BIOGAS TO CBG / CNG TECHNOLOGY

TECHNOLOGY CATALOGUE

Transforming Renewable Gas into Clean Energy

Poly Transform Knowledge Series

CHAPTER 1

ENVISION

"Every tonne of waste left to decompose unused is clean energy left on the table."

Building a circular gas economy where organic waste becomes renewable transportation fuel.

POLY TRANSFORM • KNOWLEDGE SERIES

POLY TRANSFORM PRINCIPLE #11 — WASTE HAS ENERGY VALUE

Every category of organic waste — agricultural, municipal, industrial or sewage-derived — carries recoverable chemical energy that can be captured through anaerobic digestion rather than lost to open dumping or uncontrolled decomposition.

From Organic Waste to Renewable Energy

Organic waste is generated continuously across agriculture, food processing, municipalities and industry. When this waste is directed into anaerobic digestion rather than open dumping, naturally occurring microorganisms break it down and release biogas — a renewable mixture rich in methane.

That raw biogas can be purified and upgraded into biomethane, compressed into Compressed Biogas (CBG), and used as a clean substitute for conventional CNG in transportation, industry and power generation.

Organic Waste → Digester → Biogas → Biomethane → CBG → Vehicle

⚡ **ENERGY INSIGHT**

Biogas is one of the few renewable energy pathways that simultaneously manages waste and produces a storable, dispatchable fuel.

💡 **DID YOU KNOW?**

Compressed Biogas (CBG) has a composition and energy content comparable to conventional CNG, allowing it to use similar storage, dispensing and vehicle infrastructure.

The Untapped Energy in Organic Waste

A wide range of organic waste streams can serve as feedstock for anaerobic digestion, each with distinct handling, pretreatment and digestion characteristics.

Agricultural Residues Crop residues, animal manure and farm by-products offer high-volume, distributed feedstock potential.	**Food Waste** Restaurant, retail and processing food waste is highly biodegradable and rich in digestible organics.
Municipal Organic Waste Segregated organic fractions of municipal solid waste support urban waste-to-energy programs.	**Sewage / Wastewater-Derived Biogas** Sludge digestion at treatment plants recovers energy value already present in the wastewater stream.
Industrial Organic Waste Process by-products from food, beverage and agro-industries provide concentrated, consistent feedstock.	

💡 **DID YOU KNOW?**

Biogas production can simultaneously support waste management and renewable energy recovery.

Closing the Loop

The value of biogas technology extends beyond a single conversion step. Organic waste, digestion, upgrading and end use form a continuous, self-reinforcing cycle that keeps carbon and energy in productive circulation.

Organic Waste → Digestion → Biogas → Upgrading → Biomethane → CBG → Transport / Industry

...and back again as a circular economy that continuously converts waste into clean energy.

🌱 **SUSTAINABILITY INSIGHT**

Every stage of the biogas-to-CBG pathway keeps carbon and nutrients in productive circulation — transforming a waste-management challenge into a renewable energy opportunity. This is one of the defining ideas of the entire catalogue.

CHAPTER 2

UNDERSTAND

"Scientific understanding of gas composition is the foundation of every effective upgrading system."

Understanding the chemistry and engineering that transform biogas into pipeline-quality renewable gas.

POLY TRANSFORM • KNOWLEDGE SERIES

POLY TRANSFORM PRINCIPLE #12 — PURITY ENABLES PERFORMANCE

The efficiency, reliability and market value of renewable gas depend directly on how effectively contaminants and carbon dioxide are separated from raw biogas.

Understanding Raw Biogas

Raw biogas is the direct output of anaerobic digestion — a mixture of gases whose exact composition depends on feedstock type, digester design and operating conditions. Before it can be used as a vehicle or pipeline fuel, this mixture must be understood and treated.

Methane (CH_4) The primary energy-carrying component of biogas.	**Carbon Dioxide (CO_2)** A non-combustible component that must be separated during upgrading.
Water Vapour Present from the digestion process; removed to prevent corrosion and condensation.	**Hydrogen Sulfide (H_2S)** A corrosive trace gas that requires dedicated removal upstream of upgrading.
Trace Contaminants Siloxanes and other minor constituents that depend on feedstock characteristics.	

⚙️ ENGINEERING INSIGHT

The electrolyte-free composition of biogas — a variable mixture rather than a fixed fuel — is why pretreatment and upgrading are engineered around the specific feedstock and digester in use.

💡 DID YOU KNOW?

Even relatively small concentrations of certain contaminants can influence downstream equipment selection and operating reliability.

