

# **INSTRUMENTATION** **IN CARBON CAPTURE** **INDUSTRY**



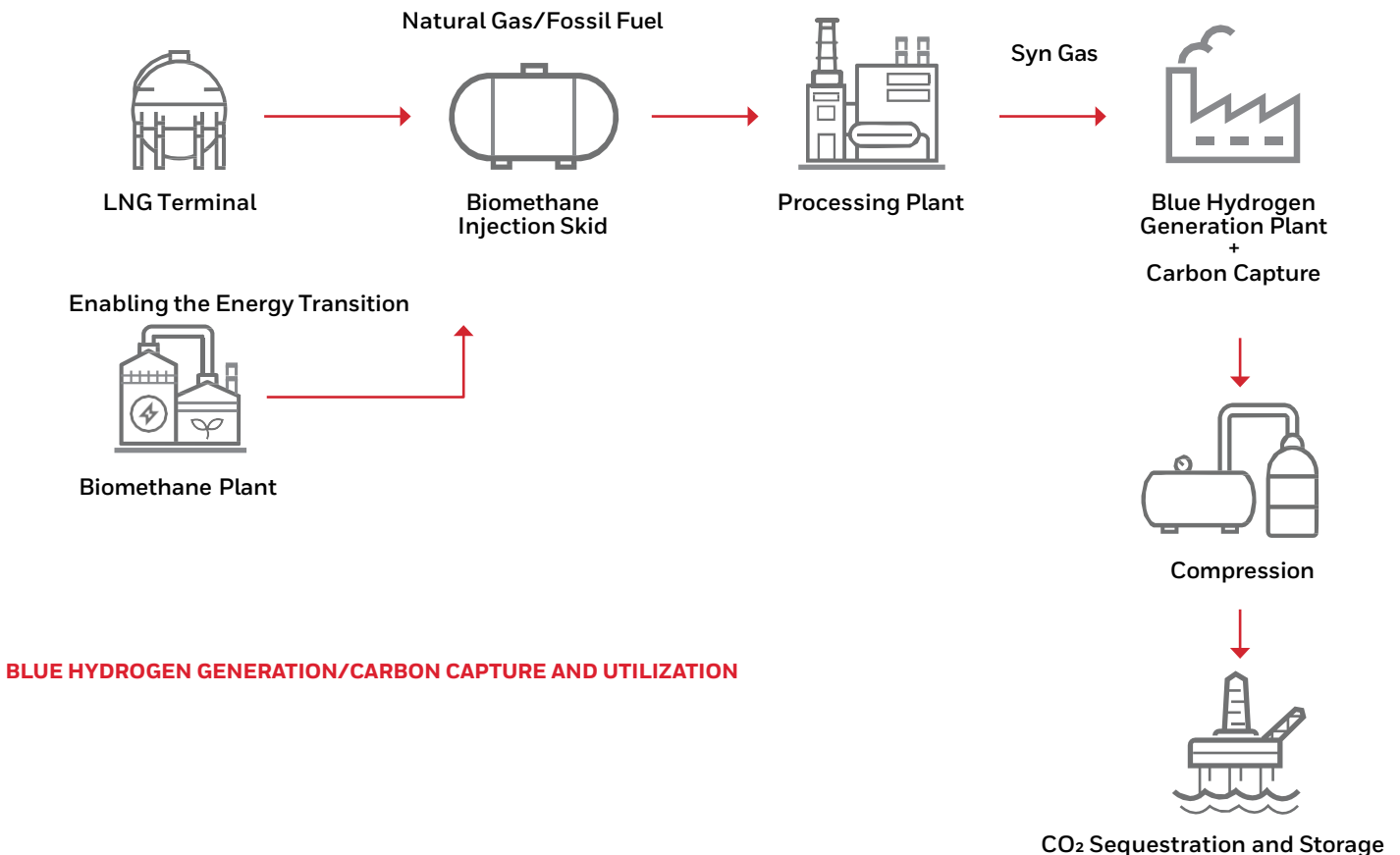
**Honeywell**

# INTRODUCTION

Carbon dioxide (CO<sub>2</sub>) emissions from various sources—primarily industrial processes—contribute to rising global temperatures and climate change.

Carbon capture encompasses a broad portfolio of technologies designed to **separate carbon dioxide (CO<sub>2</sub>) from industrial and power-generation processes**, either for **utilization in value-added applications** or for **permanent storage** to prevent its release into the atmosphere. These technologies can be applied across different stages of the value chain, including **post-combustion, pre-combustion, and natural-gas processing**, using methods such as solvent absorption, membrane separation, adsorption, and cryogenic processes.

