9 Key principles and rules for the use of marine CDR procedures

> There is no longer any doubt that humanity must remove carbon dioxide from the atmosphere if it is to achieve its climate targets. However, this removal must meet exacting requirements: neither nature nor people should be harmed, and the removal should be permanent and have a positive climate impact at the same time. Initial propositions, principles and regulatory approaches have already been developed, but the debate has only just begun.

How to regulate increased CO_2 uptake by the ocean?

> Humanity faces a dilemma. Having ignored the threat posed by climate change for decades, we now need solutions more urgently than ever. Ocean-based methods to remove carbon dioxide from the atmosphere may help us to offset a proportion of our residual emissions. However, implementing the corresponding measures in a controlled, fair and responsible manner is a mammoth task. As the conservation and management of the oceans are only possible on a collective basis, clearly defined international rules and principles are essential.

Unaccustomed dynamics

Right now, the increasingly dramatic impacts of climate change are creating unaccustomed parallels between political and scientific processes. To take two examples: in Germany, the government is already consulting an array of experts on amending the legal frameworks to enable deep subsea storage of carbon dioxide, while marine scientists are in the process of assessing the suitability of geological formations beneath German waters as potential storage sites and developing appropriate monitoring systems. Meanwhile, one of the topics being discussed at the international level is which removal and storage options may be eligible for certification, although there is still no scientific consensus on the length of time that must elapse for carbon dioxide removal and storage to be classed as genuinely permanent and therefore climate-relevant.

In politics and business, the hope appears to be slowly growing that through the use of carbon dioxide removal (CDR) methods or the capture and storage of carbon dioxide from fossil sources (CCS), it will be possible to claw back the time wasted by our decades of constant foot-dragging on effective climate action. With so much pressure to take action, the much-needed social debate on the use of ocean-based CDR is falling short. This much is already certain: this is not an easy debate, for there are numerous aspects to consider.

On the one hand, we face the increasingly urgent need for drastic emission reductions. On the other, there are justified concerns about marine and species conservation, and about potential utilization claims and conflicts. On top of that, there are issues of climate and distributive justice. And finally, a further task is to establish legal frameworks and develop institutions and mechanisms to steer and control the possible use of ocean-based CDR methods.

It is almost impossible for casual observers to keep pace with the scientific and political debate about CDR methods. Almost every week, new scientific findings or new policy strategies, recommendations and debates emerge at both the national and the international level. In most cases, it is not immediately foreseeable which role these findings and strategies will play further down the line. Seemingly innocuous technical details may acquire immense significance – for example, when it comes to the question of how much time must elapse for carbon dioxide storage to qualify as “permanent”. Some experts are proposing a minimum period of 200 to 300 years. Others argue that removal with subsequent storage for 50, 60 or 100 years helps to offset emissions in the short term; in their view, this makes an important contribution and should be supported through the allocation of subsidies or the granting of time-limited removal certificates, for example.

This chapter can therefore do no more than provide a snapshot of the current state of knowledge and debate. We are guided by the following questions. Should ocean-based CDR methods be deployed if they prove to have a positive impact on the climate? And if the answer is yes, which legal and policy instruments may be suitable for steering and regulating their use – and who are the key stakeholders in this process?

The ocean is not an untouched void

In early June 2023, a leading British daily newspaper published a passionate appeal against over-hasty use of marine CDR procedures. The main argument put forward was that the ocean is viewed by a growing number of politicians and corporate stakeholders as a vast empty space and hence as an untapped resource, ripe for human exploitation and, with a large measure of inventiveness, for transformation into something useful.

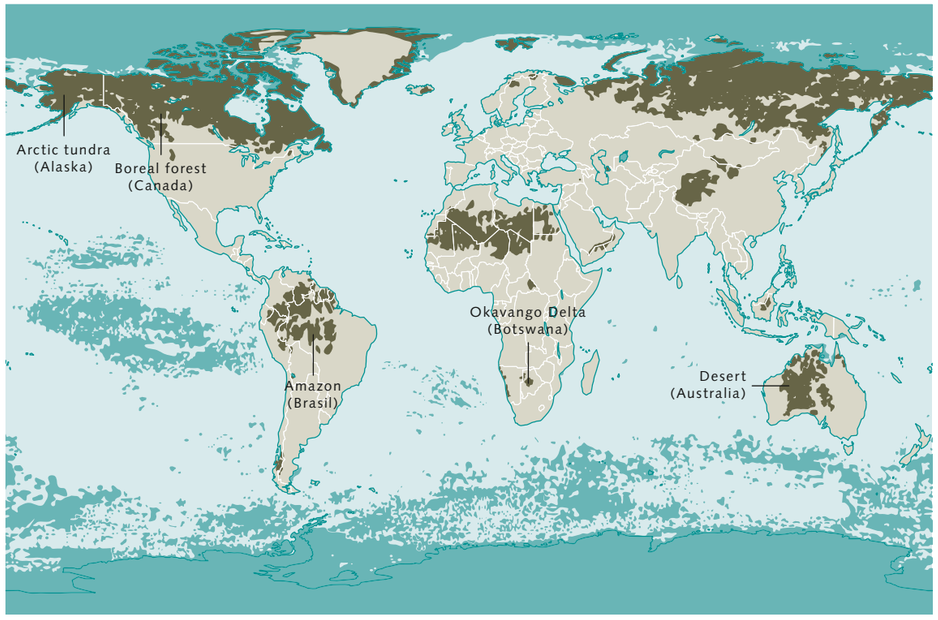
This is an extremely dangerous view, the article continued. Firstly, it ignores the ocean’s central role in ensuring the continued existence of life on Earth. And secondly, it overlooks the close linkages between physical, chemical and biological processes in the sea, as well as the fact that marine organisms are already under pressure. Any use of CDR methods will therefore bring about changes in the marine environment on a scale that is almost impossible to predict precisely because we do not yet understand how all these processes work and interact.

As scientific observers of the political debate about marine CDR procedures will confirm, proponents of increased use of ocean-based CDR often argue that the ocean is a realm of unlimited possibilities and that its use to offset emissions creates fewer problems and conflicts compared with land-based measures. An aspect ignored by these supporters of ocean-based CDR, however, is that the world’s oceans are already an intensively used space and that the human footprint is visible in almost every marine region. For example, a study published in 2018 revealed that by that point in time, 87 per cent of the ocean had already been modified by human activities. Only in the Arctic and Antarctic oceans were there a few remaining areas of marine wilderness which, by then, had seen little or no fishing and no shipping and where there was still no evidence of chemical or plastic pollution.

The prospect of industrial-scale use of ocean-based CDR methods also awakens fears that coastal waters could be privatized for commercial purposes, with displacement of local communities. These concerns have

The few spots of wilderness remaining worldwide

Remaining wilderness: terrestrial marine



9.1 > The search for genuine wilderness on Earth will soon be futile: 77 per cent of land (excluding Antarctica) and 87 per cent of the ocean has already been modified by human interventions in the natural environment.

9.2 > Stilt fishing is a centuries-old tradition in Sri Lanka and a source of food and income for many artisanal fishing families. Their claims to the sea must be taken into account when the use of CDR methods is considered and discussed.

sparked an international debate about "ocean grabbing", demonstrating just how important issues of distributive and climate justice are in this context as well.

A possible framework for discussion – nine propositions on the ethics of CDR

The current scenario, then, is as follows: intensive use by humans has already modified large areas of the ocean and its biocoenoses. At the same time, the mounting impacts of climate change compel us to take effective mitigation measures at long last – with the aid of the ocean where possible. This dilemma, philosophers argue, raises two crucial moral questions for our society: if CDR methods can contribute to the mitigation of climate change, does this mean that we should actually deploy them? And which of the potentially feasible methods are permissible or, indeed, imperative? German climate and environmental ethicists have attempted to encapsulate this philosophical debate in the following nine propositions which serve as a framework for discourse in society:

1. **A generalized assessment of CDR methods is not possible – instead, a nuanced approach is required.**
   In the philosophers' view, there is neither a convincing argument justifying CDR methods in all cases and contexts, nor a convincing argument proving that the use of these methods should never be permitted. The potentially positive climate impact of these methods is of such moral significance that a considerable number of practical CDR projects are probably permissible or even imperative from a moral perspective.