The Upgrading Process

Converting raw biogas into biomethane is a staged process. Each stage removes a specific class of impurity, progressively refining the gas until it meets the methane concentration required for compression and end use.

Raw Biogas
↓
Pretreatment
↓
H_2S Removal
↓
Moisture Removal
↓
CO_2 Separation
↓
Biomethane

ENGINEERING INSIGHT

Different upgrading technologies may be selected depending on feed composition, flow rate, pressure, required methane recovery and target gas quality.

Preparing Gas for Upgrading

Effective pretreatment protects downstream upgrading equipment and is essential to reliable, long-duration plant operation.

Hydrogen Sulfide Removal Protects downstream equipment and upgrading systems.	**Moisture Removal** Controls water vapour and prevents condensation.
Particulate / Aerosol Removal Protects sensitive downstream components.	**Siloxane / Trace Contaminant Control** Applied where feedstock characteristics indicate their presence.

> 💡 **DID YOU KNOW?**
> *Even relatively small concentrations of certain contaminants can influence downstream equipment selection and operating reliability.*

Separating CO_2 from Methane

Several proven technologies are available for separating carbon dioxide from methane, each suited to different feed conditions, capacities and product-quality requirements.

Membrane Separation Selective permeation of CO_2 through membrane materials.	**PSA** Pressure Swing Adsorption using selective adsorbents.
Water Scrubbing Selective dissolution of CO_2 in water.	**Amine / Chemical Absorption** Chemical absorption of acidic gas components.
Cryogenic Separation Low-temperature separation for specialized applications.	

⚙️ ENGINEERING INSIGHT

No single upgrading technology is universally optimal. System selection should be based on feed gas composition, capacity, required product quality, methane recovery, energy consumption and economics.

CHAPTER 3

ENGINEER

"Reliable clean energy systems emerge when scientific principles meet disciplined engineering integration."

Designing the complete renewable gas system — from digester to dispensing.

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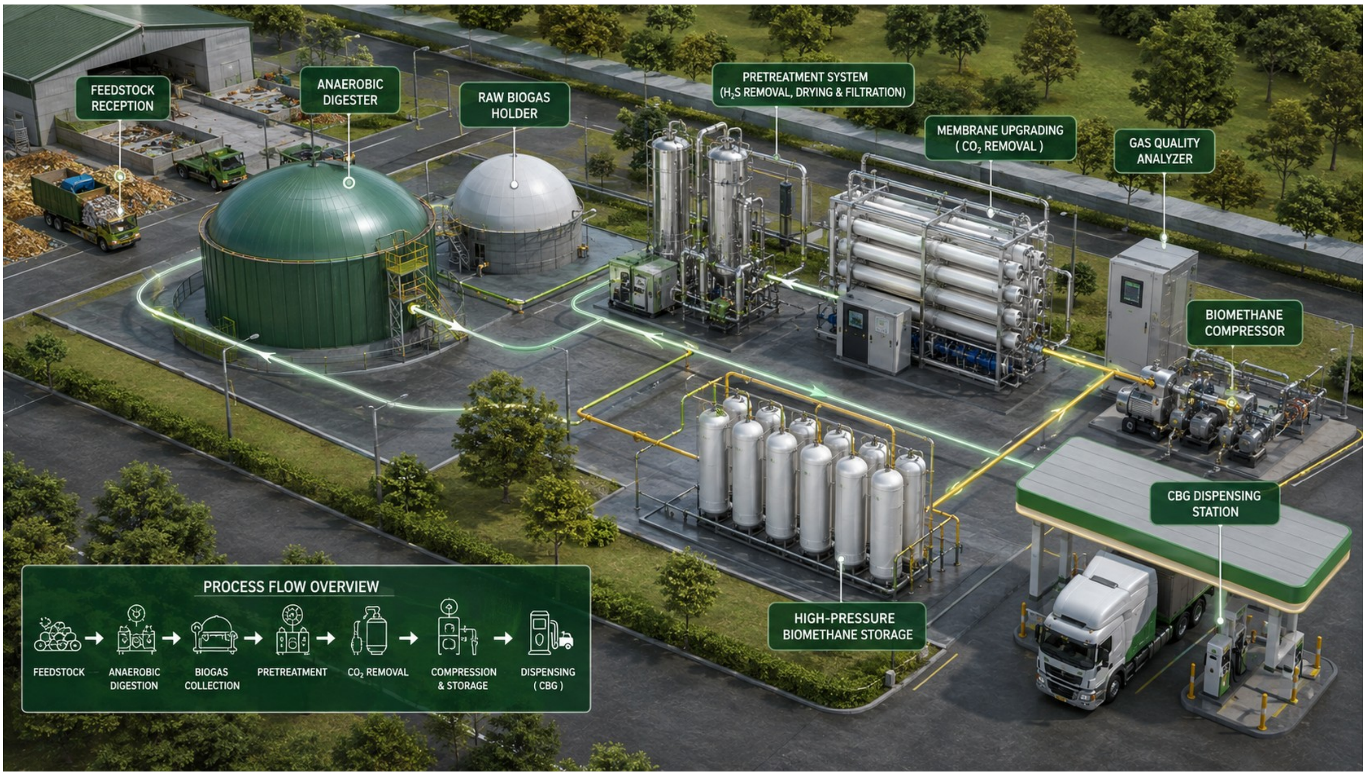
POLY TRANSFORM PRINCIPLE #13 — INTEGRATION DELIVERS RELIABILITY

