

# Carbon Capture and Storage

Implementing energy efficient solutions  
to reduce emissions, costs and enhance oil recovery



**KBR**



Environmental compliance is particularly strong for operators of mature reservoirs, who are gravitating toward the economic benefits of injecting captured CO<sub>2</sub> for enhanced oil recovery.

# Over Half a Century of Experience Implementing Energy-Efficient Solutions

Now more than ever, energy suppliers are focusing on the environment. Rising oil and gas prices are forcing operators to manage plants and power stations with maximum energy efficiency while minimizing energy waste. This focus on energy conservation raises key questions:

- Is your project timeline realistic and feasible to meet revenue streams?
- How will you economically balance technology, sustainable development and safety?
- Are you embracing designs that reduce emissions and increase energy efficiency?

KBR along with its subsidiary, MW Kellogg Limited (MWKL), has over 60 years of experience in designing, constructing and optimizing CO<sub>2</sub> facilities worldwide, and as a result, we understand the many design challenges producers face when evaluating technologies that increase efficiency and minimize potential greenhouse gases.

## Identifying Solutions for a Greener World

Increased public scrutiny, governmental regulations and a desire to conduct sustainable operations have forced manufacturers to embrace plant designs that reduce emissions such as carbon dioxide (CO<sub>2</sub>). For these reasons, carbon capture and storage (CCS) technologies, which remove CO<sub>2</sub> from a process stream before an industrial plant releases it into the environment, have received greater attention in recent years.



Along with our subsidiary, MWKL, KBR's unique gas treatment experience includes designing, engineering, constructing and optimizing hundreds of CO<sub>2</sub> facilities.



As a provider of comprehensive capture solutions to major producers around the world, KBR along with MWKL offers services that include cleaning CO<sub>2</sub> from flue gas, CO<sub>2</sub> compression and drying for transportation and sequestration or injection for enhanced oil recovery.

## Choosing Environmentally-Sound Technologies

Implementing CO<sub>2</sub> capture technologies is an expensive proposition for both retrofits and new plant installations. With this investment in mind, you will want your EPC contractor to optimize your system for reliability and efficiency without lengthy downtime. With our extensive experience in gas processing, we design CO<sub>2</sub> removal systems using all major commercialized CO<sub>2</sub> removal solvents. Whether you need a hybrid or a solitary solution, we are neutral when it comes to CCS technology and have experience working with almost all licensors and equipment suppliers.

## Cultivating Safe Worksites

Organizations that mitigate risk, take proactive measures, reward safety performance, record lost time incidents (LTI) and minimize environmental and social impact are important when choosing an EPC company. While some contractors track lagging indicators (post-incident), KBR tracks leading indicators (pre-incident) and implements best practices to create an injury-free work environment. Achieving project success

means continuously improving safety records and removing health and environmental hazards that could stall production. Further proof of our pledge to cultivate safe worksites includes holding regular safety meetings, embracing safety as one of our core beliefs and achieving 5,584,891 hours at In Salah gas and CCS development project without any recordables.



Safeguarding major processing plants and installations on schedule with an exemplary health, safety and environmental record is a testament to KBR's unshakable core value to put safety first.



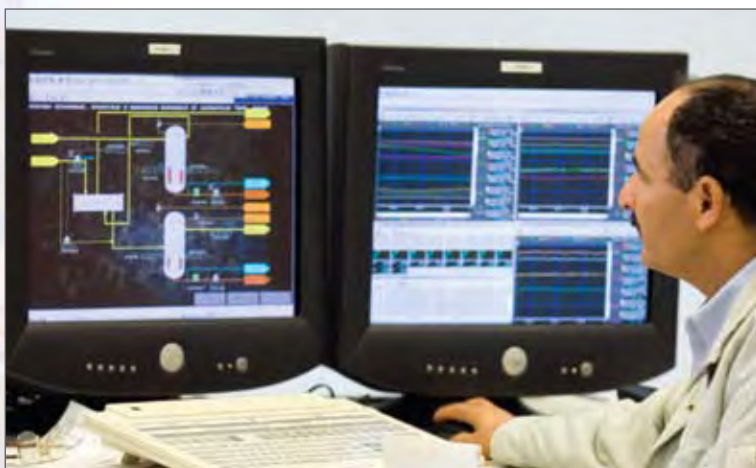
Knowing that experience means everything, BP chose KBR and its joint venture to deliver FEED, full EPC services, infrastructure and construction management to the largest dry gas export and pipeline project in Algeria – In Salah.

