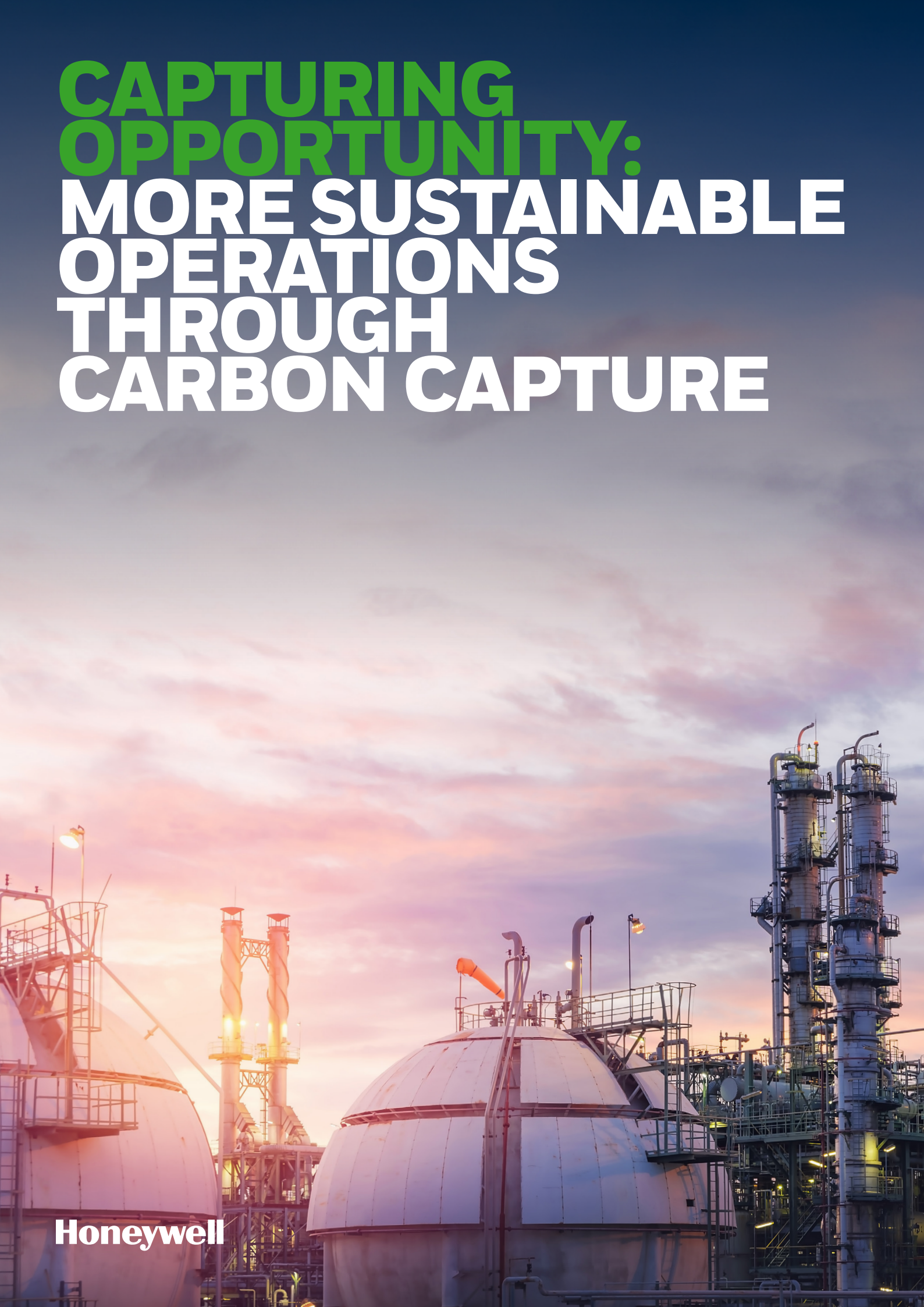
CAPTURING OPPORTUNITY: MORE SUSTAINABLE OPERATIONS THROUGH CARBON CAPTURE



Honeywell

INTRODUCTION

As the pressure to decarbonize industries grows, businesses will need to invest in abating emissions from existing sources to meet increasingly stringent sustainability expectations.

One important technology for emissions abatement is carbon capture, utilization, and storage (CCUS). According to the International Energy Agency (IEA), **CCUS capacity must increase by more than 20 times to enable the capture of 840 million metric tons per year of CO_2 by 2030** to meet global emission goals. IEA's Sustainable Development Scenario also points out that around **15% of global emissions reduction is forecasted to come from carbon separation technology[1].**

This is because there are many areas for which CCUS is the most attractive solution: while we can electrify ground transport or residential heating, for example, energy intensive industries often find CCUS is a more economically viable path to achieve net zero.