A dependable CBG plant is built not from a single technology, but from the careful integration of pretreatment, separation, compression, monitoring and control.

From Digester to CBG

A complete biogas-to-CBG facility integrates digestion, gas holding, pretreatment, upgrading, compression, storage and dispensing into a single coordinated system.

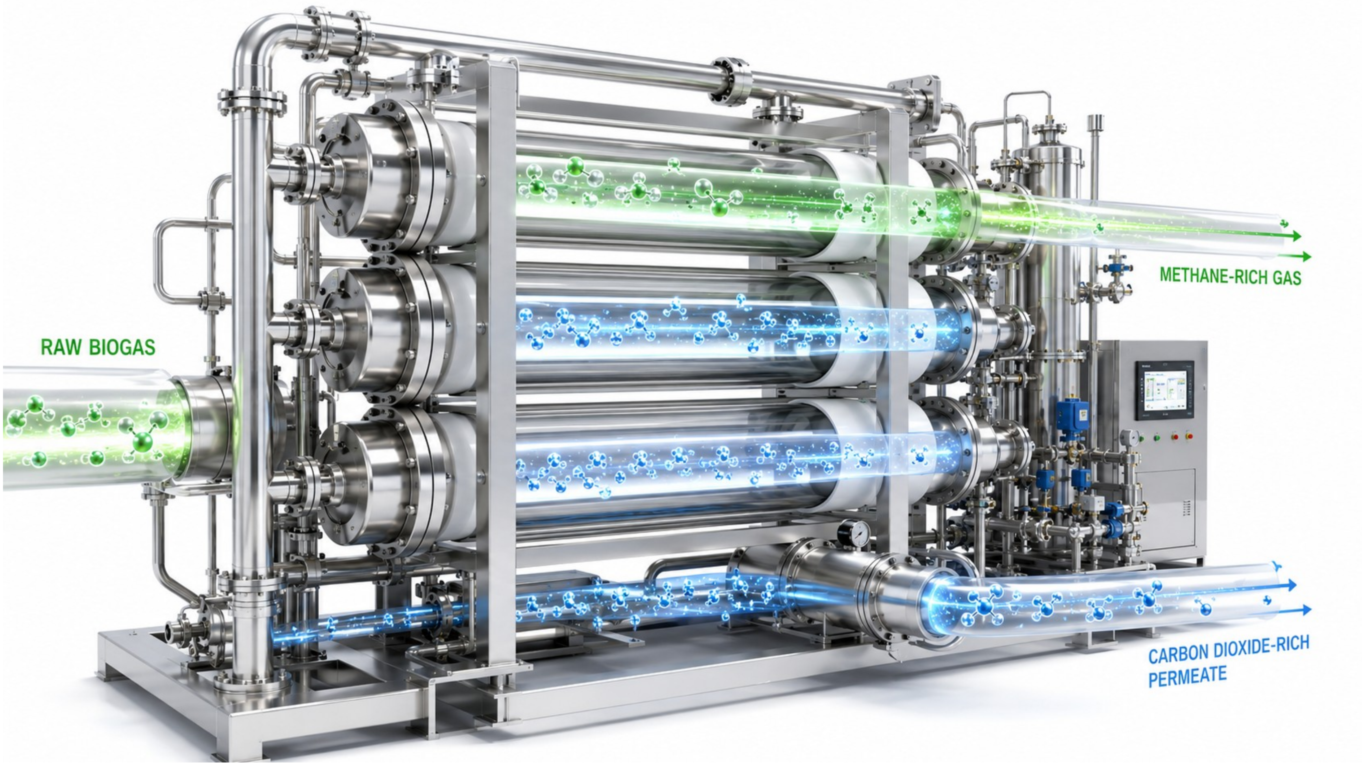


Organic Waste → Digester → Raw Biogas Holder → H_2S Removal → Drying → CO_2 Removal → Biomethane → Compression → CBG Storage → Dispensing

> ⚙️ **ENGINEERING INSIGHT**
>
> *System architecture is chosen around the feedstock and end-use requirement first — the upgrading technology is selected to fit that architecture, not the other way around.*

Advanced Gas Separation

Membrane-based upgrading separates carbon dioxide from methane through selective permeation across specialized membrane materials, without the need for chemical solvents.