Carbon capture is widely recognized as a **critical enabler of net-zero and decarbonization goals**, particularly for **hard-to-abate sectors**—such as oil & gas, chemicals, cement, steel, and power generation—where process-related emissions are difficult to eliminate through electrification or renewable energy alone. By allowing these industries to significantly reduce CO<sub>2</sub> emissions while maintaining reliable operations, carbon capture plays a key role in supporting the transition to a lower-carbon economy.



## BLUE HYDROGEN GENERATION/CARBON CAPTURE AND UTILIZATION

# AMINE BASED CAPTURE

One of the most widely used approaches for post combustion carbon capture is amine based absorption.

The figure below illustrates a typical process flow diagram, along with the associated instrumentation requirements. The key processes involved are outlined below.

**Flue Gas Desulfurization (FGD):** Sulfur dioxide (SO<sub>2</sub>) concentrations in flue gas from natural gas fired power plants are inherently lower than those from coal fired plants. In the FGD process, SO<sub>2</sub> is removed from the incoming flue gas through gas-liquid absorption.

## CO<sub>2</sub> Absorber

In the absorber section, an **amine based liquid solvent** is used to capture CO<sub>2</sub> from the incoming flue gas. Typical operating conditions range from **35 to 50 °C and 5 to 200 bar(g)**.

Under these conditions, approximately **90–95% of the CO<sub>2</sub>** is removed.

The treated flue gas, now with a low CO<sub>2</sub> concentration, is discharged to the stack, while the **CO<sub>2</sub> rich amine solution** is pumped to the **amine regeneration unit** for solvent recovery.

## Heat Exchanger

The heat exchanger enables heat recovery by transferring thermal energy from the hot solvent exiting the CO<sub>2</sub> stripper to the incoming solvent, thereby reducing overall energy consumption.

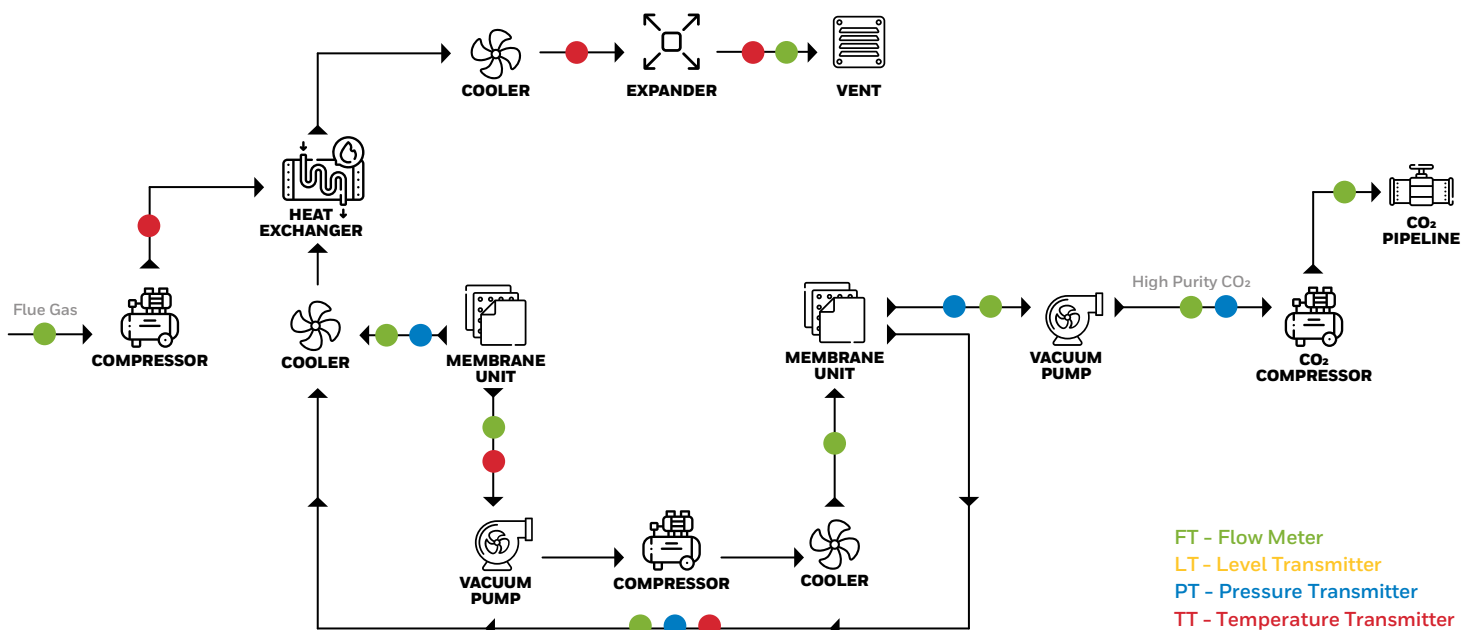
## CO<sub>2</sub> Stripper

The stripper regenerates the amine solvent by removing the captured CO<sub>2</sub> from the CO<sub>2</sub> rich solvent through the application of heat using steam. Typical steam conditions are **below 1 bar(g)** and temperatures in the range of **115 to 126 °C**.

