International Association of Oil and Gas Producers

European Petroleum Industry Association

Carbon dioxide Capture & Storage Can Significantly Reduce GHG Emissions But It Needs a Legal and Regulatory Framework

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Executive summary

1. In view of the world's rising energy demand and in the absence of breakthrough carbon-free technology applicable on a large scale, a portfolio of options is needed to manage the risk of global climate change. Capture and geologic storage of carbon dioxide is an important option that can result in large reductions in emissions of carbon dioxide.

2. It is unclear whether some applications of carbon dioxide capture and storage (CCS) are compatible with existing international, regional and national law, since CCS was not considered when such law was adopted. It is also unclear what the safety, environmental and liability conditions might be. This lack of clarity is hampering the development of CCS from its current, limited applications into a cost-effective, widespread and economically viable option.

3. Carbon dioxide that would otherwise be released into the atmosphere can be captured from chemical reactions, including hydrogen production, and combustion processes. It can be transported by pipeline or ship and it can be injected into deep saline formations and into depleted oil and gas reservoirs around the world, both under land and sea. Storage capacities are immense and CCS can contribute considerably to reducing the amounts released into the atmosphere for many decades.

4. Safety and environmental risks are linked to sudden localised releases. Gradual and diffuse leakage, depending on the volumes and the number of storage sites where this occurs, could defeat the purpose of storage to reduce carbon dioxide emissions. Given appropriate selection, operation and monitoring of storage sites, however, these risks are considered to be very low.

5. Storage projects for which the risk of leakage can be established as negligible over long time spans may qualify for emission credits under the Kyoto flexible mechanisms and related emissions trading schemes.

6. Some stakeholders fear that amending existing legislation to accommodate carbon dioxide storage might alter the spirit of the laws in question, i.e. to protect offshore and onshore waters, including the ground below them. We believe that it is possible to adapt and complement existing legislation in such a way that only carbon dioxide storage is enabled and in accordance with clear and effective rules.

7. Our members can offer expertise: The techniques of drilling injection wells and injecting carbon dioxide are similar to the techniques applied to drill for oil and natural gas. In addition, expertise has been gained in the modelling of flows and chemistry in reservoirs. Our members have also gathered experience in injecting carbon dioxide at small scale.

8. Our members can offer opportunities: Existing oil and gas installations can be adapted for the injection of carbon dioxide into depleted oil and gas fields and deep saline formations. Considerable investment, however, is required. Injection into oil and gas fields also contributes to security of energy supply by enabling the recovery of notable amounts of hydrocarbons that is currently left in the ground.

9. Clarification and adaptation of the legal framework and the development of rules for safety, environmental protection and liability are expected to have the following positive effects:
   - Paving the way for greater industrial investment, including R&D, in CCS;
   - Development of rules enabling the crediting of carbon dioxide emission reductions through storage;
   - Opening the option of using a number of existing oil and gas production facilities that are close to depletion for carbon dioxide injection before they are decommissioned.

10. It will be vital that all interested parties work together towards a common goal. The potential to turn CCS into a cost-effective, widespread and economically viable option to reduce carbon dioxide concentrations in the atmosphere should not be missed and should be seized now.

What is Carbon Dioxide Capture & Storage about?

In view of the world's rising energy demand and in the absence of breakthrough carbon-free technology, a portfolio of options is needed to manage the risk of global climate change. All sustainable options should be developed and used. Options available include: energy efficiency and conservation, energy sources with low or no emissions of carbon dioxide, and management of forests and soils to increase carbon stocks. Capture and geologic storage of carbon dioxide arising from chemical and combustion processes is an important additional option that can result in large reductions in emissions of carbon dioxide. It is a relatively new option that is rapidly gaining support. In a study released in December 2004, the International Energy Agency (IEA) says that "CCS is a promising emission reduction option with potentially important environmental, economic and energy supply security benefits".

Use of carbon dioxide capture and storage (CCS) will require enabling legal and regulatory frameworks. It is unclear whether some CCS applications are compatible with existing international, regional and national law, since CCS was not considered when such law was adopted. It is also unclear what the safety, environmental and liability conditions might be. This lack of clarity is hampering the development of CCS from its current, limited applications. Legislators and regulators are urgently invited to amend and develop the legal framework, to enable realisation of cost-effective, widespread and economically viable CCS.

How does it work and what is the potential?