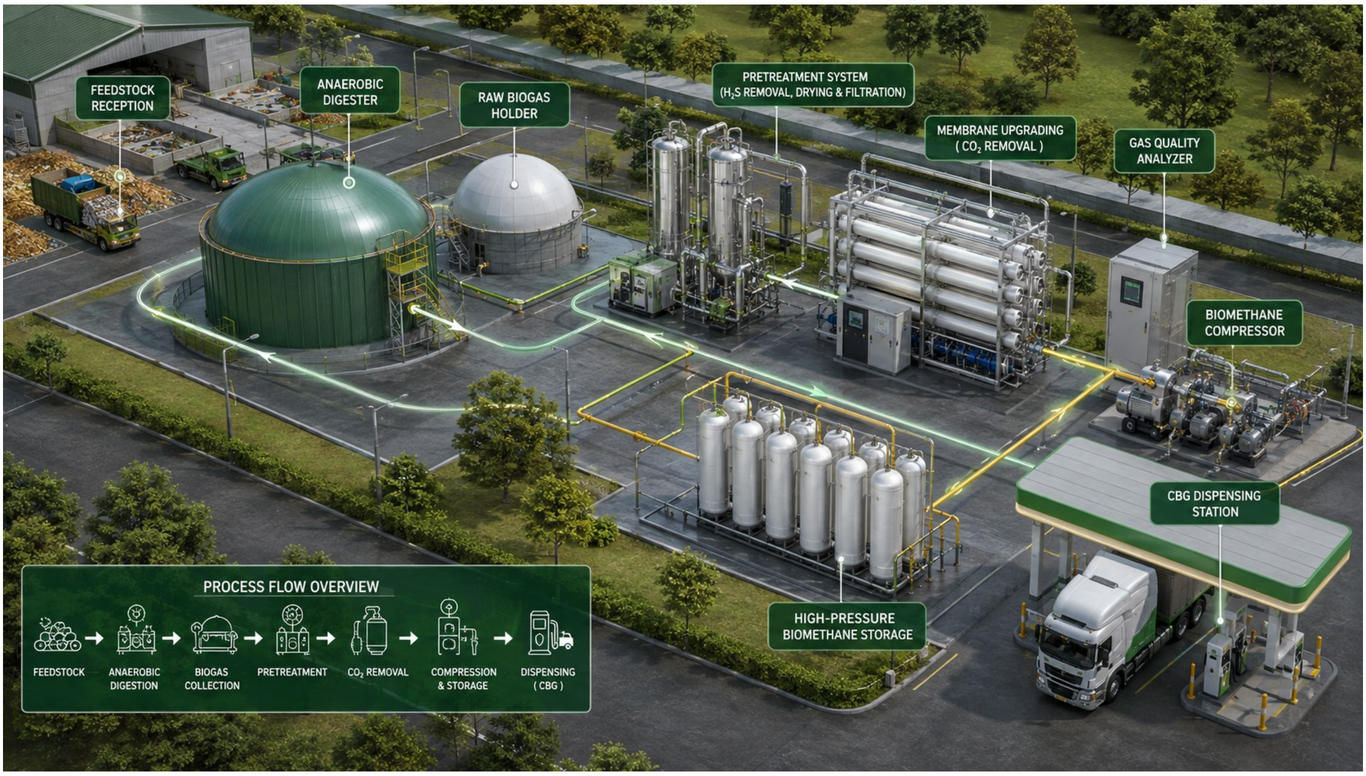
Feed Conditioning Prepares pretreated biogas to the pressure and quality the membranes require.	**Membrane Separation** Selective materials allow CO_2 to permeate while retaining methane.
CO_2 Permeation Carbon dioxide passes through the membrane as a permeate stream.	**Methane Retention** Methane is retained and concentrated in the product stream.
Multi-Stage Configurations Multiple membrane stages improve recovery and product purity.	**Methane Recovery & Product Quality** System design is tuned to balance recovery against final gas quality.

ENGINEERING INSIGHT

Membrane performance depends strongly on feed gas quality. Effective pretreatment protects membranes and improves system stability.

