July 2nd, 2007

The Honorable Loni Hancock
Chair, Assembly Natural Resources Committee
California State Capitol
PO Box 942849
Sacramento, CA 94249

Dear Chairwoman Hancock,

We are writing in relation to the scientific issues that were raised around Carbon Capture and Sequestration (CCS) in the context of AB 705 (Huffman) earlier this year. In particular, we would like to clarify some of the issues addressed in the committee staff analysis of the bill and in opposition letters.

We only wish to address the science of CCS here, in order to explain the impetus behind AB 705, which calls for the regulation of CCS operations. As the reaction to AB 705 illustrated, there is a clear need for sincere dialogue and information sharing on the matter between all parties. Environmental Justice advocates in particular raised concerns, and it is in everyone's interest and the duty of policy makers to understand them and proceed in a manner that addresses those and other concerns. Now that AB 705 is a two year bill, we have the opportunity to begin this dialogue. We will therefore not address the specifics of legislation or policy in this letter – rather, we focus exclusively on the science of CCS, on which there exists a significant body of knowledge.

As scientists and researchers, and as advocates representing over one million members and activists, we are extremely conscious of the need to be responsible and rigorous in our views. The information that we present below is based on years of field experience and peer-reviewed research. We hope that you will find it useful as a basis for ongoing, well-informed discussion.

Why consider CCS?

Climate change is one of the most pressing and challenging environmental problems of our time. The problem is real: an overwhelming majority of the world's scientists has once again rung the alarm, presenting their findings in 2007 in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), signed off by 113 governments under the United Nations, including the United States. The Earth's climate is warming, very likely due to human emissions of CO_2 and to a lesser extent other greenhouse gases.

Fortunately, we are already in possession of an array of technologies and solutions that are capable of making significant dents in our emissions. It is clear, however, that there is no silver bullet. We will need all the tools at our disposal. Maximizing energy efficiency should be the first port of call, while renewable energy should be pursued as aggressively as possible. The world still relies heavily on fossil fuels though, and breaking this dependence, even with greatly accelerated energy efficiency and renewables deployment, will not happen overnight. The window of opportunity for action to halt dangerous climate change on the other hand is narrow. The IPCC estimates that we have only ten to twenty years for global emissions to peak and start decreasing if we want to avoid dangerous climate change. The world's coal, oil and natural gas resources on the other hand are abundant, and their use is set to grow even further under a business-as-usual scenario, not least from the recent boom in developing countries such as China and India. Practical reason demonstrates that we urgently need a means to de-carbonize fossil fuel use. CCS is a technology capable of doing so, and not just for coal but for all fossil fuels. CCS can even be used with biomass and lead to net reductions of carbon from the atmosphere.

The status of CCS research

Research on CCS has been taking place for many years now, with major international conferences taking place since the early 1990s. Since then, our knowledge on the subject has greatly expanded, to the extent that the IPCC issued a special report on CCS in 2005[1]. This report represents the most significant landmark in terms of relevant publications: the report was written by almost 100 Lead and Coordinating Lead Authors and 25 Contributing Authors from industrialized countries, developing countries, countries with economies in transition and international organizations. It has been reviewed by more than 200 people (both individual experts and representatives of governments) from around the world. The review process was overseen by 19 Review Editors, who ensured that all comments received the proper attention.

Much like climate change science, there is a substantial body of evidence, knowledge and peer-reviewed literature on CCS that enables us to speak with authority on the subject. In many cases, we can speak with a very high degree of confidence. We can also identify the areas where that is not possible, and where additional research is needed. In any case, there is a very high degree of consensus on the science of CCS, and in the present letter we attempt to convey some of these areas of agreement.

This letter draws on the IPCC Special Report, and is co-signed by Lead Authors and Coordinating Lead Authors of that report.

The nature of CO_2

CO_2 is non-flammable and non-explosive. CO_2 and its products of degradation are not legally classified as toxic substances. CO_2 is non-hazardous on inhalation, is a non-irritant and does not sensitize or permeate the skin. CO_2 is considered harmless and non-toxic as a normal constituent of the atmosphere. The current US occupational exposure standard sets the maximum allowable concentration of CO_2 in air at 0.5% for eight hours continuous exposure, while the maximum concentration to which operating personnel may be exposed for a short period of time is 3.0%.

