climate policy

synthesis

Ocean acidification and climate change: synergies and challenges of addressing both under the UNFCCC

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Ocean acidification and climate change are linked by their common driver: CO_2. Climate change is the consequence of a range of GHG emissions, but ocean acidification on a global scale is caused solely by increased concentrations of atmospheric CO_2. Reducing CO_2 emissions is therefore the most effective way to mitigate ocean acidification. Acting to prevent further ocean acidification by reducing CO_2 emissions will also provide simultaneous benefits by alleviating future climate change. Although it is possible that reducing CO_2 emissions to a level low enough to address ocean acidification will simultaneously address climate change, the reverse is unfortunately not necessarily true. Despite the ocean's integral role in the climate system and the potentially wide-ranging impacts on marine life and humans, the problem of ocean acidification is largely absent from most policy discussions pertaining to CO_2 emissions. The linkages between ocean acidification, climate change and the United Nations Framework Convention on Climate Change (UNFCCC) are identified and possible scenarios for developing common solutions to reduce and adapt to ocean acidification and climate change are offered. Areas where the UNFCCC is currently lacking capacity to effectively tackle rising ocean acidity are also highlighted.

Keywords: climate change; climate policy; ocean acidification; oceans; UNFCCC

L'acidification des océans et le changement climatique sont liés par leur cause commune : le CO_2. Alors que le changement climatique est la conséquence d'une série d'émissions de gaz à effet de serre, l'acidification des océans à l'échelle planétaire est causée seulement par l'accroissement des concentrations en CO_2 dans l'atmosphère. La manière la plus efficace pour atténuer l'acidification des océans est de réduire les émissions de CO_2. Agir pour empêcher davantage d'acidification dans les océans en diminuant les émissions de CO_2 entraînera également des avantages simultanés dans l'atténuation de changements climatiques futurs. Alors qu'il est possible de réduire les émissions de CO_2 à un niveau suffisamment bas pour atténuer l'acidification des océans, tout en s'attaquant simultanément au changement climatique, l'inverse n'est malheureusement pas forcement le cas. Malgré le rôle intégral des océans dans le système climatique et les effets potentiels étendus sur la vie marine et les humains, le problème de l'acidification des océans est largement absent de la plupart des discussions politiques liées aux émissions de CO_2. Les liens entre acidification des océans, le changement climatique et la Convention cadre des Nations Unies sur le changement climatique (CCNUCC) sont identifiés et des scénarios possibles pour développer des solutions communes pour réduire et s'adapter à l'acidification des océans et le changement climatique sont proposés. Les domaines où la CCNUCC manque actuellement de capacités pour lutter effectivement contre l'acidité croissante des océans sont aussi mis en valeur.

Mots clés : changement climatique; politique climatique; acidification des océans; océans; CCNUCC

1. Introduction

Since the Industrial Revolution, more than 1.6 trillion tonnes of CO_2 have been emitted into the atmosphere as a result of the burning of fossil fuels, land-use change and other human

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activities (Matthews and Caldeira, 2008). Approximately 30% of these emissions are absorbed by the ocean (Sabine et al., 2004). This huge influx of CO_2 is changing the chemistry of the ocean, making it more acidic. On average, the ocean is already almost 30% more acidic than it was prior to the 1750s (Orr et al., 2005). Future changes are predicted to occur at such a rate that by 2050 the ocean could be more acidic than at any point over the last 20 million years (Turley et al., 2007). This influx of CO_2 is also decreasing the availability of carbonate ions, which are important building blocks used by some marine calcifiers to build their shells and skeletons.

This change in ocean chemistry is known as 'ocean acidification' and is likely to have wide-ranging impacts on marine life, with negative implications for sustainable development (UN-DESA, 2009), food security (UNEP, 2010a, 2010b) and economic diversification (Cooley and Doney, 2009). Despite its potential to be globally disruptive, the problem of ocean acidification seems to be largely absent from most policy discussions relating to CO_2 emissions and has only recently been included (and then only somewhat nominally) in discussions within the United Nations Framework Convention on Climate Change (UNFCCC).