2. **An overly cautious approach misjudges the threat posed by climate change.**
   Climate change has the potential to become one of the most cataclysmic disasters in human history. Furthermore, the ethicists say, the hazardous effects of climate change are no longer a future scenario; on the contrary, in many parts of the world, they are already harsh reality. Nevertheless, humankind can still take action to curb climate change. A non-interventionist position, by contrast, is less convincing: there is far too much at stake for that. If CDR methods should indeed prove suitable as a means of lessening the immense threat posed by climate change, this would weigh heavily in favour of their use. Negative spillover effects and other concerns should be measured against the potential benefits of using CDR methods. In the ethicists' view, understanding that in order to mitigate climate change, it may be morally imperative to deploy measures that are themselves morally problematical means having a clearer understanding of the tragic predicament into which humankind has manoeuvred itself by failing to take more timely and resolute action.

3. **An insufficiently cautious approach underrates the risks associated with CDR methods.**
   Nevertheless, from a moral perspective, humankind does not have carte blanche to undertake climate-regulating interventions in the ocean, for two reasons. Firstly, other options are available to us. There is scope to achieve larger emissions reductions and to invest more resources in adaptation. And even hard-to-avoid residual emissions could be avoided if, as a society, we were willing to pay the price for this, both economic and non-economic. And secondly, CDR measures could have knock-on effects that are highly problematical from a moral perspective. As CDR methods may differ considerably, the extent to which this applies to each method varies. A nuanced assessment of individual methods and specific usage scenarios is therefore required, the experts say. And as they point out, the moral situation is complicated by the fact that the people who may be impacted by the use of CDR methods are not necessarily those who are otherwise at risk from climate change itself. The message here, then, is that even the most serious condition (the impacts of climate change) does not justify administering every potentially beneficial remedy (use of CDR methods) if third parties are harmed as a result.

4. **The use of CDR methods must not hinder decarbonization.**
Highest on the list of priorities, from a moral perspective, is decarbonization, which ultimately means the avoidance of anthropogenic greenhouse gas emissions. In this context, one argument often put forward in the debate about CDR measures relates to "mitigation deterrence". This refers to the concern that the prospect of CDR methods becoming available, and their subsequent use, could result in humankind making less effort to avoid greenhouse gas emissions. While climate researchers present very clear arguments showing that avoiding emissions is a much more effective method to limit global warming than removing carbon dioxide from the atmosphere after it has been emitted, the ethicists draw attention to another important moral question which they see underlying this debate – namely the issue of which emissions may legitimately be offset by CDR measures and which may not. In the philosophers' view, certain forms of offsetting may well be morally acceptable as a transitional solution – notably for particularly hard-to-avoid residual emissions in food production and cement manufacturing.

9.3 > Toxic algal blooms caused by eutrophication of coastal waters are becoming increasingly common and can cause mass fish die-offs. Successful human intervention to minimize these additional stress factors would improve the health of the ocean and increase its natural carbon dioxide uptake.

5. **Climate change is a major environmental disaster – and not the only one.**
Climate change is an environmental disaster which gives rise to major global injustices and may provide moral justification for the use of CDR methods. Nevertheless, the goal of greenhouse gas neutrality is not the only imperative at present, the ethicists say. In view of the sixth mass extinction which is occurring at the same time (more on this topic in Chapter 1), ecological neutrality must be the goal, in their view. In other words, climate change mitigation and its technologies must notcome at the cost of environmental and species protection. These two dimensions require joined-up thinking in order to preserve our planet's natural resources and identify a solution to the environmental crises.

6. **CDR measures that also support nature conservation deserve particular consideration.**
Precisely because the climate and the biodiversity crises can only be solved in tandem, measures that are compatible with nature conservation goals and simultaneously achieve a positive climate impact deserve particular consideration, the experts say. Morally speaking, these are "low-hanging fruit"; in other words, there are strong arguments in favour of these measures from multiple perspectives. It is essential, therefore, to investigate and leverage their potential.

7. **The burdens resulting from the use of CDR methods should be shared equitably.**
The use of CDR methods will undoubtedly give rise to burdens, the experts note. Firstly, economic resources (money, energy, raw materials, etc.) will be consumed; and secondly, any use of CDR on a global scale will likely have substantial negative side-effects as well. Who will these burdens fall on? This is a key issue of distributive justice in the context of carbon dioxide removal measures. At this juncture, the ethicists point to the "polluter pays" principle and propose that the

9.4 > Long condensation trails (contrails) over the North Sea reveal the flight paths taken by passenger aircraft to and from Europe. International aviation is one of the fastest growing sources of greenhouse gases, accounting for around 2.5 per cent of global CO_2 emissions in 2018.

burdens should mainly fall on those stakeholders that have contributed most to the problem of climate change since it first came to light. This, they say, applies first and foremost to the prosperous strata of society, who often, although not invariably, live in affluent countries. It is unacceptable to expect demographic groups that would benefit most from the positive climate effects of the use of CDR to cover the costs – for in the main, these are poor and particularly vulnerable communities.

8. **Procedural equity is important – but challenging in practice.**
The issue of procedural equity plays an important role in the CDR debate. This includes the ambition that CDR methods will not only be transparently researched but will also be implemented fairly, should the situation arise. The requirement for transparent communication is uncontentious, in the ethicists' view. Unless there are compelling reasons against such an approach, the mechanisms and the anticipated and actual impacts of CDR use should be made public so that those affected are able to reach an informed position.

A second and much-discussed requirement is that all stakeholders who may be affected by the possible use of CDR should have the right to make their voices heard in the relevant decision-making processes. However, this raises a number of questions: who qualifies as "affected", and what kind of right to have a say is required – does this mean a right of veto or a weaker option? It can be plausibly argued that at the very least, people who will suffer the negative spillover effects of CDR use and those who will benefit from its positive climate impact count as stakeholders. However, the ethicists argue that the group of beneficiaries may be extremely large and widely distributed in time and space. Involving them in decision-making processes will therefore be very difficult. Yet excluding them is not a convincing approach either. There are therefore good grounds for at least allowing representatives or ombudspersons from communities benefiting from the positive climate impacts to participate in decision-making processes.

9. **The debate reveals our moral failure.**
In the ethicists' view, the climate crisis is not only the result of the emissions produced over the last 200 years; it also stems from the inadequate climate policies pursued in recent decades. There is thus a broad consensus in the field of climate ethics that the hitherto inadequate responses to climate change are morally reprehensible. Our situation, in other words, is characterized by moral failure. Nevertheless, there is still an opportunity to respond in a morally acceptable way to climate change, at least from this moment onwards.

The unwillingness to talk about responses to climate change that are themselves morally problematical is understandable, the ethicists say, but it fails to do justice to the situation. A key challenge for a moral debate about the use of CDR methods is therefore to acknowledge the severity of the situation without falling into fatalism, the sense that "we can do whatever we like today because it will all be too late tomorrow".

Key principles for the governance and regulation of CDR methods

Based on this philosophical line of argument and a wealth of information from the environmental and social sciences, researchers have developed four key principles to guide the governance and regulation of land- and ocean-based CDR. According to these principles,

- the reduction and avoidance of greenhouse gas emissions should be prioritized in all decision-making,
- the climate effectiveness and permanence of carbon dioxide removal should always be ensured,
- the environmental integrity of the corresponding measures should be considered, and
- potential goal conflicts should be managed.

Prioritize emissions reduction
Given that removing carbon dioxide from the atmosphere does not address the real cause of climate change (high greenhouse gas emissions), the goal of emissions avoidance must be prioritized in all climate policy decisions, for three reasons. Firstly, preventing the emission of one tonne of carbon dioxide limits global warming far more effectively than removing the same amount of carbon dioxide from the atmosphere. This is due to the multiple interactions in the Earth's climate system. Secondly, merely removing carbon dioxide certainly does not mean that the gas will not escape back into the atmosphere and affect the climate at some future time. And thirdly, the removal of carbon dioxide from the atmosphere or the ocean by technological means necessarily involves the use of energy and resources and may undermine environmental goals. It also releases additional amounts of greenhouse gases, limits opportunities for emissions avoidance or takes up areas (of the sea) that could be used for other purposes.

For this reason, climate policy-makers must ensure that emissions avoidance and reduction are prioritized at all levels. A key step would be to require governments to list their carbon dioxide removal targets separately from their emissions reduction targets, so that it can be determined at any time whether sufficient efforts have been invested in avoiding emissions.