It is not accurate to portray CO_2 as a deadly and suffocating substance. The impact of elevated CO_2 concentrations on humans depends on the concentration and duration of exposure. At low concentrations CO_2 is not harmful and is, in fact, essential for life. Only at high concentrations could CO_2 be harmful, but exposure to high concentrations is not expected to result from CO_2 storage operations. Today, more than 25 million tons of CO_2 are pumped underground each year in the U.S. for enhanced oil recovery, demonstrating that CO_2 handling and storage operations can be carried out safely and without exposing workers or the public to unsafe conditions.

Has CCS been tried before?

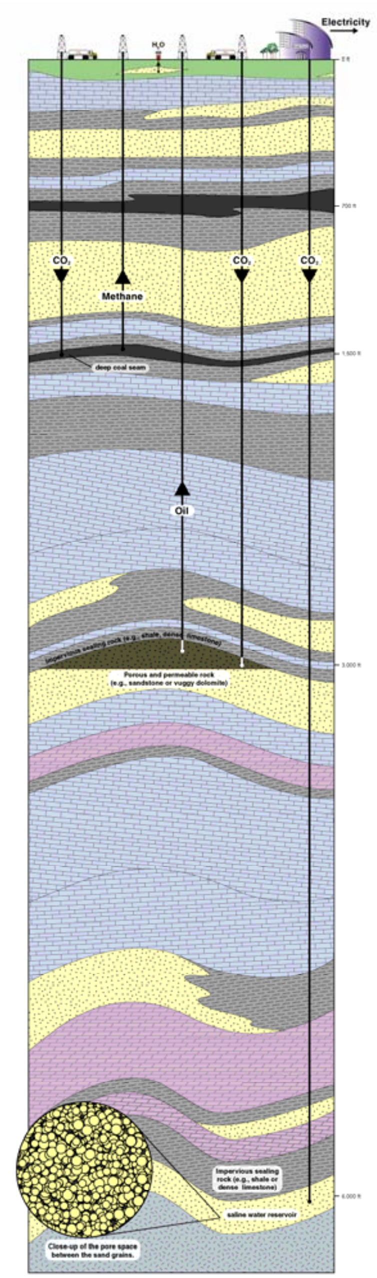
Yes. CCS is a three-stage process. It entails capturing (i.e. isolating or stripping) the CO_2 from its source, compressing and transporting it, and injecting it into a suitable geological formation. All three stages have been demonstrated and operated in large, commercial scale installations.

CO_2 is stripped from power plant or industrial facilities' slipstreams to supply the food industry. It is also routinely stripped in natural gas processing facilities to reduce the CO_2 content of the gas and bring it down to commercial specifications. CO_2 is also being stripped at synthetic fuel production facilities.

---

[1] **Intergovernmental Panel on Climate Change,** Special Report on Carbon Dioxide Capture and Storage, 2005. Available at http://www.ipcc.ch

Pipelines today operate as a mature market technology and are the most common method for transporting CO_2. The first long-distance CO_2 pipeline came into operation in the early 1970s. In the United States, over 2,500 km of pipeline transports more than 40 million tons CO_2 per year from natural and anthropogenic sources, mainly to sites in Texas, where the CO_2 is used for Enhanced Oil Recovery (EOR).



Cross section of a typical stratigraphy from the Illinois Basin, showing multiple layers of caprocks (grey) – Source: Illinois Geological Survey and Midwest Geological Sequestration Consortium

Some 35 million tons of CO_2 annually are injected in mature oil reservoirs for the purposes of EOR, a practice that has been around for several decades. The CO_2 aids in retrieving oil that is otherwise stranded in reservoirs, which would be near the end of their economic life without such advanced techniques. Although the objective in this process is to maximize oil yields and not to sequester CO_2, the two processes are fundamentally similar and share much of the same operational engineering.

Moreover, several commercial and research projects worldwide capture and/or inject CO_2 in geological formations. Of these, three stand out because of their scale and their widely publicized results: Sleipner in Norway, Weyburn in North Dakota/Canada and In Salah in Algeria. These projects have been operating since 1996, 2000 and 2004 respectively, and have been studied intensely. The results show that <u>there is no reason to expect any CO_2 leakage from these projects, and that the injected volumes are very likely to remain permanently sequestered in their respective reservoirs</u>.

