Natural Resources Defense Council

Attributes of an Effective Regulatory Regime for Carbon Capture & Storage

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Introduction

The Earth's climate is changing. According to the IPCC's Fourth Assessment Report released in February 2007, "warming of the climate system is unequivocal". According to the assessment, this alarming change can be attributed with over 90% probability to anthropogenic greenhouse gas emissions. The debate has shifted from questioning climate science itself, to identifying the best solutions to the problem and the policies that will enable their deployment.

Research, development and deployment of new technologies that will help reduce greenhouse emissions is essential. However, we already possess a wide arsenal of technologies and measures capable of addressing the climate change problem to a large extent. The "mitigation wedges" analysis by Pacala & Socolow[1] perhaps best demonstrates how existing and future technologies can be used to stabilize global emissions. The analysis maps the growing gap between Business as Usual emissions and a flat emissions path at today's levels, and fills that gap with wedges: each wedge corresponds to a particular technology or measure, such as energy efficiency, renewable energy, more efficient vehicles and others, whose contribution in reducing emissions grows over time. Opinions differ as to what the contribution of each wedge should be. The use of nuclear power is a hotly contested issue. Estimates for the potential contribution of energy efficiency, renewable energy and biofuels are very high, but political and other limitations render the sole reliance on these measures a risky strategy. The fact remains that today's global economy is heavily dependent on the use of fossil fuels – the very fuels that have enabled such an economy to develop, and which are jeopardizing its stability alongside the planet's climate. Breaking this dependence will be difficult. Scientists, policy makers and economists agree: there is no silver bullet in this quest, and pursuing a diversity of options is the best hedge against the underlying risks.

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[1] S. Pacala and R. Socolow, *"Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies"*. Science, Vol. 305, 13 August 2004.

Carbon Capture & Geological Storage[2] (CCS) has rapidly gained popularity as one such mitigation option, and it is now widely expected that it will play an important role in decarbonizing the world's energy system and facilitate a transition to a more sustainable future. CCS is often met with skepticism and apprehension, as it continues to rely mostly on fossil fuels and does not inherently tend to reduce energy consumption. Nevertheless, the International Energy Agency (IEA) projects in its Reference Case that not only will the use of fossil fuels not decrease, but it will in fact expand, particularly that of coal, the cheapest and most polluting of the major fossil fuels. The rate at which the economies of China and India are developing raises genuine concerns around the level of the resulting greenhouse emissions. A great deal of that development is, and will continue to be based heavily on fossil fuels. In developed countries, coal is enjoying a resurgence due to high and volatile oil and natural gas prices in the past two years. According to the IEA, global CO_2 emissions will rise by 55% by 2030 in the Reference Case. Business as Usual is an unacceptable scenario from a climate perspective. Finding a way to accommodate the inevitable use of fossil fuels while reducing carbon emissions is paramount, as a supplement to the promotion of energy savings and clean energy sources.

From a technological perspective, CCS is ready for deployment today. The three major international projects – Sleipner, Weyburn and In Salah – have demonstrated that CCS can be carried out safely and effectively. Several other smaller capture and/or storage projects are constantly expanding our knowledge in the field. Enhanced Oil Recovery has been performed by the oil industry for decades and is a mature, well-established technique. Gaps do remain, and CCS technology cannot yet be labeled "mainstream". A large-scale, commercial power plant that captures and sequesters its CO_2 has not yet been built, while the volumes that would be involved in such an operation have not been injected in geological formations at sustained rates. Nonetheless, the main barriers to the deployment of CCS are not technological – they are economic, regulatory and related to public perception.

Economic barriers to CCS

An analysis of the economic barriers to CCS is not the main focus of the present essay. They do deserve a brief mention, however.

CCS is a carbon mitigation technology. In the absence of a price for CO_2 emissions, the benefits from using the technology are not assigned an economic value, and hence the incentives for its deployment remain almost non-existent.

[2] NRDC does not consider ocean storage of CO_2 to be an acceptable climate mitigation option. Terrestrial storage is not discussed in this essay.

