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EUROPE'S INDUSTRIAL CARBON MANAGEMENT:

FROM POLICY FRAMEWORKS TO INFRASTRUCTURE AND DEPLOYMENT

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EDITORIAL

EUROPE'S INDUSTRIAL CARBON MANAGEMENT: FROM POLICY FRAMEWORKS TO INFRASTRUCTURE AND DEPLOYMENT

Editorial — From strategy to implementation: making industrial carbon management work in Europe

Europe has entered a decisive phase of its climate and industrial transition. The debate is no longer about whether decarbonisation is necessary, but about whether it can be deployed at scale without undermining competitiveness, security and industrial sovereignty. Industrial carbon management (ICM) now lies at the heart of this equation.

Carbon capture, utilisation and storage are no longer abstract concepts or distant options. They are becoming structural components of Europe's industrial future, particularly for hard-to-abate sectors such as cement, chemicals, refining, fertilisers, hydrogen production and waste-to-energy. The challenge is no longer technological, but systemic.

Across Europe, ambition is high. Strategies have been published, targets set and flagship projects announced. The Net Zero Industry Act, the European Industrial Carbon Management strategy and the growing number of projects of common interest all signal clear political recognition: CCS and CCU are indispensable to meeting climate objectives while preserving Europe's industrial base and enabling the scale-up of low-carbon hydrogen.

Infrastructure, regulation and financing mechanisms must evolve in parallel. Carbon capture cannot advance without predictable access to transport and storage. Hydrogen production from both fossil-based and biogenic sources cannot scale without CCS to manage residual emissions. Transport infrastructure will not be built without clear demand signals. And investments will not materialise without long-term regulatory visibility under the EU ETS, clear liability rules and credible risk-sharing mechanisms. Avoiding fragmentation remains the primary challenge for deployment.

A risk of geographical imbalance is emerging in Europe. While the North Sea region is rapidly establishing itself as a storage hub, large industrial regions in Central, Eastern and Southern Europe risk being left without credible access to storage capacity. This would constrain decarbonisation pathways for industry and hydrogen value chains alike. Without coordinated, cross-border planning, Europe could replace its dependence on imported fossil fuels with a dependence on a handful of CO_2 and hydrogen infrastructure corridors. A genuinely European approach to infrastructure planning is essential.

This dossier does not present CCUS as a silver bullet. Several contributors rightly stress that carbon capture must complement—not replace—electrification, renewable hydrogen, energy efficiency, circularity and material substitution. CCS should target unavoidable process emissions and support transitional pathways where alternatives remain limited. Used indiscriminately, it risks inefficiency and poor allocation of public resources; used strategically, it can prevent deindustrialisation, support hydrogen deployment and limit carbon leakage.

Trust is also central. Public acceptance, transparency on capture rates, rigorous monitoring of storage sites and clear governance frameworks will determine social legitimacy. The same applies to hydrogen infrastructure and associated safety and sustainability standards. Without credibility, even technically robust projects will struggle to move forward.

Finally, time is critical. Europe is operating in a context where industrial policy, energy security and geopolitics are increasingly intertwined. Delays in decision-making, permitting or infrastructure deployment carry real economic and strategic costs. The window for first-mover advantage is closing as global competitors accelerate across CCUS and hydrogen alike.

This special issue reflects the need to align policies, mobilise investment and move from fragmented projects to integrated systems.

Industrial carbon management will not succeed through declarations. It will succeed through implementation.

Editor-in-Chief
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European Commissioner for Energy

CCUS as a cornerstone of Europe's decarbonization

Carbon capture utilisation and storage (CCUS) is key for Europe's decarbonisation strategy toward 2050 and beyond.

Alongside renewable energy, and greater energy efficiency, this technology is essential to capture the hard-to-abate emissions that remain, especially from industrial processes. Moreover, carbon capture will be a pre-requisite to retaining a decarbonised and competitive industrial base in the EU. In the coming years, most captured CO_2 is expected to be permanently stored in geological formations. However, CO_2 utilisation is also set to play an important role, supported by the availability of biogenic CO_2.

The momentum for CCUS is gaining ground worldwide, including in the EU. We have seen sustained commitment from many EU Member States, who are building financing schemes and advancing legislation to facilitate and structure the deployment of CCUS. We are also working closely with our partners: last year, for example, we celebrated the start of operations at Northern Lights in Norway, which marked the first volumes of CO_2 successfully captured and geologically stored at industrial scale in Europe. In addition, we support and welcome the continued progress in the construction of key European projects, such as Porthos in the Netherlands and Greensand in Denmark, which will be the first large scale geological CO_2 storage infrastructures in the EU.

All these successful developments are great examples of how the Connecting Europe Facility (CEF) and the Innovation Fund support projects, transforming vision into reality. Stimulating the deployment of the CO_2 value chain across the European Union is a clear priority for the Commission. At the end of last year, the Commission published the second list of Projects of Common and Mutual Interest[1], which includes 4 new CO_2 transport infrastructure projects. This comes in addition to the 13 existing projects that continue to benefit from this status and have received a total of EUR 978 million in EU co-funding through the CEF in recent years.

In addition, the Commission has announced in November 2025 the allocation from the Innovation Fund of specific support to large and small-scale CCS projects, as well as CCU projects. The Innovation Fund already supports CO_2 capture projects representing 23 million tonnes per annum of targeted capacity by 2030 or shortly thereafter. It also provides direct financial support to CO_2 storage projects representing nearly 12 million tonnes per annum of additional CO_2 injection capacity.

The potential deployment of CCUS solutions is large. Heavy-emitting industries are actively developing decarbonization strategies, with industrial carbon management playing a crucial role. At the same time, the number of projects currently under development remains insufficient to meet Europe's climate targets, making urgent action necessary to scale up CCUS technologies. The Industrial Carbon Management Strategy adopted by the Commission in 2024 identifies the key obstacles and outlines where stronger efforts from both the Commission and Member States are required to remove existing barriers. It sends a clear signal to the market and to investors

1 Regulation (EU) 2022/869.

Porthos, the project for CO_2 capture and storage in Rotterdam

about the role that CCUS must play on the path to climate neutrality by 2050.

First, to kick-start this emerging market, we need to de-risk investments. Second, market and regulatory fragmentation across Member States create uncertainty for project promoters and risk leading to unequal access to CO_2 infrastructure. Third, the lack of visibility on available CO_2 storage facilities and the volume of CO_2 captured by emitters lead to significant risks for project promoters, making it difficult to plan investments and infrastructure development.

To address these challenges, the Commission is moving ahead with the preparations for a legislative proposal scheduled for this year, to establish a well-functioning internal market and infrastructure for CO_2. With this upcoming legislative framework, we are looking into how to overcome the barriers for cross-border CO_2 transportation, tackling insufficient cross-border operability and other remaining legal barriers or uncertainties. We also want to support the emergence of a competitive CO_2 value chain, for instance with rules on access to infrastructure and on how to avoid conflict of interest but also by looking into how to overcome coordination issues in the value chain. The Commission is committed to developing framework that lays the grounds, that is robust and of course avoiding measures that could negatively impact business cases or investment decisions.

In addition to this legislative effort, the EU Emissions Trading System2 will continue to provide a key incentive to scale up industrial carbon management projects, by removing the surrender obligation on operators who capture and permanently store CO_2. Achieving our climate targets will also require us to keep adapting our comprehensive policy framework.

To reach our objectives, full cooperation among Member States, stakeholders, and international partners will be essential. In support of this cooperation, the latest edition of the Industrial Carbon Management Forum—a major platform established by the Commission to facilitate exchanges on CO_2 project deployment in Europe—brought together more than 420 participants in Athens in December last year.

In conclusion, if we are to stay on course with our climate ambitions while ensuring our industries and economy remain competitive on the global stage, urgent action is required to scale up all decarbonisation technologies, in parallel to our push for more renewable energy and greater energy efficiency. The Commission is therefore firmly committed to the deployment of CCUS in Europe and to capturing the full potential of carbon capture technologies for our future.

Ørsted plans carbon capture

2 Directive (EU) 2023/959.

CCS and CCU Roadmap for Central and Eastern Europe

KRZYSZTOF **BOLESTA**

Deputy Minister of Climate and Environment.

The European Union (EU) is approaching a decisive moment for its future industrial competitiveness and supply chain security. Central and Eastern Europe (CEE), which hosts a significant proportion of EU industrial output and industrial employment, bears a disproportionate share of the transition's near-term costs and adjustment pressures. This is not because the region is less committed to climate ambitions, but because it starts from a more challenging baseline, with a higher reliance on fossil fuels and a larger role of energy intensive industries in the economic structure. In Poland alone, industry generates more than 20% of GDP and accounted for 5.1% of the EU's industrial gross value added, ranking sixth in the EU.

„Security, Europe!"

„Security, Europe!" was the motto of the last year Poland's EU Council Presidency. A well-designed climate policy, apart from driving a transition, should serve the security agenda. More than a decade of Russian pressure and provocations, followed by almost four years of Russia's full-scale war of aggression against Ukraine, has demonstrated how swiftly dependence can be exploited. Reducing reliance on imported fossil fuels reduces exposure to coercion and disruption, strengthening investment and society stability. Europe's security is reinforced when the Union acts collectively. Therefore, it is crucial to frame decarbonisation and investments in clean energy technologies as a sovereignty and resilience agenda, aligned with industrial competitiveness.

Competitiveness is dependent on carbon capture for hard-to-abate industries.

Europe's resilience also depends on its ability to produce and maintain strong domestic industrial supply chains. As free allowances under the EU ETS are progressively phased out, industries that fail to decarbonise will face rising costs. This creates a clear investment imperative and a competitiveness vulnerability, particularly for hard-to-abate sectors such as cement and lime, as well as parts of chemical, steel, refining and fertiliser industry. A significant amount of emissions in these sectors are process related. Therefore electrification cannot make them CO_2 neutral. Carbon capture, utilisation, and storage (CCS and CCU) are essential to achieve deep reductions in emissions while maintaining production in Europe. These technologies complement other clean technologies in getting our economies to net zero.

From capture to storage: building the CO_2 value chain and making projects investable.

CCS and CCU require value chains that link capture to transport, storage or use under predictable rules. CEE countries should adopt dedicated national strategies that identify priority industrial clusters, set out realistic sequencing, and translate climate objectives into investable project pipelines. In Poland, a

national CCS and CCU strategy is expected by the end of 2026.

A credible approach requires a mix of EU instruments and national measures that work together. State aid can be part of the solution, but it cannot be the sole answer, because fiscal space differs across countries and security expenditures across the EU are mounting. CEE countries should actively apply for EU funding, such as the Innovation Fund, and advocate for sustained, accessible EU support for industrial carbon management.

Regional cooperation is equally practical for infrastructure development. CO_2 corridors generate cross border benefits while planning, permitting and costs remain national. Joint planning and coordinated bids for EU support are therefore a rational approach, particularly for backbone corridors designed to expand over time and connect multiple emitters to shared storage options. In this context, an IPCEI for Industrial Carbon Management should be considered as a flagship tool to coordinate state aid across MS, de-risk capital intensive infrastructure, and crowd in private investment, with safeguards that protect the integrity of the single market.

Poland can contribute to this regional architecture with its geological storage capacity. Current assessments estimate the potential for more than 14,000 $MtCO_2$. As this potential is to be further verified, it could potentially cover domestic needs and, over time, provide a regional, affordable option of CO_2 storage for CEE countries.

Moreover, successful deployment at scale depends on public acceptance. CEE countries should prioritise communication and local engagement, publish monitoring and safety indicators transparently, and clarify institutional accountability for long-term management. Such governance reduces avoidable delays and strengthens the legitimacy of investment decisions.

The CEE must present a united voice based on our common interests at the EU level.

The European Commission is preparing a legislative initiative on an internal CO_2 market and integrated infrastructure for capture, transport and storage, planned for presentation in Q3 2026. This initiative could improve interoperability, clarify regulatory oversight, and strengthen investment conditions for cross-border networks. CEE countries should develop coordinated positions on issues that are important for implementation in our region. A common regional approach will help to ensure that EU-level rules reflect the needs of countries where industrial clusters are distant from storage basins, and where experience of deploying carbon capture is still in its early stages.

For CEE, CCS and CCU is not a side topic. It is the practical route to decarbonise hard-to-abate sectors with high process emissions, and therefore a necessary component of the EU's pathway to climate neutrality by 2050. With national strategies, regional CO_2 infrastructure planning, targeted EU financing, and a coherent CEE contribution to the EU framework, carbon capture can keep key industries competitive while opening a new market for low carbon industrial services and attracting long term investment into the region. Successful deployment of CCS and CCU can also add another good argument in demonstrating just transition in industry is not only a possibility but very much a reality.

Competitiveness of companies in the decarbonisation process

MOHAMMED CHAHIM
MEP (S&D Group, Netherlands)

The global energy transition presents European companies with a dual challenge. On the one hand, they must rapidly decarbonise their production and processes to meet ambitious climate targets. On the other, they face fierce international competition, particularly from Asian markets that benefit from lower production costs and aggressive industrial strategies. Addressing this challenge requires more than innovation alone: it calls for strategic collaboration on key components of the technologies that will define our future.

Leading in ambition, trailing in competition

Europe is rightly recognised for having some of the most ambitious climate targets in the world. These targets provide certainty to investors and companies that are committed to making the energy transition a success. They also create fertile ground for innovative businesses that help decarbonise industry and develop future-oriented business models.

Yet despite this ambition, European industry risks being outpaced by Chinese and American competitors. In key technologies such as digital infrastructure, artificial intelligence, solar photovoltaics, electric vehicles and batteries, Europe risks playing a perpetual game of catch-up. Competing products are often more advanced or simply offer better value for money.

However, this would not be the first time Europe has started from behind and ultimately emerged on top. The story of Airbus offers valuable lessons for policymakers and industry alike.

Airbus: success through collaboration

In 1970, France, Germany, Spain and the United Kingdom decided to join forces to "strengthen European aviation technology and economic and technological progress in Europe." Each country had its own aviation industry, but all faced the rise of a powerful new competitor: Boeing. Without a joint programme for aircraft development, Europe risked being left behind by Boeing's jumbo jets. Airbus was born out of this realisation.

By pooling resources on components, coordinating R&D programmes and sharing investment risks, these countries strengthened their industries by looking beyond national borders. Collaboration proved to be the key to success.

Collaborate on components, software, and investments

Today, under similar external pressure, Europe must once again join forces to secure a competitive advantage in strategic sectors. Take battery production as an example. The battery supply chain is estimated to grow by around 30% annually - yet even this rapid expansion does not fully meet global demand, which continues to surge.

Batteries are vital for our future economy. Beyond their economic importance, they are a strategic technology that shapes Europe's geopolitical position. A strong battery industry strengthens Europe's autonomy today and safeguards it for tomorrow. Batteries are indispensable for decarbonisation, alongside many other key technologies.

That is why governments must enable industry to collaborate - to innovate together, invest together and share risks. Joint action can reduce the cost of key components, boost research and development, and lower financial uncertainty. Platforms for collaboration can lay the foundations for a competitive European industry in batteries, battery recycling, solar panels, heat pumps and many other sectors of the future.

Output based support for clean tech and innovative technologies, as seen with the Inflation Reduction Act, can be a tool worth considering. Moreover, governments should

not be hesitant to take a stake in companies of strategic importance.