Can we be confident that the CO_2 will remain sequestered underground?

The projects just mentioned give us a great deal of confidence that CO_2 can remain permanently sequestered in geological reservoirs. There are multiple trapping mechanisms for CO_2 in these reservoirs, operating at various time scales. *Residual trapping* limits CO_2 mobility in a formation through capillary forces, much like a sponge traps air that has to be squeezed repeatedly in order to let water in. *Solubility trapping*, whereby CO_2 dissolves in the formation fluids, ensures that the CO_2 is no longer buoyant and therefore tends to sink rather than rising towards the surface. *Stratigraphic trapping* occurs when overlying, impermeable rock formations prevent any upwards movement of CO_2 from the underlying reservoir rock, effectively acting as lids (see adjacent figure). Appropriately selected injections sites will possess several layers of such caprocks, and thus multiple reinforcements to the other trapping mechanisms. Finally, *mineralization trapping* takes place when the CO_2 over time forms carbonate minerals and essentially becomes part of the solid rock into which it was injected.

The IPCC report concluded the following:

"Observations from engineered and natural analogues as well as models suggest that the fraction retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years. <u>For well-selected, designed and managed</u>

geological storage sites, the vast majority of the CO_2 will gradually be immobilized by various trapping mechanisms and, in that case, could be retained for up to millions of years. Because of these mechanisms, storage could become more secure over longer timeframes".

In support of that statement, a recent MIT study[2] concluded that:

"Although substantial work remains to characterize and quantify these mechanisms, they are understood well enough today to trust estimates of the percentage of CO_2 stored over some period of time – the result of decades of studies in analogous hydrocarbon systems, natural gas storage operations, and CO_2-EOR. Specifically, it is very likely that the fraction of stored CO_2 will be greater than 99% over 100 years, and likely that the fraction of stored CO_2 will exceed 99% for 1000 years. Moreover, some mechanisms appear to be self-reinforcing. Additional work will reduce the uncertainties associated with long-term efficacy and numerical estimates of storage volume capacity, but no knowledge gaps today appear to cast doubt on the fundamental likelihood of the feasibility of CCS".

The remaining 1% is a number used by IPCC authors to take into account any uncertainties such as very small amounts of CO_2 that might be vented during the operation of sites due to human factors over those very long periods, and does not reflect reduced confidence in the underlying geology or the ability of formations to retain the overwhelming majority of the injected CO_2. There is every possibility that even this tiny fraction will not reach the atmosphere with proper site operation and regulation, bringing the total retained fraction to 100%. The 1% figure in no way implies leakages that could harm human health or the environment – we examine this further below.

We must therefore caution strongly against scenarios that present leakage as inevitable, or even likely. Leakage is conceivable, but is unlikely in well-selected sites, is generally avoidable, predictable, can be detected and remedied promptly, and in any case is extremely unlikely to be of a magnitude that would endanger human health and the environment if performed under adequate regulatory oversight and according to best practices. There is overwhelming scientific evidence and knowledge that catastrophic leakage from a geological sequestration site is extremely unlikely, especially with effective regulatory controls. After all, it should come as no surprise that the same geologic formations and types of reservoirs that have stored oil, natural gas as well as naturally occurring CO_2 itself for millions to hundreds of millions of years, are also capable of permanently retaining CO_2 injected by humans.

Industrial analogues for CO_2 sequestration

We may also draw useful conclusions on the safe operation of CO_2 injections from industrial analogues with comparable risks that have been permitted and practiced under regulatory schemes for years (we are not taking a position on these practices – simply comparing risks).

Underground natural gas storage projects offer experience relevant to CO_2 storage. They have operated successfully for almost 100 years and in many parts of the world. The majority of gas storage projects are in depleted oil and gas reservoirs and saline formations, although caverns in salt have also been used extensively. Underground natural gas storage is safe and effective. Of the few projects that have leaked, this has been mostly caused by poorly completed or improperly plugged and abandoned wells, and by leaky faults. Operators are perfectly capable of ensuring the safe operation required, even very close to heavily populated areas, with a high degree of confidence. A prominent example is the Berlin Natural Gas Storage Facility, located in central Berlin, Germany, in an area that combines high population density with nature and water conservation reservations. California has nine natural gas storage sites, four of which are located

---

[2] **Massachusetts Institute of Technology.** "The Future of Coal – Options for a Carbon Constrained World, An Interdisciplinary MIT Study", 2007. Available at: http://web.mit.edu/coal/

between Santa Barbara and Long Beach, with the remainder in the northern half of the state. These have been operated safely despite the highly flammable and explosive nature of natural gas.