Carbon dioxide that would otherwise be released into the atmosphere can be captured from chemical reactions, including hydrogen production, and combustion processes. The captured carbon dioxide can be transported, if necessary, by pipeline or ship and stored in geologic formations.

Carbon dioxide can be stored in large quantities in deep saline formations and in depleted oil and gas reservoirs. Both can be found around the world, under land and sea. The IEA has estimated that the capacity for carbon dioxide storage could reach up to 10 000 gigatonnes in deep saline formations and up to 1 000 gigatonnes in depleted oil and gas reservoirs. The world emitted 24 gigatonnes of carbon dioxide in 2002. This means that even in the face of rising emissions, geologic storage could contribute considerably to reducing the amounts released into the atmosphere for many decades.

Injection technology is proven and mature, as it is very similar to the technology used in the exploration and production of oil and gas. A number of projects is operating world-wide (see annex), confirming the potential of CCS as a technically viable option to reduce carbon dioxide emissions to the atmosphere.

How safe and environmentally sound is it?

Carbon dioxide is an odourless gas that can neither explode nor burn. At high concentrations, it can, however, lead to suffocation on land or acidification of seawater. As carbon dioxide is heavier than air, direct risks are related to a sudden localised release of large quantities of carbon dioxide, particularly in low lying areas or the marine environment. Low level, diffuse leakage would not pose a direct risk to human health.

The indirect risk of leakage is that the carbon dioxide stored underground gradually finds its way into the atmosphere, which could defeat the purpose of storage, depending on the volumes that escape and the number of storage sites where this occurs. Storage projects for which the risk of leakage can be established as negligible over long time spans may qualify for emission credits under the EU Emissions Trading Directive or the National Greenhouse Gas Inventories required by the UNFCCC.

The risks of leakage related to the transport of carbon dioxide are comparable to those related to the transport of natural gas, both of which can be transported by pipeline or ship.

The technology of construction and operation of a carbon dioxide pipeline is very similar to that of a natural gas pipeline. Pipeline networks often link remote places offshore and/or abroad, wherever the gas is extracted, with local industrial plants and households. Long-distance gas pipelines are operated at high pressure. Pipelines transporting carbon dioxide safely on land over hundreds of kilometres have existed for more than 30 years, e.g. in the United States. Accidents in connection with the transport of natural gas have occurred, as recently in Belgium when a pipeline was damaged during unrelated excavation works. Such incidents, however, are extremely rare.

Liquefied Natural Gas (LNG) is transported by special ships that can keep the gas liquid at low temperatures around -163°C. Similar ships are already used today to transport carbon dioxide for industrial purposes, albeit in relatively small volumes. Larger ships using similar technology would be needed to transport carbon dioxide for large-scale geologic storage.

Ships transporting Liquid Petroleum Gas (LPG) would be suitable to transport carbon dioxide. For this, it would be sufficient to reinforce the steel tanks to resist a pressure of 10 bar.

Given appropriate selection, operation and monitoring of storage sites, the risks of carbon dioxide leakage from depleted oil and gas reservoir and deep saline formations are considered to be very low.

Are there other concerns?

Environmental non-governmental organisations have emphasised the fact that energy is required and emissions are generated in the process of capturing and storing carbon dioxide. This is true. The consensus view, however, is that there is the potential net emission reduction is considerable and that this may increase as capture technology becomes more energy-efficient.

Furthermore, some environmental NGOs have raised the concern that the development of CCS might divert efforts and financial means from the development of certain non-carbon emitting energy sources. We do not believe that the two are necessarily in competition with each other. Both have been under development in parallel by governments and industry over several years around the world, and both will be required, along with other options, to stabilise atmospheric carbon dioxide. In the management of climate change risks, it is essential to develop a portfolio of options based on their merits given the challenge presented by the large magnitude of global carbon dioxide emissions and our inability to predict how the performance of different options will improve with advances in technology.

The latest World Energy Outlook of the International Energy Agency (IEA) indicates that global primary energy demand is set to increase by 1.7% per year from 2000 to 2030 and that fossil fuels will remain dominant, accounting for more than 90% of the increase in energy use to 2030. It says that while new, renewable forms of energy will grow rapidly, they start from a small base and cannot displace fossil fuels as the over-riding source of energy in this timescale. The development of lower carbon, advanced fossil fuel energy technologies, including CCS, must therefore be part of the portfolio.