Even more so, de-risking cross-border investments with conditioned low-interest loans or guarantees for companies that serve the public good can be a way to help start-ups and industries in transformation. Partial ownership, until the loan has been paid, could be such a condition - thereby further steering a business to serve the public. Because conditioning the use of public resources by private companies is not only morally sound, it can direct investment strategies to improve the public good.

Compete on quality

Europe must compete on quality. This means not only the quality of the final product, but also the quality of the production process itself: ethically sourced raw materials, fair working conditions and environmental responsibility.

At present, Europe cannot win a race based on production costs alone. Energy prices are higher due to external dependencies, and access to raw materials remains a major challenge. Lowering standards would only

benefit those willing to lower them even further. In a race to the bottom, Europe stands to lose far more than it could ever gain.

Instead, Europe should create lead markets with strong social conditionalities. Requirements such as worker representation through trade unions can help raise standards, stimulate domestic production and accelerate industrial decarbonisation.

Decarbonisation is our guarantee for competitiveness

Ultimately, competitiveness and decarbonisation are two sides of the same coin. Climate ambition without a coherent industrial strategy risk hollowing out Europe's manufacturing base. Industrial support without climate ambition risks locking Europe into outdated technologies. The solution lies in a coordinated European approach that aligns climate targets, industrial policy and investment capacity.

Europe has the skills, the research base and the market size to succeed. What it needs now is the political courage to act collectively, to pool risks and rewards, and to back its industry with the same determination that once gave birth to Airbus.

Industrial Carbon Management: Europe's Balancing Act

SIGRID FRIIS

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Europe's path to net zero must be grounded in economic resilience as well as climate ambition. While renewables and electrification will carry the bulk of the transition, there are sectors and regions where emissions cannot yet be fully eliminated. In this context, Carbon Capture, Utilisation and Storage (CCUS) can serve as a bridge, complementing long-term decarbonisation efforts.

A bridge for Europe's industrial transition

CCUS is one of the many tools to reach climate neutrality by 2050, with potential primarily in hard-to-abate industrial sectors, such as cement, steel, and certain chemical processes, where process emissions are intrinsic to production and cannot easily be avoided through fuel-switching or electrification. There, CCUS offers a way to keep essential European industries running and competitive while avoiding a shift of emissions-intensive production to third countries.

CCUS can also serve as a transitional support mechanism in regions with heavy industrial clusters that are still dependent on fossil-based heat or waste-to-energy facilities. In these areas, targeted deployment can provide breathing space with emissions reduction without forcing immediate shutdowns or social dislocation. Done right, this can help maintain social acceptance of the broader green transition.

Keeping CCUS aligned with EU climate and security goals

Yet the technology comes with risks if deployed unwisely. Using CCUS to extend the lifetime of fossil fuels in the power and heat sectors would fundamentally contradict Europe's climate and energy security objectives. Europe's geopolitical imperative after 2022 is clear: to cut dependence on imported gas and oil from unstable suppliers. Channelling public or private investment into prolonging fossil infrastructure risks locking in both emissions and vulnerabilities.

Moreover, CCUS is a capital-intensive technology. Deploying it in sectors where renewables, electrification, or efficiency are already viable adds unnecessary cost and complexity. Every euro spent on capturing emissions that could have been avoided is a euro not invested in renewables, grids, or storage capacity, the backbone of Europe's future energy system.

There is also a carbon-lock-in risk from large-scale CO_2 transport and storage infrastructure. If designed on the assumption of continued high CO_2 output, such assets could create bad incentives to maintain emissions rather than eliminate them. This risk grows if CCUS projects rely on long-term subsidies or weak carbon pricing mechanisms that

undermine the EU Emissions Trading System (ETS).

Designing safeguards for responsible deployment

To ensure CCUS plays a constructive role, Europe needs strong policy safeguards and clear governance principles. No subsidies for fossil power should be granted under the guise of CCUS. Public support must be strictly limited to industrial process emissions that cannot otherwise be avoided.

Conditionality and transparency are crucial: only projects achieving high capture rates, minimal methane leakage, and demonstrable lifecycle benefits should qualify for public funding or ETS credits. Sunset clauses[1] and phase-out timelines must be embedded in policy frameworks to ensure CCUS remains a transitional measure rather than a permanent crutch for fossil use.

Integration with the ETS must be carefully calibrated. Over-crediting or overlapping support schemes could depress carbon prices and weaken the market signal needed to drive decarbonisation.

Finally, priority access to public funding should go to solutions with enduring mitigation potential - renewables, storage, electrification, and energy efficiency, which deliver structural emissions reductions without long-term dependency.

Balancing competitiveness and climate integrity

Europe's credibility in industrial decarbonisation depends on its ability to combine climate integrity with competitiveness. CCUS can support both,but only if treated as a targeted, temporary, and cost-effective tool within a broader industrial strategy. As carbon pricing strengthens and free allocations are phased out, the economic case for CCUS must rest on market signals, not perpetual subsidies.

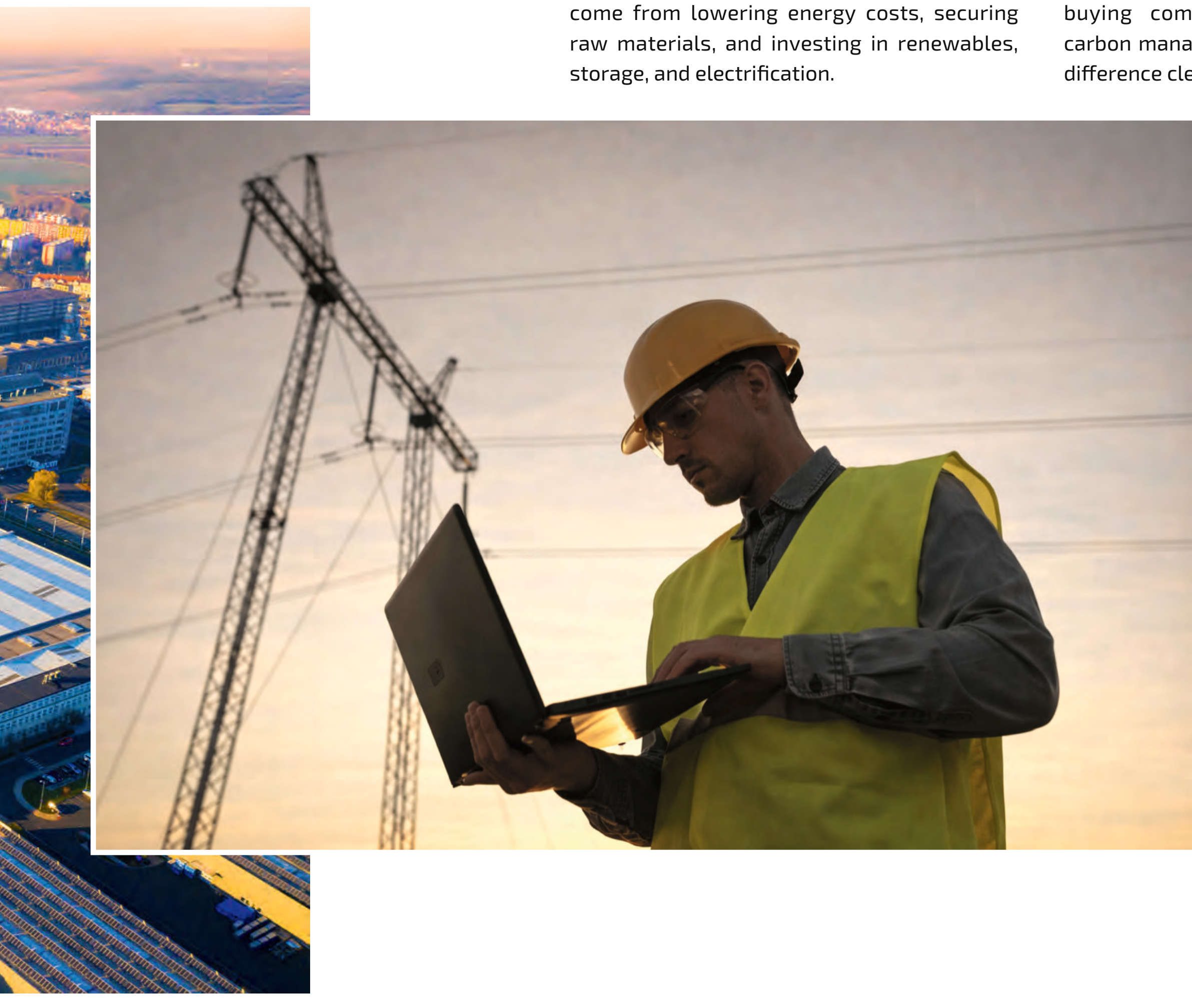
The real competitiveness challenge is global. Europe cannot compete by subsidising emissions, it must compete by scaling clean industrial solutions faster and more efficiently. Strategically deployed CCUS can help anchor high-value industrial activity in Europe during the transition, particularly in hard-to-abate sectors, but long-term strength will come from lowering energy costs, securing raw materials, and investing in renewables, storage, and electrification.

A forward-looking carbon management strategy should integrate CCUS into a broader competitiveness agenda: aligning infrastructure with emerging CO_2 value chains, fostering public-private partnerships in industrial innovation zones, and directing EU funding instruments, from the Innovation Fund to the Net-Zero Industry Act, toward technologies that deliver both climate impact and export potential.

If Europe can show that industrial carbon management reinforces, rather than weakens, its green competitiveness, it will not only secure its industrial base, it will set a global standard for climate-driven industrial policy.

Europe needs to manage industrial carbon wisely, not indefinitely. CCUS can help bridge short to mid-term gaps and protect jobs in essential industries, but it should not replace the fundamental transformation of the energy system. With the right safeguards, strict conditionality, clear timelines, and firm prioritisation of renewables, Europe can ensure that CCUS strengthens responsibly in its pathway to climate neutrality while helping with Europe's reindustrialisation.

Used judiciously, CCUS can buy time for innovation and adaptation. Misused, it risks buying complacency. Europe's industrial carbon management strategy must make the difference clear.



1 Sunset clause are legal provisions that makes a measure or obligation automatically expire or be reviewed after a set period.

SARA MATTHIEU
MEP (Greens/EFA, Belgium)

Electrification and **Circularity**: The **Smart Investment** for **Europe's Industry**

And why carbon capture will mostly remain a pipedream

When the European Commission unveiled its Industrial Carbon Management Strategy in 2024, it presented carbon capture as an important building block to industrial decarbonisation. The promise is simple and seductive: keep a large part of our carbon-intensive industries running much as they are, just add a giant vacuum cleaner at the end of the smokestack.

This promise has remained elusive for at least three decades. Carbon capture has almost exclusively been used for fossil gas and oil extraction for which a business case exists. In other sectors it simply hasn't delivered. This has led the EU power sector, for instance, to conclude that renewables are a cheaper and more profitable option, as shown by the 35:1 investment ratio of renewable generation to fossil fuel power achieved by early 2025.

However, a recent wave of renewed interest, including in industrial applications, has crashed onto the US, UK and Canada and also the EU – hence the new EU Strategy. The Commission aims at 280 million tonnes of CO_2 captured annually in 2040, and a whopping 450 million tonnes in 2050.

A risky and expensive bet

There is only one problem. Pursuing carbon capture over its alternatives is wildly expensive, and it distracts Europe from cheaper, faster and more reliable solutions that are already within reach. At a time when European industry is under pressure from high energy prices and global competition, Europe shouldn't bet on technologies that are uncompetitive and plants that risk becoming stranded assets.

The fact is that capturing carbon, compressing it, transporting it across borders and storing it safely for centuries is not cheap today. And as researchers at the University of Oxford indicate, there is little evidence it ever will be. This is because, contrary to electrotech that becomes cheaper with scale, there is no learning curve in any part of the CCS process, whether capture, transport or storage, to slash costs over time.

Still, we see industry players and local governments pouring giant sums of money into plant retrofits and infrastructure with public subsidies. According to estimates of the Institute for Energy Economics and Financial Analysis (IEEFA), Europe's current project pipeline could cost as much as €520 billion and require 140 billion € of government support.

That's a lot of money for technologies that capture on average only 49% of emissions, or in the case of a steel plant in the UAE, just 17%. And this is before even taking into account up and downstream emissions, the emissions of other hazardous pollutants, or discussing the costs for long-term monitoring, liability or leakage risks decades down the line.

With that in mind, it's in our best interest to explore all other options that will provide more bang for our buck.

Luckily, the alternatives are right in front of us

Carbon capture has often been portrayed as a necessary option for so-called hard-to-abate sectors. That outdated view now belongs to the garbage bin of history.

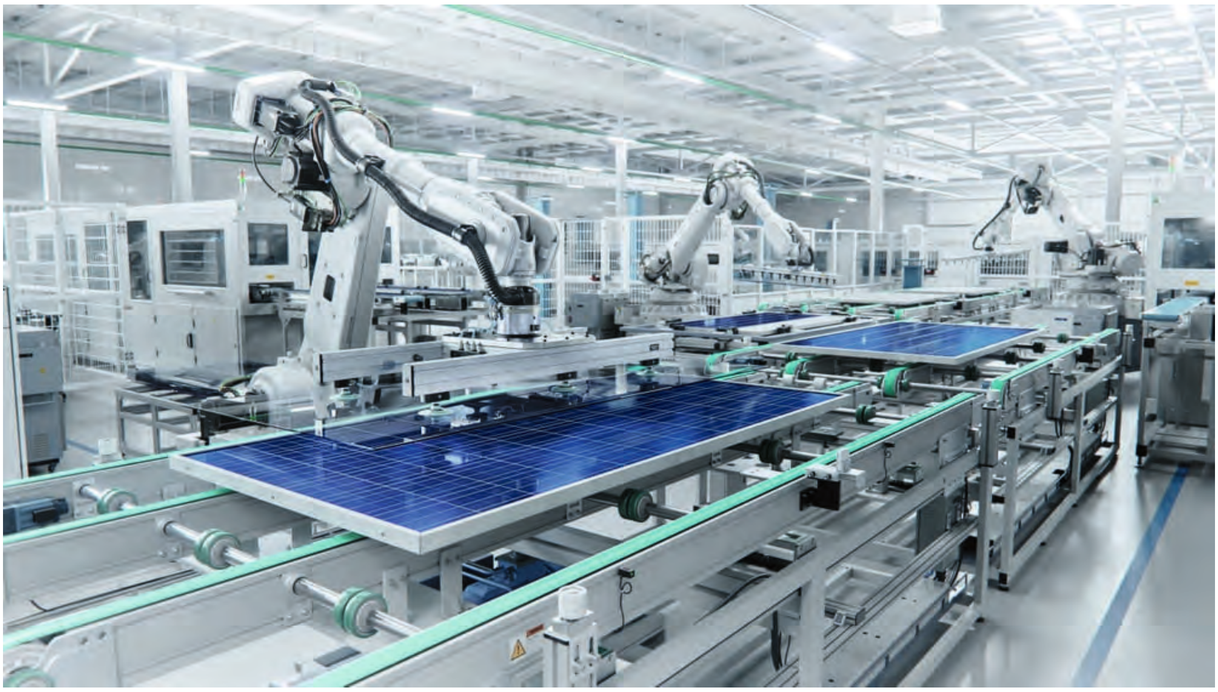
Sectors like steel and cement (and chemicals to a certain extent) can now be considered as fast-to-abate as a result of a wide range of rapid technological advances. And they open up commercial opportunities for innovators to boot.