## Managing Project Risks

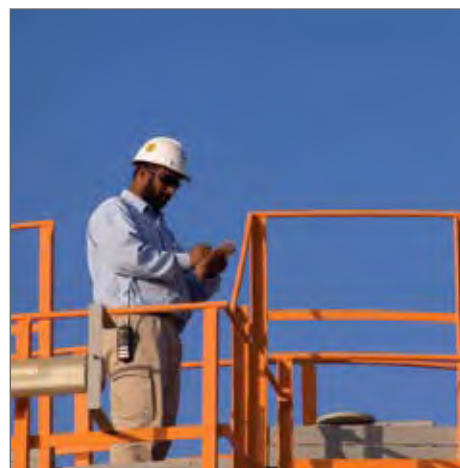
Averting risk throughout the lifecycle of your plant is important to the overall profitability of the facility. For CCS facilities this means you need an expert to manage CO<sub>2</sub> disposal during plant upsets. Thwarting other risks includes installing a CO<sub>2</sub> dehydration unit to prevent corrosion in piping or the formation of hydrates, and choosing proper machinery and material to avoid future threats. With our comprehensive knowledge of CO<sub>2</sub> product quality (composition, temperature, pressure), you can rely on our expertise to meet your injection specifications. Our teams implement plant safety programs that make allowances for populated regions, volumes of fluid processed and uncontained release events. For example, the In Salah project spans four main sites across seven natural gas fields covering 23,000 square kilometers. Some of the challenges that KBR overcame for this BP project included transporting 100,000 tons of freight in 4,500 truck movements covering nine million kilometers.

## Delivering On-Time and Within Budget

Hiring an inexperienced EPC contractor to execute a massive multi-billion dollar CCS project could damage your reputation due to non-performance of the assets, losses through schedule delays and cost overruns. Achieving your monthly objectives depends on having the right systems in place and a strong EPC team aligned with your vision and focused on your goals. At KBR, our project managers will assemble the right team to meet your production targets and local requirements. This is the reason BP, Sonatrach and Statoil among others repeatedly turn to KBR for carbon capture and storage project execution.



Overseeing rigorous process simulation, modeling, feasibility studies, process optimization and early production design and procurement support has granted KBR a reputation of solving "first of its kind" challenges.



By providing a full complement of engineering procurement and construction/ startup (EPC-CS) services, we continue to develop innovative technologies and project execution methods, enabling our teams to deliver some of the most challenging projects on earth.



Development of onshore and pipeline facilities start with KBR designers and engineers' visualization of the most hyper-efficient, cost-effective and environmentally sound project.

## Ensuring Exceptional Results

Deploying tools, systems and procedures globally combined with our advanced project management software allow for borderless work sharing and increase the success of your project. Ensuring that standards and project requirements are aligned with your vision, our experts communicate and monitor progress using business execution tools such as IPMS, project portals, 3D conceptual engineering, project dashboards, geographic information systems and object engineering. Over the years, our extensive project management tools have allowed KBR to communicate work progress while applying our CCS technologies to many projects with major energy companies. As a technology-driven EPC contractor with projects worldwide, KBR has experience with every commercially available CCS process.

## Enhancing Financial Performance with Granherne Consulting

When choosing KBR, you have access to a rich legacy in energy consulting. Our subsidiary consulting business, Granherne, is the foremost front-end engineering consultancy for onshore, offshore and deepwater oil and gas development. With experience on over 3,000 projects in more

than 20 countries, Granherne offers high-value consulting solutions at the forefront of development planning, project support and asset optimization to enhance financial performance, adding value throughout the asset lifecycle.



Helping oil and gas companies monetize their resources, KBR delivered a post-combustion study for Statoil, a feasibility study for Norsk Hydro's hydrogen-based power and conceptual engineering studies for the Norwegian Water Authority in Norway.



Touching every aspect of CCS, KBR delivers design and implementation of capture technologies to safe and efficient transport options, and finally, appropriate storage scenarios.

## Deploying Site Integration Initiatives

One important aspect of reducing the amount of CO<sub>2</sub> released into the atmosphere is improving energy efficiency. KBR has been reducing energy in existing facilities while minimizing energy requirements in new facilities for decades. Site integration links parts of process plants to utility systems and relies on waste heat from one process as a useful energy source for another. This integration process provides an opportunity to improve profitability while reducing emissions. Overall site analysis provides cost effective solutions for utility systems during major site restructuring projects, which typically involve a revamp or addition of major processing units. At KBR, our site engineers have not only conducted numerous studies demonstrating the advantages of site analysis but have also used the results to design new facilities and integrate utility systems between adjacent sites with substantial improvement in plant economics.

## Enhancing Oil Recovery/ CO<sub>2</sub> Storage

As a technology-driven EPC company, KBR has extensive experience injecting CO<sub>2</sub> hundreds of meters underground for long-term storage. Storing CO<sub>2</sub> not only lessens impact on the environment but also increases plant compliance with increasingly stringent environmental legislation. While the US and many countries are still without a carbon tax, many European countries strictly enforce CO<sub>2</sub> legislation including carbon tax. It is certainly possible the US and other countries could pass a carbon tax or other CO<sub>2</sub> limiting legislation on operators who refuse to curb their CO<sub>2</sub> emissions. With our CO<sub>2</sub> storage technology, operators can avoid penalties and fines that authorities might invoke for noncompliance and at the same time address the public's concerns about releasing potential greenhouse gases. Further proof of our capabilities includes designing and constructing In Salah, one of the world's largest CCS gas development projects in Algeria.