CCS comes at a cost: the bulk of that cost is usually centered on the capture of the CO_2, with transportation and storage accounting for smaller portions. Specific cases exist where capturing and storing CO_2 can be performed at a lower cost or offset through EOR revenues. Almost invariably however, there remains a premium for utilizing CCS over conventional practices that do not capture their carbon.

In the absence of carbon caps, CO_2 performance standards, an assigned monetary value on emissions or specific incentives for CCS, its use will remain limited in developed countries. In developing countries, the additional cost of deploying CCS simply eliminates it today from the options considered when developing an industrial infrastructure or reducing emissions from existing facilities, except where there is a niche opportunity like EOR.

There are several options for bridging this gap, which are not examined here. Even if the economic barriers to CCS are addressed, however, its deployment will remain problematic and uncertain in the absence of a sound regulatory framework.

Regulatory barriers to CCS

An integrated CCS project entails a complex chain of operations, from the point where a site is investigated and chosen, the CO_2 is then captured, compressed, transported and injected into the geological formation, to the point of closure and site decommissioning. This chain touches on a surprisingly wide array of legal issues related to:

- Ownership of subsurface rights and pore space, and compensation/royalties for their use;
- Siting of installations, including capture plants and pipelines;
- Siting of injection, production and monitoring wells;
- Technical specifications for equipment and installations;
- Risk assessment;
- Monitoring of the injected CO_2;
- Mitigation and remediation; and
- Short- and long-term liability for the injected CO_2 and the decommissioned facility

Some of these issues have been addressed as part of regulatory regimes in different contexts in the past, such as pipeline safety, hydrocarbon exploration, underground injection of waste, or power generation. It is important to note, however, that CCS connects existing activities in a unique way that merits an integrated regulatory approach. Moreover, it entails new activities that have not

been performed extensively in the past or regulated, such as the sustained injection of large volumes of CO_2 where permanent retention is intended and the related monitoring activities. There are several reasons why such an integrated approach is needed:

- To ensure that CCS is performed safely and to high standards;
- To provide industry with sufficient regulatory certainty and clarity;
- To build public confidence and acceptance around this technology; and
- To enable CCS to deliver on its significant greenhouse gas mitigation potential.

Such an approach is generally absent in host countries. It is only recently that CCS has emerged on the scene as a plausible commercial activity, and regulatory frameworks have not yet caught up with developments, although processes are under way in Australia and the European Union. Without such an approach, several pitfalls await CCS – these are analyzed further in the following section. A sound and well-designed regulatory framework can influence greatly the deployment of CCS, and as such the issue must be addressed as a matter of prime importance and urgency, especially given the extent to which the technology features in energy policy discussions as of late.

There are several levels where CCS can be subject to regulation, ranging from International Treaties through to the national/federal and state/provincial level. This essay does not examine each of these in isolation – rather it discusses the generic attributes of a regulatory system for CCS that will safeguard its sound use as a greenhouse gas reduction tool.

Attributes of an Effective Regulatory Regime for CCS

The concept of regulating a technology, or more precisely an activity, that has not yet fully matured is often perceived to have negative or restrictive connotations, and is greeted with apprehension. This apprehension is partly due to the negative aura that sometimes surrounds the word “regulation”. It is not regulation in itself that can be problematic though – it is *poor* regulation. Well-designed regulation can be simultaneously beneficial for the regulator, the regulatee and the public. CCS is a case in point where the value of a well-designed regulatory framework could not be clearer. In that sense, it is not surprising that, in several cases, diverse interests such as industry and environmental groups are joining forces in calling for CCS regulations. These partnerships are important, and can be conducive to the smooth development of the regulatory framework. Individual approaches and positions are likely to differ to some extent as the details themselves are drafted, but the common interest in the success of CCS as a

greenhouse gas mitigation technology can, and should, provide sufficient impetus for a constructive process. Before listing the attributes of an effective regulatory regime for CCS, we express the hope that the potential for collaboration, open debate and respect for diverse points of view guides the development process.