As always, we should first look at efficiency. The cleanest tonne of CO_2 is the one never emitted. Industrial efficiency measures – better process control, waste heat recovery, smarter design – reduce emissions while lowering energy bills. They pay for themselves. Carbon capture, by contrast, adds an "energy penalty": capturing carbon requires significant additional energy, increasing fuel use rather than reducing it.

Second, we should prioritize circularity. Material Economics' landmark study shows that the EU can cut emissions by 56% by 2050 in steel, cement, plastics and aluminium sectors. Looking at cement in more detail, we see that existing and commercially available solutions such as clinker reduction and substitution as well as recycling of Portland cement can be scaled up fast. If the right performance standards are in place, this can bring down the cement industry's footprint by at least 50% in a much faster and cost-efficient way.

In the case of steel, a combination of recycling steel in electric arc furnaces and direct reduced iron reactors with renewable hydrogen, together with material and energy efficiency strategies can bring down emissions to zero. Compare that to Agora Industrie's calculations for retrofits of blast furnace steel mills. Assuming a 90% carbon capture rate at the main emission sources, only 73% of the total emissions of the steel plant can be captured. Targeting the rest would be prohibitively expensive.

A third main course of action is direct electrification. This is where a real transformation potential lies, considering that fossil fuels still cover 75% of industrial process heating. According to Fraunhofer ISI's study for Agora Industrie, electric furnaces, heat pumps and other electric processes are already available and can cover about 60% of industrial heat demand today. Technologies for high temperature heat, that will be available by 2035, can boost that to 90% of total demand.



Industrial policy is about making strategic choices

An excessive focus on carbon capture risks locking Europe into continued fossil fuel use for decades. It makes Europe geopolitically vulnerable and harms European competitiveness.

On the contrary, efficiency, circularity and electrification eliminate exposure to these risks. They create jobs across Europe, not just around a handful of storage sites. They will increasingly lower operating costs for industry, in contrast to adding a permanent carbon capture surcharge. If the goal is to safeguard European industry, this is where the smart money goes.

There may be niche applications where no better option exists. But making carbon capture the centerpiece of Europe's industrial action is a costly distraction from solutions that work better, faster and cheaper.

Europe does not need a climate moonshot built on pipedreams and promises. It needs a clear-eyed industrial strategy grounded in common sense: use less energy, waste fewer materials and reuse them more, electrify wherever possible. That is how we cut emissions, protect taxpayers and give European industry a future worth investing in.

CCUS as a Competitiveness Tool for Europe's Industrial Leadership

YVAN **VEROUGSTRAETE**

MEP (Renew Europe , Belgium)

In 2026, the general consensus is that Europe is losing its edge and, at this rate, will fall entirely behind other geopolitical power players, such as the United States and China, in particular when looking at its industrial capacities.

Contrary to those geopolitical players, Europe made a commitment going beyond pure economic competitiveness: addressing the climate crisis is not an option and must permeate every single policy decision. This commitment to cleaning our industry must not be seen as a burden but as an opportunity, showcasing Europe's potential.

Greening our industry will rely on many different factors, especially the availability of green energy. While, for the first time, the EU produces more renewable electricity than it does fossil-based electricity, and the share of renewables is growing consistently in our energy mix, the energy demands of certain industrial sectors remain higher and more complex than what can be met with this input.

For those hard-to-abate sectors, carbon capture, utilisation, and storage (CCUS) technology constitutes the leading decarbonisation perspective. Despite facing a number of obstacles still, that keep it behind expectations, CCUS shows true potential to complement other decarbonisation efforts for those tricky industrial sectors, like steel, cement, and chemicals.

Currently, one of the leading issues blocking widespread CCUS implementation in Europe, is its cost. With the cost of transport alone above 200 euros per ton of CO_2, it towers above similar technology in China.

However, part of what makes CCUS an interesting tool for Europe's leadership in particular is its financing mode. At EU level, the biggest source of funding dedicated to the deployment of functional CCUS is the Innovation Fund. This fund is not cash coming from the Member States, instead, it is entirely made up of revenue from the EU's Emissions Trading Scheme (ETS). In a nutshell, it ensures that highly polluting industries pay for their emissions if have not been compensated otherwise, creating a virtuous cycle where bad players fund the development of good players that will soon help them abate their own emissions.

Additionally, the deployment of CCUS technology is lagging behind with major infrastructural needs, especially in terms of transport. However, infrastructure is also one of the strengths of CCUS, as it is one of the only technologies that can be retrofitted on existing power plants, allowing their reconversion. Moreover, the transport infrastructure required by CCUS could also serve future needs and would thus constitute a much more strategic longer term investment.

Investing in the necessary CCUS skills could also support the development of other solutions such as carbon removal via direct air capture.

A major struggle that still needs to be tackled is to strengthen the permissibility of CCUS across the EU. Several Member States are still lagging behind in terms of acceptance and implementation of this solution. Projects currently exist in Germany, Denmark, Netherlands, and soon Italy, as well as in Norway. However, a more integrated and coordinated permitting and planning approach, as well as the creation of lead markets across the EU, are needed to ensure a stronger development of this technology.

Finally, an added value of CCUS also lies in the 'U', utilisation. While carbon storage will provide a longer term solution to high pollution industries, utilisation can hit two birds with one stone: avoiding emissions from hard to abate sectors and supporting the production of green fertilisers and other sectors, such as fuel and building materials production. Even though the latter sectors should work on their own decarbonation paths, repurposing carbon into utilisable material creates an ideal closed loop scenario.

The main pitfall of CCUS is not small: by believing it to be a miracle solution, the risk of setting aside other emission reduction efforts is clear. CCUS cannot and must not be treated as a silver bullet for the entirety of our European industry. Instead, it must be deployed in a smart and targeted way, in combination with other decarbonisation efforts, to ensure we reach the targets set.

In short, while CCUS is definitely not a silver bullet, it also constitutes a genuine opportunity for hard-to-abate sectors to remain in Europe, even while setting them firmly on a decarbonisation path. In the current context of geoeconomic tensions and the unreliable partners, the EU must secure its own production of steel and chemicals, to avoid increasing potential dependencies. These will be needed if we are serious about wanting EU-made cars and a strengthened defence industry. CCUS allows us to maintain our position amongst giants while still keeping our sights on our 2050 net-zero targets.

Developing cross-border CO_2 transport and storage infrastructure

PIOTR KUŚ
General Director of ENTSOG

Over the past few years, acronyms like CCUS (Carbon Capture, Utilisation, and Storage) and terms like CO_2 Transport have been subject to increased interest by policymakers in Brussels and by industry leaders alike.

Mario Draghi's report: The future of European competitiveness[1], and the European Commission's legislative initiatives such as the upcoming CO_2 Markets and Infrastructure package set a clear trajectory for the EU compass: CCUS and CO_2 Transport are no longer ideas, but a reality of Europe's new industrial era that will allow it to meet its 2040 Climate Target.

Connecting the Dots: Planning for cross-border CO_2 transport and storage infrastructure:

At the early stages of development, Europe's future CO_2 network is likely to be characterised by industrial clusters connected to dedicated storage facilities. Over time, connections between clusters and storage sites can be expected to evolve, leading to the gradual emergence of regional, cross-border, and eventually pan-European networks. The driver for transport infrastructure development and its spanning across EU Member State borders will be strongly influenced by sheer geography, the location of main emitting clusters and potential storage or sequestration sites, whether onshore or offshore. Significant cost efficiencies can be achieved by planning this grid effectively from the outset, rather than allowing it to develop in a fragmented manner.

Close coordination between future National Development Plans (NDPs) and any requested EU Ten-Year Network Development Plans (TYNDPs) for CO_2 and those that are currently in place for natural gas, electricity and hydrogen will therefore be critical. In some cases, the CO_2 network will be built by repurposing existing gas pipelines. This makes holistic planning essential to ensure efficiency, affordability, and system-wide coherence, especially when considering the repurposing needs for hydrogen, and importantly, to ensure ongoing security of supply. This leads to a clear conclusion: a dedicated regulatory framework should be established to bring CO_2 infrastructure, both transport and storage, within the TYNDP process. Doing so would support energy system integration, enable national grid planning that reflects a broader EU perspective, and build on the trusted principles of the TYNDP integrated planning, including stakeholder consultation and transparency.

Connecting with Confidence – Standards, Interoperability and Quality:

Beyond infrastructure planning, establishing standards, interoperability, and quality requirements will be decisive for the success of a European CO_2 transport system. Specifications for CO_2 composition and quality are critical to ensuring safety and enabling cross-border flows. In addition, leveraging experience from the existing gas infrastructure can help lower costs and accelerate the rollout of the CO_2 system. Together, these principles aim to create a reliable, integrated CO_2 transport and storage system across Europe.

To this end, a minimum set of requirements for CO_2 specifications must be established, and EU-wide rules, such as an Interoperability Network Code (INT NC)[2], as has been done for natural gas transmission, should be developed for CO_2 infrastructure. Such rules would be particularly important for cross-border CO_2 flows involving different network operators. A common, EU-wide regulatory framework will be essential to support the operation of shared infrastructure and the development of a European network linking emitters and storage sites. This potential set of EU rules should therefore address key principles, including the establishment of interconnection agreements and coordination rules between adjacent operators; a harmonised unit system; defined CO_2 quality parameters; and robust data exchange requirements.

Photography : Porthos

1 Report - The future of European competitiveness: https://commission.europa.eu/topics/competitiveness/draghi-report_en

2 Commission Regulation (EU) 2015/703: https://eur-lex.europa.eu/eli/reg/2015/703/oj/eng

Until such rules are adopted, CO_2 network operators will need to manage cross-border interoperability through bilateral agreements, ideally based on these common principles. However, in the absence of EU-level harmonisation, this approach risks creating a complex patchwork of agreements that may prove difficult to align at a later stage. As an interim solution, the development of EU-wide guidelines could provide a structured framework to help operators align practices across Member States.

Interoperability considerations also extend to standardisation efforts at the European level. The European Committee for Standardisation (CEN) is expected to deliver EU standards covering key aspects of the CCUS value chain, particularly with regard to CO_2 quality. It is advisable that Member States, and by extension CO_2 infrastructure operators, adopt these standards. Early alignment with CEN standards would help mitigate potential CO_2 quality issues, promote consistency across the EU, and support a smoother regulatory transition as the CO_2 market and infrastructure framework matures.

Developing an interconnected European vision:

Ambitions will remain aspirational until technical solutions are scaled to enable cross-border networks. Interoperable CO_2 transport networks, harmonised standards, quality and coordinated planning are the key ingredients to develop robust infrastructure for CO_2 transport and storage, which will in turn support Europe's trajectory towards its decarbonised, affordable and competitive future.

The 2025 Projects of Common Interest (PCI) list[3] includes 17 CO_2 transport and storage projects, demonstrating that Europe's decarbonisation compass points in the right direction. However, reaching the destination and achieving this vision will ultimately require additional coordinated investment, clear regulatory frameworks, market rules and cross-border collaboration.

Read more about CO_2 Transport projects at [ENTSOG Innovation Projects Platform.]

3 Delegated Regulation on the second Union list of Projects of Common and Mutual Interest and its annex: https://energy.ec.europa.eu/publications/delegated-regulation-second-union-list-projects-common-and-mutual-interest-and-its-annex_en

Carbon capture is not just nice to have it's a need to have

NIELS **FLEMMING HANSEN**

Member of the European Parliament (EPP Group – Denmark), Det Konservative Folkeparti

Europe is undergoing a historic transition with an important ambition: to deliver strong climate action while at the same time safeguarding competitiveness, jobs, and the security of supply. Europe has committed itself to deliver on different climate targets and a big challenge for us is turning these ambitions into concrete solutions that works in practice and does not just look promising in political strategies and policy papers.

One of the biggest challenges is to lower the CO_2 emissions and part of the answers to deliver on these climate targets lies in carbon capture and storage (CCS). If the green transition is to succeed, Europe must invest in the right infrastructure and here a well-developed CO_2 pipeline network, will be essential.

If we think that Europe can achieve climate neutrality through only electrification and renewables, we are going to be disappointed. CCS is a key technology in the green transition, mostly because we have different sectors where electrification or renewable alternatives are not always the right solution. It's especially an important asset in heavy industries such as cement, steel, chemicals, and waste-to-energy, where unavoidable CO_2 emissions will remain for decades to come.

CCS is therefore not a choice, but a necessity if we want to maintain industrial activity in Europe rather than exporting emissions and possible jobs to third countries. However, this tool is not just about captioning the carbon and then the issue is solved. We need the right infrastructure, since the CO_2 must be transported safely and efficiently from emission sources to storage sites, often across national borders. And this requires a coherent European network of CO_2 pipelines, comparable to the gas, electricity, and district heating networks we rely on today. Only in this way can we reduce emissions and work greener while maintaining competitiveness and ensuring a sound business case.

I have recently visited one of the projects in Norway, where the focus is on capturing CO_2 from heavy industry and transporting it for permanent storage deep under the seabed. The first plant is expected to have a capacity to handle millions of tons of CO_2 annually. This project - and other projects in Europe as well - is concrete proof of how technological advances and international cooperation can translate climate goals into action.

And I must say it is very impressive to stand close to the facilities where future climate solutions are not only discussed, but also built. I believe climate policy must be pragmatic and technology-neutral. We cannot allow ideological opposition to stand in the way of the green solutions that deliver real results. CO_2 pipelines are not a symbol of continued dependence on fossil fuels, instead they are a practical tool to cut emissions now while protecting Europe's industrial base.

The European Union has a clear responsibility to create stable and predictable investment frameworks. Private companies will not commit billions of euros to support the CCS facilities and pipeline infrastructure if regulations are unclear, permitting processes take decades, or infrastructure planning remains fragmented. At the same time, safety and public acceptance must be taken seriously. CO_2 pipelines must be planned responsibly, based on proven technology and transparent dialogue with citizens and local communities. Common European standards are essential to avoid a patchwork of national rules and to ensure public trust.

If Europe doesn't act now, we risk falling behind the United States and other regions that are already investing heavily in CCS. That would harm both our climate ambitions and our economic strength. CCS enables us to reduce emissions where they are hardest to fight, while preserving industrial production, jobs, and competitiveness in Europe. And if we do not continue the development in this area, we risk moving important industries, thousands of jobs and CO_2 emissions to other parts of the world and not solving the climate issue while falling even more behind in the race of competitiveness.

The green transition must not become an experiment detached from reality. CO_2 pipelines may not be invisible, but they are critical infrastructure. If we are serious about taking responsibility for the climate without undermining Europe's industrial foundation the time has come to think big, act wisely, and invest on time.

FRANÇOIS-RÉGIS **MOUTON**

IOGP Europe Managing Director

Turning **CCS ambition** into **reality**: **Europe** must now **build** the **framework**

Despite growing political ambition, Europe risks falling short on CCS delivery. The reason is simple: targets alone do not build projects. Only a credible regulatory and investment framework does.

Carbon Capture and Storage (CCS) is no longer a theoretical option in Europe's decarbonisation debate. It is a recognised necessity if we want to keep industry in Europe. The technology is mature, the geological potential is well understood, and European industry has the knowledge to develop it and stands ready to invest - particularly for those sectors that have no viable alternatives to deep emissions reduction. Yet market development is slow due to the lack of a solid business case.