The UNFCCC is the international body designated to tackle the problem of climate change by stabilizing GHGs in the atmosphere, largely through a reduction in global emissions (most significantly of CO_2). The reduction of CO_2 emissions is the most effective mitigation strategy for both climate change and ocean acidification, and it is therefore sensible that both are addressed under the UNFCCC. Although the UNFCCC was not originally designed to address ocean acidification, it does provide one framework within which both ocean acidification and climate change can be tackled. Setting up a second international mechanism to deal solely with CO_2 reductions would be superfluous, confusing and unrealistic.

Ocean acidification is probably best dealt with under the auspices of the UNFCCC, but it is important to recognize that ocean acidification is a problem concurrent to climate change and not simply a symptom of it. Consequently, policies that are designed to deal solely with climate change will not necessarily mitigate rising ocean acidity. As a result, it is vital that ocean acidification be given larger recognition within the UNFCCC and that opportunities are sought to incorporate it further into UNFCCC policies and mechanisms.

There are currently several large national and international research efforts that are seeking to improve our understanding of the ecological and (to a lesser extent) the socio-economic impacts of ocean acidification. However, there is a gap between the scientific and policy communities on this issue. The clear urgency and concern that is felt within the scientific community (Monaco Declaration, 2008; IAP, 2009) is not being translated into policy action. Thus, a better understanding is required of the potential of existing policy mechanisms to address ocean acidification.

Several scientists, research institutions and NGOs have worked to raise awareness around the issue of ocean acidification within the UNFCCC, especially at the 15th and 16th Conference of the Parties (COP 15 and COP 16) in (respectively) Copenhagen and Cancun. This article builds upon this existing work by identifying the policy linkages between ocean acidification and the UNFCCC and outlining ways in which ocean acidification can be addressed through the processes and mechanisms of the UNFCCC. It also acknowledges the efforts already under way to address this issue and highlights areas where the UNFCCC is currently lacking capacity to effectively continue these efforts. Scenarios are offered for possible common solutions to mitigate and adapt to ocean acidification and climate change within the UNFCCC. This is not intended to be the final say on the issue, but rather an early attempt to provoke thinking about further integrating ocean acidification into the UNFCCC.

2. Changing ocean acidity

Scientific studies show that ocean acidification may have wide-ranging consequences for species throughout the ocean (Royal Society, 2005; Kleypas et al., 2006; Schubert et al., 2006). Decreases in coral skeletal growth may be linked to rising acidity (Fabricius et al., 2011) and could be the first indicators of impacts to come. In some species, important biological and physiological processes such as reproduction (Havenhand et al., 2008), growth (Orr et al., 2005), calcification (Gooding et al., 2009) and even behaviour (Munday et al., 2009) have been found to be disrupted by increasing acidity and decreasing availability of carbonate ions.

Species as varied as fish (Munday et al., 2009), oysters (Gazeau et al., 2007) and squid (Rosa and Seibel, 2008) show direct effects arising from ocean acidification. Coral reefs appear to be particularly vulnerable (Hoegh-Guldberg et al., 2007; Kleypas and Yates, 2009; Anthony et al., 2011), and the combination of ocean acidification and increased water temperatures due to climate change could result in coral reefs shifting from net growth to net dissolution during this century (Silverman et al., 2009).

Coral reefs provide vital habitat and food for a plethora of species, as well as livelihoods and protection for many coastal populations. If reefs are weakened or destroyed by rising acidity, there will likely be cascading effects for the people and species that depend on them. Reefs and their related fisheries support hundreds of millions of people and are estimated to provide some US$30–70 billion annually to the global economy through coastal protection, tourism, fishing and other goods and services (TEEB, 2010).

Molluscs (such as clams, oysters and mussels) also appear to be particularly vulnerable to ocean acidification, both at larval and adult stages (Gazeau et al., 2007, 2010). Crashes in these populations could present great losses both economically and to the ongoing provision of ecosystem services worldwide (Cooley and Doney, 2009).

Other commercial fisheries may be similarly threatened by ocean acidification either directly, through biological and physiological changes, or indirectly, through changes in habitat and prey availability. Polar and sub-polar regions are highly productive and support some of the world's most important commercial fisheries. However, these areas are predicted – due to their already low levels of carbonate ions – to be most severely impacted by acidification within the coming decades (Guinotte and Fabry, 2008; Fabry et al., 2009; Feely et al., 2009; Steinacher et al., 2009).