"Acid gas" injection operations also represent a commercial analogue for some aspects of geological CO_2 storage. Acid gas is a mixture of H_2S and CO_2, with minor amounts of hydrocarbon gases that can result from petroleum production or processing. Although the purpose of the acid gas injection operations is to dispose of H_2S, significant quantities of CO_2 are injected at the same time. Acid gas is currently injected into 51 different formations at 44 different locations across the Alberta Basin in the provinces of Alberta and British Columbia. Carbon dioxide often represents the largest component of the injected acid gas stream, in some cases up to 98% of the total volume. A total of 2.5 million tons CO_2 and 2 million tons H_2S had been injected in Western Canada by the end of 2003 with no detectable leakage. Injection takes place in deep saline formations at 27 sites, and into depleted oil and/or gas reservoirs or the underlying water leg at 23 sites. Since the first acid-gas injection operation in 1990, 51 different injection sites have been approved, of which 44 are currently active. No safety incidents have been reported since the first operation in the world started injecting acid gas into a depleted reservoir on the outskirts of the city of Edmonton, Alberta. Given that H_2S is more toxic and corrosive than CO_2, the success of these acid-gas injection operations indicate that the engineering technology for CO_2 geological storage is in a mature stage[3].

The Lake Nyos/Monoun incidents – or "What does an oil field have in common with a volcano?"

Some geologic systems, typically spas and volcanic systems, are inherently leaky and not useful analogues for geological sequestration. Extensive open fault structures offer leakage pathways for gases like CO_2 to the surface. The Kilauea Volcano in Hawaii emits on average 4 million tons CO_2/yr. More than 438,000 tons CO_2/yr leaked into the Mammoth Mountain area, California, between 1990-1995.

Seepage of naturally occurring CO_2 into Lake Nyos (Cameroon) resulted in CO_2 saturation of water deep in the lake, which in 1987 produced a very large-scale and (for more than 1700 people) ultimately fatal release of CO_2 when the lake vented. Two years earlier in nearby Lake Monoun there was a smaller release of CO_2 that killed approximately 37 people.

The Nyos and Monoun events have been studied extensively, The International Energy Agency compiled a report on natural releases of CO_2 specifically to address concerns and to explore any parallels with engineered sites[4]. The report was submitted for peer review by experts, and below we draw on its findings. The IPCC itself concluded that "[the venting of] Lake Nyos, a deep, stratified tropical lake and release of CO_2 from it are not representative of the potential seepage through wells or fractures that may occur from engineered geological sequestration sites".

Why is this so? There are several factors that render the Lake Nyos/Monoun incidents unique, and that make them very different to CO_2 sequestration sites:

- Nyos and Monoun are volcanic lakes, surrounded by high crater walls. Any leaking CO_2 will therefore tend to sink into and "hug" the adjacent valleys, since it is heavier than air. Engineered sites would often be located where mixing of air would lead to the dilution of any CO_2.

---

[3] **Bachu, S. and W.D. Gunter.** Overview of acid-gas injection operations in western Canada. In: Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies. Volume 1: Peer-Reviewed Papers and Plenary Presentations, Vancouver, BC, September 5-9, 2004.

[4] "A Review of Natural CO_2 Occurrences and Releases and their Relevance to CO_2 Storage". Available at: http://www.co2storage.org/Reports/Natural%20Releases%20Report.pdf

- There was a constant supply of CO_2 to the bottom of the lakes through the subsurface. Volcanic regions are characterized by the presence of high fluid pressures and explosive activity. Tectonic activity also leads to the development of cracks, voids, vents and fissures in the ground, all of which are conducive to the migration of CO_2 through the subsurface and buildup at the ground surface. In stark contrast, the sedimentary basins that would be utilized for CO_2 sequestration lie in stable geologic environments commonly containing natural fields of oil and gas, which prove their ability to retain buoyant fluids, frequently for millions of years. The trapping mechanisms outlined previously would ensure that no CO_2 would ever reach the ground surface or lake bottoms at properly chosen and operated sites – in fact it would remain in the storage formation where it was injected, thousands of feet deep underground.