A clear differentiation must be made in the corporate sector as well: firms should not be permitted to use CDR measures as they see fit in order to offset avoidable emissions. Otherwise, emission reductions could all too easily be neglected in favour of offsetting measures – a strategy known as "mitigation deterrence" in the debate about CDR. This can be prevented by stringent

9.5 > The Earth's coastal zones are some of the most intensively used landscapes on our planet. Measures to increase carbon dioxide uptake by the ocean would constitute a further intervention which, depending on the method, may benefit, limit or even preclude other forms of use.

rules in European emissions trading, among other things. Without a more rigorous focus on prioritizing emission reduction measures, the experts conclude, there is a fear that efforts to tackle the causes of the climate crisis will decrease.

Effective and permanent carbon dioxide removal

As carbon dioxide can linger in the atmosphere for very long periods of time while continuing to affect the climate, it is essential to ensure, when CDR methods are applied, that the removal of carbon dioxide from the atmosphere is permanent wherever possible. If this cannot be guaranteed, potential leakage pathways along which the removed carbon dioxide can escape back into the atmosphere must be considered in decision-making – for example, by accounting for these deductions when inventorizing carbon dioxide removals. In the experts' view, carbon dioxide storage sites must be continuously monitored, and funding for this monitoring must be secured for the long term. In order to assess the specific contribution of a given method to carbon dioxide removal, all greenhouse gas emissions that are caused indirectly must also be accounted for. This includes emissions from transport and the manufacturing of precursor products, but also from the generation of the energy that is used.

Comprehensively assess CDR methods – from a climate, environmental and social perspective

The use of marine CDR methods consumes energy, resources and space. In some cases, it may adversely affect coastal areas and their ecosystems or, indeed, the ocean as a whole, particularly if the methods are to be applied on a global scale. It may also have potentially negative social impacts which can arise if human communities that are heavily dependent on marine resources are suddenly no longer able, or are no longer permitted, to access them to the full extent. The impacts of a technology may often also vary according to local conditions.

For these reasons, CDR methods should not only be assessed in terms of their potentially positive climate impact. Their effects on people and the environment must also be comprehensively reviewed – the experts are almost unanimous in voicing this demand. What is lacking at present, however, are adequate strategies for achieving this goal. One proposal is to set minimum criteria for specific technologies or groups of technologies to ensure the intervention's climate effectiveness and minimize possible environmental impacts and resource consumption. Experts from a German research mission are currently developing review guidelines which are intended to aid decision-makers in conducting this type of assessment of CDR methods and specific projects.

Successfully resolve or avoid goal conflicts

On their own, however, minimum criteria will not be sufficient as a steering mechanism to resolve or avoid the goal conflicts that will arise from the use of interventionist, resource-intensive CDR methods. The problems associated with the climate and biodiversity crises and, simultaneously, the ongoing overexploitation of our natural resources are far too complex for that, the experts say. It is crucial, therefore, to conserve the spaces and resources that we have left, or at least to use them as efficiently as possible. Should there be a case, nonetheless, for resorting to minimum criteria for the governance and regulation of CDR measures, these criteria must be regularly reviewed and amended to bring them into line with the best available science and technology. And on a cautious note, the experts point out that it is also important to consider, from the outset, the option of exiting from less sustainable methods and consistently implement this approach if a method proves to have adverse effects.

It may be expedient to hold a competition in order to identify the most sustainable solutions, which should then be integrated into the criteria-led selection or funding of the methods concerned. Here, it is essential to consider not only the climate-specific advantages and disadvantages of all the natural and technological CDR options but also the positive impacts on biodiversity and ecosystems. As a desired outcome of this approach, the measures selected should mainly be those which strengthen natural carbon sinks, thus generating additional benefits for ecosystems.

What is needed is a clear strategy for managing residual emissions. The fact is that the use of CDR methods on the required scale cannot be organized as an afterthought: it will take time and will require targeted incentives, international cooperation and clear rules for all stakeholders. Consistent implementation of the key principles outlined above may help to ensure that carbon dioxide removals from the atmosphere make an additional contribution to combating the climate crisis without worsening the existing environmental crises. Under these circumstances, any delay in reducing avoidable emissions must be ruled out; the same applies to any further weakening of terrestrial and marine ecosystems through the use of CDR.

Existing regulations on marine CDR procedures

Procedures for the removal of carbon dioxide from the atmosphere have featured as a topic in various international bodies and negotiations at least since the signing of the Paris Agreement in 2015, although the Agreement itself does not refer specifically to carbon dioxide removal and its possible regulation. The main focus of the Agreement is the mitigation of greenhouse gas emissions and the goal of global greenhouse gas neutrality in the second half of this century. The text of the Agreement leaves unanswered the question of how the desired "balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases" is to be achieved. Nor does it differentiate explicitly between natural sinks (terrestrial vegetation and ocean) and technological sinks. According to expert opinion, therefore, the Paris Agreement does not give rise to a legal obligation to perform technical procedures for carbon dioxide removal.

If the Paris Agreement is in future to serve as a global regulatory framework for carbon dioxide removal methods – which is entirely conceivable – the Parties would have to adopt a corresponding amendment to the existing Agreement or agree its revision by passing resolutions at the annual Conference of the Parties. To date, only the Article 6.4 mechanism has been negotiated in earnest. Its purpose is to establish a regulatory framework specifying the conditions for the issuing of emission reduction and carbon removal certificates to countries, companies and individuals, as well as for the trading of these certificates within and between states.

At the present time (autumn 2023), the development of a global regulatory framework for CDR methods under the Paris Agreement seems a fairly unlikely prospect, largely because the individual land- and ocean-based CDR technologies differ from each other in fundamental ways. Developing a common regulatory framework that would be appropriate for all the various CDR methods would be an extremely challenging task. A further factor to consider is that not all countries are in a position to implement ocean-based procedures. Land-locked countries such as Switzerland and Austria have no coastal waters of their own where they would be able to sequester captured carbon dioxide in subsea formations or massively expand the coastal ecosystems. Does this mean that land-locked countries should be excluded from possible negotiations on a global regulatory framework for marine CDR?

International environmental law, too, does not currently include any binding CDR-specific norms which would regulate the exploration and use of these technologies on a comprehensive and overarching basis. Experts doubt that the international community will ever agree on a universally applicable regime for climate engineering in international law that would then also regulate the use of marine CDR procedures. At present, there are two factors mitigating against such an approach. Firstly, the provisions of international environmental law are already highly fragmented. Interventions which, in essence, involve the discharge of substances into the sea are regulated by the Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Protocol). Other techniques, such as the creation of artificial clouds or solar radiation management in the stratosphere, are covered by the Vienna Convention for the Protection of the Ozone Layer and the accompanying Montreal Protocol, or by the Geneva Convention on Long-range Transboundary Air

Climate engineering
The term "climate engineering" describes various human interventions whose purpose is to counteract global warming. They typically include carbon dioxide removal methods (CDR) and solar radiation management measures (SRM). The term "geoengineering" is sometimes used as a synonym for climate engineering.

Pollution. Secondly, most efforts made in recent years to reduce this fragmentation through the development of new overarching treaties have failed. A positive exception is the new global Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ Treaty), adopted in June 2023.

Legally binding norms and principles of international environmental law

The thematic area of "marine CDR procedures" is not entirely unregulated at present, however, as various general norms and principles pertaining to the management of the environment – most of which are recognized in customary international law – apply, which would regulate the use of marine CDR procedures both for research purposes and for large-scale deployment to offset residual emissions. They include:

- the prevention principle,
- the notification and consultation requirement,
- the duty to conduct an environmental impact assessment before initiating a planned intervention,
- the precautionary principle,
- the principle of cooperation, and
- the guiding principle of sustainable development.

The prevention principle

The prevention principle is based on the prohibition of significant transboundary environmental harm and imposes a duty on states to take all possible and reasonable measures, prior to a planned activity, to prevent probable transboundary environment harm, and to do so by exercising due diligence. This means that technical standards, such as "best available techniques" and "best environmental practices" must be adhered to.

The notification and consultation requirement

In order to safeguard compliance with the prevention principle, information-sharing and communication are essential. Countries that are planning an intervention which involves a risk of significant transboundary environmental harm therefore have a duty to provide prior and timely notification about these activities to potentially affected countries. They must then engage in consultations.

