CLEAN AIR TASK FORCE

CARBON LIMITS

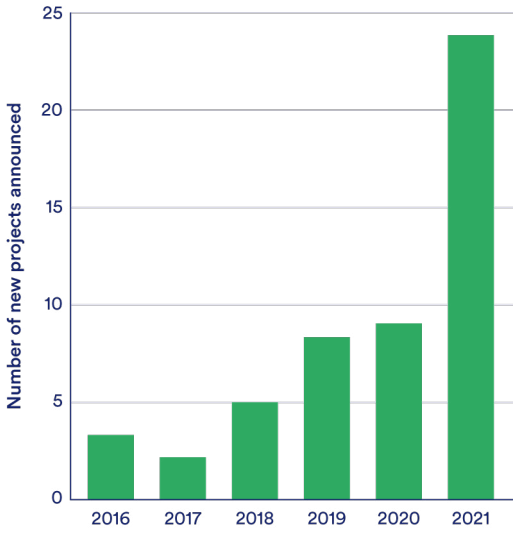
The — gap between carbon storage development and capture demand

In light of the increasing CO_2 capture ambitions announced throughout Europe, will the region have enough CO_2 storage capacity developed in time to meet demand?

As highlighted by the most recent Intergovernmental Panel on Climate Change report,[1] carbon capture and storage is an essential tool for reducing greenhouse gas emissions, as well as for achieving CO_2 removal from the atmosphere through direct air capture or bioenergy-based applications. Throughout Europe, more than 40 CO_2 capture projects have been announced so far, predominantly for industrial clusters centred around large petrochemical, chemical or iron and steel facilities, but also for individual facilities. Most of these projects were only announced in the past three years.

To effectively avoid the captured CO_2 being emitted to the atmosphere, the CO_2 needs to be permanently stored in geological formations,[2] as has been successfully demonstrated for the past 25 years by the Sleipner project in Norway. Therefore, together with the **capture** projects, several CO_2 **storage** projects are being developed across Europe, either as integrated components of capture projects or as stand-alone initiatives. But will these be sufficient to cover the capture demand? That is the question this analysis has set out to answer, relying on CATF's European carbon capture and storage project database.

Figure 1: New carbon capture and storage projects announced over the past 5 years



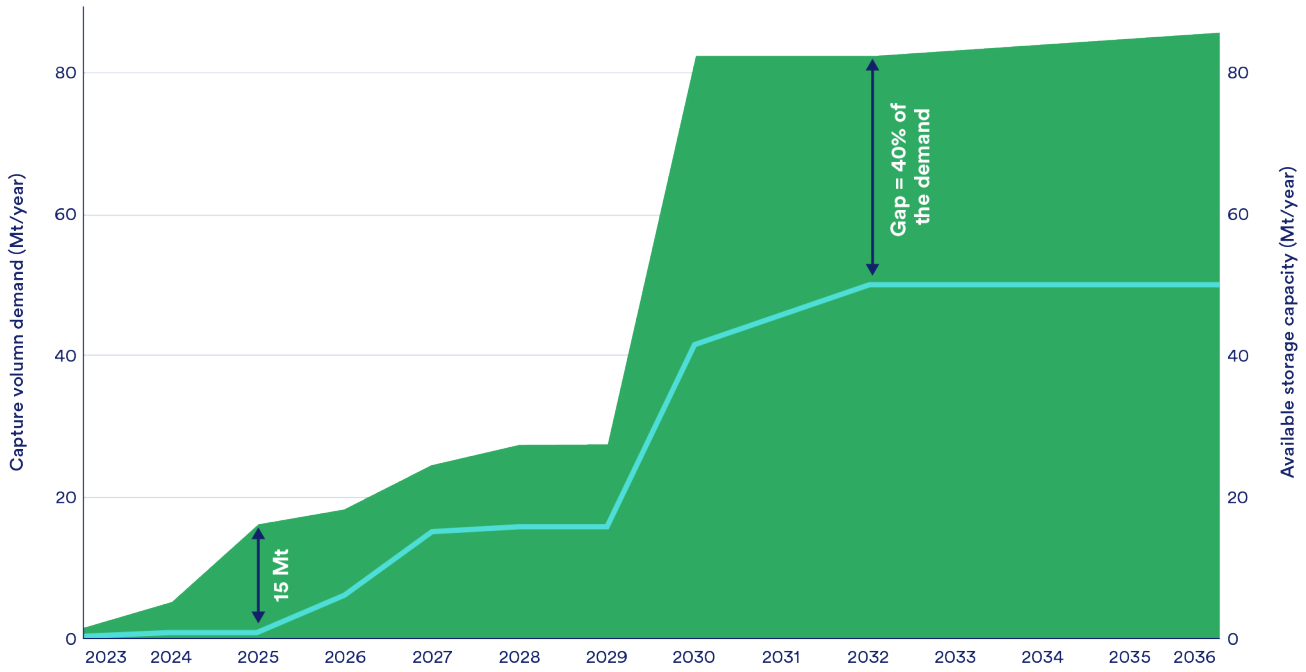
Source: CATF's European carbon capture and storage project database

