



## Sinking to Zero: the role of carbon capture and negative emissions in EU climate policy

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### Summary

The updated EU long-term climate strategy with its net-zero emissions objective and the IPCC's Special Report on the 1.5°C target prompt a renewed strategic look at negative emissions and carbon capture. Reaching net-zero greenhouse gas emissions requires more carbon sinks and other approaches to remove CO<sub>2</sub> from the atmosphere. Furthermore, it will also require carbon capture technology to deal with residual emissions in energy-intensive industry that are otherwise difficult to avoid.

Carbon capture and negative emissions are necessary, not just to compensate for any residual emissions, but also in their own right to reach the objectives set out in the Paris Agreement. Conventional mitigation should get precedence over compensation through negative emissions, owing to its high costs and resource demand. Trade-offs between mitigation and various negative emissions technologies should be acknowledged. Some approaches have only limited potential. Others require significant amounts of low-carbon energy and infrastructure.

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The updated EU long-term climate strategy with its net-zero emissions objective and the IPCC's Special Report<sup>1</sup> on the 1.5°C target prompt a renewed strategic look at negative emissions. Both the EU's strategy and the IPCC report reinforce the need for transformational change. Globally, even the 2°C scenarios require significant negative emissions, with more ambitious targets, such as the 1.5°C objective, escalating the need for them.<sup>2</sup> As such, a closer look at the available options to reach these targets, within the framework of the EU's long-term strategy is warranted.

In the long-term strategy for the EU and its goal of achieving net-zero greenhouse gas emissions by 2050, the need for negative emissions and carbon sinks is explicitly acknowledged. The strategy discusses various pathway scenarios, two of which are compatible with the 1.5°C target. Among these two scenarios, negative emissions and carbon capture play an important role in compensating for remaining unabated emissions by 2050;<sup>3</sup> a combination of carbon sinks and carbon capture compensate for the remaining, and most difficult to abate, emissions. Nevertheless, carbon capture is featured even in the lower ambition scenarios of the 2°C target. Within all scenarios in the strategy, the role of carbon capture ranges from 52 MtCO<sub>2</sub> to 606 MtCO<sub>2</sub>.<sup>4</sup> The role of sinks varies between 236 MtCO<sub>2</sub> and 472 MtCO<sub>2</sub>.<sup>5</sup> Thus, irrespective of ambition-level and scenario pathway, there is a need for sinks and carbon capture, whether the carbon is then used or stored.

In the EU, recourse to negative emissions or sinks may be an attractive way to compensate for residual greenhouse gas emissions that would otherwise be challenging to avoid. Second, the transformational change required for energy-intensive industries such as steel cement or chemicals to achieve decarbonisation will necessitate technology that allows for capturing emissions. Third, carbon capture and storage (CCS) is required irrespective of the need to also

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<sup>1</sup> See IPCC "Global Warming of 1.5°C" at <https://www.ipcc.ch/sr15/>

<sup>2</sup> For 1.5°C, there is a lower bound of 200 GT over the course of this century (EU emissions are 4GT). With maximum mitigation, the likely need for staying below 2°C is estimated at around 100-200 GT. In terms of landmass, 1.5°C requires 1.7 million km<sup>2</sup> for energy crops.

<sup>3</sup> See European Commission, 2018, In-Depth Analysis In Support Of The Commission Communication COM(2018) 773, [https://ec.europa.eu/clima/sites/clima/files/docs/pages/com\\_2018\\_733\\_analysis\\_in\\_support\\_en\\_0.pdf](https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf), p. 55

<sup>4</sup> See European Commission, 2018, In-Depth Analysis In Support Of The Commission Communication COM(2018) 773, [https://ec.europa.eu/clima/sites/clima/files/docs/pages/com\\_2018\\_733\\_analysis\\_in\\_support\\_en\\_0.pdf](https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf), p. 198

<sup>5</sup> Land use, land-use change, and forestry (LULUCF) only. See European Commission, 2018, In-Depth Analysis In Support Of The Commission Communication COM(2018) 773, [https://ec.europa.eu/clima/sites/clima/files/docs/pages/com\\_2018\\_733\\_analysis\\_in\\_support\\_en\\_0.pdf](https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf), p. 198

deliver negative emissions, especially after 2050. Negative emissions can help contribute to 2050 targets in sectors where no other sufficient abatement options currently exist. They are an essential means to compensate for residual emissions and for a potential overshoot of the temperature targets in the future.