CCUS is also closely linked to the future of hydrogen production, with effective solutions capturing **as much as 98% of the overall CO_2 emitted** and delivering hydrogen that can act as a new energy carrier.[2]

Conditions are now aligning for effective, rapid deployment of carbon capture solutions. Longstanding technological development is coming to fruition with the regulatory environment being increasingly supportive of CCUS implementation. This is demonstrated by different policy measures such as the 45Q tax credit, part of **the US Inflation Reduction Act which incentivizes the use of CCUS technology**, and the UAE's policy of expanding CCUS capacity through direct state project investment.[3] [4]

While the legislative approaches may vary, these policies show an encouraging willingness to support energy companies around the world to adopt ready-now CCUS technologies for emissions abatement.

The first step to CCUS is effective technology to capture the CO_2 found in process streams. Honeywell UOP's carbon capture solutions have been developed and deployed in numerous applications and geographical settings. This experience, coupled with our deep sector and regional expertise, allows us to go beyond product offerings to offer our customers value-adding guidance.

This guide will introduce you to Honeywell UOP's carbon capture technologies and applications that can help you fuel a successful future, sustainably.

HONEYWELL SOLUTIONS

HONEYWELL UOP'S CO_2 SEPARATION TECHNOLOGIES TARGET THE TWO MAIN MODES OF CARBON DIOXIDE CAPTURE.

Pre-combustion processes cover the capture of CO_2 from streams within the process prior to any combustion. This can include CO_2 removal from natural gas streams, the removal of CO_2 from syngas (a gaseous mixture of mostly hydrogen and CO_2) that is produced via steam methane or auto-thermal reforming, or CO_2 capture from refining and petrochemical off-gas streams.

Post-combustion processes, meanwhile, separate CO_2 from a combustion stream, which characteristically has high volume, low pressure, and high oxygen content. The CO_2 is separated and produced at the quality required for it to be transported and safely stored.

The right technology mix for any given plant will vary, combining a range of solutions across pre- and post-combustion processes, and needs to be identified through a consultative process.

HONEYWELL SOLUTIONS

OUR CO_2 SEPARATION TECHNOLOGY PORTFOLIO

Honeywell UOP has a wide suite of solutions to support oil and gas sector leaders to begin lowering their carbon footprint. Our team of experts can work with you to determine the best solution to meet your CO_2 emissions reduction goals through our range of **chemical and physical solvent systems, pressure swing adsorption systems, cryogenic systems, and membranes.**

CHEMICAL SOLVENTS

- **AmineGuard™ Process:** Solvent for high-concentration, MEA-based systems
- **AmineGuard™ FS Process:** Family of specialty MEA-based formulated solvents for CO_2 removal across diverse industrial applications
- **Benfield ACT-1:** Inorganic solvent for pressurized highly oxidative streams
- **ASCC:** Advanced amine-based solvent system specifically designed for post combustion applications

PHYSICAL SOLVENTS

- **Selexol™ Process:** Physical solvent for selective CO_2 separation in high pressure gas streams and gasification

ADSORBENTS

- **Polybed™ Pressure Swing Adsorption (PSA) System:** A pressurized adsorbent system that, through a series of pressurization and depressurization cycles, selectively rejects CO_2 from a gaseous stream

CRYOGENICS AND MEMBRANES

- **Separex™ Membrane Systems:** Compact and lightweight systems used to separate CO_2 from gaseous streams with a high partial-pressure CO_2 across a range of industrial applications
- **Ortloff® CO_2 Fractionation:** A fractionation system with a proprietary refrigerant blend to separate CO_2 and capture it as a high-purity dense phase product

HONEYWELL SOLUTIONS

FOCUS ON: POST-COMBUSTION CARBON CAPTURE USING ADVANCED SOLVENT CARBON CAPTURE

Advanced Solvent Carbon Capture (ASCC) is Honeywell UOP's latest CO_2 capture offering. Utilizing a proprietary solvent developed by leading researchers at the University of Texas at Austin, ASCC combines Honeywell UOP's engineering expertise and UT's **20+ years of research in amine-based scrubbing** to help reduce CO_2 emissions.

In the ASCC process, a gaseous stream containing CO_2 is mixed with a proprietary amine-based solvent, and the CO_2 is absorbed into an amine solvent. That CO_2-rich solvent is sent to a stripper where CO_2 is separated from the solvent, and the CO_2 gas stream is then compressed and transported to be utilized or stored geologically. Honeywell UOP's ASCC solutions are specifically designed for post-combustion flue gas applications, enabling **greater than 95% CO_2 capture.**[5] The patented solvent enables a system design with a lower-cost capture of CO_2 emissions from power plants, heavy industry, and other heavy emitters.

