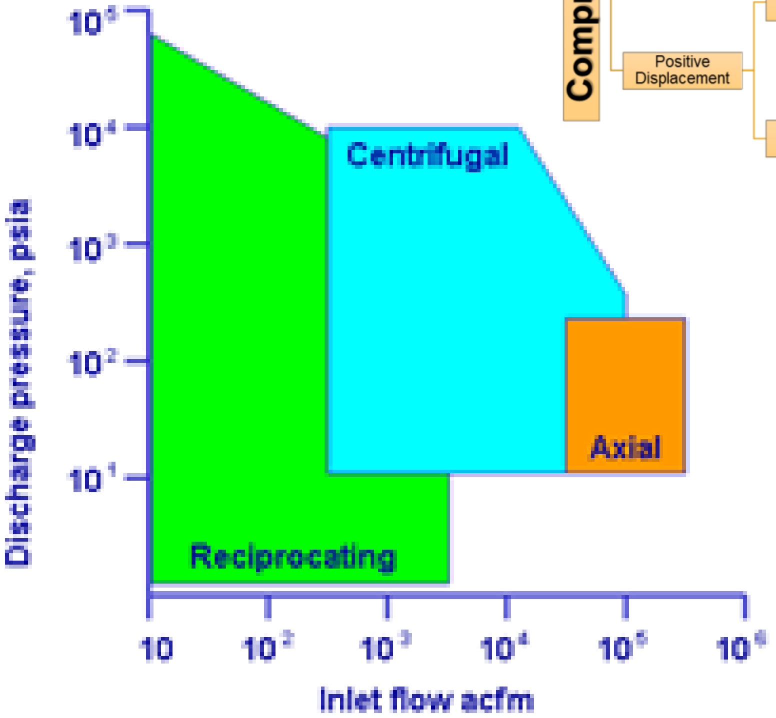
	TYPICAL PRODUCTION RATE M3/HR (BIOGAS)	TYPICAL PROCESS PRESSURE (KPA)	COMMON RECOVERY RATE	TURN DOWN AS % OF MAXIMUM	SPECIFIC IMPURITY CONSIDERATION	CONSUMABLES
Membrane	<1000	1300-1400	94-98%	20-30%	Molecule size less than CH_4 Oxygen – None Nitrogen - None	Membranes (PSA Medium, where PSA used for H_2S, VOC, N_2 and O_2 removal)
Pressure Swing Absorption	Any (Dependent on Impurities)	800-1000	95-97%	20-30%	Can remove O_2 and N_2	PSA Medium
Water Wash	>1000	800-1100	98-99%	30%	2500ppm H_2S 10micron particulate Oxygen – None Nitrogen - None	Water Expect to use 0.2L/m3 created Desiccant for drying

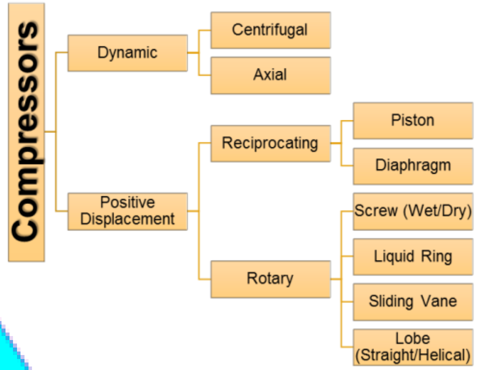
These values are generic numbers for reference and may not be reflective of current processes.