When ambition runs ahead of reality

With the Net-Zero Industry Act (NZIA), the European Union took the decisive step of introducing a binding obligation for 44 oil and gas producers to collectively deliver 50 million tonnes of annual CO_2 injection storage capacity by 2030. This is an unprecedented challenge in any industrial sector, that shoudn't be solved by only one segment of the entire CCS value chain. Let's keep in mind that a CSS project takes typically between two to follow the years to develop.

The numbers tell a sobering story

Today, only around 0.025 million tonnes of NZIA-eligible CO_2 storage is in operation in the EU. If we count projects tahat have taken Final Investment Decision (FIDs), EU storage capacity would reach only around 3 million tonnes. Looking across Europe as a whole, that figure rises to roughly 20 million tonnes by 2030 - still far short of the EU-level 50 million tonnes target.

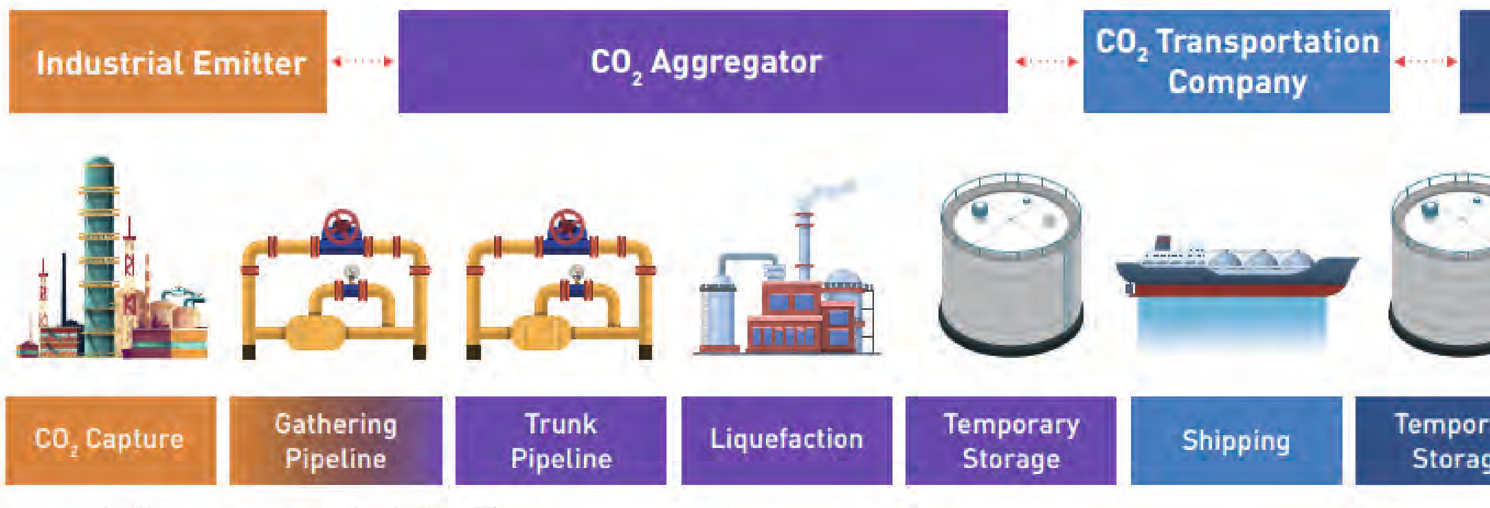
This gap is not the result of a lack of commitment or technical readiness: it simply reflects a mismatch between political ambition and the actual administrative, business, and operational preconditions needed to turn it into reality.

Targets do not make projects - business cases do!

For CCS to scale, every part of the value chain needs to come together. Today, it does not. Emitters still lack sufficient incentives to invest in CO_2 capture. Cross-border transport rules remain incomplete. And without long-term demand certainty, storage developers cannot take final investment decisions. On top of this, permitting timelines still often exceed the years available before 2030.

In short, the sequence is wrong. Europe has put the storage obligation in place before ensuring that carbon capture, transport, and market conditions are aligned.

Our industry's objective, however, remains unchanged: to deliver safe, competitive and large-scale CO_2 storage for Europe. Doing this, in respect of the highest standards, requires



'Creating a Business Case for CCS Value Chains'
Rapport by IOGP Europe

a renewed policy focus on the fundamentals that make the CCS value chain investable.

Strengthening the business case for carbon capture

No storage project can reasonably exist without CO_2 to store. Today's EU Emissions Trading System price alone is insufficient to unlock widespread investments into capture, particularly in hard-to-abate industrial sectors.

This is why dynamic, complementary policy instruments are essential. These include de-risking mechanisms such as Carbon Contracts for Difference, guarantee funds, and targeted support through 'Important Projects of Common European Interest (IPCEI)' or the Connecting Europe Facility (CCFDs). First movers also need predictable rules, including clarity on grandfathering at the moment of final investment decision. Demand-side incentives will naturally encourage long-term contracting between emitters and storage providers.

Without these elements, there is no value chain - only stranded ambition.

Building Europe's CO_2 transport backbone

Even with a stronger business case for capture, CO_2 must be able to move efficiently from emission points to storage sites. Today, this remains one of the most significant bottlenecks.

Fragmented national rules, limited pipeline and shipping capacity, poor integration between transport modes, and slow permitting processes all stand in the way. In many cases, emitters are simply unable to access suitable storage, even where it exists.

The forthcoming EU legislation on CO_2 markets and infrastructure, the first legislative initiative from the Industrial Carbon Management Strategy, represents a critical opportunity. It should focus on planning cross-border transport corridors linking industrial clusters to storage hubs, streamlining permitting to avoid multi-year delays, and mobilising instruments such as IPCEIs, the CEF and guarantee schemes for first-of-a-kind infrastructure.

Crucially, the framework must allow for a mix of transport modes - pipelines, ships, and interim solutions - so the system can scale progressively in an efficient way. This is the physical backbone of CCS: steel in the ground and routes on the map.

Making CO_2 storage a competitive European service

Once capture and transport are in place, the focus shifts to market design. Who can access storage, under what conditions, and across which borders?

A functioning European CO_2 market should enable competition between storage sites, ensuring efficiency and innovation. It must guarantee cross-border access to the best available storage resources, including those in the North Sea and neighbouring EEA and UK regions. Fragmentation must be avoided.

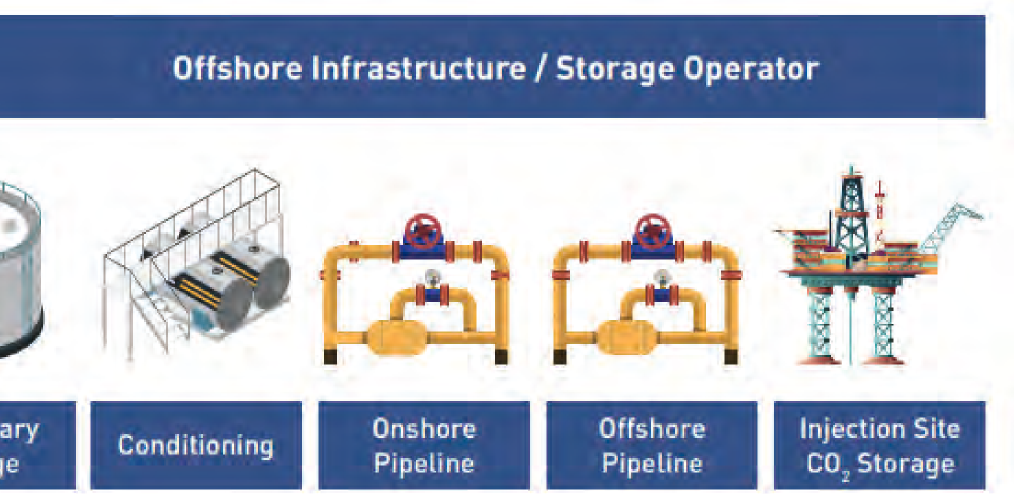
At the same time, regulation should remain proportionate. The analysis by the University of Groningen shows that CO_2 storage markets already display competitive characteristics. What is needed is not heavy-handed regulation, but common principles on liability, monitoring and access - while allowing storage to remain a competitive service rather than a regulated utility.

A moment to get it right

The debate surrounding the NZIA storage obligation has been intense, but the direction of travel is clear. CCS must scale, and Europe needs a framework capable of delivering it. The path forward is well defined:

- Incentivize carbon capture to underpin storage investment;
- Lift remaining national bans on CO2storage;
- Accelerate permitting; enable cross-border transport corridors;
- And keep regulation flexible as the market matures.

The technology is ready. Europe now has a narrow window to align ambition with delivery. If it succeeds, CCS can underpin climate progress, industrial competitiveness, and a credible pathway to net zero.



BERGUR LØKKE RASMUSSEN

Director, CCS Europe

Breaking Down Borders: Why Europe Must Simplify Cross-Border CO_2 Transport Now

Europe risks stalling its industrial decarbonisation unless we fix CO_2 transport - fast. Without dependable routes to permanent storage, capture projects cannot reach FID and emitters face untenable risks. The NZIA's 50 Mtpa storage goal and the 450 Mtpa capture need by 2050 make clear: cross-border, interoperable transport is essential and urgent.

Today, the deployment of CO_2 transport infrastructure in Europe is still nascent – like the rest of the CCS value chain. However, the direction is clear: According to the EU's Industrial Carbon Management Strategy, Europe will need to capture 450Mt CO_2 annually by 2050 to deliver the EU's net-zero target. Most importantly, CCS is not just critical to decarbonise the energy-intensive sectors but also to prevent Europe from deindustrialising.

To do so, we must develop a transport network that matches our need for carbon capture and storage and that takes into account the varying needs of all emitting sites, both large and small, remote and in clusters. To make this possible, the EU must take on a stronger role: aligning and empowering Member States, enabling action at different starting capacities, and creating a regulatory framework that is fit for purpose, without becoming overly complex. This will provide the investment certainty needed to build the cross-border transport backbone Europe requires and unlock FIDs across the full value chain.

From Patchwork to Platform

As noted, the CO_2 transport infrastructure and industry in Europe is still nascent – and the progress across Europe is as diverse as Europe itself. While some Member States have already fully developed a CO_2 transport legislation on national level, others have not even started yet. To be able to deploy CCS at a large-scale across Europe, we need the EU to step in, coordinate planning for cross-border CO_2 infrastructure and support multimodal transport strategies - pipelines, ships, and rail – and empower national governments to unlock the EU's potential for CO_2 transport infrastructure. This is not just about efficiency; it is industrial policy.

Streamlined rules, harmonized permitting, liability, and access rules for cross-border CO_2 flows would give companies the confidence to commit billions in infrastructure investment. A centralised knowledge-sharing platform between national authorities, stewarded by the European Commission, could be a gamechanger. The Commission should apply its convening power urgently, introducing single contact points, clear time limits, mutual recognition, standardised documentation, and model contracts. All CO_2 transport modes must be recognised within an interoperable pan-European network linking clusters and storage hubs. Practical digital tools - shared permitting trackers and common data rooms - would bring transparency and speed. Predictability and proportionality must be the guiding principles.

De-Risking Early Investments Along the Value Chain

Development of standards and common rules take time. Time that creates investment uncertainty – and halts the much needed FIDs not only for CO_2 transport infrastructure that needs to be built, but also for emitters that need to install the capturing plants.

To ensure that the required CO_2 transport infrastructure is ready when needed – and can support first-mover projects, we need to introduce de-risking mechanisms. These could include blended finance and risk-sharing mechanisms and additional measures like time limited-contractual backstops (offtake guarantees or availability payments), regulated tariffs, a regulatory asset base model can address revenue risk. Or, even the development of dedicated first-loss guarantee program for CCUS value chain.

Most importantly, there is no CO_2 to transport, without emitters taking FID. Their main hurdles are the underlying risks across the value chain for such first-of-a-a kind ventures: Today, any disruption along the value chain until the permanent storage, e.g. delay in development of infrastructure across the value, could require the venting of the captured CO_2. Despite having invested in carbon reduction technologies or carbon infrastructure, the emitters would still be held liable under the EU Emissions Trading Scheme (ETS) for these unintended emissions ("double penalty" risk). Therefore, also de-risking mechanisms for early-movers on the emitters-side are needed, such as a funds to cover unexpected ETS exposure.

Why This Matters Now

With NZIA storage capacity targets now in place, Europe has momentum. But without a coherent, EU-led effort to align permitting rules, technical standards and cross-border procedures, the deployment of a true low-carbon economy will stall. Our message is clear: regulation must align everything, but remain simple enough for Member States with different levels of capacity and experience to act quickly.

Simplifying and standardising cross-border CO_2 transport will accelerate industrial decarbonisation, strengthen Europe's industrial base, protect jobs, and secure our climate commitments. The Commission must step in to enable Member States to cooperate more easily, de-risking investments, ensuring predictability, and avoiding unnecessary complexity.

The choice ahead is stark: act now to build the connected CO_2 transport infrastructure Europe's value chain depends on - or risk watching the opportunity pass us by.

CO_2 management is part of the **economic** and **climate** equation for the **Industry** in **Europe**

EMILIE **MOUREN-RENOUARD**

Executive Committee member in charge of Europe, Africa, Middle-East, India – Air Liquide

As a world leader in gases, technologies, and services for industry and healthcare, Air Liquide develops and operates CO_2 capture technologies to help decarbonise the processes of its clients, as well as its own hydrogen production. Air Liquide is committed to absolute CO_2 emission reduction of 33% by 2035 (compared to 2020) on its path to carbon neutrality by 2050. Through our technology portfolio and expertise we moreover have the opportunity to contribute to decarbonisation of a variety of industries. Indeed, Air Liquide is a trusted partner in several CC(U)S projects to decarbonise heavy industry plants, with the support of the EU Commission.

As the European Union moves toward its ambitious climate targets, Carbon Capture and Storage (CCS) has become an industrial need. For cement and lime where process emissions are unavoidable, but also for other hard-to-abate industries such as chemicals, steel or existing hydrogen production, CCS represents the most viable pathway to deep decarbonisation. For Europe to keep its critical industries on its ground, the EU needs to address decarbonisation in a pragmatic way. CCS has proven to be one of the technologies that can support these objectives in a number of different ways and sectors.

Air Liquide is already at the forefront of this transition, deploying mature, scalable technologies across the continent for over a decade. However, for these technologies to fulfill their potential, the European CO_2 market must overcome critical hurdles in access to storage, financing and regulatory certainty.

Access to CO_2 storage sites based on balanced terms and conditions

The European CO_2 storage market is currently in its infancy, characterized by a concentration of storage sites in the North Sea and a limited number of operators. At the same time, it must be noted that affordable, open, transparent and timely access to CO_2 sinks, based on balanced terms and conditions, is key for the development of the market.

Opening new storage sites will play a critical role in the development of a functioning CO_2 market, especially since CO_2 sources are dispersed and storage locations seem rather concentrated in a single region. Against this background, the development of onshore capacity will be key, also since it has a clear competitive advantage compared to offshore sites, mainly because onshore storage offers the possibility to store CO_2 closer to emission sources.