The regenerated (lean) solvent exiting the stripper is routed back through the heat exchanger and returned to the absorber, completing the closed loop absorption-regeneration cycle. The **CO<sub>2</sub> rich steam** leaving the stripper is cooled and condensed before being sent to the CO<sub>2</sub> compression system.

## CO<sub>2</sub> Compressor

The compressor pressurizes the CO<sub>2</sub> stream exiting the stripper to **supercritical conditions**, achieving a final pressure typically **around 76 bar or higher**. The supercritical CO<sub>2</sub> is then suitable for transportation via pipeline for **enhanced oil recovery (EOR)** or **permanent underground sequestration**.



# MEMBRANE BASED CAPTURE

Carbon capture from natural gas streams can be achieved using membrane separation technology, which does not require the use of chemical solvents.

A membrane is a thin, flexible material that acts as a selective barrier, allowing certain components to pass through while restricting others. A typical membrane-based process involves the following steps:

## 1. Feed First Stage

The flue gas mixture, at 38 bar and 105 °F, is introduced into the membrane separation unit. A pressure gradient across the membrane drives selective gas permeation, resulting in the formation of a permeate stream on one side of the membrane. The remaining CO<sub>2</sub>-lean retentate stream is then routed to downstream systems, including gas turbines.

## 2. Post processing First stage

The permeate gas stream is compressed, cooled, and routed to the second membrane stage for further separation.

## 3. Feed Second Stage

The compressed permeate stream is fed to the second membrane stage, where further separation results in a CO<sub>2</sub>-rich product. The CO<sub>2</sub>-rich gas is subsequently compressed to meet downstream transport or utilization requirements.

## 4. Post processing Second stage

The remaining gas stream that does not permeate the second membrane stage (the retentate stream) is compressed and routed to downstream systems or applications, such as gas turbines or recycle streams.