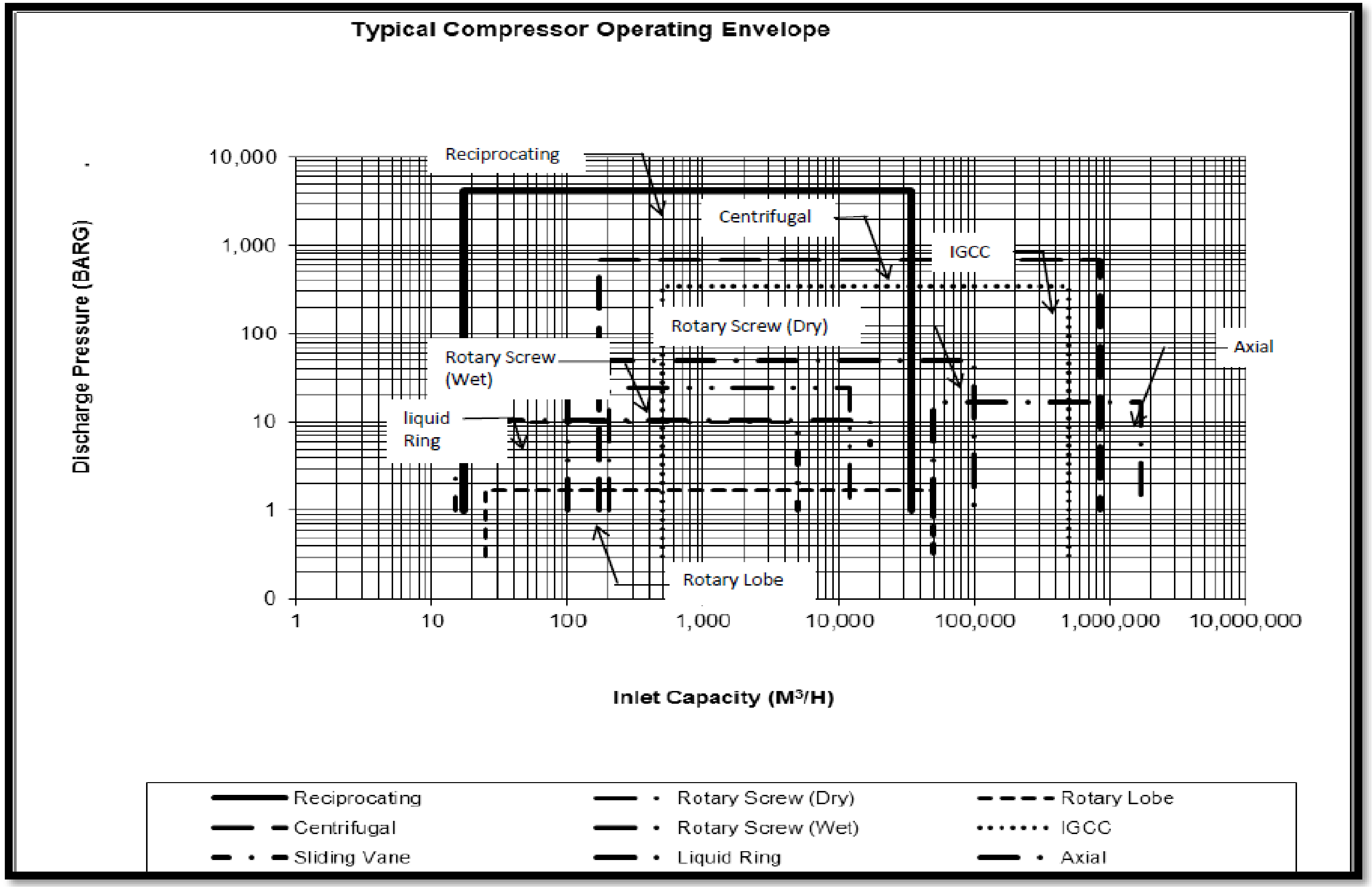
Gas Compression Selection Criteria

Compression selection guideline

Renewable natural gas compressors are used for boosting up the pressure of cleaned biogas output from the purification units to a pressure above the utility natural gas pipeline taking into consideration pressure losses within the injection station.







Process Industry Practices Machinery PIP REEC001: Compressor Selection Guidelines

Types of compression

	Advantages	Disadvantages
Positive Displacement		
Reciprocating	**Wide pressure ratios** **High efficiency**	**Heavy foundations** **Higher vibration** **High maintenance costs** **Sensitive to liquids in gas**
Rotary Screw	**Wet has high efficiency & pressure** **Dry can handle dirty gases**	**Noisy**

- Positive displacement compressors are more efficient than dynamic compressors when operating requirements vary between high and low flow and head requirements.
- Positive displacement compressors are used for low flow and large thermodynamic head/pressure lift requirements and when a wide range of operating conditions must be met.

Compression selection guideline

- As a rule of thumb, turbine driven centrifugal compressors are used for transmission and reciprocating compressors are used for storage injection.

- There are similarities between RNG and storage operations, where gas is produced from a source similar to a well, purified in a way similar to dehydration units, and then transferred into pipelines. Motor driven reciprocating or rotatory gas compressor units are the most relevant for this application. Reciprocating compressors have high up-front costs because of the material and infrastructure requirements as well as unit costs.

- Electric powered units are typically more appropriate for this application; they require the least material and additional infrastructure.

- Electric powered compressors are only an economically feasible option if three phase electrical service is available and gas driven engines should be investigated if required power is not economical.

Renewable Natural Gas Injection Station

Injection station guideline

- **Four generic station sizes considered**
  - <42m3/h
  - 400m3/h
  - 3200m3/h
  - >3200m3/h

- **Guideline defines terms and expectations**
  - Redundancy for maintenance vs. redundancy for flow.
  - Station bypass.

- **Required safety equipment**
  - Remotely operated inlet valve.
  - Gas quality monitoring.
  - Check valve.