Beyond the Upgrading Unit

The upgrading unit is only one component of a complete CBG plant. Reliable operation depends equally on the surrounding balance-of-plant systems.



Feed Blower / Compressor Delivers raw biogas at the pressure required by downstream equipment.	**H_2S Removal** Protects piping, instrumentation and the upgrading unit.
Dryer Controls moisture ahead of separation.	**Filters** Removes particulates and aerosols from the gas stream.
Upgrading Unit Separates CO_2 from methane to produce biomethane.	**Gas Analyzer** Continuously verifies product gas quality.
Compression & Storage Prepares biomethane for high-pressure CBG storage.	**Control & Safety Systems** Coordinate safe, automated and efficient plant operation.

🏭 **POLY TRANSFORM INSIGHT**

The upgrading technology is only one part of a complete CBG plant. Reliable operation depends on the integration of pretreatment, separation, compression, monitoring and control.

Quality Before Compression

Before biomethane is compressed into CBG, its quality must be verified against the parameters that determine safe, efficient and compliant end use.

Methane Concentration Determines the energy content and fuel value of the product gas.	**Carbon Dioxide** Residual CO_2 affects energy density and downstream compliance.
Hydrogen Sulfide Must be controlled to protect equipment and end-use systems.	**Moisture** Controlled to prevent corrosion and freezing in storage and dispensing.
Oxygen & Nitrogen Monitored as indicators of air ingress and system integrity.	**Siloxanes & Other Contaminants** Checked where feedstock characteristics indicate their presence.

> 📌 **IMPORTANT NOTE**
> *Final product gas quality must be verified against the applicable fuel specification and regulatory requirements for the intended end use.*

CHAPTER 4

IMPACT

"The true measure of clean energy technology is the value it creates for communities and industry."

Renewable gas in the real world — transportation, industry and power.

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POLY TRANSFORM PRINCIPLE #14 — COLLABORATION ACCELERATES THE TRANSITION

Transformational renewable gas infrastructure emerges when waste generators, technology providers, industry and communities work together toward shared sustainability goals.

Where Renewable Gas Creates Value

Renewable gas technology is increasingly adopted across transportation, industry, power and municipal waste management.

🚛 **Transportation** CBG-compatible vehicles including buses, trucks and passenger fleets.	🏭 **Industry** Industrial heating and thermal applications.
⚡ **Power** Gas engines and combined heat-and-power (CHP) systems.	🌾 **Agriculture** Integration with agricultural waste management.
🗑️ **Municipal Waste** Organic waste diverted into energy recovery.	🏢 **Commercial / Institutional** Suitable for distributed energy applications.

> ⚡ **ENERGY INSIGHT**
>
> *Renewable gas is versatile by design — the same biomethane molecule can fuel a heavy-duty truck, heat an industrial process, or generate distributed power.*

Our Renewable Gas Technology Platform

Poly Transform's role in the renewable gas value chain spans feedstock understanding, process engineering and system integration.

Feedstock Assessment Understanding the source and characteristics of organic waste.	**Process Engineering** Designing integrated gas treatment and upgrading systems.
Membrane Integration Advanced gas separation and pretreatment strategies.	**Compression & Storage** Integration toward CBG delivery.
Monitoring & Optimization Gas-quality monitoring and process optimization.	

🔬 **RESEARCH OBSERVATION**

Innovation is driven by understanding feedstock and process chemistry before scaling toward commercial deployment.

From Research to Real-World Impact

Poly Transform's renewable gas program is envisioned as a long-term research and engineering initiative aligned with the transition toward sustainable energy systems.

Feedstock Studies → Process Selection → Laboratory Validation → Pilot Development → System Integration → Demonstration → Commercial Deployment

🔬 **RESEARCH OBSERVATION**

Technology leadership is built through consistent progress, evidence-based development, and long-term commitment.

POLY TRANSFORM PRINCIPLE #15 — ENGINEERING CREATES IMPACT

Research becomes meaningful when scientific knowledge is translated into reliable engineering solutions.

ENGINEERING THE CIRCULAR GAS ECONOMY

Turning organic resources into renewable energy for a cleaner and more resilient future.

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Closing the Loop with Clean Energy Innovation

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"Together, let's power the future with clean renewable gas."

CLOSING THE LOOP WITH CLEAN ENERGY INNOVATION

DEVELOPMENT STATUS

The technologies described in this publication represent Poly Transform Pvt. Ltd.'s ongoing research and development initiatives in renewable gas and biomethane upgrading. Certain technical characteristics, performance expectations and commercial applications remain subject to laboratory validation, engineering optimization, regulatory requirements and future commercialization milestones.