Ocean acidification has the potential to drastically change the ocean and alter the availability of marine goods and services. Future high CO_2 conditions may favour some species such as jellyfish (Winanas and Purcell, 2010), algae (Connell and Russell, 2010) and seagrasses (Hall-Spencer et al., 2008). Unfortunately, these beneficiaries are unlikely to be able to support the broad diversity of species and ecosystems that exists in the ocean today and upon which humanity depends.

Although there is still much uncertainty regarding the exact changes that will take place in the ocean, there is great concern among the scientific community and many are calling for swift precautionary actions to avoid the worst impacts of rising ocean acidity (see Monaco Declaration, 2008; IAP, 2009).

3. Ocean acidification and the UNFCCC

The most effective way of preventing dangerous climate change is to stabilize the level of GHGs in the atmosphere. This is reflected in the ultimate goal of the UNFCCC and all affiliated bodies, which is to achieve 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' (UN, 1992, Article 2). It is largely

agreed that the most effective method of achieving this goal is to reduce emissions, particularly of CO_2 (the main driver of climate change). Reducing CO_2 emissions is also the most effective strategy for addressing ocean acidification. Thus, the solutions for mitigating both ocean acidification and climate change are closely related. Given the strong relationship between the causes of, and solutions to, these two problems, and the role of the UNFCCC as the only international body mandated to reduce CO_2, it seems pertinent to couch discussions and policy actions on ocean acidification within the UNFCCC.

Additionally, the ocean is an integral part of the climate system. By absorbing large amounts of CO_2 it plays an important role in helping to moderate the rate and severity of climate change (Sabine et al., 2004; Fung et al., 2005; Turley and Findlay, 2009). Unfortunately, this benefit jeopardizes the health of the ocean and its ability to continue to provide important ecosystem services, which could prevent the successful adaptation of ecosystems, and threaten food production and sustainable economic development as required by the objectives of Article 2 of the UNFCCC. Because the ocean plays an important role in the climate system, addressing the impacts of CO_2 on the ocean and the goods and services it provides seems warranted under the mandate of the UNFCCC (Schubert et al., 2006).

The interconnected nature of mitigating climate change and ocean acidification, the fact that the ocean is an integral part of the climate system, the likely impacts of increased anthropogenic CO_2 on the ocean and the important goods and services it provides, together suggest that the UNFCCC is the international regime best suited to dealing with ocean acidification.

3.1. Ocean acidification and the UNFCCC to date

Ocean acidification has begun to take on greater significance within the UNFCCC due to a better understanding by the scientific community of its impacts, the raising of awareness by civil society and concern by several governments. It remains, however, largely on the periphery. For example, ocean acidification is mentioned only once in the Cancun Agreements as part of a footnote in which it is listed as one of many slow onset events caused by climate change (UNFCCC, 2011, Decision 1/CP.16). This not only highlights the lack of importance placed upon ocean acidification within the COP, but also suggests that the COP erroneously views rising ocean acidity as a symptom of climate change rather than as a concurrent problem.

The advisory bodies of the UNFCCC, including the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Intergovernmental Panel on Climate Change (IPCC), have taken a somewhat greater role than the COP in discussing ocean acidification and its possible consequences. In 2005, SBSTA was mandated to inform Parties about emerging scientific information and to communicate the views of the Parties on research needs and priorities back to the scientific community via the research dialogue (UNFCCC, 2006, Decision 9/CP.11). Through this forum, ocean acidification has been identified as one of the most pressing emerging issues and priority needs relevant to the UNFCCC (UNFCCC/SBSTA, 2010a, 2010b, 2010c, 2010d, 2010g, 2011).

The IPCC, like SBSTA, provides scientific advice to the Parties and included a variety of references to ocean acidification in its 2007 Fourth Assessment Report, in which it highlighted that 'the main driver of these changes [lower oceanic pH and carbonate ion concentrations] is the direct geochemical effect due to the addition of anthropogenic CO_2 to the surface ocean' (Solomon et al., 2007). Ocean acidification is also tabled to be discussed more profoundly in the IPCC's Fifth Assessment Report and in inter-sessional activities (IPCC, 2009, 2010a, 2010b), indicating a growing international recognition of ocean acidification and its linkages to climate change and the carbon cycle.