For fully mitigating emissions in energy-intensive industries such as cement and steel, carbon capture could be particularly suitable, due to the concentrated nature of the CO<sub>2</sub> stream and the limited decarbonisation potential inherent in current production processes. As global emissions continue to grow, or remain steady, the demand for technologies that go beyond compensation into net-negative emissions may only grow further.<sup>6</sup>

In conclusion, the group of negative emissions approaches and technologies therefore can have at least a two-fold purpose: first as a general mitigation technology focusing on capturing emissions (carbon capture and storage or use – CCS or CCU), and secondly as a means of removal of CO<sub>2</sub>, either to achieve negative emissions on its own, or to compensate for other emissions. Negative emissions can thus be seen as an extension of conventional mitigation. Given the very high demand in terms of energy and resources to deliver negative emissions, it is both environmentally prudent and economically wise to limit the volume of negative emissions to the minimum and prioritise mitigation efforts.

## Infrastructure for all technologies

Infrastructure for capture and transportation is needed irrespective of how the CO<sub>2</sub> is captured. Depending on the technology options chosen, and the feasibility of its usage on a larger scale, this will necessarily involve infrastructure that allows for transporting the captured CO<sub>2</sub> to a location for usage or storage.

Development of such infrastructure requires large-scale investments. As such, the means of financing this infrastructure development will be a considerable point of contention: whether it should be mostly private project developers or if there is a larger role for public funding. For private investors to invest, policy contributing to the prospect of a stable carbon storage environment is essential. Transportation and storage infrastructure that could be used by multiple sectors would be a significant way of lowering costs for industry.

There is also a twofold geographical dimension to infrastructure and storage development. First, storing carbon dioxide is best done on offshore locations due to the availability of appropriate sites. Second, a significant share of industrial emissions is concentrated in a relatively low number of industrial clusters across the EU. The port of Rotterdam is a case in point.<sup>7</sup> Therefore, the infrastructure should best be focused on those regions where most capture and storage can actually take place, but this does not obviate the need for transport solutions from other emitting sites. Alternatively, industrial clusters should be redeveloped in

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<sup>6</sup> As for example reflected in the latest UNEP report on the growing ‘emissions gap’, see <https://www.unenvironment.org/resources/emissions-gap-report-2018>

<sup>7</sup> See Bellona’s 2018 report “An Industry’s Guide to Climate Action”, chapter 4. <http://bellona.org/publication/an-industrys-guide-to-climate-change>

places where CCS and CCU are most likely to be successful – an equally challenging political economy question.

### Bioeconomy: sinks and material substitution

A bioeconomy approach could be an alternative that reduces reliance on carbon capture, transport and storage infrastructure (except in the case of BECCS; see below). The first aspect of this approach is the contribution to carbon sinks through forests and their sustainable management. Afforestation and reforestation are thus available methods of increasing the absorption of CO<sub>2</sub> from the atmosphere that are already in use. Nevertheless, the potential of this approach is limited by competition for, and constraints on land use. More advanced absorption approaches have been imagined, but do not exist at scale yet (e.g. oceanic fertilisation) and there is still a lot of uncertainty about their potential side-effects. A second aspect of the bioeconomy approach is the potential of material substitution, where carbon-intensive materials (e.g. steel, cement, aluminium, plastics) are replaced with biomaterials. This could contribute to emissions reductions and features in the circular economy strand in the EU's long-term strategy.<sup>8</sup> Nevertheless, a key constraint in use of the bioeconomy as a contribution to carbon sinks and negative emissions is that it affects the availability of the resources for other uses, and as such, any potential effects should be carefully considered and compensated for.