Another viable option would be to fully take advantage of CO_2 emissions captured and transported for storage in a facility in a non-EU/non-EEA country such as the United Kingdom. Therefore, in order to facilitate and speed up the access to CO_2 sinks, it is essential that an EU wide agreement with the UK ensures mutual recognition of storage of CO_2 under the ETS.

A fit regulatory framework to allow the creation of CCS market

While regulatory certainty regarding open access is essential for high-investment, cross-border CO_2 pipelines that serve large numbers of emitters, it is equally vital to avoid regulating local infrastructure and industrial hubs where market-based competition is already thriving. In these concentrated hubs, CO_2 transport is short-distance and driven by diverse technologies, meaning heavy regulation would only stifle the specialized technical expertise that operators need to remain agile and competitive.

At the same time, it needs to be recognized that pipeline transport is only one part of the solution. To reach storage sites, the EU must provide full regulatory recognition for non-pipeline transport, including ships, barges, trucks, and rail. Independent shipping solutions are particularly vital to ensure that the transport and storage businesses remain unbundled, fostering a competitive market.

Another key piece of the puzzle will be to ensure that the currently 'early mover CCS

Air Liquide has been successfully capturing CO_2 from its Port-Jerôme (Normandie) Hydrogen plant for over 10 years.

projects' reach Final Investment Decisions (FIDs) without delay. Based on the current carbon price, the ETS incentive, even if topped up with Innovation Fund and CEF support, is not enough to launch a well-functioning CCS Market. Other tools, such as CCfDs will be needed. Also, the EU must address the "double-penalty risk" that these industrial frontrunners are facing. Any disruption in the nascent CO_2 transport or storage chain could force emitters to vent captured CO_2, leaving them to bear both the sunk cost of their capture technology and the sudden ETS compliance costs. Implementing a de-risking mechanism, such as a dedicated fund to cover unexpected ETS exposure, is essential to protect early movers from these vulnerabilities and provide the security needed to decarbonise.

It is moreover important the CO_2 specifications/standards for CO_2 transport & storage are developed. While adhering to the safety and operational considerations, the CO_2 specification should be technically feasible without imposing an unreasonable (financial) burden and take into account the specific possibilities of the respective steps in the CCS chain.The transport and storage site's specification must reflect a well-balanced effort across the entire value-chain.

Incentivise Low-carbon value chains in Europe

Decarbonising industry and transport will require a portfolio of technological solutions that can be implemented as effectively as possible, given the economic (capital intensity of projects that companies cannot afford on their own) and climatic context. Such solutions should of course be based on strict carbon intensity criteria. Rather than favouring certain technological solutions, the EU should leverage the diversity of available and mature solutions. All mature technologies that effectively decarbonise industry should thus be equally supported and incentivized.

This is particularly important with the expected publication of the Industrial Accelerator Act (IAA) in mind. Supporting lead markets is key to sustainable growth. Capitalizing on low-carbon products solutions will be crucial. For example, given the climate ambition of the EU and the pace of development of renewable energies, low-carbon hydrogen must be developed simultaneously with renewable hydrogen. Such low-carbon hydrogen can be produced either from Natural Gas reforming with Carbon Capture and Storage or via electrolysis using low-carbon electricity, e.g. nuclear based. Without low carbon hydrogen, it will be close to impossible to reach 2030 decarbonisation targets due to scarcity of renewables and cost of RFNBO.

Moreover, to further mitigate the risks of decarbonisation projects especially during the early stages of market development, the EU must aim to provide regulatory certainty for investment decisions but also enhance the flexibility of combining different state aid and funding schemes for the uptake of emerging markets (e.g. CCS).

Air Liquide is one of four industrial launching customers for the Porthos project, designed for CO_2 reduction in Rotterdam, the largest industrial port in Europe .Construction of the project started in early 2024 for completion in 2026.

Therefore, the decarbonisation of Europe would benefit from availability of both renewable and low-carbon hydrogen, and thus from dedicated targets and (financial) support mechanisms for the uptake of low-carbon hydrogen and low-carbon end products. We urge the European Commission to fully implement and recognize these needs in the upcoming publication of IAA.

Mind existing merchant CO_2 applications

Apart from capturing CO_2 waste for the purpose of sequestration, CO_2 is also used in the industrial gas market for numerous applications. Merchant CO_2 is used in agri-food and pharmaceutical industry applications (food, vaccines, carbonated drinks, slaughterhouses etc.), as well as in other industrial uses (fire extinguishers, semiconductors, water treatment, etc). The volumes of CO_2 used as industrial gas represent merely 0.1% of total emissions in Europe.

Currently, the EU ETS guarantees the "zero-rated" accounting status for emissions that are captured and sequestered through CCS technologies. However, in the case of CO_2 usage, such benefits are limited to CO_2 that is permanently chemically bound in a product and does not re-enter the atmosphere while used. Nevertheless, it will be important to also include in ETS additional CO_2 usage applications that can qualify for "zero-rated" emissions, particularly in cases of essential existing applications of CO_2, such as in medical or food & bev sectors. To this aim, alternative frameworks should be explored within the ETS that assess a CCU application's eligibility for "zero-rated" emissions status based on the criticality of its end-use and the effective duration of the carbon storage. Shortage of this merchant CO_2 has happened in the recent past with severe impacts on relevant value chains. As this specific CO_2 is genuinely a byproduct of the fertilizer industry, also dedicated support to the EU's domestic ammonia/fertiliser industry is needed to mitigate potential CO_2 shortages.

In addition, CCU applications can demonstrate clear climate benefits. The ability to re-use CO_2 captured from an industrial process as feedstock for the production of chemicals, fuels or materials can lead to the avoidance of additional emissions. Effectively, this recycled CO_2 substitutes for virgin fossil carbon that would otherwise be emitted. Therefore, if climate benefits are proven, it should be ensured that such CCU applications are accordingly recognized.

MARIA **FRANCESCA NOCITI**

Eni Head of CCS Services and Stakeholder Engagement

Developing Large-Scale Carbon Management in Europe: Eni's Vision for Integrated Capture, Transport and Offshore Storage Solutions

Building Europe's Carbon Management Backbone for a Competitive NetZero Economy

Developing large-scale carbon management is no longer an option but a necessity for Europe to achieve climate neutrality while safeguarding industrial competitiveness. Geopolitical shifts, environmental challenges and technological revolutions are reshaping global growth, energy security and industrial dynamics. In this complex and uncertain context, it is important not to simply adapt but to steer: anticipating trends, assessing risks, and seizing opportunities through innovation is essential. This proactive approach defines Eni's vision for the energy transition.

With more than 31,000 people across 64 countries, Eni is an integrated energy tech company committed to reaching net zero by 2050. This transformation relies on a diversified portfolio of solutions adopting a technologically neutral approach that balances technical, economic, and social considerations, combining growth and sustainability to accelerate the transition. This portfolio includes renewables from solar and wind, biofuels, biochemistry, Carbon Capture and Storage (CCS), and research into new paradigms such as magnetic confinement fusion.

Among the above-mentioned solutions, CCS stands out as a key lever for decarbonization, leading international organizations such as the IEA, IPCC and IRENA consider CCS essential for achieving global climate targets, estimating that by 2050 storage capacity must reach 6–7 billion tons of CO_2 per year, a hundredfold increase from today.

In particular CCS offers a safe, proven, mature and scalable solution for hard-to-abate sectors such as cement, chemicals, steel, glass, and fertilizers, where no alternative solutions are equally effective in terms of avoided emissions and efficient in cost and timing. These sectors are vital to Europe's economy: without viable decarbonization options, they risk losing competitiveness or relocating, a phenomenon known as "carbon leakage", undermining European employment levels and industrial strength without delivering real climate benefits.

Eni's Integrated CCS Strategy: Scaling Proven Technology by Leveraging Experience, Infrastructure and Partnerships

For Eni, CCS is both a lever to reduce its own emissions and an opportunity to create value through a new transition-linked business. By leveraging Eni's expertise and CCS distinctive model based on the conversion of its offshore depleted gas fields and the possibility of reusing existing infrastructure, the company is developing cost-effective large-scale CCS hubs with an accelerated time to market. This approach allowed Eni to achieve a leadership position in developing CCS projects in Europe.

In the development of its activities, including those related to the energy transition, Eni applies a "satellite model," creating entities focused on low-carbon products and solutions that can grow autonomously thanks to their capability to attract investments. This is the case for fast growing companies such as Plenitude and Enilive. CCS is being developed as part of this model.

Within this framework Eni has also established "Eni CCUS Holding," which consolidates global CCS assets, including UK projects (HyNet and Bacton), the EU Connecting Europe Facility grant awardee L10 project in the Netherlands, and future rights for Ravenna CCS in Italy.

Last December, Eni announced the closing of a 49.99% co-control stake sale in Eni CCUS Holding to Global Infrastructure Partners (GIP), a leading global infrastructure investor now part of BlackRock. This partnership signals growing interest from financial investors in CCS as a scalable business opportunity, confirming that CCS is not only a technological solution for decarbonization but also an emerging sector capable of attracting long-term capital.

Connecting Emitters to Offshore Storage: A Pan-European Network from the North Sea to the Mediterranean

In the United Kingdom, Liverpool Bay CCS, located in the Northwest of England and North Wales (referred to as the HyNet North West encompassing the emitters cluster), was selected by the government in 2021 as one of two CCS priority hubs for industrial decarbonization. The project aims to cut emissions in one of the country's most active industrial regions by transporting CO_2 captured from local emitters and storing it in Eni's depleted gas fields approximately 30 kilometers offshore. HyNet involves cement plants, waste-to-energy facilities and a future hydrogen production site, with additional partners expected to join. Eni will manage the CO_2 transport and storage network, starting with an initial capacity of 4.5 million tons per year and scalable to 10 million tons after 2030. The project is expected to be operational in 2028, as per the emitter's schedule. It reached financial close with UK authorities in April 2025 with the award of an economic licence by the UK Gov to Eni, initiating the construction phase. In September 2025, two industrial partners secured financing for the first capture installations, with a combined capacity of 1.4 million tons per year.

In the UK, Eni also operates the Bacton CCS project, aiming at creating an integrated CCS hub to support the industrial decarbonization of the East of England and the Thames Estuary area near London. The storage site will be the Hewett depleted gas field in the southern North Sea, with an estimated capacity exceeding 300 million tons of CO_2. Together, HyNet and Bacton form a cornerstone of the UK's strategy for industrial decarbonization.

Across Europe, CCS has moved to the forefront of policy. The EU's Industrial Carbon

Management Strategy launched in 2024 envisions a continent-wide system for capturing, transporting and storing CO_2, with a storage capacity target of at least 50 million tons per year by 2030. This framework is reinforced by the EU Emissions Trading System, which imposes a rising cost on CO_2 emissions, and by dedicated funding streams that support the development of decarbonization technologies and networks.

Eni contributes to European target with two projects: L10 in the Netherlands and Ravenna CCS in Italy.

The L10 project in the Netherlands will convert depleted gas fields in the Dutch North Sea into permanent CO_2 storage sites, and it is part of an emerging European infrastructure connecting industrial emitters to offshore storage hubs.

Ravenna CCS: Southern Europe's Anchor Hub for Industrial Decarbonization and LongTerm Competitiveness

Italy is moving decisively in the same direction. The Italian National Energy and Climate Plan (NECP) sets a target of 4 million tons of captured and stored annually by 2030. A recent study published in August 2025 by Italian Ministry of Environment and Energy Security (MASE) shows that for hard-to-abate sectors, where renewable energy has very limited applicability, CCS emerges as the most economically competitive option right after energy efficiency, which remains the most cost-effective solution. In these sectors where the remaining potential for increased energy efficiency appears slim since high average levels have been already achieved, a different solution is required. Importantly, the MASE analysis includes infrastructure costs for capture plants, transport and storage, while equivalent system costs for other technologies, such as grid upgrades, H2 and battery storage, are not fully accounted for, potentially underestimating the relevant investments required. This fact-based comparative analysis demonstrates the fundamental role CCS can play in safeguarding industrial competitiveness and accelerating decarbonization of hard to abate sectors where other solutions have limited effect or are more expensive.

Within this national and European context, the strategic importance of Ravenna CCS, developed as a 50/50 joint venture by Eni (operator) and Snam, extends well beyond Italy's borders. It is not merely an Italian initiative; it is a key infrastructure for securing European industrial competitiveness and advancing climate objectives. Ravenna CCS provides a concrete, scalable and secure solution to reduce industrial emissions across Mediterranean, supporting the energy transition while maximizing the value of existing EU investments and fostering the creation of an integrated, resilient CCS supply chain in Southern Europe.

Furthermore, Ravenna CCS has the advantage of exploiting depleted fields and at very competitive cost leveraging on the infrastructure (pipes, wells, platforms) already in place, resulting in a total unit technical cost of less than €80 per ton. This mechanism applies to Eni projects in general.

The project follows a phased approach with progressive capacity growth. Phase 1, started in August 2024, achieved outstanding results by capturing CO_2 from Eni's gas treatment plant and storing it in the depleted Porto Corsini Mare Ovest reservoir, with an injection capacity of up to 25,000 tons per year and a capture efficiency of over 90% in the most severe industrial conditions in terms of CO_2 concentration, equal to approximately 2.4% at atmospheric pressure. In terms of energy efficiency, the power supply is guaranteed by the recovery of self-produced thermal energy and by electrical energy from renewable sources. Resultantly the volume of CO_2 captured effectively corresponds to net quantity reduced.

Phase 2, under development, aims at scaling to 4 million tons per year by 2030 while further expansions after 2030 could reach approximately 16 million tons annually, leveraging the vast storage potential of Eni-operated depleted gas fields in the Adriatic offshore, estimated at over 500 million tons.

This storage potential represents about 70% of all announced capacity in Southern Europe and the Mediterranean, positioning Ravenna CCS as the reference hub for geological CO_2 storage in the region. Notably, Phase 2 alone will contribute roughly 8% of the EU's 50 million tons per year storage capacity target by 2030, foreseen by the Industrial Carbon Management framework and set by the Net Zero Industry Act, underlining Ravenna's central role in Europe's decarbonization strategy. Equally important is the project's flexibility: through multimodal access options, offshore transport by ship and onshore transport via pipeline, rail or truck, Ravenna CCS can serve Italian and European emitters, creating an open access decarbonization infrastructure for the entire Southern European region. This design enables multiple sectors and geographies to connect efficiently, reduces dependency on single transport modes, and supports phased investments that align with policy signals and evolving demand. Market interest is strong, with more than 30 preliminary agreements signed with national and international emitters, representing over 30 million tons per year, including 6 million tons per year already supported by European funding.

In addition to the environmental benefits Ravenna CCS will also provide for tangible economic and social benefits. By providing industries with viable decarbonization options, CCS contributes to preserve competitiveness, protecting jobs and create new opportunities in a high-tech sector aligned with Europe's climate ambitions (about17,000 long term jobs according to a 2023 study from The European House Ambrosetti). In a context driven increasingly by ETS dynamics and carbon cost visibility, enabling access to a credible, scalable storage capacity can prevent carbon leakage and reinforce Europe's industrial base, complementing parallel investments in efficiency, electrification, renewables and other solutions.

By combining innovation, partnerships and a long-term vision, Ravenna CCS stands out as a cornerstone of European climate policy implementation, as it establishes a strategic hub in Southern Europe where technical capabilities enable substantial progress towards climate targets in synergy with industrial resilience.