The requirement to conduct an environmental impact assessment before initiating a planned intervention

Environmental Impact Assessment (EIA) is a statutory multi-staged process involving the timely identification, characterization and evaluation of all the direct and indirect effects of a given project on specific environmental factors, including its cumulative ecological impacts. For projects with transboundary environmental impacts, the environmental impact assessment must be conducted in a cross-border context. It is thus a key element of the prevention principle. However, general international law does not specify precisely which criteria should apply to environmental impact assessments in individual cases. This may, however, be determined from specialized international treaty law, European Union law and/or the national law of the states concerned. The gaps existing at the global level will in future be closed by the provisions of the Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ Treaty), provided that it enters into force. It defines minimum standards for environmental impact assessments which all Parties must comply with in future.

The precautionary principle

The precautionary principle states that the environment is protected most effectively when conceivable harms are avoided from the start. It thus supports risk assessment and takes effect at an earlier stage than the prevention principle, namely as soon as an environmental hazard potentially exists but there is scientific uncertainty about its occurrence. The precautionary principle is enshrined in international treaties in a variety of ways, which hinders its operationalization. A key question, for example, is this: how should states proceed if there is a lack of conclusive scientific certainty about possible risks? Some countries, including Germany, apply a highly restrictive approach in such cases. They tend to start by prohibiting anything that may pose a risk, and then examine, on a case-by-case basis, where there is scope for allowing exceptions. In the US, by contrast, risks are accepted more readily. This involves a trade-off, however: all stakeholders are aware that in the event of any harm being done, they face paying substantial sums in compensation.

Despite these differences, many experts in international law view the precautionary principle as a vital risk management tool. Against the backdrop of climate change in particular, one idea being proposed is to operationalize the precautionary principle as an evaluation mechanism that can be used to manage goal conflicts between various assets that are protected under international environmental law, e.g. between biodiversity conservation on the one hand, and mitigation of climate change on the other. This view is not yet widely accepted, however.

The cooperation principle

According to this principle, environmental protection is a task for all the forces within society; in other words, all governmental and social stakeholders should collaborate in environmentally relevant opinion-forming and decision-making processes.

The guiding principle of sustainable development

The concept of sustainable development was recognized as a guiding principle by the international community at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, in 1992. Since then, it has informed environmental law at national, transregional and international level. Sustainable, environmentally compatible development is human-centred in principle. It aims to satisfy everyone's socioeconomic needs and guarantee decent living conditions for all the world's people. However, these goals should not be achieved at the expense of future generations.

A further key element is that due to the close linkages and interactions between them, all the various environmental, economic and social objectives can only be achieved on a sustainable basis through a holistic approach. Economic development and poverty reduction have thus become key topics in international efforts to protect the environment.

9.6 > A parrot and a flower feature on one of several commemorative stamps issued by Brazil's national postal service to mark the United Nations Conference on Environment and Development (Rio Summit) in Rio de Janeiro in 1992.

Individually assessing and regulating ocean-based CDR methods

Based on these six principles of international environmental law and the provisions of the United Nations Convention on the Law of the Sea (UNCLOS), experts identify a need for very detailed regulation of ocean-based methods of carbon dioxide removal. But which specific form should a regulatory mechanism take? That must be assessed and determined for each CDR method on an individual basis. Method-specific answers must therefore be found to a multitude of questions. The most important include the following: where can the method be applied with the least possible risk? What should a prior risk assessment look like? Would it be feasible to suspend a method once it has begun? Are there any best practice examples that would serve as a basis for identifying regulatory approaches? And how can predictable harms be minimized?

As the answers to these questions will vary considerably depending on the CDR method concerned, legal experts recommend regulating marine CDR procedures separately by integrating them into their respective specific regulatory contexts. This is a feasible approach, as the example of the London Protocol shows. This international agreement, which originally solely covered waste disposal and incineration at sea, is in essence applicable to all activities involving the discharge of substances into the marine environment. This includes technologies to boost the alkalinity of the ocean, as well as artificial upwelling techniques, methods to expand carbon-rich coastal ecosystems, and concepts for carbon dioxide storage in deep sub-seabed formations.

The London Protocol model

The United Nations Convention on the Law of the Sea (UNCLOS) requires States Parties to adopt globally applicable laws, regulations and standards to prevent, reduce and control pollution of the marine environment from the introduction of substances and materials. The international community complied with this requirement with the adoption of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) in 1972. In 1996, the Convention was amended and modernized by the London Protocol – at least for all 53 States Parties that have so far ratified the Protocol, enabling it to enter into force in 2006. The provisions of the London Protocol follow a clear logic: in essence, any discharge of materials and substances is prohibited. However, there is scope for exemptions from this provision where convincing grounds exist.

The London Protocol has its own scientific working groups whose members monitor international developments in marine and environmental policy and make recommendations to Parties on the extent to which the Protocol would need to be amended in order to guarantee that a scientifically informed regulatory framework is in place. In this way, legal principles and procedural rules on carbon dioxide storage in sub-seabed formations were introduced in 2006. This was followed three years later by further provisions specifying the conditions under which countries with no sub-seabed carbon dioxide storage sites of their own may export the captured greenhouse gas for the purpose of sub-seabed storage in other countries. Due to an insufficient number of ratifications, these latter provisions have not yet entered into force; however, Contracting Parties have agreed to allow provisional application of these provisions. To that end, they must deposit a formal declaration with the International Maritime Organization (IMO), which is the Secretariat for the London Protocol.

Legal developments which came about between 2008 and 2013 are of key importance for any future regulation of marine CDR procedures under the London Protocol, however. Initially, they related solely to ocean fertilization activities. At the time, there were serious concerns that companies might apply this technique on a large scale in pursuit of their commercial interests, without sufficient knowledge being available on how the methods might work and what kind of risks they posed to the environment. In 2013, a formal amendment to the London Protocol was then adopted which, provided that it enters into force, will potentially be applicable to all marine geoengineering methods. It brings together the following key amendments in particular.

Firstly, marine geoengineering interventions were included in the Protocol's scope of application. A new article now defines "marine geoengineering" as "a deliberate intervention in the marine environment to manipulate natural processes, including to counteract anthropogenic climate change and/or its impacts, and that has the potential to result in deleterious effects, especially where those effects may be widespread, long lasting or severe". Nowadays, the term "marine geoengineering" is considered obsolete, but in essence, it refers to marine CDR procedures.

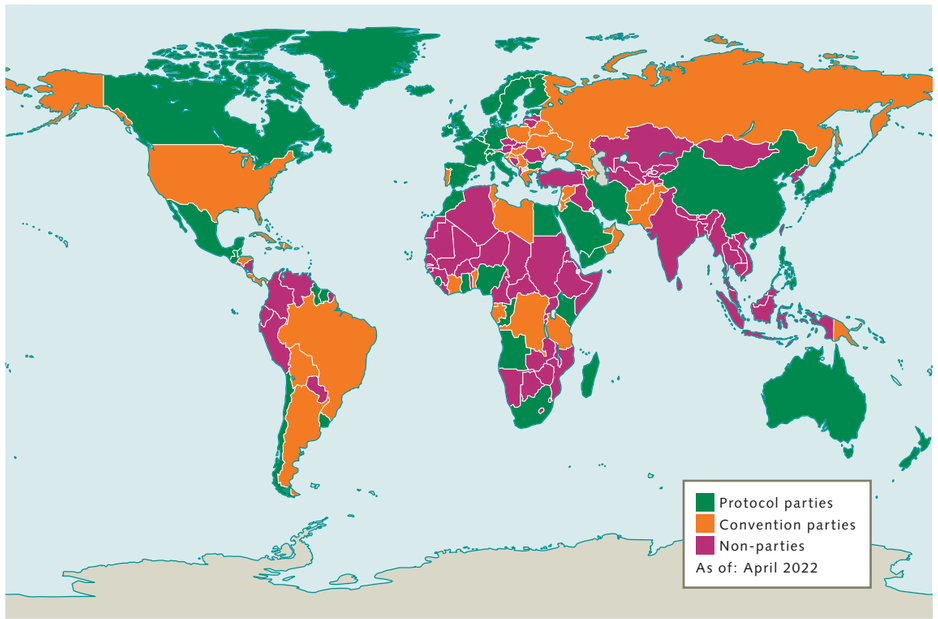
Secondly, the Contracting Parties agreed to establish an approval process, initially for scientific research only. At the present time (autumn 2023), commercial uses of ocean-based CDR methods aimed at offsetting greenhouse gas emissions from fossil sources are still prohibited. And even the fundamental willingness to assess research projects is strictly limited: it merely encompasses those ocean-based CDR methods which are listed in a new annex to the Protocol, namely Annex 4. Ocean fertilization is, however, the only activity included in the listing at present.