4. UNFCCC and the capacity to mitigate ocean acidification

The UNFCCC appears to be the most appropriate body to address ocean acidification, and the growing importance being placed upon this issue in the advisory bodies indicates a growing desire to do so. However, the UNFCCC was not established explicitly with the intention of tackling ocean acidification alongside climate change and is, therefore, currently lacking the capacity to successfully do so. A more comprehensive approach with policy incentives for private sector engagement and guidance for global financial investments is required to ensure that ocean acidification is appropriately addressed. One of the most fundamental adjustments required involves the recognition of the differences between the mitigation strategies of the two interlinked problems of ocean acidification and climate change, as this will ultimately influence the types of measures that are used to address them.

Without this recognition, the mitigation strategies currently used by the UNFCCC are unable to ensure the simultaneous mitigation of climate change and ocean acidification. The ultimate stabilization goal of the UNFCCC is currently interpreted in such a way that mitigation policies are designed to avoid dangerous climate change rather than ocean acidification. As a result, the Kyoto Protocol (UN, 1998) – and presumably any post-Kyoto agreement – attempts to meet this objective by regulating four GHGs (CO_2, methane, nitrous oxide and sulphur hexafluoride) and two groups of gases (hydrofluorocarbons (HFCs) and perfluorocarbons). In doing so, the Kyoto Protocol has created a basket of gases from which countries can choose in order to reduce their emissions. This provides countries with flexibility, as some gases may be cheaper and easier to reduce than CO_2. However, it should not be assumed that regulating this basket of gases collectively will be effective in mitigating ocean acidification, as rising acidity is a problem caused by the emission of CO_2 (and not one caused by GHGs in general). Therefore, to mitigate ocean acidification, CO_2 should be regulated independently of the other GHGs managed by the UNFCCC.

Regulating CO_2 emissions is, however, a difficult task. Discussions have suggested focusing on rapid reductions of non-CO_2 GHGs, such as methane, to act as a stop-gap measure while the more difficult question of CO_2 emission reductions continues to be discussed (UNFCCC/AWG-LCA, 2009a). Other discussions have focused on using alternative strategies to reduce global temperatures without stabilizing atmospheric levels of CO_2 (Royal Society, 2009b; UNFCCC/AWG-LCA, 2009b). Although these strategies may be effective at alleviating or offsetting the symptoms of global climate change, they simply avoid dealing with ocean acidification in the short term (see Matthews et al., 2009) and almost certainly condemn future generations to ever worsening impacts. To avoid this, it is critical that CO_2 emission reductions are not put on hold while other emissions are reduced or global temperatures are managed.

Non-CO_2 GHG emissions are an important contributor to climate change and their reductions should not be overlooked. However, they may be most effectively regulated outside of the UNFCCC. This could free up space within the UNFCCC, allowing more time and effort to reduce CO_2 emissions. For example, the phase-out of hydrochlorfluorocarbons, and possibly HFCs, could be tackled under the Montreal Protocol on Substances That Deplete the Ozone Layer (UNEP, 2010b). Dealing with non-CO_2 GHGs under other more specialized conventions may be a more effective way of reducing these emissions, and to some extent this is already being realized (Bodansky and Diringer, 2010).

Stabilizing the climate will first require establishing a target level of atmospheric CO_2 and GHGs below which humanity should aim to remain. This target is currently subject to debate within the UNFCCC, with Party viewpoints generally ranging from an atmospheric level of 350–550 parts per million (ppm) CO_2e (UNFCCC/AWG-LCA, 2009c), but does not currently explicitly aim to avoid the impacts of ocean acidification. To do so would require setting separate targets for CO_2 and other non-CO_2 GHGs, as well as setting the CO_2 target low enough to mitigate both ocean acidification

and climate change. The likely result of this would be a crystallization of the stabilization target towards the lower end of the currently debated range. Present scientific knowledge suggests that a target of 350 ppm CO_2 may be required to maintain marine systems as humanity knows them and that an overshoot to 450 ppm CO_2 would likely be catastrophic for at least some species, such as corals (Veron et al., 2009; Royal Society, 2009a). Setting an appropriate target is integral to the effective mitigation of either ocean acidification or climate change. As the UNFCCC is already mandated to regulate CO_2 with respect to climate change, it is reasonable to expect that a CO_2 target should be set low enough to also mitigate ocean acidification.