[1] IPCC report, 2021 – Chapter 4 (4.6.3.2 Climate response to mitigation by Carbon Dioxide Removal (CDR)

[2] Some carbon utilization technologies can also lead to permanent CO_2 storage but some uncertainties remain around the effectiveness of these solutions and the volumes which could be permanently stored are relatively limited and would not achieve current carbon reduction targets alone.

Are there enough planned CO_2 storage sites?

Figure 2: Evolution of announced available CO_2 storage capacity (blue line) and capture volumes requiring storage (green area) over time



Note: this figure only presents capture volumes which have not yet secured storage capacity for their planned capture volumes and storage capacity which has not yet been assigned to specific capture projects.

Source: CATF carbon capture and storage project database and Carbon Limits analysis

There is theoretically sufficient geological CO_2 storage potential in Europe (estimated at around 507 Gt),[3] equivalent to over 100 years-worth of CO_2 emissions in the European Union at 2019 levels.[4] However, CO_2 storage sites can take from 5 up to 15 years to develop, depending on the existing level of characterisation of the area, while CO_2 capture projects tend to be faster to implement and have high ambitions to scale up quickly. As shown in Figure 2, CO_2 storage space availability, as currently announced, lags behind capture demand for the foreseeable future and most notably in the short term, until around 2025. In 2025, capture projects without related storage are expected to provide 15.8 Mt/year of CO_2 while only 0.7 Mt/year of CO_2 storage capacity for third parties will be available at that time, exclusively associated with the Northern Lights project in Norway. The gap then reduces thanks to the expected commissioning of several storage projects with available capacity for third parties. Later, in 2030, the CO_2 storage capacity gap deepens significantly as new capture projects are launched or existing projects scale up, leaving only enough available capacity to meet half of the 82 Mt/year demand. Beyond 2030, some additional storage capacity for third parties should allow for a slight reduction in the gap.

[3] European Commission, *CO_2StoP – Assessment of the CO_2 storage potential in Europe*, 2015, https://ec.europa.eu/energy/studies_main/final_studiesassessment-co2-storage-potential-europe-co2stop_en and Geological Survey of Denmark and Greenland for CATF, EU Geological CO_2 storage summary, October 2021

[4] 3.29 Gt CO_2 emissions in 2019, UNFCCC Greenhouse Gas Inventory data, European Union (Convention), https://di.unfccc.int/flex_annex1

Overall, a shortage in storage capacity is expected, but the importance of this shortage, both in relative and absolute value, varies over time. Storage covers less than 5% of the prospective captured emissions in 2025 and less than 60% in 2032, but for much larger volumes. This is due to announced capture projects targeting 2030 to start effective capture or significantly increase the volume of CO_2 captured, likely in relationship to the EU 2030 climate objective as well as national targets which have set 2030 as an important milestone for emissions reduction targets.

Based on the existing and announced projects, there will be a shortage of developed storage capacity (around 15 Mt/year in 2025 and 40 Mt/year in 2030 of missing storage capacity) and competition for storage space will be strong. This underlines the need for the development of additional storage sites allowing for open access to significant long-term storage capacity, bearing in mind that abundant suitable geological storage reservoirs exist.

The start-up dates of both capture and storage projects, many of which are still at an early stage of development, cannot always be assessed precisely. Depending on the cost of capture and storage, the price of CO_2, available funding, policy developments, and the evolution of industries in Europe, projects might be initiated, accelerated, downscaled, or abandoned.

On the storage side, it can be expected that several additional projects will be commissioned as some countries, such as Norway[5] and the UK,[6] are opening up new offshore CO_2 storage licenses. As these areas are still at an early phase of analysis, it is not yet possible to provide an estimate of the CO_2 storage potential. In addition, given the current development time for storage projects, these might not be available in time to match capture ambitions. With experience, it might become possible to optimize the storage development process and help meet the capture demand.