For research projects on ocean fertilization, the London Protocol's Contracting Parties agreed a clearly defined assessment process back in 2010, which was formally integrated into the London Protocol with its amendment in 2013. The assessment process must be integrated by the Contracting Parties into the approval procedures conducted under their respective national laws and entails the following:

1. an assessment of the proposed project in order to determine whether a proposed activity is covered by the listing in Annex 4 and is thus eligible to be considered for evaluation as a research project;
2. a detailed environmental impact assessment of the planned research project;
3. a decision on whether the given experiment may be conducted or not;
4. subsequent review of the project; the findings should inform future decision-making and improve future assessments.

This assessment process relies heavily on elements of risk characterization and risk management; in essence, the London Protocol states that marine researchers may conduct experiments on ocean fertilization if they are able to clearly estimate the potential harm and apply appropriate precautionary measures for its prevention. In all cases, however, they require a government permit for their research projects. The assessment process thus embodies and implements the precautionary principle and forms an indirect link between the international law of the sea and international environmental law. The key principle which applies here is: "If the risks and/or uncertainties are so

Scheme of parties to the London Convention/Protocol



9.7 > The London Convention and its additional London Protocol have not yet been ratified by all countries. The scheme shows which countries had acceded to the Convention/Protocol by April 2022 and which had not.

great that they are deemed to be unacceptable in terms of protecting the marine environment with due regard for the precautionary principle, a decision should be taken to review or reject the proposal."

But which risks or uncertainties may be deemed unacceptable? The provisions of the London Protocol do not provide clarification here. According to experts in international law, this circumstance and the explicit reference to the precautionary approach show that the assessment process may be informed by recourse to the stipulations of international environment law, as well as by social policy discourses that extend beyond the purely legal aspects.

It is also important to note that planned research projects are not assessed by the London Protocol's own international experts. This task and the final decision on whether a permit will be issued are a matter for the authority responsible for implementing the London Protocol on behalf of the Contracting Party under whose jurisdiction the experiment would be conducted. In the case of a project by German marine researchers, for example, this would be the German Environment Agency (UBA, *Umweltbundesamt*).

The competent authority at the national level, in turn, must respect the stipulations of the London Protocol. One such stipulation is that permission may only be granted to research projects which comply with all the provisions of the Protocol. Legal scholars term this a decision "ad referendum". In accordance with Article 210, paragraph 6 of the United Nations Convention on the Law of the Sea, the provisions of the London Protocol apply to all States Parties to UNCLOS, not only those which have acceded to the Protocol.

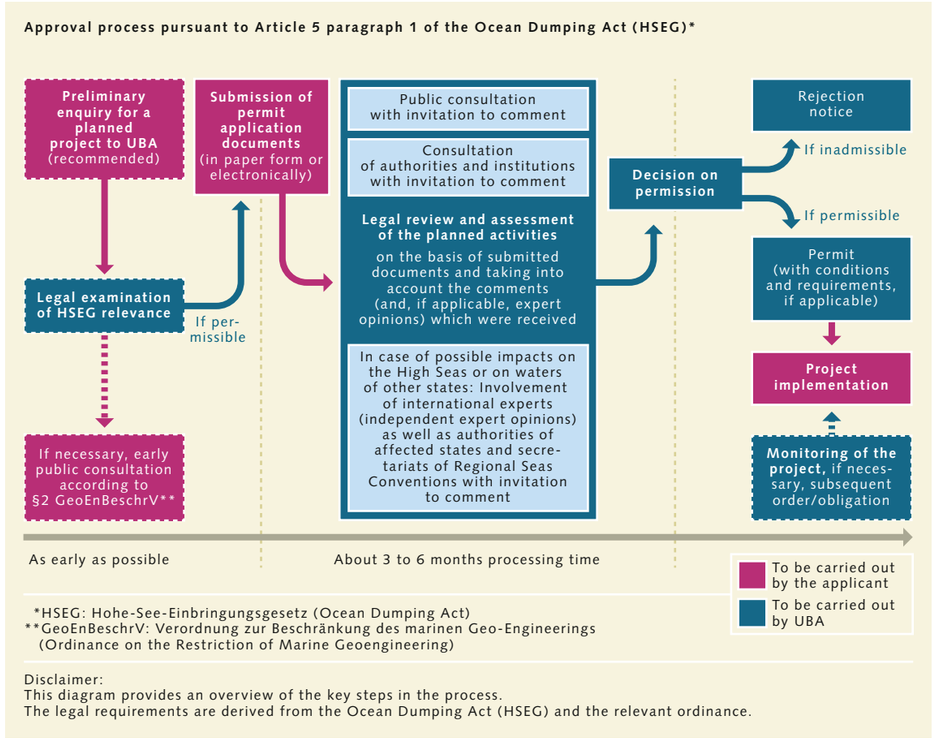
To recapitulate: the regulatory mechanism for marine geoengineering under the London Protocol currently applies solely to research projects on ocean fertilization. In the experts' opinion, however, it would be relatively straightforward to extend this mechanism to other ocean-based CDR methods – firstly, because the regulations on ocean fertilization have already proved their worth; and secondly, because it is quicker to elaborate rules dealing with this type of specific issue than to develop an overarching treaty, thereby enabling all the competent bodies to agree on specific provisions fairly swiftly.

Initial discussions on extending the Annex 4 listing are already under way. Experts from the GESAMP Working Group 41 on Ocean Interventions for Climate Change Mitigation have proposed the inclusion of other procedures to the London Protocol's scientific bodies and developed criteria for method-specific risk assessments. In October 2022, the London Protocol's Contracting Parties identified four of these proposed techniques for priority evaluation. However, only two of them involve carbon dioxide removal. The other two focus on management of solar radiation on the surface of the sea. The proposals involve:

- the application of substances to enhance ocean alkalinity (goal: to increase carbon dioxide uptake by the ocean – CDR),
- macroalgae cultivation combined with artificial upwelling (goal: to increase carbon dioxide uptake by the ocean – CDR),
- spraying tiny seawater droplets on the surface of the sea; this is known as marine cloud brightening (goal: to increase the ability of the sea's surface to reflect incoming sunlight back into space – SRM),
- production of microbubbles in surface water, or introduction of reflective particles/material (goal: to increase the ability of the sea's surface to reflect incoming sunlight back into space – SRM).

If these methods are adopted at any point in future, the corresponding research projects would be assessed in the same way as scientific projects on ocean fertilization.

However, to enable commercial/large-scale CDR interventions to be regulated under the London Protocol, its scope would have to be expanded accordingly. Will the Contracting Parties agree this move? That remains to be seen. So far, not even the 2013 amendment to the Protocol has entered into force. For that, it would have to be ratified by at least two-thirds of the London Protocol's Contracting Parties. Unofficially, however, most Parties operate as if the new provisions were already in force.



9.8 > In Germany, the German Environment Agency (UBA) is the competent authority for permitting and monitoring scientific projects attributed to marine geoengineering and involving intended substance discharges into the oceans. Each of these projects must pass through the application and approval process shown here.

Which stakeholders now come into play?

Regardless of whether or not marine CDR procedures are to be deployed on a large scale at some future time, the international community should do its utmost to establish a common regulatory framework in good time. The world's ocean, with its international waters as the "common heritage of mankind", concerns us all and, like the climate, it can only be protected effectively and managed sustainably on a collective basis. Key steps in establishing a common regulatory framework are accession by as many countries as possible to the London Protocol, and ratification of the agreement and all the amendments already adopted on marine geoengineering. Their respective provisions must then be transposed into national law; this is the responsibility of national governments and parliaments.

According to some experts, market-based incentives are also required. Often, what such statements imply is a call for a market for the trading of carbon removal credits or certificates. Stakeholders would be issued with certificates for their carbon dioxide removals and would be able to sell them on to producers of hard-to-avoid emissions. If this type of market were initiated or carbon removal certificates integrated into the existing emissions trading systems, this might spur countries and companies to boost their investment in the research and application of CDR methods, supporters argue.