PAOLO TESTINI
Director CCS, Snam

The **Mediterranean decarbonization hub**: **Ravenna CCS** as a strategic infrastructure to preserve **European industrial competitiveness**

The European Union's journey toward Net Zero by 2050 is no longer a matter of mere environmental ambition; it has become an existential challenge for industrial sovereignty. As the "Industrial Carbon Management" strategy and the "Clean Industrial Deal" by the European Commission suggest, reaching our climate goals while maintaining a competitive manufacturing base requires a pragmatic, multi-technology approach. In this landscape, Carbon Capture and Storage (CCS) is a fundamental decarbonization lever. For Snam, and for Italy, the Ravenna CCS Project represents the cornerstone of this new European energy geography.

Enabling CCS: a necessity for hard-to-abate sectors and beyond

A common misconception in the current climate debate is that electrification and renewable energy alone can decarbonise the entire economy. This view fails to recognise that the effectiveness of these levers ends at the doorstep of hard-to-abate industries, where fundamental process constraints apply.

At times when the strategic autonomy of the EU and the promotion of clean and domestic value chains for "made in EU products" are at the top of the political agenda, it is crucial to understand the fundamental process constraints that apply to CO_2 emissions reduction in sectors such as cement, steel, and chemicals, which form the backbone of the European economy and support millions of jobs.

CO_2 emissions in these sectors fall into two main categories: combustion emissions from burning fuels to reach the extreme process temperatures, and process emissions inherent to the underlying chemistry (for example, limestone calcination in cement, responsible for about 60–70% of the sector's emissions). While cutting combustion emissions in hard-to-abate sectors remains technically and economically constrained at scale, process emissions are fundamentally unavoidable and therefore structurally embedded in these industries.

Beyond hard-to-abate sectors, CCS can enhance the role of Waste-to-Energy by enabling carbon-neutral or carbon-negative waste treatment, while delivering electricity and heat to local communities. CCS also supports decarbonised, flexible, and dispatchable power generation, which is essential to enable higher penetration of renewables without compromising grid stability.

Over the longer term, the development of capture technologies and the availability of transport and storage infrastructure will unlock large-scale carbon removals through BECCS and DACCS, required to rebalance atmospheric CO_2 levels, while the capacity of natural ecosystems to absorb CO_2 is progressively decreasing due to climate change. In parallel, a growing CO_2 utilisation market can leverage existing infrastructure and complement the CCS value chain.

From Ravenna CCS to CALLISTO: a strategic infrastructure for Europe and the Mediterranean

Ravenna CCS Project, developed in joint venture by Eni and Snam, provides over 70% of planned CO_2 storage capacity in Southern Europe. The project, which successfully completed the first operational phase that began in 2024, is on track to reach a storage capacity of 4 million tonnes per year (Mtpa) by 2030, in line with the Net Zero Industry Act's 2030 target of 50 Mtpa. Looking further ahead, the project will expand to store 16 million tonnes per year by 2040, serving a wider array of industrial districts. Cumulative potential storage capacity exceeds 500 million tonnes.

Ravenna CCS is characterized by a precise and modular roadmap, which ensures that the infrastructure remains optimized for the actual demand, to avoid the risk of underutilization. Its operational success serves as the foundation for a much broader infrastructure strategy. Snam is currently spearheading the development of a dedicated CO_2 transport network in Northern Italy, designed to connect major industrial clusters to the offshore storage sites. The first phase of the pipeline development, which has already been submitted for Environmental Impact Assessment (EIA), includes a combination of repurposing existing assets (about 20 km pipeline formerly used for natural gas) and laying new infrastructure (about 80 km). To meet the anticipated demand of 4 Mtpa by 2030, the network under study is expected to extend to a total of approximately 350 km.

Ravenna CCS is embedded in the more ambitious CALLISTO (CArbon LIquefaction transportation and STOrage) Mediterranean CO_2 Network. Confirmed in the Project of Common Interest (PCI) list under the TEN-E Regulation in November 2025, CALLISTO aims to establish the first integrated industrial CCUS value chain in the Mediterranean. The project foresees CO_2 collection hubs in Italy (the Po Valley, Priolo-Augusta, and Taranto) and France (Fos-Marseille). Its multimodal infrastructure (pipelines and shipping) can also serve industrial clusters across Southern Europe, including Greece, the Balkans, Spain, and Austria, which lack sufficient domestic CO_2 storage capacity relative to their needs.

This cross-border connectivity, enabled by the infrastructural facilities developed also for the Ravenna CCS project, and facilitated by Snam's and Eni's expertise in managing complex, integrated energy systems, aligns perfectly with the EU's vision for shared European assets for climate resilience and interconnected CO_2 transport network.

Market validation: demand outstripping supply

One of the most compelling arguments for the necessity of developing Ravenna CCS is the resounding signal from the market. In 2024, Eni and Snam conducted an extensive market survey to assess the potential demand for CO_2 transport and storage services in Italy. The results were clear: the demand from industrial operators is six times the targeted 2030 CO_2 storage capacity and 2.5 times the long-term maximum capacity.

This is not a theoretical interest. Numerous industrial players, both in Italy and across Europe, have already secured funding through the EU Innovation Fund for their carbon capture projects. Crucially, many of these beneficiaries have explicitly identified Ravenna CCS as their reference storage site. Synchronization between industrial capture projects on one hand, and Snam and Eni's infrastructure development on the other, is vital.

Data show that the market views CCS not as a distant possibility, but as a near-term operational requirement. However, for this potential to be fully realized, the transition from pilot projects to a full-scale industrial value chain must be enabled by a robust and transparent regulatory framework. Much like the gas and electricity grids, CO_2 transport and storage infrastructures need a non-discriminatory "open access" for all emitters, the prevention of market distortions, and long-term predictability to de-risk their investments. A regulated model, overseen by independent authorities, has proven to be the most effective way to achieve these objectives and ensure that CCS infrastructures remain a neutral enabler of competitiveness for the entire European industrial fabric, rather than a fragmented set of private assets.

The economic rationality: cost of inaction and cross-technology comparison

Any decarbonization solution must be assessed against both its economics and the cost of "inaction". As EU ETS allowance prices rise, the financial burden on non-decarbonising industries risks becoming unsustainable. In this context, the Ravenna CCS project is an exercise in resource efficiency: by repurposing existing offshore platforms and parts of the pipeline network, it minimizes capital expenditure and environmental impact compared to greenfield projects. This is circularity applied to infrastructure. Moreover, the project acts as a catalyst for economic growth, with Phase II expected to generate over €22.7 billion in value across the CCUS value chain over the next six years in Southern Europe.

A detailed cost assessment focused on CCS in Italy was performed by the Italian Ministry for the Environment and Energy Security (August 2025)[1]. Elaborating these data, the subsidies required to kick-start the CCS value chain in Italy result in a significantly lower cost of abatement than alternatives, such as renewables and energy-efficiency, which have received the bulk of public funding to date.

Ensuring integrity: safety, monitoring, and the "focal operator" role

Infrastructure of this scale demands the highest standards of transparency and safety. Experienced developers such as Snam, with a proven track record in complex energy infrastructure, are responsible for ensuring the full integrity of CO_2 transport and storage and for communicating this clearly and consistently. This is essential to address the persistent gap in public acceptance of CCS, which continues to lag behind other decarbonisation technologies without objective justification.

The depleted gas fields in the Adriatic have contained natural gas for millions of years, demonstrating their geomechanical stability. Building on decades of geological expertise, advanced subsurface modelling, and real-time monitoring technologies, the project ensures permanent and secure CO_2 sequestration. Operated within a strict regulatory framework and in continuous dialogue with national and European authorities, CCS is deployed as a responsible, robust, and verifiable solution for emissions that cannot otherwise be abated.

Conclusion: Leadership through infrastructure

The European Clean Industrial Deal has shifted the debate from the "what" to the "how" of delivering EU decarbonization and competitiveness goals. In this implementation phase, infrastructure is decisive, and CCS development, like all large-scale infrastructure, requires a stable and predictable policy framework with 15–20 years of visibility.

The long-awaited EU regulatory framework for CO_2 transport is therefore essential for projects such as Ravenna CCS and CALLISTO. By clarifying long-term liability, permitting, and operational standards, it is expected to provide the certainty needed to unlock investment, support industrial decarbonization strategies, and enable cross-border CO_2 transport and storage.

Integrating CCS into Europe's strategic energy backbone goes beyond meeting climate targets: it underpins industrial competitiveness and technological leadership. Through initiatives like Ravenna CCS and the CALLISTO Mediterranean CO_2 Network, the Mediterranean can evolve from a transit corridor into a hub of a new, sustainable industrial system.

Europe's choice is straightforward: build tomorrow's infrastructure today, or risk losing the industries that shaped our past.

1 https://www.mase.gov.it/portale/documents/d/guest/mase_studio_ccus_2025-pdf

MARTIN FRINGS

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Plans for a German CO_2 pipeline network as a fundament to reach the climate targets in Europe

CO_2 Infrastructure: The Missing Link to Climate Neutrality

The European Union has set itself the goal of becoming climate neutral by 2050, with an interim target of reducing net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. Germany has enshrined similar targets in its Climate Protection Act, which aims for greenhouse gas neutrality by 2045 and a 65% reduction in emissions by 2030 compared to 1990 levels.

Among the most important technologies for achieving these ambitious goals are renewable electricity sources such as wind and solar, which are becoming increasingly competitive with fossil fuels. In addition, battery technologies and hydrogen as a climate-friendly energy carrier are of great importance. However, despite all efforts to reduce greenhouse gas emissions, there are certain industries where carbon dioxide (CO_2) emissions cannot be avoided, even when using the most advanced technologies and processes.

The best-known examples of this are the cement and lime industries and waste incineration, where fossil or geological CO_2 emissions are mainly caused by the underlying physical or chemical process and cannot be avoided. Consequently, these unavoidable emissions must be effectively captured, transported and either stored or utilised in order to achieve climate targets. Although various methods, including pre-combustion, post-combustion and oxy-fuel combustion techniques for CO_2 capture, are already state of the art, there are still no large-scale CO_2 transport systems in Europe. Pipelines are the most common and cost-effective option for transporting large quantities of CO_2 or other mediums over long distances. Studies such as those by the German Cement Association (VDZ) (VDZ, 2024) show that the development of a CO_2 infrastructure is essential for the cement, lime and waste incineration industries. According to their study, annual CO_2 emissions from these three sectors alone are estimated at around 58-65 million tonnes per annum (Mtpa) in Germany. The VDZ therefore emphasises that without a transport infrastructure, climate neutrality cannot be achieved by 2045 and a CO_2pipeline network is necessary by 2035 at the latest in order to meet climate targets.

In order to support the initiative for a climate-neutral economy and thus contribute to strengthening the competitiveness of German industry, Open Grid Europe GmbH (OGE) is planning a CO_2 pipeline infrastructure for Germany. As shown in Figure 1, OGE's CO_2 network is based on demand-oriented planning that connects emission-intensive regions and enables cross-border transport. However, the development of a CO_2 transport infrastructure also presents various challenges, ranging from technical and economic implementation to political support and public acceptance, which are explained in more detail in this article.

Who is OGE?

OGE is one of the leading gas transmission system operators (TSOs) in Europe and can look back on over 90 years of company history and expertise. Today, OGE operates a natural gas pipeline network of around 12,000 km in length, is part of the German H_2core network and commissioned its first hydrogen transport pipelines at the end of 2025.

As a company, OGE has always accompanied the transformation of energy supply and actively driven forward the associated changes, starting with the expansion and establishment of city gas networks, through the switch to natural gas, to the current step into the world of hydrogen. OGE is a reliable partner for business, politics and the public, as we were able to prove once again in 2022 when the WAL (Wilhelmshaven connection pipeline) was built in a record-setting nine months to connect the first German LNG terminal.

Another chapter in this story is now being written by enabling the future transport of CO_2. OGE is currently working with various

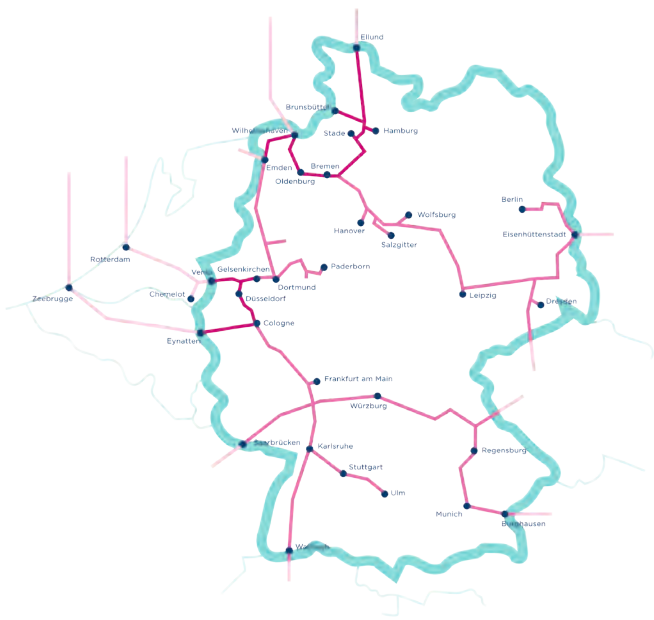


Figure1 : The CO_2infrastructure proposed by OGE for Germany (Open Grid Europe GmbH, 2025)

international partners and is working on the implementation of the first CO_2 infrastructures.

Key challenges in project implementation

OGE is currently working on various projects to establish the first CO_2 pipeline infrastructure in Germany. The emissions data base is our market survey which confirms, that North Rhine-Westphalia (NRW) alone is responsible for around 40% of hard-to-avoid emissions in Germany. Almost all projects are being carried out in a European context and within the framework of European cooperation. These projects are:

- **Cluster Elbe**: Together with Holcim Germany, OGE intends to construct and commission the first German CO_2 pipeline infrastructure to enable climate-neutral cement production at the Lägerdorf site, north of Hamburg.
- **Delta Rhine Corridor (DRC):** OGE is working with Gasunie and partners BASF and Shell to develop a large-scale pipeline solution from the key region of North Rhine-Westphalia to storage options in the Netherlands.
- **Belgian North Sea CO_2 Corridor:** Via Fluxys in Belgium, an evacuation route to Norwegian storage facilities is being developed using Equinor's CO_2 Highway Europe. Initially, the target on the German side is the key region of North Rhine-Westphalia.
- **WHV CO_2 Corridor (WHVCC):** The aim is to connect German and, in the future, European emitters with export projects such as the CO2T pipeline project from Gassco to Norway, the TES-H2 CO_2 export terminal and others on the German North Sea coast around Wilhelmshaven.
- **DK CO_2 Corridor (DKCC):** The aim is to establish a cross-border transport link to the Danish border to give German and European emitters access to Danish storage options (onshore and offshore).
- **German Carbon Transport Grid (GCTG):** OGE draft of a German CO_2 transport system in Europe, for Europe and part of the upcoming PMI list

As a company, we are therefore involved in many promising projects and in constant dialogue with European partners. Our aim is to initially think about the challenges from a European perspective, as Germany, with its geographical location and nine borders, can and should play a decisive role in solving European challenges. With regard to the time required for the implementation and deployment of CO_2 infrastructures, we believe that the following aspects have emerged as the greatest challenges for development in Europe and Germany:

- **Coordination**: The EU and, for in OGE's case, Germany should play a stronger role in coordination. We see many interested companies, but also many options and, all in all, a high degree of uncertainty. The markets will coordinate themselves, but not at the necessary speed.
- **Risk hedging**: The development of value chains requires massive investments, especially on the large scale that is necessary. A large project such as the Delta Rhine Corridor or the North Sea CO_2 Corridor requires investments in the mid double-digit billion-euro range and the coordination of investment decisions. Storage, transport and capture units must go into operation at almost the same time and rely on each other. This requires long-term contractual relationships in the CO_2 value chain, while emitters tend to maintain short-term agreements with their customers. In addition, there are default risks or risks relating to changes in the political framework. All in all, risk hedging is more important than subsidies from the perspective of an infrastructure operator.
- **Double burden**: A solution must be found for the potential double punishment of issuers, which represents a high risk for them. In practice, it may happen that an issuer has concluded all contracts and the entire chain is functioning. However, if part of the chain (pipeline, ship terminal or storage facility) fails due to a force majeure event, the issuer still has contractual obligations in the chain and must additionally purchase CO_2 certificates, thus creating a massive imbalance.
- **Bankability**: All these points ultimately contribute to one aspect. The CO_2 market must become bankable, and it can only do so if certain parameters are reliable. The markets that are already developing, e.g. Norway and the UK, have so far managed to do this, particularly because the governments here are ready to coordinate and provide security, which makes the market predictable. Due to the lack of an existing commodity and the fact that the framework has not been finalised, the uncertainties are very great and difficult to manage quickly.