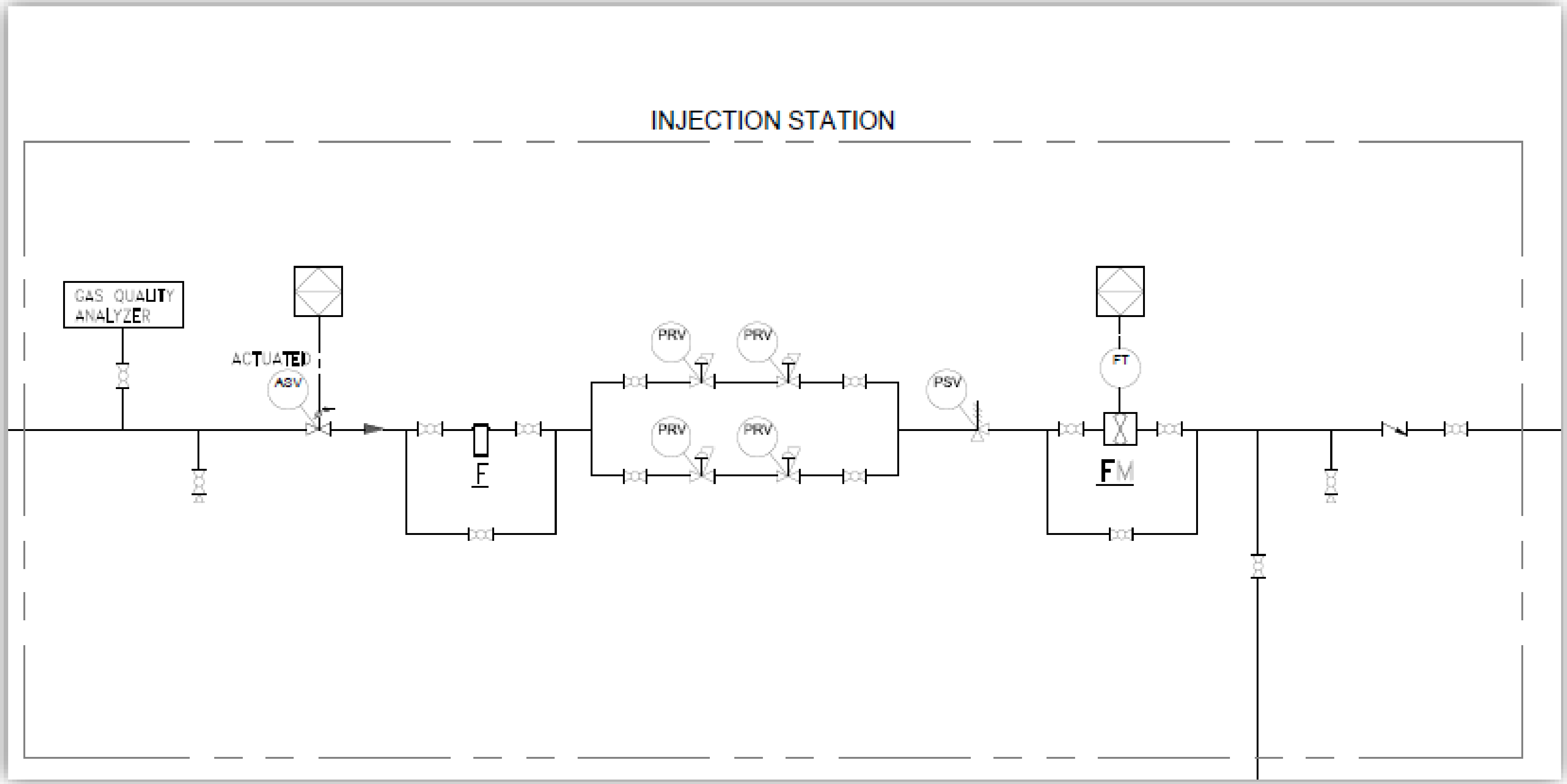
Injection station design guideline

- **Operating Parameters**
  - Total energy, GJs or BTUs.
  - Designed for clean volumes.
  - Maximum operating pressure (MOP).
  - Operating temperature limitations.

- **Piping and Fittings**
  - CSA Z662-15 - TSSA code adoption document FS-328-18.
  - Class “4” location recommended as it will not have a significant impact on station cost.

Injection station design guideline

Four standard layouts: small and large stations; with and without redundancy



Hourly > 3700 Sm3/hr with Redundancy

Gas Quality Monitoring

Gas quality

On-line monitoring can be at the injection station or via producer signals

- Critical parameters for continuous monitoring/measurement include but may not be limited to:
  - Carbon dioxide (always monitored at injection station).
  - Water vapour.
  - Hydrogen sulphide.
  - Oxygen.

The RNG shall be analyzed for contaminants during commissioning of the purification process and periodically afterwards

- After the RNG facility is commissioned, sampling shall be performed at a frequency determined by an engineering assessment.

Q&A