The German Environment Agency (UBA) and other experts, for their part, criticize proposals that would enable emitters to offset their emissions, whether hard-to-avoid or not, by purchasing CDR certificates. These mechanisms, they argue, could deter companies from reducing their avo-

idable emissions – particularly if that required high-cost interventions. Instead, carbon dioxide removal interventions should be accounted for separately from emissions trading, and the use of removal certificates for the purpose of fulfilling emission reduction commitments should not be permitted. Stakeholders that voluntarily engage or invest in carbon dioxide removal could be given support in the form of government subsidies, for example. However, these funds should only be disbursed if the CO_2 removals are properly certified.

Notwithstanding the above, anyone intending to issue emissions certificates for a specific carbon dioxide removal will require a harmonized procedure to measure, document and verify the actual carbon dioxide fluxes in a removal project. Successfully establishing a harmonized system worldwide would make it possible to reduce legal uncertainties, prevent abuse and introduce appropriate environmental standards for CDR methods.

There are high expectations of the scientific community as well. Scientists should provide core data as the basis for the proper conduct of the environmental impact assessments stipulated by the London Protocol. They are also tasked with developing concepts and technologies for a reliable monitoring, documentation and verification system, which is fundamental for the issuing of emissions certificates. In addition, all the findings must be shared in a transparent and timely manner with decision-makers and the general public alike.

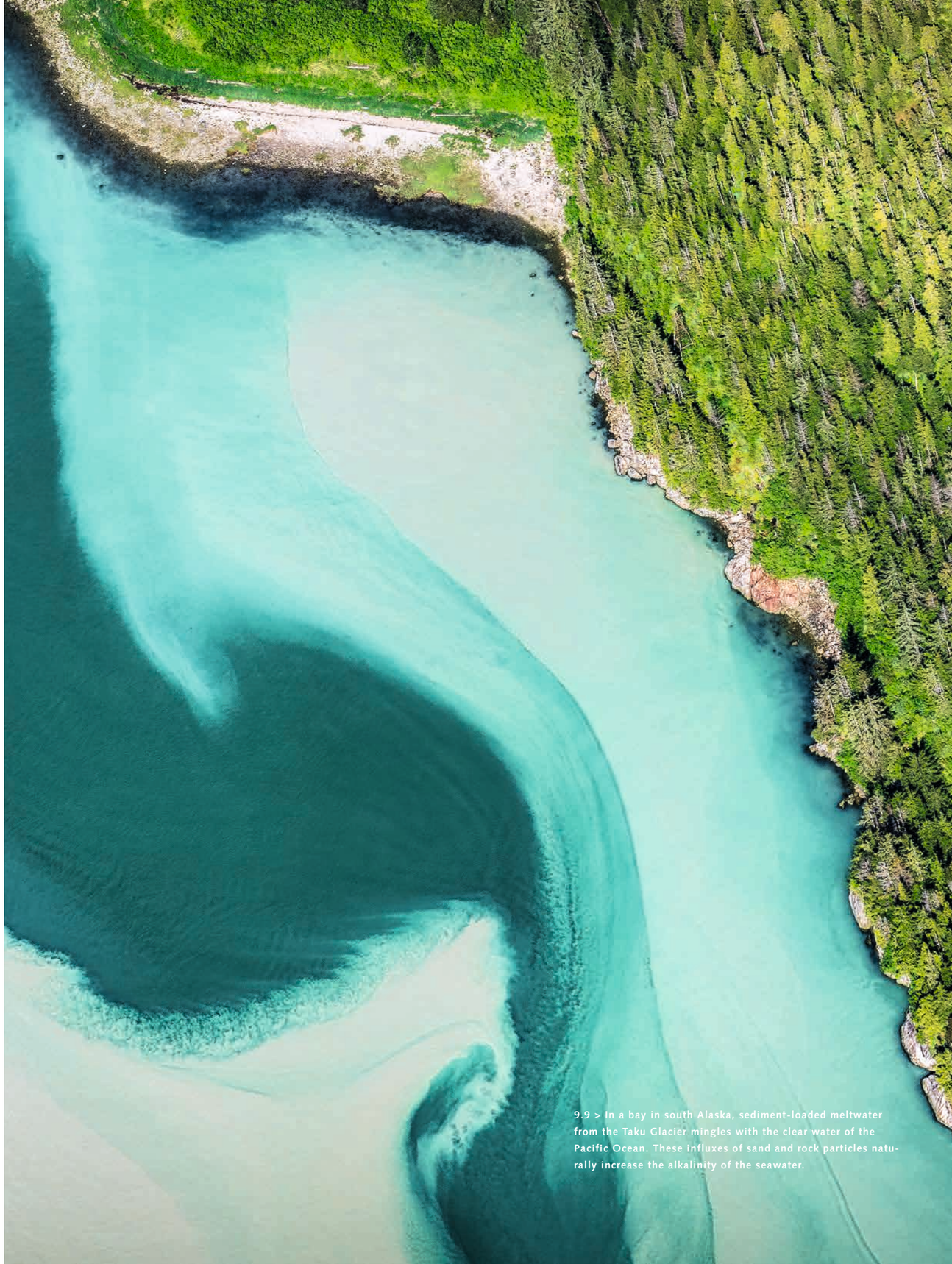
A long overdue public debate

A far more intensive public debate is also required, however, focusing on whether humankind should intervene in the ocean system for the purpose of mitigating climate change, and if so, which risks and harms we are willing to accept to achieve this objective and how we intend to compensate those affected. This highly significant social debate is not yet taking place. It is unclear, therefore, how the public would react to various CDR methods or to specific plans for their deployment.

Researchers note that when forming an opinion, people are often led by their emotional responses to interventions in nature rather than by rational arguments. In many cases, opinion-forming is also coloured by a close attachment to social norms. People's positions on CDR will depend, among other things, on whether they perceive a technique to be "natural" or "unnatural". For example, if the capture of carbon dioxide from the ambient air and its subsequent storage are described as "removal by artificial trees", the method will encounter far more support than if it is depicted as a chemical process in a technical installation. When it comes to ocean-based CDR techniques, experience shows that methods involving the restoration and expansion of mangrove forests, seagrass beds and salt marshes or intensive macroalgae cultivation are perceived to be "natural", whereas ocean alkalinity enhancement is more likely to be viewed as unnatural and risky even though this technique is also based on natural processes.

The general level of public awareness of individual CDR methods and the opinions that people form on this basis will be crucial in determining how we move forward with methods to remove carbon dioxide from the atmosphere. It is already clear that the political and social debate about marine CDR procedures will not be easy; firstly, because there are not always clear and straightforward answers that would provide clarity on questions about possible risks; this applies even if these methods are tested in large-scale field trials at some point in the future. And secondly, in view of ongoing global warming and the associated harms, it is surely quite apparent that we have delayed taking effective climate action for far too long and that under the present circumstances, we can no longer preserve the full array of environmental assets. Our overarching goal can only be to reduce greenhouse gas emissions as swiftly as possible and do the best we can to adapt to the new climate in order to minimize the risks it poses to ourselves and the natural world.

To succeed, we must engage in new discussions about the trade-offs arising from the entirely new challenges we face. To take one example: if our society considers it necessary to use marine CDR procedures, we will probably have to accept that this will involve some residual risk.



9.9 > In a bay in south Alaska, sediment-loaded meltwater from the Taku Glacier mingles with the clear water of the Pacific Ocean. These influxes of sand and rock particles naturally increase the alkalinity of the seawater.

The EU Emissions Trading System (EU ETS) – Europe's most effective climate change mitigation mechanism

The European Union is the third largest producer of carbon dioxide emissions worldwide and is simultaneously pursuing an ambitious climate goal: it aims to significantly reduce its greenhouse gas emissions by 2030 and achieve net zero emissions by 2050. A key mechanism on the pathway towards greenhouse gas neutrality is the EU Emissions Trading System (EU ETS), established in 2005. It covers not only the 27 EU Member States but also Norway, Iceland and Liechtenstein, as well as electricity generators in Northern Ireland. The EU ETS has also been linked to the Swiss emissions trading system since 1 January 2020.

The EU ETS enshrines the "polluter pays" principle and currently requires operators of around 9000 European power plants and energy-intensive industrial installations, as well as intra-European aircraft operators (since 2012), to submit an emission allowance for each tonne of greenhouse gas that they emit. One allowance gives the right to emit one tonne of carbon dioxide equivalent.