A global temperature target is often used alongside atmospheric GHG concentrations as a metric to indicate the limit that, if passed, would result in dangerous changes to Earth's climate and ecosystems. Although this target has widely been accepted as 2°C above pre-industrial temperatures, many Parties, including Small Island and African nations, are calling for a limit of 1.5°C. Temperature is an appropriate indicator for the successful mitigation of climate change because it is the increased heat in the climate system from additional GHGs in the atmosphere that is causing the perturbations around the globe collectively referred to as 'climate change'. Temperature, however, is not a driver of the changes resulting from CO_2 in the ocean and is therefore an inappropriate indicator of ocean acidification.

An indicator reflecting the chemical changes in the ocean should be placed alongside temperature in all UNFCCC discussions and decisions. Measures such as pH or saturation state may be suitable indicators (Rockstrom et al., 2009; Bernie et al., 2010). pH could be used to reflect the changes in acidity and alkalinity that are taking place in the ocean, while saturation state can be used to indicate the availability of carbonate ions and whether or not calcium carbonate structures are likely to dissolve. However, neither measure has been accepted as the preferred indicator for ocean acidification. Further research is required to identify which would be the most effective.

5. A comprehensive approach to dealing with ocean acidification

Several countries (Australia 2007, Indonesia 2007, Ireland 2007, DEFRA 2010, Japan 2009) refer to ocean acidification and its implications for marine ecosystems and fisheries in their national climate change plans and strategies, in particular in their climate change adaptation plans. However, a more comprehensive, international, action-oriented approach, including guidance on how to address and include ocean acidification in national climate change mitigation and adaptation programmes, is greatly needed.

The formal recognition of ocean acidification by Parties to the UNFCCC is warranted in order to identify common solutions to ocean acidification and climate change, and to ensure that ocean acidification is addressed in a long-term and coherent manner within the UNFCCC itself. This could occur through a decision of the COP that recognizes ocean acidification as a consequence of increased anthropogenic CO_2 in the atmosphere that is acting alongside climate change. Such a decision could also affirm the urgent need to take meaningful action to reduce the impacts of ocean acidification such as ensuring that food production is not threatened or enabling ongoing sustainable economic development. Such a decision could also recognize the need to explore opportunities to address ocean acidification in conjunction with climate change under the auspices of the UNFCCC.

The COP could also invite Parties to support the activities of the UNFCCC, for instance by maintaining and strengthening extant national research efforts on ocean acidification, especially on its socio-economic impacts.

Additionally, the COP could further agree to call for follow-up activities to formally expand the mandate of the UNFCCC to include ocean acidification in the work of all its relevant bodies. For

example, SBSTA could take up further work in a more coordinated and complete manner on both mitigation and adaptation. It could establish a work programme on ocean acidification to identify future needs and priorities for understanding and responding to ocean acidification. This could lead the search for options to address ocean acidification under the existing mechanisms and processes of the UNFCCC and, if needed, propose the development of new mechanisms and processes. Such a work programme could ensure that the proposed actions on ocean acidification within the UNFCCC, discussed in the previous paragraph, continue to move forward in an aligned fashion with a common goal.

The SBSTA work programme could also review the range of mitigation strategies that are currently proposed for tackling climate change for their effectiveness in simultaneously addressing ocean acidification. Approaches that do not address atmospheric CO_2 concentrations, or that threaten to exacerbate ocean acidification, could then be carefully evaluated for their usefulness and appropriateness for large-scale deployment. This work would provide clear signals to the UNFCCC and other international conventions on the most effective mitigation strategies that should be pursued and those that should not.

Other extant mechanisms and programs could also be revised to more effectively tackle ocean acidification. For example, ocean acidification could be incorporated into the Clean Development Mechanism (CDM) by requiring larger investments in CO_2 (rather than other GHG) abatement projects. As it stands, the CDM is designed to promote emission-reduction projects in developing countries by allowing the projects to earn certified emission reductions. Each credit is equal to the reduction of 1 tonne of CO_2 and can be traded, sold and used by industrialized countries to meet parts of their emission reduction targets under the Kyoto Protocol (UN, 1998).