Concern has also been expressed about amending existing legislation to accommodate carbon dioxide storage, as the spirit of the laws in question, i.e. to protect offshore and onshore waters, including the ground below them, might be altered. We believe that it is possible to adapt and complement existing legislation in such a way that only carbon dioxide storage is enabled and in accordance with clear and effective rules.

What can our members do?

The techniques of drilling injection wells and injecting carbon dioxide are similar to the techniques applied to drill for oil and natural gas. Expertise has been gained in the modelling of flows and chemistry in reservoirs. Carbon dioxide, where it is readily available, is already injected in certain reservoirs around the world to mix with, mobilise and enhance the recovery of oil in mature fields. In certain circumstances, carbon dioxide can also be used to enhance the recovery of natural gas. An estimated 30-50% of the carbon dioxide injected for these purposes comes back to the surface along with the hydrocarbons produced, but this may again be separated and the carbon dioxide re-injected for permanent storage.

Enhanced oil and gas recovery, for which there are a number of techniques next to carbon dioxide injection, can also contribute to security of supply. The worldwide average recovery rate for oil fields is currently about 35% and about 70-80% for gas fields. In other words, 65% of oil and 20-30% of gas in producing fields is currently left in the ground. The additional amount that could be extracted if the recovery rate were increased by only 1% could meet the current global demand for 1.5 years. In the United States alone, an estimated 18 billion barrels of additional oil could be extracted through the use of carbon dioxide.

Most enhanced oil recovery (EOR) experience has been gathered in the United States, where carbon dioxide is injected today into more than 70 fields. The volumes are in the order of 45-40 million tonnes of carbon dioxide per year. 70% of these volumes come from natural sources, i.e. the carbon dioxide is produced from natural underground reservoirs, and 30% come from industrial sources. The reason why there are not more industrial sources is that the capture of the carbon dioxide produced is currently too costly, as concentrations of carbon dioxide in exhaust gases from industrial processes are rather low. In the United States, legislators and authorities are currently considering financial and fiscal incentives to improve the economics of new power generation and EOR.

The United States also offers two excellent examples of carbon dioxide being piped safely on land over large distances. In Texas, a network of pipelines has been transporting carbon dioxide from natural resources over several hundred kilometres for EOR for more than 30 years. Since 2000, a 323km pipeline linking North Dakota in the U.S. and Weyburn in Canada has been transporting some 4 million tonnes of carbon dioxide each year from a U.S. plant converting lignite into natural gas and a number of useful by-products, to Canadian oil fields for EOR. Some 20 million tonnes of carbon dioxide are expected to be permanently stored in the reservoir.

Our members have also gathered experience of injecting carbon dioxide into deep saline formations where it has been a cost-effective measure and legally possible. For example, the gas produced on the Norwegian platform Sleipner naturally contains large volumes of carbon dioxide. The carbon dioxide is separated from the natural gas on the platform and is injected into a deep saline formation above the reservoir. Since 1996, approximately 1 million tonnes of carbon dioxide have been injected each year. This amount is equivalent to the emissions from a quarter of a million cars. Costs are offset by the reduction in carbon dioxide tax levied in Norway on emissions.

The In Salah project in Algeria is now also storing 1 million tonnes of carbon dioxide per year two kilometres below the surface of the desert. The storage geology at In Salah is very similar to other areas in Europe where large volumes of carbon dioxide could be stored. Over the life of the In Salah project, it is planned to store 17 million tonnes at a cost of around €6/tonne carbon dioxide. There is currently no source of revenue or savings for this storage project.

More projects of EOR and storage in deep saline formations are listed in an annex to this paper. We can provide further details and a considerable number of case-studies.

Another asset of our members is the increasing availability of installations. The North Sea, for example, is a mature area of oil and gas production. This means that recovery is expected to decline and installations are expected to be decommissioned over the next 10-15 years. Some of the installations could be used to inject carbon dioxide for enhanced recovery and/or storage. Once the installations are decommissioned, however, the opportunity will be lost.

What do we need to develop CCS as a cost-effective, widespread and economically viable option?

A number of research framework programmes include CCS and projects are under way to develop the technology and to make it more economic. This has to be complemented by the development of an appropriate legal framework.

Any industrial activity today is controlled by rules relating, inter alia, to safety, environmental protection and liability. The investor has to take the requirements resulting from these rules into account when establishing the technical and economic feasibility of an activity. Also in the case of existing oil and gas installations, considerable technical adaptation and investment is required to make them suitable for CCS.