This is a point source carbon dioxide removal technology which can be retrofitted to existing plant installations as well as designed into new ones, and multiple emissions sources from one facility can be combined and fed to one ASCC unit. This gives the technology significant potential to reduce emissions globally.

Key advantages of the ASCC technology include high mass transfer properties which enable a smaller and more efficient absorber column, high solvent stability which allows the system to operate the CO_2 stripping process at higher pressure and therefore reduces compression requirements, and a high-efficiency heat exchanger system which reduces overall energy consumption. ASCC is being successfully demonstrated at the National Carbon Capture Center in Alabama in the United States, where **over 4,000 hours of testing** has been done in multiple ongoing projects across a wide range of flue gas compositions.

HONEYWELL SOLUTIONS

FOCUS ON: DECARBONIZING HYDROGEN PRODUCTION

Most industrial-scale hydrogen production today uses the steam methane reforming (SMR) process, which relies on hydrocarbon feedstock, and therefore yields CO_2 as a by-product, while also generating additional emissions from the fuel gas to fire the process furnaces.

To produce hydrogen in a way that we view as more sustainable, this CO_2 needs to be separated, captured, and stored or used elsewhere. Honeywell offers multiple solutions which are well-suited to hydrogen production processes.

The UOP CO_2 Polybed® PSA System is our simplest, most straightforward carbon separation option, offering low capital and operational expenditure while **removing 90-98% of the CO_2 in the pre-combustion stream.**

The UOP AmineGuard™ FS Process is an amine-based solvent technology which can **achieve 99% CO_2 removal from the synthesis gas stream**, regenerating solvents using steam. An amine unit is a highly reliable, well proven choice for CO_2 recovery, albeit at a higher cost of capture than tail gas recovery.

The UOP Ortloff® CO_2 Fractionation System delivers bulk CO_2 removal from natural gas streams with high CO_2 content, recovering it as a liquid. The system can remove CO_2 down to 18% in the residue gas stream, and a coupled physical solvent like Selexol™ can **remove the remaining CO_2 to less than 2%, providing extremely high purity hydrogen yields of over 99.9%**[6]. This advanced system can produce food-grade CO_2 if required, and its liquid CO_2 product is ideal for rail or ship transport.

HONEYWELL SOLUTIONS

SOLUTION KEY FEATURES

UOP CO_2 POLYBED® PSA SYSTEM	UOP AMINEGUARD™ FS PROCESS	UOP ORTLOFF® CO_2 FRACTIONATION SYSTEM
90-98% CO_2 recovery from PSA tail gas (~50-60% overall direct CO_2 emissions reduction in typical existing SMR)	>99% CO_2 recovery from SMR syngas (~60% overall direct CO_2 emissions reduction in typical existing SMR)	>99% CO_2 recovery from SMR syngas (~60% overall direct CO_2 emissions reduction in typical existing SMR)
High purity CO_2 gas (>95 mol%)	Very high purity CO_2 gas (99 mol%)	Ultra-high purity CO_2 liquid (99-99.9+ mol%)
No steam usage for carbon capture	Requires steam usage for carbon capture	No steam usage for carbon capture
"Bolt-on", no-revamp system	Revamp of H_2 PSA may be required	"Bolt-on", no-revamp system
Optimal when lower purity or lower recovery of CO_2 is acceptable	Well-established, energy-efficient process	Lowest levelized cost of CO_2

HONEYWELL SOLUTIONS

FOCUS ON: AUTOTHERMAL REFORMING

As hydrogen production comes into focus as a clean energy source of the future, many hydrogen producers are evaluating the use of the autothermal reforming (ATR) process rather than SMR processes.

While this still relies on a hydrocarbon feedstock, it does not generate additional emissions from the flue gas, so all of the CO_2 is in the pre-combustion stream and can be captured from one part of the process. This means that efficient separation of the CO_2 can enable the production of hydrogen from a hydrocarbon feedstock that still has a very low carbon intensity.

For large-scale hydrogen production using an ATR process, Honeywell UOP has designed a hydrogen purification and CO_2 removal system that minimizes the overall carbon intensity from the production process while generating high-purity hydrogen and high-purity dense phase CO_2. The process leverages multiple Polybed® PSA systems in combination with the Ortloff® CO_2 Fractionation process to efficiently separate these components. The system also features a recycling loop to ensure that no carbon is emitted and that all of the product from the ATR is converted into either H_2 or CO_2.