### Carbon Capture, Storage or Use

Discussions on the need for carbon capture and storage preceded the establishment of the current consensus on a more general need for negative emissions technology. In the past, CCS was seen as a mitigation technology mainly for the power sector. However, the high capital costs, social acceptability, and increased attractiveness of other alternatives (i.e. renewables) prevented CCS from moving beyond the pilot stage in most cases. This could be different for energy-intensive industries, however, as many of these sectors do not have other abatement options than CCS if they are to reach the zero emissions target. Sectors that could make use of CCS include some of the biggest industrial emitters such as steel, cement, refining and chemicals.

Another dimension of the bioeconomy is that it allows for net-negative emissions, through the use of bioenergy with CCS (BECCS). Using sustainable biomass to generate energy while capturing the CO<sub>2</sub> emitted can deliver negative emissions. Unlike with regular forests, the absorption capacity of which is limited, BECCS allows for continuous delivery of negative emissions. Scale, however, is a challenge: even at the lower end of estimates, delivering 1GT of BECCS requires a landmass the size of Mexico, with upper estimates being nearly 5 times as large.<sup>9</sup> As a result, the same constraints of and competition for land use that apply to the

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<sup>8</sup> See European Commission, 2018, In-Depth Analysis In Support Of The Commission Communication COM(2018) 773, [https://ec.europa.eu/clima/sites/clima/files/docs/pages/com\\_2018\\_733\\_analysis\\_in\\_support\\_en\\_0.pdf](https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf), p. 56.

<sup>9</sup> <https://link.springer.com/article/10.1007/s10584-012-0682-3>

bioeconomy approach through sinks, could also apply to the use of BECCS, depending on scale. BECCS also presupposes the availability of CCS technology and its transport and storage infrastructure.

While it may be necessary to develop some CCS for the power industry at a smaller scale to deal with peak demand continuing to be served by gas-fired power generation, power generation based on BECCS may provide a more promising avenue. Due to its potential for going beyond zero emissions, it has the potential to integrate the power sector into negative emissions pathways. Moreover, district heating or industrial biomass use can also be combined with BECCS. This would also put biomass to use in sectors that face a more difficult path to decarbonisation than electricity generation.

Rather than being stored, carbon could also be put to productive use; through carbon capture and use (CCU). This may be an attractive approach for those wishing to create a commercial rationale for carbon capture. Examples exist, particularly in the chemicals and fertiliser industry, which can use CO<sub>2</sub> as inputs in their production processes, as well as in the plastics and building materials sectors. However, the CO<sub>2</sub> bound in new products made through CCU may be released again,<sup>10</sup> thereby limiting the positive impact it would have on the emissions balance. As a result, CCU may be unsuitable for contributing to negative emissions and cannot substitute for storage of CO<sub>2</sub>. The uncertainty of CCU in terms of its climate mitigation potential is moreover acknowledged in the EU's long-term strategy.<sup>11</sup> It is, moreover, unlikely that the demand for CO<sub>2</sub> to be used in other products will ever be of the same order of magnitude as its supply. The European Commission estimates global annual demand for CO<sub>2</sub> to be at 222 million tonnes,<sup>12</sup> well below EU industrial emissions levels. Even if the potential for CCU is limited, it could play a role in developing a business case for capturing emissions in the first place, irrespective of their later use or storage.