Rules applying to oil and gas exploration and production could serve as a model for CCS. Discussions have started on the relevance and need of adaptation for CCS of the following international, regional and EU legislation, to mention just the most important:

- The 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter and its 1996 Protocol

- The 1992 OSPAR Convention on the Protection of the Marine Environment of the North-East Atlantic
- The 2000 EU Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)

The following may highlight the unsatisfactory legal situation: In a report of June 2004, the OSPAR Group of Jurists and Linguists concluded that geologic storage of carbon dioxide produced onshore and injected from a ship, an offshore installation or other structure in the maritime area (excluding pipelines) for the purpose of mitigating climate change may require amendments to the Convention. In contrast, injection from offshore installations of carbon dioxide produced on the same or other installations offshore, e.g. together with natural gas, for climate change mitigation would not.

There is optimism that the existing regulatory frameworks in North America and Canada, which already allow the mentioned EOR operations, can be easily extended to carbon dioxide injection for the purpose of storage.

Clarification and adaptation of the legal framework and the development of rules for safety, environmental protection and liability are expected to have the following positive effects:

- Paving the way for greater industrial investment, including R&D, in CCS;
- Development of rules enabling the crediting of carbon dioxide emission reductions through storage under the Kyoto flexible mechanisms and related emissions trading schemes;
- Opening the option of using a number of existing oil and gas production facilities that are close to depletion for carbon dioxide injection before they are decommissioned.

The need to clarify and adapt the legal framework has been recognised around the world. It has been under discussion within the Conventions, within the EU and at national level. Organisations, such as the IPCC, the IEA and the Carbon Sequestration Leadership Forum (CSLF) have taken it on board. Workshops have been held at which decision-makers have informed themselves about the safety and environmental soundness of carbon dioxide storage.

What seems to be needed now is the political will to make things happen. Legal decisions cannot be taken overnight and usually require several years to mature. If a beginning is not made soon, precious time will be lost.

Our members have relevant experience and would be pleased to provide data and information they have available to assist in the development of the necessary legal framework and practical rules and to understand technical and economic issues, and it will be vital that all interested parties work together towards a common goal.

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Annex - List of current CCS projects

Sleipner, North Sea in Norway: There is currently a carbon dioxide injection project at the Sleipner gas field operated by Statoil in the North Sea. carbon dioxide has been injected here into a deep saline reservoir, the Utsira Formation, since 1996.

Weyburn, Canada: The location of the project is the Weyburn oilfield in Canada, first discovered in 1954. In October 2000, EnCana began injecting significant amounts of carbon dioxide into a Williston Basin oilfield (Weyburn) in order to boost oil production. Overall, it is anticipated that some 20 Mt of carbon dioxide will be permanently stored over the lifespan of the project. The gas is being supplied via a 323 km long pipeline from the lignite-fired Dakota Gasification Company synfuels plant site in North Dakota.

K12-B, North Sea in the Netherlands: This is a Gaz de France project demonstrating subsurface storage of carbon dioxide in (nearly) depleted gas reservoir and enhanced gas recovery.

In Salah, Algeria: BP will inject carbon dioxide stripped from the natural gas produced into the boundaries of the gas field.

Japan: Small-scale carbon dioxide injection and monitoring projects under way, involving storage in depleted oil and gas fields.

Europe (RECOPOL) and United States: Small-scale injection projects involving storage in coal are under development.

Snøhvit, Barents Sea in Norway: Statoil is planning a project where gas from the Snøhvit field will be treated to remove carbon dioxide. The stripped carbon dioxide will be injected into a geologic formation below the gas field.

Barrow Island, off Western Australia: ChevronTexaco is planning to exploit the gas reserves in the Gorgon field. The carbon dioxide in the gas will be stripped and injected into the Dupuy Formation at Barrow Island.

CRUST, the Netherlands: The project is examining issues leading to the creation of an underground carbon dioxide buffer facility, capable of making the carbon dioxide available subsequently for commercial application.

CO2SINK, Ketzin near Berlin, Germany: It is planned to inject approximately 30,000 tonnes of carbon dioxide into an aquifer which situated under a redundant gas storage reservoir. The target reservoir is 600 - 700m deep.

Mendoza, Argentina: Carbon dioxide produced at the wells at Cerro Fortunoso oil field, operated by Repsol, will be injected to reduce greenhouse gas emissions.