- The lakes released a very large volume of CO_2 in a very short amount of time, in what has been since termed as a "limnic eruption" (as opposed to the well known "phreatic" volcanic eruption). Both lakes are "stratified", meaning that the various layers of water along their depth do not mix. CO_2 had been accumulating in the bottom of the lakes undisturbed for years at steady rates, dissolving in the water. The eruption and release of the CO_2 took place when the stratification of the lakes was disturbed, likely because consecutive cloudy days and lower temperatures allowed water from the top of the lake to sink towards the bottom, disturbing the water column. A positive feedback system, or chain reaction, was set up, whereby the CO_2 came out of solution all at once, bubbling up to the surface. The amount released at Lake Nyos is estimated at 1.24 million tons CO_2, approximately equal to the amount injected each year in the world's largest sequestration projects today. The sudden release of a year's or so worth of CO_2 from engineered sites in such a short amount of time is simply not possible: neither release through geological pathways nor through man-made wells could lead to such catastrophic rates. Geological leakage pathways are inherently convoluted, and involve the CO_2 weaving its way through several thousand meters of rock structures that do not facilitate its passage – any leakage from such pathways would only be slow and gradual, and would in any case only take place at unsuitable sites that should not have been chosen in the first place. Leakage from wells on the other hand would be limited by several mechanisms (such as low CO_2 mobility in the injection reservoir and the "Joule-Thomson effect" whereby CO_2 would freeze and solidify on its way up a well due to the sudden drop in pressure), is easily detectable and can be plugged in a routine fashion to stop the leak completely.

- The presence of the still, stratified water body of the lakes prevented the CO_2 seeping up from the ground from being released at a constant rate. Instead, it allowed it to accumulate and huge volumes to be released all at once. For offshore geological reservoirs that lie underneath the ocean floor surface, the same would not be possible. Ocean water mixes freely due to wind, waves and seasonal temperature fluctuations. This would ensure that any leaking CO_2 – and again we must stress that it is unlikely that there would be any – would be vented instead of building up.

Deliberate degassing of Lake Nyos

As part of an international program to eliminate hazard from Lakes Nyos and Monoun, a degassing program is now in place. CO_2 from the bottom of the lakes is now deliberately brought up to the surface at a steady rate using man-made tubes[5]. This prevents a similar CO_2 bubble from forming, and releases the gas at rates and concentrations that are harmless. An engineered sequestration site is several steps ahead of even this harmless arrangement, ensuring that no CO_2 leaks in the first place. Multiple layers of impermeable caprocks, thousands or hundreds of meters below the ground surface, would ensure that the CO_2's chances of reaching the surface are slim or non-existent, in stark contrast to the volcanic vents that deposited a constant supply of CO_2 at the bottom of the two volcanic lakes.

---

[5] http://perso.orange.fr/mhalb/nyos/index.htm

Engineered CO_2 sequestration sites can be carefully chosen and operated specifically to minimize the prospect of leakage with several degrees of redundancy, minimizing and controlling any leakage pathways for CO_2 to reach the surface. Simply put: an oilfield or deep saline formation and a volcano have very little in common when it comes to studying CO_2 releases. The Lake Nyos and Monoun incidents cannot be used as evidence against the efficacy or safety of CCS.

The Frio injection project – or "Will CO_2 eat through rock and escape to the surface"?

The Frio experiment was undertaken to answer questions such as:

- If CO_2 released from fossil fuel during energy production is returned to the subsurface, will it be retained for periods of time significant enough to benefit the atmosphere?
- Can trapping be assured in saline formations where there is no history of hydrocarbon accumulation?
- What tools can be used to monitor the movement of CO_2 in the subsurface?