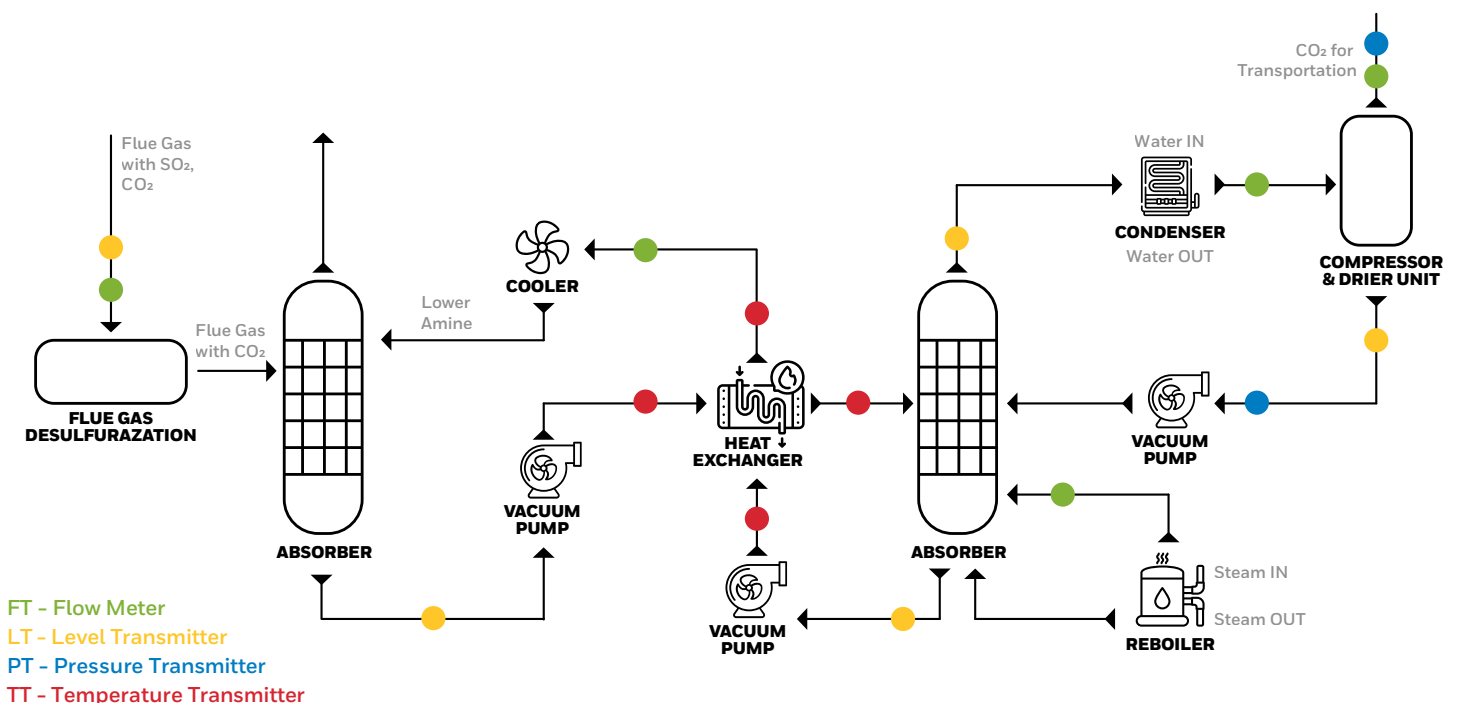
## KEY COMPONENTS OF A CARBON CAPTURE MEMBRANE TECHNOLOGY SYSTEM

### 1. Flue Gas Inlet

This is where the flue gas, containing CO<sub>2</sub>, enters the system. The gas typically comes from industrial processes or power plants.

### 2. Pre-treatment Unit

Before the flue gas reaches the membrane, it may pass through a pre-treatment unit to remove impurities and moisture that could affect the membrane's performance.



### 3. Membrane Module

The core component of the system, where the separation of CO<sub>2</sub> from the flue gas occurs. The membrane selectively allows CO<sub>2</sub> to pass through while blocking other gases.

### 4. Compressor

A compressor is used to increase the pressure of the flue gas before it enters the membrane module, enhancing the efficiency of CO<sub>2</sub> separation.

### 5. Permeate Side

This is the side of the membrane where the CO<sub>2</sub>-enriched gas (permeate) is collected after passing through the membrane.

### 6. Retentate Side

This is the side of the membrane where the CO<sub>2</sub>-depleted gas (retentate) is collected. This gas is typically released as exhaust.

### 7. CO<sub>2</sub> Compression and Storage

After separation, the CO<sub>2</sub>-enriched gas is compressed and stored for further use or sequestration. This component ensures that the captured CO<sub>2</sub> is handled safely and efficiently.

### 8. Exhaust Gas Outlet

After CO<sub>2</sub> capture, the treated flue gas is released through the exhaust gas outlet. This gas has significantly reduced CO<sub>2</sub> concentration.

## TRANSPORTATION AND STORAGE

Captured carbon dioxide (CO<sub>2</sub>) can be transported over long distances via

pipelines, similar to natural gas, or by ships, particularly for overseas transport in liquid form under cryogenic conditions.

The transported CO<sub>2</sub> can be permanently stored in underground geological formations or utilized in industrial applications, such as enhanced oil recovery (EOR) or chemical production.

## CHALLENGES

Carbon dioxide (CO<sub>2</sub>) can exist in different phases—including gas, liquid, solid, or supercritical—depending on operating temperature and pressure. In carbon capture systems, CO<sub>2</sub> is typically brought to supercritical conditions during the final stages of compression for efficient transportation and storage.

When CO<sub>2</sub> is saturated with water, it can pose corrosion risks, and improper containment may also lead to leakage risks, requiring careful material selection and monitoring.

## SMARTLINE TRANSMITTERS

- Honeywell's SmartLine Transmitters empower businesses to enhance reliability, performance, and monitoring while optimizing operating costs.
- Our smart field devices measure critical variables such as pressure, temperature, flow, and level, which are essential to safe and efficient production.
- In largescale industrial facilities, where thousands of transmitters are deployed, even marginal performance improvements can deliver significant savings over time.

## WHY HONEYWELL?

Honeywell offers end-to-end solutions for carbon capture, helping operators improve efficiency, safety, and sustainability across the entire process. Through our SmartLine™ portfolio of field instrumentation, we enable more reliable operations while reducing total cost of ownership.

Honeywell's comprehensive measurement and control solutions provide the critical foundation for accurate measurement, control, and data acquisition—from the field sensor to the control room and everything in between. Our solutions help you optimize operations, manage assets effectively, improve product quality and productivity, and enhance safety, all while lowering lifecycle costs.

Whether deployed as stand-alone instruments or fully networked systems, Honeywell delivers a complete measurement and control solution, including:

- Pressure transmitters
- Temperature transmitters Flowmeters
- Equipment health monitoring solutions

## SMARTLINE APPLICATION AND VALIDATION TOOL

AVT is a cloud-based tool that requires no licenses or passwords, making it easy to access and use. It helps users select the most appropriate technology and accurately configure transmitters for their specific applications.

**The platform** provides a range of engineering tools and reference resources—including material compatibility charts and a wake frequency calculator—designed to strengthen engineering confidence, improve decision-making, and deliver valuable technical insights.



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5240909 Instrumentation In Carbon Capture  
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