Capturing CO<sub>2</sub> is most easily done, in terms of the costs and energy required, where its concentration is highest, i.e. in emission-intensive industrial sectors. Yet, another approach has been proposed: Direct Air Capture (DAC), directly capturing CO<sub>2</sub> from the air where it is present at just over 400 parts per million. Due to the low concentration of CO<sub>2</sub> in the air, combined with the large amounts of low-carbon energy required by the process, capturing emissions will always be inherently costlier on average, compared for example to capturing emissions from industry. Nevertheless, DAC features prominently in both of the 1.5°C scenarios of the EU's long-term strategy.<sup>13</sup> In either case, transport and storage infrastructure for the captured CO<sub>2</sub> is still required.

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<sup>10</sup> [https://ec.europa.eu/research/sam/pdf/sam\\_ccu\\_report.pdf](https://ec.europa.eu/research/sam/pdf/sam_ccu_report.pdf)

<sup>11</sup> See European Commission, 2018, In-Depth Analysis In Support Of The Commission Communication COM(2018) 773, [https://ec.europa.eu/clima/sites/clima/files/docs/pages/com\\_2018\\_733\\_analysis\\_in\\_support\\_en\\_0.pdf](https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf), p 62

<sup>12</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5101260/>

<sup>13</sup> See European Commission, 2018, In-Depth Analysis In Support Of The Commission Communication COM(2018) 773, [https://ec.europa.eu/clima/sites/clima/files/docs/pages/com\\_2018\\_733\\_analysis\\_in\\_support\\_en\\_0.pdf](https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf), p 198

## Outlook

The technologies that can deliver negative emissions are often energy and/or resource intensive. This holds particularly true for DAC, but to a lesser extent also for capturing industrial emissions more generally. In the case of DAC, the low concentration of CO<sub>2</sub> in the air necessitates significant amounts of both power and heat. As this energy should be delivered in an as low-carbon way as possible for there to be a positive impact on emissions, the further development of negative emissions technologies could spur innovation in low-carbon energy more generally. DAC may therefore be attractive not solely for the CO<sub>2</sub> that would be captured from the air, but for how it may encourage the scaling up of low-carbon technologies, which could contribute to general mitigation efforts. Specifically, CCS as well as low-carbon fuel and blue hydrogen production could be integrated in a DAC strategy, making it more attractive as part of a general long-term climate strategy. Low-carbon fuels could be CO<sub>2</sub>-based synthetic fuels, thereby also increasing demand for CO<sub>2</sub> as an input, which is otherwise limited. Synthetic fuels, combined with DAC, could potentially also reduce the demand for biomass or biofuels. Crucially, however, the great energy and (financial) resource demands of DAC means it should not be pursued as a replacement for mitigation.

Up to now, the failure of CO<sub>2</sub> removal or carbon capture technology to emerge at scale has reinforced a negative public perception of such technologies. This perception may be justified to some extent for electricity generation. In the industrial sector, however, this is certainly not the case, and the demand for any form of CO<sub>2</sub> removal is only set to grow, so long as emissions remain on their current trajectory. Another problem of perception lies with the reliability and permanence of storage. Opposition is based on the perception that CCS is not 'real' mitigation, even if appropriately chosen and managed storage sites are likely to retain 99% of the CO<sub>2</sub> for more than 1000 years.<sup>14</sup> As such, these may be more political than technological issues, but they remain barriers nonetheless.

Given the costs and resources required to deliver any amount of negative emissions, the share of residual emissions left by conventional emission reductions to be compensated by negative emissions technology would ideally be limited. As such, any trade-off between mitigation and negative emissions, with an overreliance on the latter serving as a disincentive for conventional emissions reductions, should be limited. Ultimately, carbon capture and negative emissions technology more broadly create the possibility to address emissions from processes which are hard to decarbonise while generating both physical and economic space for net-negative emissions.

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<sup>14</sup> See European Commission, 2018, In-Depth Analysis In Support Of The Commission Communication COM(2018) 773, [https://ec.europa.eu/clima/sites/clima/files/docs/pages/com\\_2018\\_733\\_analysis\\_in\\_support\\_en\\_0.pdf](https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf), p 193-194