The injection program was led by Susan Hovorka, a co-signatory to this letter. 1,825 tons CO_2 were injected during two injections into the Frio Formation, which underlies large areas of the United States Gulf Coast. Reservoir characterization and numerical modeling were used to design the experiment, as well as to interpret the results through history matching. Closely spaced measurements in space and time were collected to observe the fate of the CO_2 during and after injection. The Frio project collected very detailed information on what happens during injection of CO_2 into the subsurface in a brine-filled reservoir associated with an oil field in Texas over a multi-year period.

Researchers observed that, as expected, CO_2 dissolved into the brine in small spaces within the rock, making the brine more acidic (with a pH[6] of approx. 3.5 – the same acidity as California orange juice, and less acidic than carbonated beverages or vinegar). This acidic brine within a few days dissolved parts of the naturally thin iron-stained coatings on sand grains that make up the brine-filled reservoir. Again, this was not an unexpected outcome. Researchers noted as a new contribution that the composition of these minor but reactive coatings as well as the major minerals that make up the rock must be considered in order to assure protection of water quality in the case that the brine and/or the CO_2 migrate into drinking water aquifers.

Three important points stand out here:

- The CO_2 did not dissolve the surrounding rock to create leakage pathways that would allow the brine or the CO_2 to reach the surface – it dissolved only very small parts of grain *coatings*, releasing natural salts into the reservoir. Most of the rock is composed of minerals like quartz, feldspar and clay that are not at all soluble in weak acid.

- For salts to escape to the surface or contaminate groundwater, the dense salty fluids would have to migrate more than five thousand feet upward from the injection area through thick layers of clay. The most likely potential leakage path would be the retrofitted old well used for research observations, which was monitored using very sensitive tools, and which could be readily attended to and maintained if unacceptable levels of CO_2 were detected – plugging wells is a routine operation which can be carried out at a fraction of the cost of a capture and storage project. Sensitive tests at the surface have so far detected no evidence of leakage.

---

[6] The pH of a solution is a measure of acidity or alkalinity. Values less than 7 indicate acidity, whereas values greater than 7 indicate alkalinity.

- The dissolution of the CO_2 in the brine deep within the subsurface, which made it more acidic, is in fact a storage mechanism for the CO_2: the process of "dissolution trapping" mentioned earlier. Dissolution trapping decreases the chances of CO_2 leaking outside target formation, and increases our confidence of permanent storage. Dissolution of minerals neutralized the weak acid over a period of a week, so that the pH returned to near normal. The volume of rock is very large compared to water, which is nearly stagnant, and this also limits the ability of the water to dissolve rock.

The results in the paper published in the scientific journal *Geology*[7] emphasize that it is important that the dissolution of CO_2 into water, forming a weak acid, should be considered as part of assurance that storage will be safe and permanent. Some people have misinterpreted or misquoted the relevant statement in the *Geology* paper as an alarming new discovery; properly considered it should be taken as reinforcement that the effects of geochemical interaction of CO_2 with rock and water should be properly assessed to assure that storage is safe. In fact, such chemical reactions must be considered in order to get a permit to inject fluids underground in the US.

In summary, the CO_2 from this test is still retained where it was placed, will not escape, and appears to be already nearly immobile as a result of physical processes. This was tested by opening the injection well and measuring what was produced (nothing). Testing shows that after injection, the CO_2 spread for a short time, and then was trapped as small isolated bubbles in small pores within the rock (phase trapping, a well known physical process). The project was open to diverse researchers and to observers from all over the US and around the world. Recent opening of the wells and additional testing at the Frio site in the presence of three news organizations further verified that the CO_2 is still trapped in the injection zone. A consensus was reached by the researchers and observers that the results of the Frio test are favorable and result in increased confidence for large volume use of the subsurface for CO_2 sequestration. The Frio project therefore did not show that CO_2 will eat through rock and escape to the surface – in fact it verified the exact opposite.

Conclusion

Deployment of CCS requires thought, planning and effective regulatory controls. Adequate regulation does not currently exist. A range of issues need to be addressed in a comprehensive manner, such as site selection, monitoring, and liability. The technology does come with additional costs, which is why other options such as energy efficiency and renewables need to be deployed to the maximum. However, the severity of the climate problem calls for urgent reductions within a narrow time window. The atmosphere does not distinguish between countries or emission sources. Even if the developed world manages to reduce its emissions, China and India are currently fueling their growth mostly on fossil fuels and CCS is also needed to contribute to reducing emissions there. All effective emission reduction options need to be considered.