The CDM currently covers all GHGs regulated by the Kyoto Protocol and does not give preference to the reduction of one over another. However, there are clear economic incentives to reduce those gases with a stronger warming effect than CO_2, as the reduction of 1 tonne of them will equate to multiple CO_2e equivalents and provide more credits than reducing 1 tonne of CO_2. To make the CDM more effective at addressing ocean acidification more importance needs to be placed on the reduction of CO_2.

The Nairobi Work Programme (NWP) is designed to distribute improved knowledge and assessments of climate change impacts, vulnerability and adaptation and thus could also be used as a platform to improve the understanding, and assessment, of best practices for adapting to ocean acidification. Although the NWP has generated increased momentum in the adaptation community at large, it is currently up for review (UNFCCC/SBSTA, 2010e). An overhaul could include regional or thematic partnerships, and a knowledge- and information-sharing hub on ocean acidification, which would both enable enhanced integration of efforts and interactions among Parties, partners and other stakeholders, and strengthen education, training and awareness-raising activities (UNFCCC/SBSTA, 2010f).

6. Conclusion

Despite an increase within the international climate negotiations in the scientific discussions about, and references to, ocean acidification, it remains largely on the periphery and is mostly dealt with in a piecemeal fashion. The significance of ocean acidification, its close relationship with climate change and the opportunity to develop common solutions for both have not yet been addressed.

Given the current state of climate negotiations it is not an easy task to ensure that mitigation strategies are effective at curtailing both climate change and ocean acidification. After the lacklustre results of COP 15 in Copenhagen, COP 16 in Cancun presented some positive outcomes in the form of the

Cancun Agreements and restored faith in a process that was beginning to be seen as too unwieldy to achieve meaningful results. Parties to the UNFCCC are continuing to negotiate the legal options for an overall agreement and are also seeking clarification of two of the major issues remaining: long-term finance and emission reduction commitments. Reaching an agreement over these two sticking points will in all likelihood take up most of the space in the run-up to COP 17 and beyond, making it difficult to fit ocean acidification into an already heavy COP and SBSTA agenda. However, streamlining the UNFCCC by moving the regulation of non-CO_2 GHGs to other conventions could alleviate some of this congestion and allow for more effectiveness within it. The difficult task of effectively addressing both climate change and ocean acidification under the UNFCCC will also require overcoming political hurdles. The failure to address ocean acidification jeopardizes the success of any agreement, as mitigating climate change does not necessarily equate to mitigating ocean acidification.

Despite the fact that the COP has not yet explicitly decided to address ocean acidification alongside climate change and the difficulties of including ocean acidification in an already overburdened system, the UNFCCC appears to be the most appropriate body to address ocean acidification given that it is already mandated to regulate CO_2 emissions – the cause of rising ocean acidity. The interconnected nature of mitigating climate change and mitigating ocean acidification and the integral role the ocean plays in the climate system also suggest that the UNFCCC is the regime best suited to dealing with this issue.

Attempts to address ocean acidification more completely within the UNFCCC will require actions that recognize that ocean acidification is a concurrent problem to climate change and not a symptom of it, such as acting immediately to reduce CO_2 emissions (rather than those of non-CO_2 GHGs such as methane), developing separate targets for CO_2 and the other GHGs regulated under the UNFCCC, setting CO_2 targets low enough to mitigate the impacts of both climate change and ocean acidification, and setting an indicator for ocean acidification, such as pH or saturation state, alongside temperature.

These steps will need to be incorporated thoroughly across all the programmes and mechanisms of the UNFCCC. Analysing the best ways to do this could be undertaken through the initiation of a new SBSTA work programme. Opportunities to revise existing mechanisms and programmes, or to develop new ones, exist under the UNFCCC. Such revisions should be designed to develop mitigation and adaptation strategies that protect humanity from the worst impacts of both climate change and ocean acidification.

Ocean acidification has the potential to cause widespread changes throughout the ocean. For people that depend either on direct (e.g. food security and economic wellbeing) or indirect (e.g. climate regulation and oxygen production) goods and services provided by the ocean, such change will in all likelihood have cascading impacts. The UNFCCC has the ability to address both ocean acidification and climate change. It is hoped that it will not let the opportunity to address both CO_2 problems in a coherent and effective manner slip through its fingers.

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