Overall, in Europe, significant theoretical storage potential exists both onshore and offshore. Theoretical potential implies that further studies are required to precisely identify the structures in which CO_2 can be safely stored and to refine the storage potential estimate. Typically, effective storage capacity is lower than theoretical potential due to the identification of flaws in geological structures and potential competition with other surface or subsurface activities which can make areas unsuitable or unavailable for storage, leading to reduced, but more certain, capacity estimates. The 507 Gt of theoretical storage potential includes both onshore and offshore storage. However, in some countries, onshore storage of CO_2 is not permitted and, in general, onshore storage tends to be less socially accepted compared to offshore storage. An important share of the offshore potential is located around the North Sea, where the large majority of planned storage projects and volumes are located, on the UK, Dutch, Danish and Norwegian continental shelves.

Figure 3: Effective storage capacity expected to be used by planned storage projects compared to total theoretical storage capacity in Europe



Note: Not all theoretical capacity might be suitable for storage. Theoretical capacity represents the estimated capacity in geological formations which require further study before start of injection. A lifetime of 20 years was assumed for planned projects.

Reference: CATF carbon capture and storage project database, CO_2Stop

[5] Offshore Engineer, Norway Allocates Two Areas for CO_2 storage, 14 September 2021, https://www.oedigital.com/news/490590-norway-allocates-two-areas-for-co2-storage

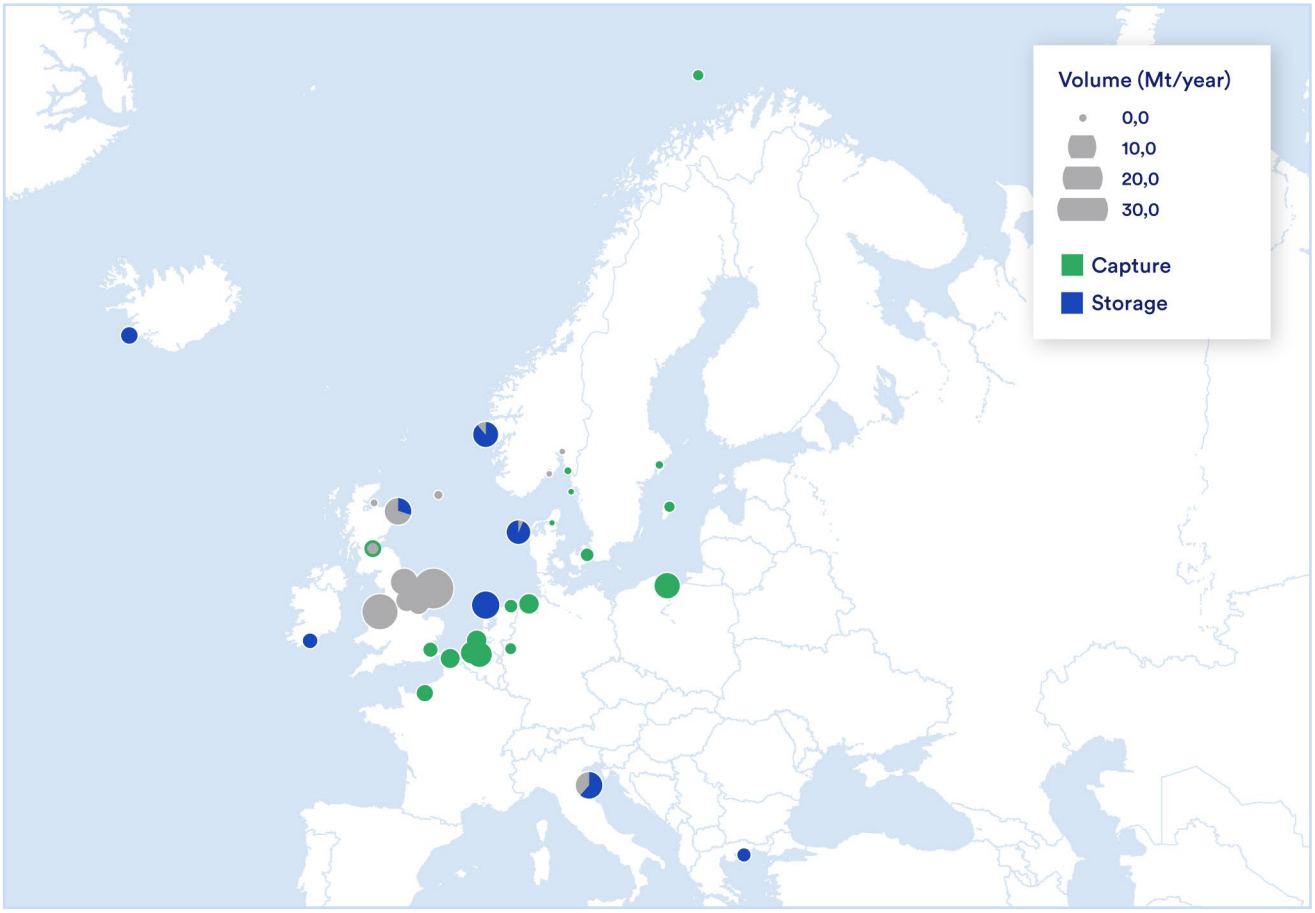
[6] ENI, Energy integration in action: Eni project awarded carbon storage licence, 8 October 2020, https://www.eni.com/en-IT/media/press-release/2020/10/carbon-storage-licence-uk.html