The EU ETS reporting period is a calendar year. By the end of March each year, operators calculate the greenhouse gas emissions from their plants for the preceding year. These data are checked first by nationally accredited verifiers and are then forwarded to the national authority responsible for the implementation of the EU ETS; in Germany, this is the German Emissions Trading Authority (DEHSt, *Deutsche Emissionshandelsstelle*). The data are also entered into the Union registry for emissions trading. The operator must surrender sufficient allowances by the end of April to cover its reported emissions for the preceding year.

Companies may obtain emission allowances at primary market auctions run at the European Energy Exchange (EEX) in Leipzig. Emission allowances are auctioned here on a more or less daily basis by individual Member States and by the European Commission. Since the start of the third trading period (2013 to 2020), auctioning has been the basic principle for allocating allowances Europe-wide in the EU ETS. Emissions-intensive industries and heat producers continue to receive a free allocation of allowances for a transitional period, based on a "benchmarking" approach. Product benchmarks are based on the average greenhouse gas emissions of the best performing installations manufacturing that product. Free allocation is intended to reduce the risk of "carbon leakage", i.e. the shifting of emissions to other countries. However, there are plans to phase out free allocation in the coming years.

Emission allowances can also be traded by market participants on the secondary market, e.g. on the exchange or through bilateral transactions. This has given rise to the term "emissions trading", but strictly speaking, it is the allowances – i.e. the right to emit the corresponding quantity of greenhouse gases – rather than the emissions themselves which are traded. Trading is the price-forming mechanism for greenhouse gas emissions, and it is the price which is intended to motivate participating companies to reduce their emissions.

So that it becomes increasingly costly to emit greenhouse gases, the total number of available emission allowances decreases year on year. This reduction is determined at the political level. Germany has a share of around 22 per cent of this Europe-wide auction volume. In 2021, approximately 101 million emission allowances with an average price of 52.59 Euros were auctioned for Germany. The following year, 85 million allowances were auctioned; the average price was 80.32 Euros. In the first half of 2023, Germany auctioned around 45 million emission allowances at an average price of 87.11 Euros per allowance.

The financial pressure generated by the EU ETS is now having the desired effect; by 2021, emissions from installations covered by the EU ETS fell by 38 per cent compared to 2005.

From 2027, emissions from buildings and the transport sector will also be covered

Up to 2023, the installations covered by the EU ETS produced an estimated 40 per cent of the EU's greenhouse gas emissions. In order to increase the share of emissions covered by the trading system, the European Parliament and the governments of the Member States agreed in spring 2023 to extend mandatory emissions trading to small industry and maritime transport (incrementally from 2024). In addition, a second emissions trading system (EU ETS 2) will be introduced in 2027. EU ETS 2 will cover carbon dioxide emissions from fuel combustion in buildings and road transport. It will have its own quantitative limits and probably also different price levels and will operate independently of the existing EU ETS. Participants in EU ETS 2 will also be able to acquire emission allowances and trade them with each other. Unlike the existing EU ETS, which covers companies that produce emissions themselves (so-called downstream emissions trading), the new system will involve businesses that place fuels on the market, such as gas suppliers and petroleum industry companies (so-called upstream emissions trading).

The two emissions trading systems will in future cover 85 per cent of all the EU's greenhouse gas emissions. It has also been agreed that the total number of emission allowances available will be reduced by 62 per cent by 2030 compared to 2005.

Concepts for the inclusion of carbon dioxide removal credits in the EU ETS

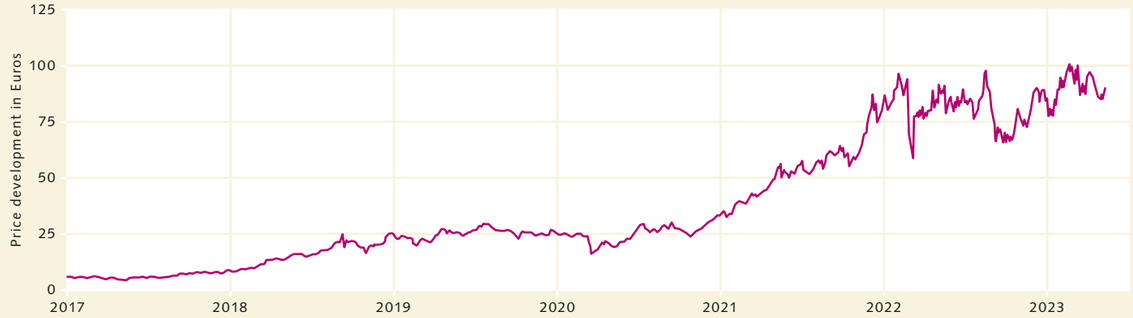
In view of this reduction in the number of emission allowances, businesses and experts are asking whether and how it might be possible to utilize carbon dioxide removals in the EU ETS system in order to offset greenhouse gas emissions and prevent an excessively rapid rise in the price of emission allowances over the long term. The assumption is that overly high emission prices might disadvantage Europe's economy and reduce public acceptance of emissions trading as a climate policy instrument.

Currently, carbon dioxide removals achieved by CDR methods are not covered by the EU ETS. Experts are now considering how carbon dioxide removals could be integrated into emissions trading. One proposal is to establish a central carbon agency which would, in the near future, start acquiring and accumulating carbon dioxide removal credits on Europe's behalf. A corresponding certification process is currently being developed at EU level. The agency would then release the removal credits to the EU ETS if the price of emission allowances rose above a specific level.

Currently, however, only Direct Air Carbon Capture and Storage (DACCS) and Bioenergy with Carbon Capture and Storage (BECCS) are being discussed as reliable methods for the generation of these removal credits; both involve the subsequent storage of carbon dioxide in deep geological formations. There are two reasons for focusing on these methods. Firstly, DACCS and BECCS are technically advanced and ready for use. Secondly, these two methods are most likely to allow controlled removal and permanent storage of carbon dioxide in the amounts needed to have a tangible impact on prices in the EU ETS. For that to be achieved, both methods would have to be deployed on a much larger scale than at present.

The proposal to use BECCS on a larger scale has met with criticism, however. The German Environment Agency (UBA, *Umweltbundesamt*), for example, in its Evaluation of the *Commission Proposal on Certification of Carbon Dioxide Removals*, voices clear opposition to certification of bioenergy with carbon capture and storage removals, given the limited availability of sustainable biomass.

Development of the price of emission allowances (EUA)



9.10 > In Europe's emissions trading system, the price of an emission allowance was far lower than expected for some considerable time. In recent years, however, the participating companies have had to pay much higher prices, creating more incentive to invest in emission reduction measures.

Ten key terms in the CDR debate	
Anyone wishing to have a voice in the debate about emission reductions and carbon dioxide removal needs to understand the concepts behind the following ten technical terms:	
Term	**Brief definition**
Carbon neutrality or **net zero CO_2 emissions**	Arithmetically, net zero anthropogenic carbon dioxide emissions are achieved when residual CO_2 emissions are balanced by CO_2 removals from the atmosphere.
Greenhouse gas neutrality or **net zero greenhouse gas emissions** (commonly known as climate neutrality)	Arithmetically, net zero anthropogenic greenhouse gas emissions are achieved when residual emissions of all relevant greenhouse gases are balanced by removals of equivalent climate-relevant greenhouse gas emissions.
Fossil carbon dioxide sources	Burning of fossil fuels, such as coal, oil and natural gas, and industrial processes in which carbon-based components (e.g. limestone) are used and carbon dioxide is released during the processing of these materials (e.g. cement manufacturing).
Biogenic carbon dioxide sources (known as land-use emissions)	Microorganisms, flora and fauna which naturally emit carbon dioxide, e.g. when they break down biomass and oxidize carbon. These natural processes have always formed part of the Earth's carbon cycle. However, many of them are additionally initiated or amplified by human activity, e.g. in land-use changes, intensive soil use in agriculture, drainage of wetlands, or overexploitation and degradation of carbon-storing forests and coastal ecosystems such as mangroves and seagrass beds.
Carbon Dioxide Removal (CDR)	The IPCC defines CDR as anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial (e.g. soil/vegetation) or ocean reservoirs, or in products. CDR experts additionally identify three fundamental principles with which CDR interventions must comply: 1. The carbon dioxide that is removed must come from the atmosphere. 2. The subsequent storage of the removed carbon dioxide must be permanent; the CO_2 must not escape back into the atmosphere later. 3. The carbon dioxide removal must result from human efforts and be additional to the Earth's natural CO_2 uptake processes.
Net (carbon dioxide) removal	Difference between the amount of removed carbon dioxide and all new greenhouse gas emissions (calculated in carbon dioxide equivalent) resulting from the removal process.
Net negative (greenhouse gas) emissions	Net negative (greenhouse gas) emissions are achieved when, as a result of human activities, more greenhouse gases (particularly CO_2) are removed from the atmosphere than are emitted into it.
Conventional CDR methods (known in Germany as **natural climate protection**; known at EU level as **carbon farming**)	All the sustainable agricultural and forestry methods that have been used for centuries and enhance carbon storage in soil and terrestrial vegetation. Examples are afforestation/reforestation, restoration of degraded ecosystems, sustainable forest management and soil-conserving farming practices. Many of these methods are already deployed on a large scale and are listed in national climate action plans. They account for more than 99 per cent of current removals globally.
Novel CDR methods	Methods that involve the storage of captured carbon dioxide in geological formations, in the ocean or in products. At present, these techniques are only deployed on a small scale and some have not yet been tested. Examples of novel CDR methods are Bioenergy with Carbon Capture and Storage (BECCS), Direct Air Carbon Capture and Storage (DACCS), production and use of plant-based biochar, and ocean alkalinity enhancement. Novel CDR methods currently account for a 0.1 per cent share of total global carbon dioxide removals.
Carbon management	Carbon management typically refers to the following three process chains: • Carbon Capture and Storage (CCS), • Carbon Capture and Utilization (CCU) and • Carbon Dioxide Removal (CDR).