We as OGE will tackle these challenges together with our partners, future users and political decision-makers. This will be crucial in the next phase in order to realise large-scale CO_2 transport infrastructures in good time. This is necessary in order to fully exploit their benefits for the timely achievement of climate targets.

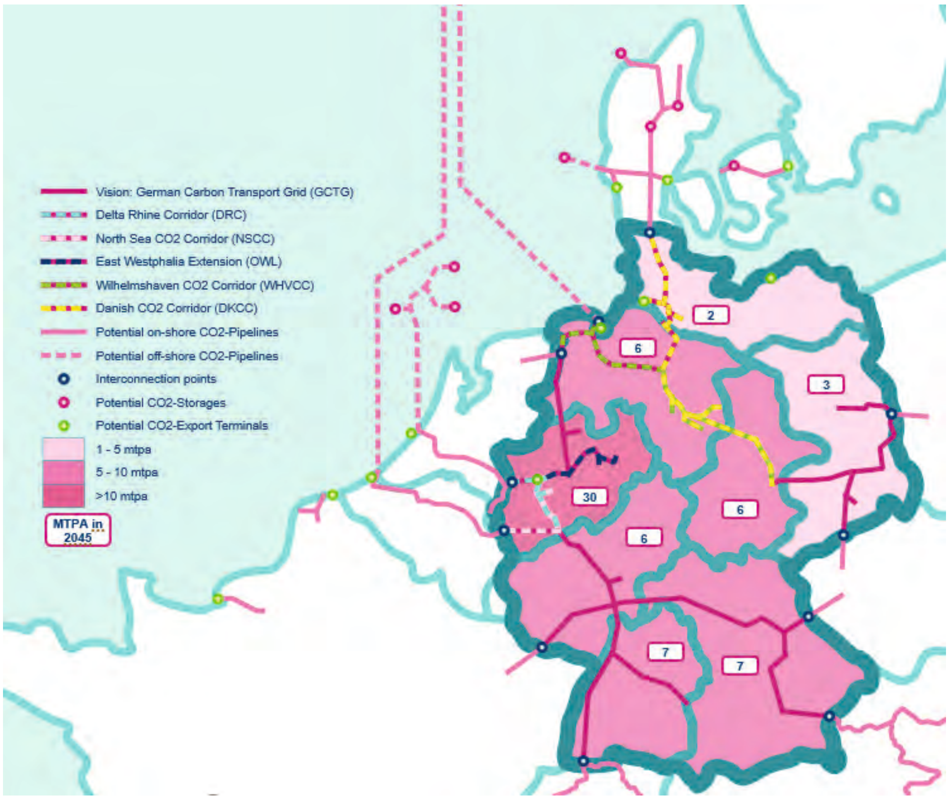


Figure 2: German Carbon Transport Grid (GCTG) with projects on potential tons, Open Grid Europe GmbH, 2025)

References

Open Grid Europe GmbH. (01. 07 2024). Retrieved from https://oge.net/de/co_2/co_2-netz

VDZ. (2024). *Requirements for a CO_2 infrastructure in Germany – prerequisites for climate neutrality in the cement, lime and waste incineration sectors.* Düsseldorf: VDZ.

TUDY BERNIER

Policy Director at CO_2 Value Europe

Capturing and **reusing carbon**: the key role of **CCU** in **building Europe's CO_2 single market**

The incoming new legislative package for CO_2 markets and infrastructure in Europe is good news: it means that the European Union is ready for planning and investing in carbon capture to deliver on climate targets. But it will be successful under one condition: the package must address not only geological storage of CO_2, but also carbon utilisation.

The European Union (EU) agreed in December 2025 on a clear trajectory for reducing greenhouse gas (GHG) emissions in the coming years: it is now bound by a net 90% GHG emission reduction target by 2040 compared to 1990 levels, with a contribution of up to 5% of "*high-quality international carbon credits*". In other words, the EU needs to accelerate its clean transition through a wide range of levers: deployment of renewable and low carbon energy, electrification, energy efficiency, decarbonisation, defossilisation, and carbon removals. Industrial carbon management – a concept that brings together carbon capture and storage (CCS), carbon capture and utilisation (CCU), carbon removals (CDR) and CO_2 transport – is a key pillar for reaching those climate objectives. And that's where the new EU CO_2 markets and infrastructure package comes in.

Without CCU, no net zero target is reachable

In 2024, the European Commission released its Industrial Carbon Management (ICM) Strategy, which described ICM technologies as "*a sound and important building block for a sustainable and competitive economy in Europe*". This EU strategy spells out that not every economic activity can be electrified – for example, sectors like cement, lime, steel, aviation or shipping, which together account for more than 15% of total GHG emissions in Europe and are the hardest to reduce. In those sectors, the strategy shows that carbon management pathways (CCS, CCU, CDR) are a must: to manage CO_2, one needs to capture it; once captured, it can then be transported to be geologically stored or be utilised and turned into products in the form of synthetic fuels, e-chemicals or stored in mineralisation products. Transporting CO_2 is a major part of those value chains, as it enables to bring CO_2 towards geological sites or utilisation sites – when the latter are not located where the CO_2 is generated.

As CO_2 Value Europe, we represent the utilisation part of carbon management: by using captured carbon as feedstock to manufacture products, CCU technologies help defossilising the economy, build industrial sovereignty by deploying novel processes, and reduce dependency on imported fossil fuels.

Defossilisation is essential where industrial processes and products cannot be replaced by carbon-free alternatives – whether it is by manufacturing drop-in synthetic fuels for planes or ships that cannot be electrified, or by providing alternative non-fossil carbon feedstocks for chemicals that are carbon-based by nature, meaning critical molecules essential to making pharmaceuticals, solvents and other building blocks needed for producing everyday goods. The ICM Strategy assesses that CCU will play a key part in decreasing emissions in Europe: it quantifies that in 2040 "*[up] to a third of the captured CO_2 could be used*" – hence, about 93 out of 280 Mt CO_2 –, and roughly 45% in 2050 (about 200 out of 450 Mt CO_2). At least 26 CCU projects are expected to be operational in the EU27 and Norway by 2030 for an overall capacity of around 2 300 000 tonnes of CCU products per year.

CCU can substitute fossil-based products with fossil-free equivalents and build a circular carbon economy, where the waste from one sector can become feedstock for another. And in a world where we continue to use carbon-based products, CCU is an absolute must to reduce our dependency on fossil resources to manufacture those products while reducing our GHG emissions.

In other words, reaching net zero emissions by 2050 requires deploying CCU at scale, along many other levers.

CO_2 infrastructure deployment must consider both storage and utilisation

So far, the bulk of EU discussions on CO_2 transport infrastructures have focused on storage. Of course, transport infrastructures are consubstantial to any CCS project, so it is understandable that it takes a certain focus. Some CCU projects can also be developed without transport, if the carbon is utilised where it has been produced.

But it would be short-sighted to consider CO_2 transport will only matter for CCS, or that CCS and CCU projects could not develop in synergy. As a matter of fact, several projects have both CCS and CCU outputs. More generally, CCS and CCU are like wind and solar power: they are both needed, they have their respective constraints and advantages for their deployment, and they can complement each other. And more importantly, CO_2 transport can help both technologies thrive.

This is confirmed by the EU ICM Strategy, which says that "*CO_2 transport infrastructure is the key enabler common to all [carbon management] pathways. Where the captured CO_2 is not used directly on-site, it will need to be transported and either used in industrial processes (e.g. for construction products, synthetic fuels, plastics or other chemicals) or permanently stored in geological formations*".

Unfortunately, in current consultation and discussions, such inclusivity of all carbon management pathways is not always followed. We call on EU authorities to correct course and ensure that CCU, CCS and CDR are adequately and proportionately addressed in the future CO_2 markets and infrastructure package.

CCU projects will not only complement storage projects, but they can also help diversify destinations of CO_2 and bring additional revenues to deploy those infra-structures. It is equally important to consider that projects can target both CCS and CCU destinations: for example, a waste-to-energy plant could direct its fossil-derived CO_2 to CCS, while sending its biogenic CO_2 to CCU.

Additionally, it is essential that CCU projects have stable access to carbon feedstock. Such important quantities cannot be provided solely by neighbouring sources. This is why it is essential that the design of the Union's CO_2 transport infrastructures fairly considers the needs of both CCU and CCS.

CCU technologies are going to be central to the creation of a European CO_2 single market: ensuring that wherever needed, CO_2 is captured, transported, and stored or utilised. And CCU, as a modular and flexible techno-logical solution, is bound to contribute to creating a consistent and coherent CO_2 single market, where CO_2 is considered a commodity connected to the market of the downstream CCU products.

It is crucial that this infrastructure is built for CCU as well as CCS and that both are properly included in the development of the networks. This should be reflected in network planning, permitting, and other additional legislative obligations. And this is why we call for the creation of an open-access intermodal transport infrastructure where CO_2 can enter and exit the network as needed along the way, and is accessible to small and medium emitters and off-takers, as well as larger ones.

Creating a fossil-free Europe

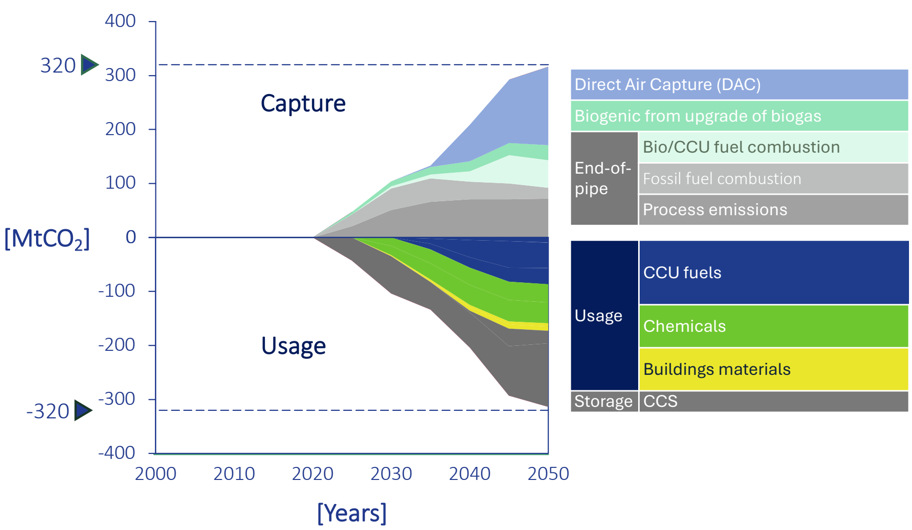
CCU is about making fossil-free products and fossil-free markets: e-methanol to run ships, e-kerosene to fly planes, e-methane to make industries function, e-chemicals to produce textiles, polymers and pharmaceu-ticals, or construction products to store CO_2 permanently. Those novel products can be manufactured today, the technologies are ready, those markets can be deployed. CCU products bring value because they are high-quality and fossil-free. And they are com-modities that can be sold and exchanged, and revenues from those markets can contribute to the deployment of transport infrastructures.

What makes CCU a game-changer is that it's about redefining business models and transforming EU industries. It's about reusing captured carbon to replace fossil resources and move away from our current reliance on imported fossil feedstocks to meet our products' needs. It's about building a fossil-free Europe. Yes, it comes with a cost, it comes with bold policy choices in an uncertain world, and a rupture with a modern economy built on coal, oil and gas. In a world struggling with climate change, and on a continent with little fossil resources, defossilisation is both the rational and strategic way forward.

It requires incentives, it requires access to infrastructures, and it requires a long-term vision of considering fossil fuels a relic of the past. Delivering on this vision means capturing CO_2, transporting CO_2, and utilising CO_2.

A new EU CO_2 market and infrastructure package must be the next step towards defossilisation. But it will only be able to deliver if it embraces CCU technologies. www.co2value.eu

Carbon Capture, Usage and Storage applications based on the CO_2 Value Europe expert vision scenario 2050



Source: *The contribution of carbon capture and utilisation towards climate neutrality in Europe*, CO_2 Value Europe, February 2024

E-fuels should become a national security priority

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Fall 2032. After months of crises, Russia launches a "special military operation to protect Russian minorities" in the Baltic countries. Limited parts of EU territory are seized. European land forces quickly put the Russian offensive to a halt. But this war is one that Russia intends to win by sieging the European Continent. Swarms of submarine drones start hitting oil and LNG tankers sailing towards western European ports. Oil and gas prices spike. European access to liquid fuels, which are mission - critical for EU navies and air forces, is no longer guaranteed in the medium term.

This scenario is an adaptation of a realistic scenario published last October by Le Grand Continent[1]. It begs the question: how can Europe win the battle for the Atlantic when it is starved of access to global fossil fuels?

In the Middle Ages, castles were often lost after long sieges. Food and water were the mission-critical assets of the day. For 21^{st} century Europe, oil and gas continue to represent around two thirds of the final energy mix, and that share is much bigger for the military. And because of its geological uniqueness, Europe imports 90% of its gas and 97% of its oil, almost entirely by sea[2].

Oil is a unique energy source. It is energy dense - a lot of energy in a small mass and volume - and an easily transportable liquid. Oil emerged as a strategic energy resource at the dawn of the twentieth century, when the British Navy chose oil over coal. As modern armies increasingly relied on aviation, tanks and trucks, oil became ever more mission-critical. Among the reasons why the Third Reich and Japan lost World War II is the scarcity of their oil supplies. The Third Reich always was constrained by its lack of access to oil. When the Allies started to successfully bomb the Romanian oil fields, Nazi Germany's days were numbered. The last Nazi offensive of the war was in January 1945, to retake the western-Hungarian oil fields.

