Climate change and CCS in the GCC

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The year 2014 was recently described by Imperial College London as 'a pivotal year; one which, in time, we will look back on as being the dawn of the age of sustainable fossil fuels', based on major advances in carbon capture and storage. This comment was inspired by progress on power plants with carbon capture in Canada, the USA, and the UK, but it could also have applied to the Gulf Cooperation Council (GCC) countries.

In November 2013, the Abu Dhabi National Oil Company (ADNOC) and the Emirate's clean energy vehicle Masdar announced the formation of a joint venture, whose operations will commence with the world's first commercial-scale carbon capture and storage (CCS) project on an industrial source, in this case a steel plant.

'GCC IS ONE OF THE MOST FAVOURABLE AREAS IN THE WORLD FOR DEVELOPMENT OF A CCS INDUSTRY. ITS CARBON DIOXIDE EMISSIONS ARE AMONGST THE WORLD'S HIGHEST.'

In many ways, the GCC is one of the most favourable areas in the world for development of a CCS industry. Its carbon dioxide (CO_2) emissions are amongst the world's highest: Qatar being at an unwanted number one with 44 tonnes per capita, and Kuwait, the UAE, and Bahrain also in the top ten.

A large fraction of this CO_2 comes from big stationary sources amenable to capture – power plants, waste streams from gas processing, and industrial facilities. In Qatar, as much as 86.5 per cent of total emissions come from such sources: 50 per cent from the oil and gas sector (the giant LNG and gas-to-liquids plants), 27 per cent from power generation, 8.5 per cent from industry, and 1 per cent from oil refining. In Abu Dhabi, the leading oil producing emirate of the UAE, 44 per cent of greenhouse gases come from stationary fuel combustion (mostly power generation), 5 per cent from industry, and 2 per cent from cement. Abu Dhabi is also increasingly developing 'contaminated' gas fields with high contents of natural CO_2.

A high-potential technology

Carbon dioxide sources are in close proximity to many of the world's giant oilfields (making them suitable for enhanced oil recovery (EOR)), and to well-characterized and extensive saline aquifers. Thick shale and evaporite seals have held huge oil and gas columns over geological time – 500 million years or more in the case of some fields in Oman – with little sign of leakage. Carbon dioxide enhanced oil recovery (CO_2-EOR) provides the economic rationale missing in many other CCS projects worldwide. Giant fields with high-quality reservoirs and low production costs make EOR more feasible than in the expensive North Sea, for instance.

GCC-level figures are not available, but the Global Carbon Capture and Storage Institute estimated in 2009 that the Middle East and North Africa as a whole could store 96 gigatonnes of CO_2 in EOR projects, releasing 316 billion barrels of additional oil in the process. This would represent a 60 per cent increase on current reserves (already the world's largest), while the storage capacity represents at least 40 years of the region's emissions from all fossil fuels. Of course, it is probable that a much larger capacity is available from storage in saline aquifers and depleted gas reservoirs.

Local populations are familiar with the oil and gas industry, and environmental lobbies are unlikely to oppose CCS as they have done in Europe. In any case, the oil-fields are generally in sparsely populated deserts or offshore, easing community and safety concerns.

Environmental awareness is growing, although still lagging behind many other countries. The 2006 launch of Abu Dhabi's clean energy vehicle, Masdar, was a particularly notable step. Last year, both Abu Dhabi and Dubai released their first greenhouse gas inventories. And in this wealthy area, government funding is readily available for strategic projects.

Abu Dhabi is by far the most advanced of the Gulf states in advancing carbon capture. The first project for the ADNOC–Masdar joint venture will be to capture 0.8 million tonnes per year of CO_2 emitted from the Emirates Steel plant and to use it for EOR. This $120 million project builds on several years of trials at the Rumaitha field. The Emirates Steel Plant has the advantage that its Direct Reduced Iron process already produces a stream of relatively pure CO_2.