Are CO_2 storage sites close enough to CO_2 capture sites?

The analysis conducted above matches total capture and storage capacity throughout Europe but does not look further into optimizing capture and storage location. However, there are important disparities between countries. According to current project plans, by 2032, some countries will have an oversupply of storage space while others will have excess captured emissions compared to storage capacity. Countries with the most storage capacity planned tend to also have important capture ambitions and, aside from Norway and Denmark, are not expected to have additional storage space if all capture projects materialize. Greece, Iceland, Ireland, and Italy, also appear as having an oversupply of storage in 2032, but successful development of the storage sites in these countries is likely to be contingent on the sourcing of locally captured CO_2.

In addition, in some countries, there are currently no storage projects announced despite ambitions for capture projects. Some of these countries do not have geological storage capacity, do not allow onshore CO_2 storage on their territory, or need to carry out further characterization of storage formations before developing storage projects. This is the case for Belgium, France, Germany, Poland, and Sweden. Projects in these countries will need to secure storage space in other countries, at least in the near term. This demand is relatively evenly distributed between these countries.

Figure 4: Location of announced carbon capture and storage projects by type and capacity in 2032



Reference: Carbon Limits analysis based on CATF carbon capture and storage project database

Note: in grey, reserved volumes that do not require additional third-party storage for capture projects, or storage capacity already reserved at storage sites, based on the available data

In some cases, the distance over which the emissions need to be transported to an available storage site might alter the timeline or even relevance of a project and encourage facilities to find alternative decarbonization solutions. In this analysis, transport and storage were marked as instantly available in the database from the date they were announced and no gradual scaling up of capacity was considered unless a timeline with the scale-up through different project phases was published. The commissioning of transport routes, both through pipeline and by ship, takes time and the availability of volumes might occur more progressively and more directly in alignment with the timeline of capture projects.

What stands behind this analysis?

Ongoing and announced carbon storage and capture projects throughout Europe were identified on a best effort basis. Additional data was collected for those with sufficiently detailed timelines and volumes. Projects at a very early stage of development and/or which have not yet published clear deployment plans were excluded from the analysis. Some capture projects are directly related to a storage site (e.g. Sleipner has a dedicated storage site located in the direct vicinity of the capture site) or have already secured storage space with a project offering storage as a service. These were not included for further analysis and their reserved capacities at their storage counterparts were also marked as unavailable for other capture projects. Therefore, this analysis only presents capture volumes which have not yet secured storage capacity for their planned capture volumes and storage capacity which has not yet been assigned to specific capture projects.

For projects with a phased implementation plan, the increase in capture or storage volume over time was also taken into account to better represent when storage would be required for capture projects and when storage space would become available. Some storage projects have announced that capacity could be made available depending on demand, in which case a mid-range storage capacity was considered, and assumptions were made as to when storage would become available. There is, in Europe, much more theoretical storage capacity, but in this analysis, we only focused on storage space which has been announced for development.

Both storage availability and expected capture volumes were then plotted over time to identify when a shortage or surplus of storage capacity might arise and its magnitude.

References

CATF, Europe Carbon Capture Activity and Project Map, https://www.catf.us/ccsmapeurope/ – updated by Carbon Limits

Note: only projects with sufficient timeline and volume data were considered in this analysis.
Projects announced after October 2021 were not considered.