Understanding client objections and offering innovative solutions that reduce risk in CCS projects across the globe is how KBR employees operate on a daily basis.



To avoid venting gas into the atmosphere at In Salah, KBR and JGC along with the joint venture between Sonatrach, BP and Statoil designed CO<sub>2</sub> capture facilities and injected CO<sub>2</sub> into a brine formation one mile below the surface.

## Producing Hydrogen and Removing CO<sub>2</sub>

Hydrogen as an energy source is moving towards widespread use. Hydrogen use has the potential to dramatically improve air quality in cities and carbon emissions in the atmosphere because when hydrogen burns it only produces water. KBR is on the forefront of bringing clients economical and environmentally friendly production of hydrogen. One such KBR hydrogen technology includes a combination of KBR Reforming Exchanger System (KRES™) with an AutoThermal Reformer (ATR) or a Steam Methane Reformer (SMR) which provides a low energy and low capital cost alternative to traditional reforming technology, and accelerates client profitability. One such example of increased profitability using ATR and KRES is the Methanex plant in Canada.

## Regardless of the scope of your project, KBR deploys experts worldwide to deliver energy-efficient CO<sub>2</sub> technologies

### Delivering the Optimum Solution in Texas

When Amoco needed an advance CO<sub>2</sub> removal and injection system in Wasson, Texas, they turned to KBR. Besides understanding Amoco's unique challenges, KBR won the EPC contract for this CO<sub>2</sub> enhanced-oil recovery facility. The plant processes 2.4 million standard m<sup>3</sup>/day of associated gas for CO<sub>2</sub> recovery, liquefaction and reinjection. This project included a 15 MW inlet gas compression system with sulfur removal using LO-CAT™ process and dehydration with TEG (triethylene glycol). Besides these offerings, KBR provided a Ryan Holmes CO<sub>2</sub> recovery (1.4 MTPA), liquid CO<sub>2</sub> reinjection at 119 bar, propane refrigeration system, fuel gas treating with MDEA and a waste heat recovery from GT exhaust.



Delivering the FEED and full EPC of one of the world's largest full-scale carbon dioxide capture projects at a gas field, KBR and its joint venture partners are helping the environment by making it possible to inject about one million tonnes of CO<sub>2</sub> into a reservoir each year.



Whether it's a modern large-scale grassroots plant, a revamp or a process unit, KBR has the expertise to meet your business objectives.

## Largest Dry Export and Pipeline Project in Algeria

BP chose KBR and our joint venture when needing detailed engineering, installation and commissioning for its In Salah gas processing plant in Algeria. The project scope included capturing 1,140,000 metric tons per annum CO<sub>2</sub> from the natural gas feed using an MDEA unit, CO<sub>2</sub> compression leaving the MDEA unit and dehydration of CO<sub>2</sub> at a compressor inter-stage with TEG. The gas facility spans four main sites across seven natural gas fields covering 23,000 square kilometers in southern Algeria. The project team designed this gas gathering and export project for 850 million standard cubic feet per day (SCFD). Some of the challenges of a project of this scale included transporting 100,000 tons of freight in 4,500 truck movements covering nine million kilometers. Completing a benchmark project like In Salah that required pipelining dry CO<sub>2</sub> to remote reservoirs 14 to 20 kilometers from the plant is a testament of the talent, innovation and dedication that KBR brings to every project.

## Among the Largest Sellers of Crude Worldwide: StatoilHydro

Delivering a competitive FEED for StatoilHydro's LNG plant in Norway on the island of Melkoya, KBR provided the oil magnet with CO<sub>2</sub> removal from feed gas using aMDEA (activated methyldiethanolamine), CO<sub>2</sub> compression, TEG dehydration as well as CO<sub>2</sub> liquefaction

and export via a pipeline. Besides this LNG FEED, KBR delivered other studies in Norway including a post-combustion study for Statoil and a feasibility study for Norsk Hydro's hydrogen-based power plant and conceptual engineering studies for the Norwegian Water Authority.

## Conserve Energy. Reduce Emissions. Lower Costs. Minimize Taxes.

Creating cleaner environments by capturing, transporting, compressing and storing CO<sub>2</sub>, KBR brings its extensive engineering experience to bear on refineries and power plants alike. Together, we can design, construct and maintain CO<sub>2</sub> plants and pre-and-post-combustion processes to help you reduce your carbon footprint, while allowing you to process energy in the most efficient and reliable manner possible.

**To learn more, visit: [carboncapture.kbr.com](http://carboncapture.kbr.com) or email [carboncapture@kbr.com](mailto:carboncapture@kbr.com)**

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