However, if new scientific findings then show that this may have entirely unexpected negative consequences, the competent authorities must intervene immediately. For this reason too, intensive scientific control and monitoring of individual CDR projects are so crucial.

An informed and transparent social debate also requires clarity on what terminology and definitions are used. The plethora of specialist terms, often with highly diverse definitions and usages, makes it much more difficult for casual observers to follow the scientific and political debate at present. This lack of terminological clarity simultaneously impedes rapid progress on the development of effective interventions, legal provisions, funding guidelines and regulations. This is exemplified by the discussion about when the term "residual emissions" should be used, and when we should be talking about "hard-to-avoid" emissions.

Experts from a German research mission, for example, define "residual emissions" as merely denoting anthropogenic greenhouse gas emissions that will enter the atmosphere during and after the target year for net zero. They differentiate between residual emissions and hard-to-avoid emissions. Which emissions are classed as "hard-to-avoid"? Definitions vary across stakeholder groups and depend on the individual motives, the experts say; the reasoning underlying categorization often differs as well. Other stakeholders, by contrast, still use the terms "residual emissions" and "hard-to-avoid emissions" as synonyms.

A matter of human survival

Following the political, technological and social debates and developments around land- and ocean-based CDR methods is and will remain a challenge. However, this should not act as a deterrent, given that ultimately, nothing less than our survival is at stake. If we wish to prevent even more serious climate-related loss and damage to people and nature, we must succeed in our efforts to keep global warming below two degrees Celsius – and ideally limit it to 1.5 degrees Celsius. We will only achieve this target if we emit less carbon dioxide from 2050 onwards than we remove from the atmosphere by various methods. From a scientific perspective, this is now beyond reasonable doubt.

Ocean-based removal methods may help us to offset residual emissions. However, it is already clear that we cannot rely on one single method to remove the very large quantities of carbon dioxide from the atmosphere in an environmentally friendly and equitable manner that would enable us to limit global warming to well below two degrees Celsius Instead, we will have to use a broad mix of land- and ocean-based CDR methods – deploying each one wherever its use, including all its positive and negative spillover effects, is most compatible with the goal of sustainable development. Methods which rely on the restoration and expansion of carbon-rich coastal ecosystems could even be implemented relatively soon. Technological processes such as alkalinity enhancement, by

9.11 > In November 2018, climate activists at the Aletsch Glacier in Switzerland used a postcard covering 2500 square metres and made up of 125,000 regularly-sized postcards from children and young people from more than 35 countries to demonstrate for effective climate action and compliance with the 1.5-degree target.

contrast, are still largely untested. It is likely to take some years, if not decades, for the majority of these processes to reach a level of technological advancement that would allow their large-scale and controlled deployment.

The common feature of all CDR methods – those with which we are already familiar, and those which are still being developed – is that in each case, their feasibility and carbon dioxide removal potential will depend on local, context-specific conditions. This includes the locality's climate and environmental characteristics, the availability of infrastructures and resources, and the level of much-needed public support. Clear rules governing their use are also required, along with political incentives, in order to prevent harm to people and the environment, make optimum use of the theoretical removal potential and leverage possible additional benefits.

CDR approaches that look promising must be integrated into national and international strategies on the management of residual emissions. The required transport networks and infrastructures will also need to be established – a step which must be taken in parallel to the further expansion of renewable energies and more broad-scale use of technologies and behaviours that boost energy efficiency and conserve resources. In the experts' view, carbon dioxide removal methods can only help us reach our 2050 goal of global greenhouse gas neutrality if they are combined with the maximum feasible greenhouse gas emissions reductions and improved energy and resource efficiency. And the principle which applies at all times is that the lower our residual emissions, the less carbon dioxide removal will be required to offset them. Now for the good news: the international community already has a mechanism available that would facilitate the governance and regulation of, first, research projects and then large-scale deployments of marine CDR procedures. Yet these deployments will not be entirely without risks or consequences. For that reason, careful consideration of trade-offs is required in all decision-making. This is an immensely challenging task. However, the time for simple solutions is long gone, due to our inaction on climate change.

Conclusion

Regulating potential uses of CDR – clear strategies and rules are vital

In view of the increasingly dramatic impacts of climate change, humankind must do its utmost to keep global warming to a minimum. This will need to include the employment of promising ocean-based CDR methods. They are not the only solution to the climate crisis, however. They must rather form part of a broader programme of action designed to manage residual emissions. Above all, it is essential to drastically reduce and avoid anthropogenic emissions; this approach facilitates faster, more effective, more affordable and less risky mitigation of climate change compared to any CDR method.

If ocean-based CDR methods are used, they will put further pressure upon an ocean that is already subjected to diverse forms of human use and exploitation. In order to conserve ocean ecosystems and guarantee fair burden-sharing, carefully considered CDR strategies are required at national and international level alike, with clear targets and rules for all stakeholders. Experts have already developed initial principles for the governance and regulation of land-based and ocean-based CDR. In their view, in addition to prioritizing emissions avoidance, it will be important to ensure in advance that the carbon dioxide removal is permanent and that the interventions will not themselves emit more greenhouse gases than the quantity of carbon dioxide removed from the atmosphere. The methods must also be assessed comprehensively in advance from a climate, environmental and social perspective and possible goal conflicts avoided or resolved; this will need to be achieved in an eco-friendly and equitable manner.

In the experts' opinion, there are few indications at present that the international community will agree on a common regulatory framework for all forms of carbon dioxide removal. The numerous land-based and ocean-based CDR methods vary too much for there to be a one-size-fits-all solution. Proposals on separate regulation of ocean-based CDR methods in their specific regulatory context appear more promising. The London Protocol shows how this might work. This legislation has been extended in recent years to include marine geoengineering. Provisions on ocean fertilization and carbon dioxide storage in sub-seabed formations have also been included. Such a regulatory approach offers scope for similar integration of provisions on other CDR methods involving the introduction of substances or technologies in the sea.

Harmonized procedures for monitoring, documenting and verifying the carbon dioxide fluxes that arise in removal projects are also urgently required. Monitoring is essential because it can reduce legal uncertainties and prevent abuse while offering scope for certification of permanent CO_2 removals. A robust system of this sort would encourage companies to invest in ocean-based CDR projects if certified CO_2 removals were to attract public funding or came with other benefits.

At the same time, we need a broad debate involving all sections of society about the possible use of carbon dioxide reduction methods. So far, this debate has merely involved scientists, businesses and a small number of political institutions. Yet strong public engagement is essential for successful climate change mitigation for many reasons. This applies particularly to social groups living in areas where CDR interventions may be implemented. The struggle against climate change is now a struggle for human survival. We must all play a part in mastering this challenge.