Regulations must be based on sound science – and as such evolve alongside the scientific advancements

A concern often expressed in relation to regulating CCS is that the science itself is not yet developed enough to inform detailed standards. This is only partly true. As the number of large-scale projects that inject significant volumes of CO_2 underground grows, our understanding of the underlying processes is also bound to evolve. In that sense, the content of regulations should evolve with our scientific understanding, while still maintaining all the necessary safeguards to protect public health and environment. The specific content of regulations must be based on our scientific understanding.

Nevertheless, we know enough in several areas of CCS to develop first generation rules now. The IPCC Special Report on CCS has demonstrated that there is scientific consensus on the status of the technology, and that there is high confidence in its success. In a direct analogy to climate, questioning the underlying science must not be used as an excuse to delay action. The evolution of the science and the regulatory framework are best done concurrently, not sequentially. These two are fundamentally different processes, and can inform each other in very useful ways: science itself can dictate the nature and content of the regulations, whereas regulatory questions can provide direction for additional scientific research and improved understanding.

The evolving nature of our scientific understanding of CCS implies that the regulations themselves will need to *evolve dynamically*. Careful and focused navigation will be needed. Regulations are binding by definition, and constantly changing such requirements is neither wise nor desirable. In the case of CCS, the relative role of guidelines, operating protocols and standards will change over time. Hundreds of detailed or hypothetical questions remain unanswered in relation to CCS, which do not fail to surface in workshops. It is not feasible to answer all of these questions during the first stages of a regulatory framework. Issues will need to be ranked and prioritized, with the most pressing ones in terms of risk and functionality addressed first.

Careful attention will need to be paid to this evolving nature by regulators, to ensure that the direction remains constant, and that potential changes are

anticipated and spelled out clearly in advance. The competence of the regulatory agencies and the resources available to them will prove crucial in that respect.

Single point of reference

As mentioned above, CCS entails a complex chain of operations. Different parts of that chain can fall under the jurisdiction of different agencies, multiplying the regulatory burden and decreasing the overall coherence of the resulting framework. While it may not always be possible to call upon a single agency to regulate the entire chain, or to create a new, specifically dedicated agency, it is vital to ensure that the regulatory process is streamlined in order for it to be effective. This may imply that agencies may need to coalesce under the umbrella of an advisory or coordinating board, in order to ensure that multiple permitting procedures, inconsistent requirements and poor coordination do not interfere with the objectives of a CCS regulatory framework.

Along similar lines, it is important that CCS be regulated in a uniform manner throughout states or provinces within a single nation. A patchwork of regulatory systems can only lead to additional burdens for industry and uncertainty. However, if national rules have not been written then state rules may be needed in the interim to assure that early projects are subject to appropriate safeguards. Nor does the desire for a uniform national approach imply that region-specific parameters cannot be taken into account but the steps which have to be followed in planning, operating and decommissioning a CCS project should be uniform, preventing undue administrative efforts and differing quality of standards.

Integration with incentive frameworks

Regulatory frameworks for CCS must provide an interface with possible incentive frameworks. The prime example here is an emission trading scheme, where the performance of projects, monitoring and verification and other aspects are directly linked to accounting or administrative issues under the scheme. In some cases or parts of the world, a regulatory framework for CCS might develop prior to the enactment of carbon caps and the related logistics. There is little doubt that the world of the 21st century will be carbon constrained, however. Consequently, CCS regulations must anticipate these logistics and be designed to provide a seamless link with cap-and-trade schemes or other frameworks.

Maximize transparency

The general public is skeptical about CCS. Often individuals have never even heard about CCS, and are confronted abruptly with the prospect of large volumes of CO_2 being injected underground in the vicinity of their property. Parallels are

often drawn with nuclear waste, and opposition from local groups exacerbates opposition to the technology.

It is not reasonable to expect the public to be familiar with concepts that reside in the field of expertise of the geologist, petroleum engineer or scientist. Even though industry experts are familiar with the workings of CCS, a mentality of "we know best" that seeks to minimize interference from non-experts will set CCS on a perilous path. Outreach and education will have a major effect on how CCS is perceived by the public. Regulations can go a long way in assuring the public and interest groups that there is adequate oversight during all stages of a project, and especially after the CO_2 has been injected underground where a "black box" mentality often takes over. Knowing that a qualified body is keeping a close watch on operations can ease concerns and provide the assurances needed for CCS projects to be deployed.