Although a major step forward, this project is smaller and later than was originally planned at Masdar's launch. Originally, three projects were to capture 5 million tonnes of CO_2 annually: a hydrogen power plant in partnership with BP; the Taweelah aluminium smelter; and the Emirates Steel project. Other CCS plans have been advanced: for example, ADNOC has a roadmap for progressively moving to CO_2-EOR, including from natural (contaminated gas) sources, while Maersk has been advocating its TriGen technology, an oxyfuel gas combustion process which produces

electricity, high-purity CO_2, and potable water.

Various applications in the GCC context

Dubai, amongst other emirates of the UAE, has considered building a coal-fired power plant with CCS, but it now seems that the project, if it goes ahead, will simply be a standard plant, albeit with pollution controls. The small northern emirate of Ras Al Khaimah plans a $1.5 billion, 270 MW coal-fired power station with carbon capture, the CO_2 to be used for industrial uses and EOR, although in which fields is not clear.

Saudi Arabia's state oil firm Saudi Aramco plans the injection of 0.8 million tonnes of CO_2 from gas processing into the Uthmaniyah section of the world's largest oilfield, Ghawar, over a three-year period starting in 2015. The Kingdom maintains that it will not need CO_2-EOR to meet its oil production goals for many years to come, and that this is a pilot project to build expertise. Linde will construct a 0.5 million tonne per year CO_2 capture plant at two ethylene glycol plants in the petrochemical centre of Jubail, with the CO_2 used for methanol, urea, and food processing.

Research institutions such as the King Abdulaziz City for Science and Technology and the King Abdullah Petroleum Studies and Research Centre have also been carrying out studies.

By autumn 2014, the Qatar Fuel Additives Company plans to install a 180,000 tonne per year CO_2 recovery unit at its methanol plant, at a cost of $80 million. Qatar's maturing oilfields and giant high-purity CO_2 source at Shell's Pearl gas-to-liquids plant make it theoretically an ideal candidate for CO_2-EOR. But otherwise, apart from studies on the Dukhan and Al Shaheen fields, and the establishment of a joint CCS research centre with Shell, there has been little progress.

Bahrain has a carbon capture unit at its Sitra petrochemical complex, which extracts about 160,000 tonnes of CO_2 per year for urea and methanol synthesis. Kuwait's petrochemical company Equate also captures some CO_2 for sale to industrial users.

Oman has done least in CCS amongst the GCC members, perhaps surprisingly given its use of a range of other EOR techniques. However, it does have very large deposits of peridotite, which can be used in mineral carbonation to lock up CO_2 in solid form, a potential long-term option to reduce the amounts of CO_2 that have to be injected underground. Other long-term technologies that might be applicable in the GCC include: calcium looping for carbon capture from cement plants; and using CO_2 for enhanced growth of algae for biofuels, which is being researched at the Masdar Institute.

Incentives vary

The incentives to advance CCS vary between the various Gulf countries. Possible motivations are economic, environmental, technological, strategic, and reputational.

Economic drivers include the value of additional hydrocarbons recovered or saved from reinjection. Abu Dhabi injects some 2 Bcf (billion cubic feet) per day of gas for enhanced oil and condensate recovery. With an increasing 'gas crunch' over the next few years – being faced with the development of more costly sour gas resources and plans for LNG imports late in the decade – replacement of re-injected gas with CO_2 can be seen as highly cost effective. A simple calculation suggests that avoided LNG imports could be equivalent to a CO_2 price of more than $250 per tonne, far above likely capture costs. Full replacement of all re-injected gas suggests the potential for some 40 million tonnes per year of CO_2 injection, about a third of the country's total emissions from gas combustion.

Mature oilfields in Oman, Bahrain, and Qatar, now in a phase of decline, could also benefit from CO_2-EOR. Saudi Arabia and Kuwait will require EOR in the future, though large-scale application may be one or two decades away. As noted, four of the GCC states are already using captured CO_2 in industrial processes, albeit on a relatively small scale.

The environmental goal – reducing CO_2 emissions – is accepted as a useful side benefit but is not a core driver of policy. Technological objectives, stressed by Saudi Arabia, include the creation of new skills and industries.

