Institute for Energy Economics and Financial Analysis

Fact Sheet

Risks across the carbon dioxide disposal chain

Carbon capture and storage (CCS) is proposed as a means for addressing a portion of anthropogenic carbon dioxide (CO_2) emissions by the oil and gas industry, along with other high carbon-emitting industrial processes.

CO_2 disposal is not one activity but a string of separate projects that include CO_2 capture from effluent streams; separation, purification, and compression for transport; transportation; compression for well injection, and geologic disposal underground or, in most cases, use for forcing more oil and gas out of older production fields in a process referred to as "enhanced recovery." Each of these steps in the disposal chain entails its own set of challenges and risks.

Goals

- CCS attempts to mitigate emissions by capturing CO_2 from industrial effluents and production processes, transporting it, then injecting it underground for disposal:
  - CO_2 is compressed into a "supercritical state", making it dense like a liquid but still expansive like a gas
  - CO_2 is then injected at high pressure, a minimum of 800 meters below the surface
  - CO_2 is forced into subsurface pore spaces to attempt to trap or chemically bond it with rock
- **Carbon capture, utilization, and storage (CCUS)** attempts to find uses for the captured carbon instead of sequestering it:
  - In more than 95% of the cases, it is used for enhanced oil production where the primary purpose is not to store the CO_2 but to force more oil out of the ground

Challenges

- Real-world data shows carbon capture efficacy rates vary widely, averaging 50%, and none even close to the industry targets of 90%-95%
- Storing carbon dioxide underground is not an exact science, carrying more risk and uncertainty than drilling for oil or gas, given the very limited practical, long-term experience of permanently keeping CO_2 underground
- Even those scientists and engineers working on storage projects concur that CO_2 behavior will remain unknown until it is put into the ground, regardless of prior survey, engineering, or lab work that goes into site design and preparation
- Even minor leakage rates are unacceptable as that undermines the permanent climate premise of CCS

> **Subsurface CO_2 storage is an amalgamation of probabilities and risks, some of which can be identified, others remaining unknown until troubles materialize. These risks – and the costs that accompany them – are not being made part of public discourse by either industry or government.**
>
> Grant Hauber, Strategic Energy Finance Advisor, Asia

Risks

CO_2 Purity Requirements

- CO_2 purity requirements for CCS are very high, reaching 99.998% for super-critical fluid
- Contaminants can change CO_2 properties, affecting the liquid-gas density point and potentially resulting in accelerated corrosion of pipeline and well casing systems
- CO_2 needs pre-processing to remove such contaminants like water, gasses, hydrogen sulfide, and heavy metals, with filtration byproducts requiring proper disposal

CO_2 Pipelines

- Limited number and length of underground CO_2 pipelines globally
- Challenging permitting, extensive implementation timeframes
- CO_2 pipelines need higher quality/higher cost alloy steels due to corrosion potential
- Leaks can displace oxygen at ground level leading to the risk of asphyxiation in humans

CO_2 Shipping

- Vessels that can transport CO_2 do not currently exist and must be built
- Higher CO_2 purity needed during transportation, above 99.7%
- Ships carrying CO_2 over long distances may require reliquefication plants
- Handling CO_2 requires specially designed and configured ports
- Transportation vessels require specialty materials and designs and cannot be used to carry any other commodities
- Small-scale and specialty operating requirements mean higher costs per tonne-kilometer

Subsurface CO_2 Injections

- CO_2 well design is much more stringent compared to oil and gas, requiring specialized alloy drill casings, gaskets, and high specification cements
- Wellhead fittings and equipment need to be specifically designed and certified to handle CO_2 and must withstand wider temperature and pressure ranges than oil and gas standards
- Most of these fittings and equipment remain in the research and development stage
- Maintenance cycles are also shorter and more critical

Reality Check

- Renewable energy, energy efficiency, and eliminating fugitive methane emissions can address more than 80% of the world's decarbonization requirements by 2030
- International Energy Agency (IEA) and Intergovernmental Panel on Climate Change (IPCC) projections show a small and shrinking role for CCS in overall decarbonization efforts as the costs and reliability of alternatives becomes clearer
- CCS, even if its technical deficiencies can be overcome, due to costs, uncertainties, and risks, can only provide a minimal contribution to decarbonization
- Putting CO_2 back into the ground is proving to be far more technically complex and filled with uncertainty
- The ongoing costs of monitoring, studying and contingency plans are material
- In the event of a performance deviation, the need for action may be immediate, requiring high levels of technical and financial resources as well as specialist equipment
- Even with the best talent and resources, experts are still uncertain whether the CO_2 will behave as required

References

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