This has implications as to which are the most suitable agencies to regulate CCS. Geological expertise tends to reside with the oil and gas agencies, which justifiably want to claim jurisdiction over CCS. This, however, can prove a dangerous strategy in seeking public acceptance. Environmental and other agencies commonly enjoy higher levels of trust, and as such can be instrumental in a CCS regulatory framework. Suitable arrangements will need to be worked out so that the regulators themselves enjoy the public's trust – this will prove beneficial to all agencies involved and outweigh any initial administrative hurdles that might need to be overcome.

Public access to information and transparency should be an integral part of any regulatory framework for CCS. Public acceptance is not a luxury where CCS is concerned – it is absolute necessity. The fate of the technology rests heavily on it, and there can be no shortcuts taken in this area. The shining example of Norway, where enlightened state involvement and oversight has resulted in high public awareness and acceptance for CCS must be replicated worldwide if CCS is to be deployed as one of the mitigation wedges in tackling climate change.

Ensure the highest levels of performance

An overarching theme for any regulatory framework for CCS must be to ensure the highest levels of performance. This is especially important in earning public acceptance. Despite facing skepticism, and putting aside mining and siting issues, CCS as a greenhouse gas reduction technology is essentially starting with a clean slate. Unlike other industries, it does not carry the burden of major accidents or pollution incidents. It is essential that this remain so.

The bar must be set high right from the outset and no compromises made. CCS has to attain an impeccable track record, and has the realistic potential to do so. This should be reflected in the accompanying regulatory framework, which must ensure that best available practices and technologies are used, that sites are chosen carefully, that leakage potential is reduced to very low probabilities, and that issues of remediation and liability are addressed comprehensively before injection begins. The requirement for high standards from the outset need not be inconsistent with the need for the regulatory framework to evolve with scientific understanding, as long as proper attention is paid to the degree of confidence or uncertainty in each case, to the magnitude of the risks involved, and the precautionary principle is used where uncertainty is high.

An issue that is regularly debated and deserves mention here is that of leakage, or storage permanence. Is it acceptable to allow a certain extent of leakage, or should permanent storage be a requirement? The term "permanence" in itself is insufficient. In order to specify the question, the probability that a specified fraction of injected CO_2 is retained over a specified period of time needs to be considered. These three parameters will be subject to debate in any regulatory system. Allowing for a moderate degree of retention might be seen as a partial mitigation strategy. As a strategy to build public confidence around CCS, however, it is a risky proposition, and therefore ill-advised. CCS projects should be designed with the view to retain all of their CO_2 for very long periods of time. The IPCC Special Report on CCS stated that "[…] the fraction retained in appropriately selected and managed geological reservoirs is very likely [i.e. with a probability between 90-99%] to exceed 99% over 100 years and is likely [i.e. with a probability between 66-90%] to exceed 99% over 1,000 years". We believe that these numbers can form the basis for requirements within a regulatory system.

Public acceptance is not bought – rather it is earned. In its quest for public acceptance, CCS must strive for excellence, and it is the role of the regulatory framework to require such standards of performance.

Conclusions

A regulatory framework for CCS is not an accessory. It is a necessary element for its success. Even though our scientific understanding of CCS will continue to develop, we understand enough to start developing such a framework now. Moreover, we *need* to start now if the first large-scale CCS projects are to be performed under adequate oversight and certainty – these are already being developed at a fast pace. Regulations must be based on sound science. As our scientific knowledge evolves, so must the regulations in order to keep abreast of

developments. The regulations must be well designed and streamlined. They should also provide a smooth interface with any incentive or cap-and-trade systems that affect the development of CCS. They should ensure best practices, and the highest levels of performance. The regulatory framework should be administered by agencies with expertise and that enjoy the public's trust – all relevant stakeholders must be involved in the development of the framework. Transparency and disclosure of information must be an overarching principle in the regulations if CCS is to earn public acceptance. In a carbon constrained world with a climate problem, pore space is a valuable resource. An effective regulatory framework can help this fact become common belief.