Title
How the low price of oil can spur CCS research innovation

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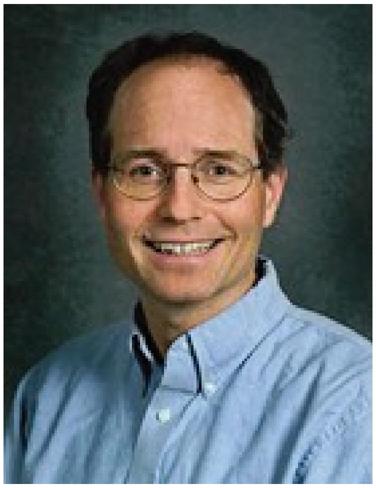

The global consumption of oil grew in 2015 as prices fell due to oversupply. Low oil prices are problematic for greenhouse gas (GHG) reduction efforts because they tend to discourage use of energy-efficient vehicles and encourage driving and related CO_2 emissions. From this perspective, low oil prices would seem to be entirely detrimental to lowering GHG emissions. When you factor in the fact that low oil prices have reduced oil-company-sponsored funding for carbon capture and storage (CCS) research efforts which aim to develop safe and feasible ways to reduce GHG emissions from the use of fossil fuels, the picture for lowering GHG emissions seems even gloomier.

But there is at least one potential silver lining in low oil prices for CCS research and development, and this involves utilization, and in particular, geologic interim storage of CO_2. Specifically, it has long been recognized that the high costs of capture and storage have discouraged widespread development and implementation of CCS. On the other hand, if CO_2can be beneficially utilized, for example for CO_2-enhanced oil recovery (CO_2-EOR), then these costs can potentially be recovered through the sale of oil that would otherwise be left underground. With the current low price of oil, there is very little incentive now for utilization through CO_2-EOR. But what about investing in a utilization option for a future when the cost of oil will inevitably be much higher than it is today? The fact is that CO_2 can be captured today and stored underground for future beneficial utilization that would still ensure its isolation from the atmosphere.

This goal of storage and recovery of CO_2 brings up the long debate in the CCS community about the use of the words ‘sequestration’ and ‘storage’. Most of us carrying out research in the subsurface part of CCS have emphasized trapping and immobilization of the CO_2 to ensure minimal likelihood of leakage to groundwater resources or surface leakage to the atmosphere. We generally think of geologic carbon sequestration as a one-way process by which CO_2 is injected and left permanently sequestered in the deep subsurface. The term storage, on the other hand, can be interpreted to imply an interim solution to fossil fuel GHG emissions and conveys the possibility of recovery of the CO_2 if needed, for example, for later utilization.

Under the current situation of low oil price, the objective of interim storage appears to be strongly motivated by (i) the current lack of economic incentive for utilization, (ii) today's lower cost of CO_2 capture afforded by low energy cost, (iii) the critical need to reduce CO_2 emissions, and (iv) the prospect of higher utilization value in the future when oil prices inevitably rise.

So why is the low price of oil and the need for interim storage of CO_2 a potential boon to CCS research innovation? The fact is that the objective of trapping CO_2 for permanent sequestration differs substantially from the objective of storing CO_2 for potential recovery and utilization. For example, the sequestration objective is to maximize CO_2 trapping by residual phase saturation, dissolution into native brine, and mineral reactions. The storage objective in contrast needs to maximize retention of CO_2 in its free-phase and mobile forms. Storage requires high-quality reservoirs (high permeability and porosity, and low reactivity) with excellent cap rock for containment. Sequestration without potential recovery allows for a much larger range of reservoirs including dipping structures and thick variably-baffled structures that allow CO_2 migration and promote residual phase trapping. While most of the subsurface part of CCS research to date has focused on studying processes and geologic structures that maximize trapping, new efforts in CCS research can now focus on optimizing interim storage of CO_2.

For example, in the area of capacity assessment, sequestration, and interim storage attributes will need to be separated so that regional opportunities for both endeavors can be identified and quantified. As for temporal containment requirements, researchers will need to acknowledge the vastly different time scales for storage versus sequestration effectiveness, the latter generally requiring millennia to be effective whereas the former may be only decades in duration – a factor which may open up some storage opportunities that have been ruled out by the long-term sequestration objective. In the area of injection design and reservoir engineering, there is the possibility of pre-conditioning a reservoir to maximize mobility, for example by removing as much brine as possible before storing the CO_2. This could be accomplished most directly by brine extraction through pumping wells, but could also potentially be addressed by the injection of air to drive brine out of the reservoir through displacement and vaporization. Native water residual saturation could be reduced potentially by injecting viscosity- and/or surface-tension-reducing agents that could make native brines more mobile during brine removal in preparation for the storage of CO_2. And of course the storage objective would favor certain containment strategies currently considered too small for large-scale geologic carbon sequestration, including solution-mined salt caverns, which are known to be excellent storage containers. Of course there will be many other innovative research areas to pursue as identified by the creative minds working on the critical problem of reducing GHG emissions from the use of fossil fuels.

Can we get started on CO_2 storage innovation today? Yes, a few projects come to mind for which captured CO_2 was intended to be used for CO_2-EOR, a need that may now not be economically feasible in the near term. These are the SaskPower Boundary Dam and Aquistore projects in Saskatchewan, Canada, and the Kemper County project in Mississippi, USA. Each of these projects was designed with the objective of selling CO_2 for EOR, and each project has made large capital investments in capture capabilities. What are they to do with all of their captured CO_2? It appears that a strong argument can be made that captured CO_2 should be stored for potential later recovery for beneficial utilization when the price of oil becomes high enough to make CO_2-EOR attractive. In the meantime, new research efforts that complement existing sequestration research can be focused on the safe and practical injection of CO_2 to optimize the interim storage and recovery objectives needed to meet this future utilization demand.

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Editor-in-Chief