FOCUS ON: LOW CARBON TRADE AND TRANSPORT

The ability to transport hydrogen over long distances is also an important consideration as the hydrogen economy grows. H_2 production capabilities and H_2 demand will each be concentrated in different geographies – and it has been forecasted that a significant quantity of H_2 will need to be transported from North America to Asia and Europe to meet net zero emissions targets.[7]

This makes ammonia, a mature commodity that can be shipped globally, a very attractive potential carrier of hydrogen: it can be produced a low carbon intensity, shipped, and cracked (where the NH_3 is split back into nitrogen and hydrogen) at the point of demand to provide low carbon H_2.

During ammonia production, CO_2 is separated from the process gas to meet gas quality requirements, after which it has historically been vented to the atmosphere. Implementing Honeywell UOP's PSA and CO_2 fractionation process for CO_2 separation enables an ammonia producer to remove the CO_2 in a high purity dense phase stream, giving the produced ammonia a low carbon intensity.
This technology also selectively rejects any impurity from the H2 product stream that is not suitable for ammonia synthesis, minimizing any further processing prior to the ammonia synthesis step and reducing overall production cost.

CASE STUDIES: MAKING A SUCCESS OF CCUS

EXXONMOBIL[8]

As one of the world's largest energy companies, ExxonMobil has invested in a long-term plan to reduce its emissions in order to improve quality of life while meeting society's evolving needs.

As part of that commitment, through its new low-carbon hydrogen, ammonia, and carbon separation facility in Baytown, Texas, ExxonMobil plans to produce over one billion cubic feet of low-carbon hydrogen per day and capture over 7 million tons of CO_2 annually. This is expected to be the largest low-carbon hydrogen project in the world when operations commence in 2027-2028.

Honeywell UOP's CO_2 fractionation and hydrogen purification system will be integrated into the design of ExxonMobil's Baytown facility, enabling it to **capture more than 98% of associated CO_2 emissions while producing high purity low-carbon hydrogen.** Any CO_2 captured from this project will be sequestered and stored permanently by ExxonMobil.

CASE STUDIES: MAKING A SUCCESS OF CCUS

WABASH VALLEY RESOURCES LLC[9]

In 2016, Wabash Valley Resources LLC (WVR) acquired a large gasification plant, aiming to turn it into a hydrogen production plant with carbon capture capabilities.

WVR selected a host of different Honeywell UOP technologies to capture and **sequester up to 1.65 million tons of carbon dioxide every year** while also producing clean, hydrogen-based energy.

Honeywell's involvement will include the provision of technology licenses, engineering services, and specialty equipment including a MOLSIV™ molecular sieve dehydration unit, an Ortloff® CO_2 Fractionation unit, and a Polybed™ PSA unit to sequester carbon dioxide and process synthesis gas from the gasification unit.

Honeywell UOP's fractionation solution will produce a high-purity liquid CO_2 stream which will then be sent for permanent geological storage. It will also produce hydrogen-rich stream which will be purified separately by the PSA unit and used to fuel turbines, producing low-carbon electricity. This stream can also be used for chemical synthesis or sold as clean transportation fuel.

CASE STUDIES: MAKING A SUCCESS OF CCUS

CVR ENERGY INC.[10]

> CVR Energy is a diversified holding company primarily engaged in renewables, petroleum refining and marketing businesses.

Since 2021, the business's Coffeyville Resources & Marketing, LLC subsidiary has been working with Honeywell UOP to evaluate the use of its UOP Ecofining™ technology to convert oil and grease inputs into high-quality, renewable diesel fuel.

As a further step in its emissions reduction initiatives, CVR Energy is now evaluating a further reduction of its carbon footprint at the Coffeyville site by using Honeywell UOP carbon capture technologies.

The feasibility study aims to demonstrate the viability of **recovering over 99% of the CO_2 in the existing hydrogen plant** syngas, dependent on the inlet gas composition and product requirements. The carbon capture solution is also expected to increase the plant's yields of high-purity hydrogen.

CASE STUDIES: MAKING A SUCCESS OF CCUS

ECOPETROL S.A.[11]

> **Ecopetrol is one of the largest oil and gas companies in Colombia and is the first energy company in the region to set a net zero target for scope 1 and 2 emissions by 2050.**

The company has selected Honeywell UOP's Advanced Solvent Carbon Capture (ASCC) technology to evaluate CO_2 capture from its Fluid Catalytic Cracking (FCC) units.