Strategic goals include: the ability to play a constructive role in international climate negotiations, to establish gas as a long-term sustainable energy source, and to create 'carbon space' for continued oil exports. With a gas reserves life of 160 years at current production rates, Qatar is particularly exposed to a more stringent climate policy regime towards mid-century. This is analogous to the interest in CCS from major coal producers and exporters such as the USA, Australia, and China.

Reputational benefits include: bolstering an image of technological progress, and reducing embarrassingly high CO_2 footprints at a time when the UAE and Qatar, in particular, are seeking to become global centres of business and tourism.

These various goals are mostly congruent with other clean energy approaches being adopted by the GCC – energy efficiency initiatives, solar power, and (in the UAE and perhaps Saudi Arabia) nuclear power.

Lagging progress

Given all these advantages, why has the GCC not made more progress in CCS?

Some of the reasons are common to most carbon capture initiatives worldwide: the lack of a commercial rationale in the absence of strict emissions limits or carbon pricing; the challenge of matching utility and oil company business models; and the high cost and perceived technical risk of the capture process. The UAE put its support behind efforts, successful in late 2011 at the UN Climate Change Conference in Durban, South Africa, to include CCS in the Clean Development Mechanism and so make it eligible for carbon credits.

But carbon prices around the world have collapsed because of: oversupply as emissions plunged during the financial crisis, competing policies on renewable energy targets, and failures to agree stricter climate targets. EU carbon prices reached a record €32 per tonne in 2006 but have now fallen to about €5 per tonne. The collapse in carbon prices makes it only a minor contributor to the economics of CCS projects – a problem for putting carbon capture on an equal footing with mandated renewables.

National oil companies (NOCs) and (usually monopoly) utilities tend to be technically conservative and risk-averse. They have to work together to advance CCS projects, but commercial coordination has proved problematic – just as it has in many Western countries. The Masdar–ADNOC joint venture is important in this regard, but it is notable that it does not yet include the emirate's power generation utility ADWEC. The national oil companies' priority is to achieve oil production targets at minimum cost; that of the utilities, to provide reliable, low-cost electricity. The government has to set a strategic goal for carbon capture to be compatible with these considerations.

Subsidies and non-commercial pricing of gas and electricity are also problematic, as in other areas of GCC clean energy policy. With gas priced cheaply or even free to oilfield operators, they have no incentive to replace it with CO_2 – which has to be purchased – for EOR. A single monopoly NOC and utility engage in a zero-sum negotiation over CO_2 pricing. Although environmental awareness in the GCC is rising, it is still not high enough to overcome the historical and political bias towards heavy energy subsidies – unfavourable for clean but relatively costly generation technologies.

'CARBON DIOXIDE ENHANCED OIL RECOVERY PROVIDES THE ECONOMIC RATIONALE MISSING IN MANY OTHER CCS PROJECTS WORLDWIDE.'

There are also specific GCC political challenges. The six nations have relatively limited economic integration, and have neither common energy policies, nor a shared gas grid (the Dolphin pipeline from Qatar to the UAE and Oman being the only exception). This makes plans for CO_2 pipelines between states appear rather unlikely at the moment, although given ample storage space within national boundaries this may not be a problem. However, it does inhibit cross-border learning; this is unfortunate as the geological, economic, and regulatory challenges are very similar throughout the bloc.

However, the Masdar–ADNOC project and the Saudi Uthmaniyah scheme will make the GCC into one of the world's leading areas for CCS. Specific experience here can be applied to other giant fields in the MENA region, and worldwide. Together with the new CCS projects in Canada, the USA, and the UK, within a few years there should be a full spectrum – coal and gas; pre-combustion, post-combustion and oxyfuel; and industry – of demonstration plants worldwide. Real cost benchmarks and operational experience should enable the next generation of projects to go forward faster and with more confidence. It will no longer be possible for opponents to write off CCS as an 'unproved' technology.

Carbon capture has seen several false dawns since its birth in 1996. It may still encounter new obstacles. But the GCC, more than any other region, needs the age of 'sustainable fossil fuels' to emerge soon.

Robin Mills has published the books The Myth of the Oil Crisis *(2008 Greenwood Press), and* Capturing Carbon *(2011, Columbia/Hurst).*