It is well documented that the impacts of climate change will be most severe for poor countries and communities. These impacts will be both social and economic. As the Stern report[8] pointed out, the economic impacts from climate change will hugely outweigh the costs of addressing it. With the right policies, the initial costs of transitioning to cleaner technologies can be very manageable, and the most sensitive communities shielded from undue burdens.

---

[7] **Y.K. Kharaka, D.R. Cole, S.D. Hovorka, W.D. Gunter, K.G. Knauss, and B.M. Freifeld.** "Gas-water-rock interactions in Frio Formation following CO2 injection: Implications for the storage of greenhouse gases in sedimentary basins". Geology 2006 34: 577-580

[8] **Sir Nicholas Stern.** "The Economics of Climate Change – The Stern Review", Cabinet Office, HM Treasury, October 2006. Available at: http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

In a carbon-constrained world, pore space in geological reservoirs is a resource. CCS is not a technology of the distant future – it is available to us today, and it can be perfectly safe as we highlight above. It is time to begin a sincere exchange on how to regulate CCS effectively to provide for carefully selected, well designed and managed sites involving all stakeholders to ensure that our common goals are served. We hope that the present letter will serve as a starting point.

Sincerely,

Sally Benson, Peter Cook, Howard Herzog, Susan Hovorka, George Peridas

Dr. Sally Benson is a Professor (Research) in the Energy Resources Engineering Department in the School of Earth Sciences at Stanford University and the Executive Director of the Global Climate and Energy Project. She was a Coordinating Lead Author of the Underground Geological Storage chapter in the IPCC Special Report on Carbon Dioxide Capture and Storage. Since 1998, Dr. Benson has focused her research on geological storage of CO_2, leading a number of research programs at Lawrence Berkeley National Laboratory, including the GEO-SEQ program, LBNL's Zero Emissions Research and Technology Program (ZERT) and WestCarb's Geological Pilot Tests. At Stanford she conducts l research on multiphase flow of CO_2 in saline formations, monitoring technology and risk assessment.

Dr. Peter Cook CBE is the Chief Executive of the Co-operative Research Centre for Greenhouse Gas Technologies (CO2CRC) in Australia. He has previously served as Executive Director of the Petroleum CRC, Director of the British Geological Survey and Associate Director of the Bureau of Mineral Resources. He established the GEODISC program and subsequently CO2CRC, which is conducting one of the world's largest research and demonstration programs on carbon dioxide capture and geological storage. He was Coordinating Lead Author of the IPCC Special Report on Carbon Dioxide Capture and Storage, and is a member of Australia's Technical Committee to the Carbon Sequestration Leadership Forum.

Dr. Howard Herzog is a Principal Research Engineer at the Massachusetts Institute of Technology (MIT), where he has over 18 years experience in Carbon Capture and Sequestration research. He was a Coordinating Lead Author for the IPCC Special Report on Carbon Dioxide Capture and Storage and a co-author of the MIT study on The Future of Coal. He serves as a US delegate to the Carbon Sequestration Leadership Forum's Technical Group.

Dr. Susan Hovorka is a Senior Research Scientist at the Gulf Coast Carbon Center, Bureau of Economic Geology, Jackson School of Geosciences, at The University of Texas at Austin. She has worked on diverse topics related to water quality protection as well as reservoir characterization to enhance oil production. Her current research focuses on assessment of the cost, safety and effectiveness of subsurface geologic sequestration of CO_2 as a mechanism for reducing atmospheric greenhouse gas emissions. She is also active in facilitating exchange between applied scientists and the broader public, with a focus on pre-college students and teachers. She is in the final stages of completion of the Frio Pilot, a first US field test of storage of CO_2 in brine-filled sandstones.

Dr. George Peridas, is a Science Fellow with the Natural Resources Defense Council (NRDC), a non-profit environmental policy organization with over 1.2 million members and activists, more than 250,000 of whom are Californians. He works in NRDC's Climate Center and leads the organization's research, advocacy and education efforts in the area of carbon capture & storage. He has worked as a research engineer in solid mechanics and as a senior consultant in energy markets. He has advised the UK government's Department of Trade and Industry on the economics of carbon capture and storage.