These post-combustion flue gases present particular challenges for CO_2 capture due to their inherently lower concentration and lower pressure. The ASCC process of absorbing CO_2 into an amine solvent and diverting it to a stripper unit for separation offers an effective route which can be retrofitted to existing plant operations.

Accounting for around 3% of overall global CO_2 emissions, refineries are an important site of intervention for emissions reduction. FCC units are significant sources of CO_2 emissions, accounting for 15-20% of overall emissions in a typical FCC-based refinery. Honeywell's ASCC technology enables **greater than 95% CO_2 capture on this process.**

THE HONEYWELL ADVANTAGE

TOMORROW'S SOLUTION, READY NOW

As the IEA points out, there were only around 20 commercial CCUS operations worldwide as of 2020. Given the importance of carbon capture technology to the ongoing decarbonization drive, this is nowhere near enough for organizations or nations to reach their net zero goals.

But Honeywell is helping to drive momentum and increase the installed capacity of carbon capture around the world. Today, **15 million tons of CO_2 per year is being captured using Honeywell UOP's technology** and sent to storage and utilization applications.

Decarbonization doesn't have to mean a complete overhaul or lengthy downtime. For oil and gas companies seeking alternative delivery models for the deployment of CO_2 separation technologies, we offer modular carbon separation builds. With scales ranging from demo options all the way up to commercial deployments, our experts will consult on your needs to deliver modular carbon capture units with simplified and accelerated installation.

Our modular approach lowers risk through controlled off-site fabrication, accelerates timelines by reducing on-site work, assures fixed costs and schedules, and minimizes interruption to operating assets. With **over 1,700 modular process units delivered so far worldwide**, we are enabling oil and gas companies to move towards their own net zero targets while minimizing disruption to their businesses.

THE HONEYWELL ADVANTAGE

A PROVEN PARTNER

Meeting the sustainability goals of tomorrow demands action today. The deployment of carbon separation technology across production operations is an effective, efficient intervention that can be implemented alongside other initiatives and in line with a business's internal decarbonization timeline. To ensure that the complex, intricate process of carbon capture technology deployment is successful, however, industry players need an experienced and strategic technology provider that can help them reinvent energy operations for the next decade and beyond.

Honeywell UOP can support the drive towards sustainability with domain expertise, technology, and infrastructure. With over a century of experience in molecular management for the oil and gas sector, we have extensive experience in developing technologies for CO_2 reduction. In fact, our separation technologies have been developed and refined for over fifty years, seeing use in applications such as acid gas treatment. Today, by combining these technologies with carbon avoidance solutions such as process optimization and real time operational excellence via digital solutions, we help operators to right size their investments for their specific needs.

With over **70 licensed processes, 5,000 active patents, and decades of expertise,** Honeywell UOP is ready to help operators and businesses around the world de-risk their decarbonization journey.

To start shaping a more sustainable, more successful future together, contact a Honeywell expert today.

References:

1. https://www.iea.org/reports/ccus-in-clean-energy-transitions/ccus-in-the-transition-to-net-zero-emissions
2. https://pmt.honeywell.com/us/en/about-pmt/newsroom/press-release/2023/02/exxonmobil-to-deploy-honeywell-carbon-capture-technology
3. https://carbonherald.com/what-is-45q-tax-credit/
4. https://www.worldenergy.org/assets/downloads/World_Energy_Issues_Monitor_2022_UAE_commentary.pdf
5. https://pmt.honeywell.com/us/en/about-pmt/newsroom/press-release/2023/02/ecopetrol-selects-honeywell-technology-for-advanced-solvent-carbon-capture-study-in-colombia
6. https://pmt.honeywell.com/content/dam/pmt/en/documents/document-lists/data-sheet/UOP-Hydrogen-Solutions-Datasheet.pdf
7. https://hydrogencouncil.com/wp-content/uploads/2023/11/Global-Hydrogen-Flows-2023-Update.pdf
8. https://pmt.honeywell.com/us/en/about-pmt/newsroom/press-release/2023/02/exxonmobil-to-deploy-honeywell-carbon-capture-technology
9. https://www.honeywell.com/us/en/press/2021/04/honeywell-technology-enables-large-us-carbon-capture-and-storage-project
10. https://pmt.honeywell.com/us/en/about-pmt/newsroom/press-release/2022/05/cvr-energy-subsidiary-selects-honeywell-for-a-lower-carbon-hydrogen-study-at-coffeyville-site
11. https://pmt.honeywell.com/us/en/about-pmt/newsroom/press-release/2023/02/ecopetrol-selects-honeywell-technology-for-advanced-solvent-carbon-capture-study-in-colombia

For more information
www.honeywell.com

© 2024 Honeywell International Inc.

Honeywell