When it comes to oil, Europe's position today is more analogous to 1942 Japan. It can access overseas oil. Japan lost that access when the US submarines systematically sank Japanese oil tankers in the Pacific. This contributed to the 1945 Japanese choice to resort to kamikaze attacks, as kamikaze pilots required less oil to be trained, since they do not need to learn how to land.

Today, although electric drones are ubiquitous, oil remains the central fuel of warfare. This is especially true for the NATO way of war, which relies on overwhelming air support. A single F-35 fighter burns approximately 6.000 liters per hour[3]. So, could European forces win the second battle of the Atlantic if they run out of oil? Probably not. And this is why, more than ever, European freedom depends on a serious e-fuels policy.

Just like biofuels, electrofuels (e-fuels) constitute a true alternative to fossil oil for European air forces. E-kerosene is a manmade molecule that essentially requires three main inputs: water, CO^2, and lots of electricity -mostly to transform water into hydrogen and oxygen (Aurora Research 2025). At molecular level, e-kerosene is just like fossil kerosene. It's a "plug and play solution", you can blend e-kerosene with fossil kerosene, or even make a jet fighter run only on e-kerosene.

Today and in the near future, our armies will continue to rely on liquid fuels. While batteries take an increasingly important role for drones, naval and land warfare, the situation will not change drastically for military aviation: the energy density of military-grade kerosene is 43 times higher than the most advanced batteries.

At this stage of the article, a key question should arise: as e-fuels are vital to ensure European military survival in case of a long confrontation with Russia, what is the EU doing about e-fuels? Short answer: too much, too little and too late.

Too much. E-fuels are like champagne: expensive, limited in quantity, precious, and to be kept for the most strategic uses. Using a trivial metaphor, yes, you *can* drink champagne while watching TV and eating chips, but it is neither the best systemic nor cost-efficient tool, as Belgian beer or Czech pils would probably deliver a better service at a lower cost. This is the same for the use of e-fuels in cars. Yes, you *can* invest hundreds of terawatt-hours of electricity and trillions of euros to manufacture e-fuels for cars, attempt to manufacture social acceptance to pay 6-10€/liter, but it is many times less optimal than direct electrification through battery electric cars. In that context, the current push to dismantle the EU CO^2 standards for cars regulation to make room for e-fuels is not only an economic, industrial and air-pollution nonsense, it is also a national security threat. For our own security, we need as many civilian vehicles as possible to switch from liquid fuels to electricity, to ensure our soldiers have the greatest possible access to liquid fuels both in times of trouble, and in time of war. So, when it comes to cars and e-fuels, the EU is doing too much. Let's not add more bureaucracy, let's not try to fix what is not broken. Let us keep the CO^2 standards for cars regulation as is and focus on what we still need to do to rise to the moment.

Too little. The EU crafted one central piece of legislation to provide certainty to e-fuel entrepreneurs: the Sustainable Aviation

1 S. Audrand, « Poutine et la guerre à l'Europe : le scénario du front atlantique », Le Grand Continent, 20 October 2025.

2 European Parliament resolution of 8 July 2025 on the security of energy supply in the EU (2025/2055(INI)).

3 Lockheed Martin F35 Lightning II website.

Fuels (SAF) mandate. Through this tool, the EU provides predictability to the industry by mandating that at least 2% of all aviation fuel in Europe is made of SAF, with that percentage increasing gradually to reach 70% in 2050. Given that SAFs are currently more expensive than untaxed fossil kerosene, the SAF mandate obviously increases the cost of aviation. A typical Brussels-New York flight costs around 500€, of which zero cent is spent on VAT, nor on kerosene taxes, nor on the non-CO^2 impact of aviation. Depending on the level of the SAF mandate and SAF costs, it would increase the plane ticket by a few tens or hundreds of euros. Would the Brussels-New York air travel disappears because of such increase? Obviously not. But some companies might provide less generous dividends and share buybacks programs to shareholders. So, borrowing from the diesel lobby textbook, rather than investing in industrial transformation to structurally transform civilian aviation, they invest in lobbying to structurally transform EU legislation into an empty shell, expecting active support from the pro-Putin far-right. Like many policies pushed by President von der Leyen in her first mandate, the SAF mandate risks being thrown under another omnibus during her second mandate. This would not only be a tragedy for humanity's future - as we still need a healthy environment to live - it would also be the death of what's left of Europe's regulatory stability, and a blow to our capacity to counter a Russian energy siege of the European continent.

Refueling of a next-generation A350-1000 widebody aircraft at the Singapore Airshow (2024)


Joint surveillance mission over the Black Sea by the French Air and Space Force with Belgium and the United Kingdom (2025)

Too late. So far, close to zero final investment decisions have been taken. And time is running out as it typically takes seven years to go from FID to operational production. This is also true in my home region of Normandy. The city of Le Havre is one of the best places in the world to produce e-fuels. It has historic refining capacities, competencies and skills. It benefits from massive access to decarbonised electricity, with already 12 GW of nuclear and 1,5 GW of wind power, with wind power potential rising to 10 GW by 2035. It also already sits on the kerosene pipelines that supply kerosene to the Parisian airports. All the planets are aligned to see the dawn of e-kerosene production, and yet, not a single final investment decision has been made yet…

So what to do?

First, do no harm. Let's not complexify EU legislation to push for e-fuels and biofuels in areas where we already know they have no strategic role to play.

Second, do good. Let's launch an industrial platform, a genuine European Commission-led e-fuels Alliance modelled after the EU Battery alliance, to build an industrial pathway for the massification of e-kerosene, looking at the entire value chain from electricity generation to decentralised small-scale e-kerosene refineries.

Third, act quickly. To borrow the words of Russian diplomats stated in a recent article, Russia considers "burning everything until the English Channel"[4]. We know they have the intention to destroy us, through military means in countries where political groups remain true patriots, and through political means in countries like France or Germany where pro-Kremlin parties Rassemblement National and AfD could realistically win the forthcoming elections. Time is of the essence, and if there is one organisation built to react quickly, it's the army. Commissioner Kubilius should therefore deepen his engagement with national ministries of defence, to push them to sign offtake agreements for e-kerosene with European companies, with our air force as first customers.

Conclusion:

We now need to make Europe in a world of bullies. The more uncertain our future becomes, the more we need to think creatively, build disruptive scenarios, and accept that we decide in uncertainty.

In this world of uncertainty, we can always refer to something that is certain: the laws of physics. Because of physical constraints, biofuels and e-fuels will both remain available in limited quantities. Burning them in civilian cars is not only wasteful from an energy-system perspective, it would nowadays also constitute a threat to national security.

Working with national air forces to support them in signing offtake agreement for domestic production of e-kerosene is one of the clear no-regret option that we must now take. The time is now, because the more time we waste, the more destructive Putin's energy siege of Europe might become.

4 G. Lancereau, « Tout brûler jusqu'à la Manche » : face à l'Occident, la diplomatie russe appelle au sang », *Le Grand Continent*, 1 December 2025.

Decarbonising Energy Intensive Industries: The Role of CCUS in Europe's Industrial Transition

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Europe's energy intensive industries are expected to deliver rapid emissions reductions at a time of unprecedented competitive pressure. Structurally high energy prices, rising carbon costs and increasing regulatory complexity are eroding Europe's industrial base, while imports from regions with lower climate constraints continue to grow. For hard to-abate sectors such as cement, this combination risks not only delaying the transition, but displacing production, and emissions, outside the European Union.

Cement illustrates this challenge clearly. As a fully local industry, with more than 200 plants across the EU supplying the construction value chain that underpins housing, infrastructure, energy systems, the digital economy and defence needs, cement is both essential to Europe's strategic autonomy and highly exposed to carbon leakage. Around two-thirds of the sector's emissions are process-related, arising from the chemical transformation of limestone, and therefore cannot be eliminated through energy switching alone. Ensuring that such industries can decarbonise while remaining viable in Europe is therefore a prerequisite for delivering the EU's climate objectives.

The European cement industry is investing and moving from ambition to deployment. However, for sectors generating unavoidable process emissions, carbon capture, utilisation and storage (CCUS) is required to complete the transition, provided it is embedded within a coherent industrial framework that aligns decarbonisation with competitiveness.

From ambition to deployment: integrating CCUS into an industrial transition

In 2020, the European cement industry published its first roadmap to climate neutrality. Five years on, supported by significant investments and technological progress, the sector has strengthened its ambition and is moving decisively into implementation. The updated Net Zero Roadmap (published in 2024) now foresees a 37% reduction in CO_2 emissions on cement by 2030, 78% by 2040, and net-zero emissions on cement by 2050, with the potential to become carbon-negative across the value chain.

These reductions are already being delivered through extensive deployment of energy efficiency, fossil fuel replacement through increased use of alternative fuels, clinker substitution, circularity, and the progressive role of concrete carbonation in the built environment. Together, these measures significantly reduce emissions well before capture technologies are applied.

However, after all available abatement options are deployed, a substantial share of emissions remains structural. According to the sector's Net Zero Roadmap, around 43% of cement emissions must be addressed through capture, use or permanent storage to achieve climate neutrality.

Why CCUS is unavoidable for hard-to-abate sectors

Cement is responsible for around 4% of EU emissions, yet the sector has already reduced its net emissions by 28.9% since 1990, despite the predominance of process-related emissions. This places cement among a group of industries where emissions are inherent to production processes.

For these sectors, CCUS is not an add-on solution; it is a structural requirement that complements other decarbonisation levers. More than 120 innovation projects are currently under way across the European cement value chain, including largescale CCUS projects.

From projects to systems: deployment now depends on an integrated framework

If CCUS is essential for reaching climate neutrality, the central question is now how quickly it can be deployed at scale. This challenge is at the heart of the Cement Europe Action Plan, which signals a strong sense of urgency and calls for a clear policy partnership to establish the regulatory, financing and infrastructure framework needed to match the sector's decarbonisation efforts. The main barriers are not technological, but systemic. Effective deployment depends on three interlinked conditions moving forward together: infrastructure, funding and regulatory certainty.

CO_2 transport and storage infrastructure remains underdeveloped and unevenly distributed across Europe, with slow permitting procedures hampering progression. At the same time, the scale of investment required for capture, transport and storage is unprecedented, and existing EU and national funding streams remain insufficient and poorly coordinated. Regulatory uncertainty, ranging from access conditions for CO_2 networks to long-term visibility under the EU ETS, further complicates investment decisions.

These constraints reinforce one another. Infrastructure will not be built without predictable demand; capture projects will not proceed without guaranteed access; and financing will not materialise without legal and economic certainty. The EU's Industrial Carbon Management Strategy and the Net Zero Industry Act provide an important foundation, but delivery now requires coordinated implementation, including accelerated permitting, scaled up storage capacity and clear rules for CO_2 networks.

Competitiveness as the condition for decarbonisation

Industrial decarbonisation will only accelerate if it is compatible with economic viability. Today, the cement industry faces structurally higher electricity prices than global competitors, rising carbon costs cumulatively estimated at €97–162 billion between 2023 and 2034, and mounting exposure to imports. Since 2016, cement and clinker imports have quadrupled, often with a higher carbon intensity than EU production, while exports have fallen sharply.

Addressing these pressures is central to the business case for CCUS and other net-zero technologies. A coherent competitiveness framework requires reinvestment of EU ETS revenues into industrial deployment, effective derisking instruments, long-term predictability under the ETS, particularly beyond 2030 and 2040, and a watertight Carbon Border Adjustment Mechanism (CBAM) aligned with ETS rules to ensure a level playing field for both imports and exports.

Legal clarity on CO_2 use

Alongside storage, CO_2 use is relevant for parts of the cement sector, particularly for installations located far from storage sites. CO_2 captured from unavoidable process emissions can provide a reliable input for industrial applications. However, regulatory uncertainty currently risks delaying CCU related investment decisions.

Providing clarity, through secondary ETS legislation, on which uses qualify as permanent, and ensuring that CO_2 accounting takes place at the point of release into the atmosphere rather than at the point of capture, are essential to preserve environmental integrity while enabling deployment.

Turning investment into impact

Europe's cement industry is ready to deliver the low carbon, circular materials required for housing, infrastructure and the green and digital transition. CCUS will play a decisive role in addressing the residual emissions that remain after deep abatement has been achieved. Whether Europe secures this opportunity will depend on its ability to align competitiveness, infrastructure rollout, funding and regulation within a coherent policy partnership. The investments are ready; what is needed now is delivery.

What role for **hydrogen** in **data centre management**?

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With the dramatic increase in the use of artificial intelligence (AI) tools only set to accelerate, an associated increase in data centre capacity will be necessary. The US, China, and EU – as the leading hosts of most the world's data centres - are all keenly aware of this fact and are positioning themselves accordingly.

This not only means building them, but figuring out how to power them. Traditional data centres require significant but predictable amounts of energy, but adding AI into the mix actually creates comparatively dramatic levels of variability in demand that further complicates the task at hand. Therefore, as data traffic continues to grow exponentially, so does the urgency of powering data centres – leading to extreme growth in total energy demand.

While the world reels from fast-moving geopolitical disruption, the threat of climate change has not gone away. The world must deal with this increase in energy consumption without falling back on its climate promises, less the gains we have made over the last two decades in renewable energy proliferation be for nothing. Moreover, those same geopolitical changes mean the security and resilience of both our energy system and our data are paramount.

Currently, data centres typically rely on utility grids for their primary electricity and diesel generators for backup power during outages. They already represent a substantial amount of total energy demand, as detailed in Hydrogen Europe's report on the topic. As of 2024, Europe had over 1,400 installed, representing demand of 96 TWh (3.1% of Europe's total power demand). By 2030, this could rise to 150-200TWh. Data centres in Europe are predominantly located in the FLAP-D markets (Frankfurt, London, Amsterdam, Paris, and Dublin), which are already suffering from grid congestion issues. In these regions the share of electricity going to DCs is disproportionately high: in 2023, data centres consumed 33% to 42% of all electricity in Amsterdam, London and Frankfurt – and almost 80% in Dublin.

Renewable and low-carbon hydrogen can offer a transformative solution for how data centres manage power, bolster resilience against outages – nefarious or not - and keep us on track towards carbon neutrality.

Unlike diesel, hydrogen fuel cells provide a zero-emission alternative for both backup and potentially primary power.

When we speak of resilience we mean the ability to maintain operations despite and during grid disruptions. This is naturally critical for data centres, where even seconds of downtime can cost millions and compromise critical services. Hydrogen fuel cells contribute to resilience in the short term by serving as backup generators, and are preferable to battery systems for their flexibility, long-term storage capacity, and lower set-up costs (for larger data centres, a battery capable of serving it would need to be equal or greater in size as the data centre itself).

In the longer term, as the supply of hydrogen grows, it can become a primary power option for data infrastructure – which means reducing the pressure of the grid it shares with regular businesses and private consumers. In fact hydrogen systems can be integrated into onsite microgrids, enabling facilities to operate independently of grid availability. This is particularly valuable in regions with unstable grids or extreme weather events that threaten power reliability.

This is more than fanciful concepts. Companies around the world are already working on these solutions. Microsoft has been one of the most visible leaders in hydrogen experimentation for data centres, having conducted multiple pilots showing hydrogen fuel cells can replace diesel generators for backup power. In one recent demonstration near Cheyenne, Wyoming, Microsoft and Caterpillar successfully powered a data centre for 48 continuous hours during a simulated outage using a 1.5 MW hydrogen fuel cell system paired with battery storage, proving both performance and durability even in harsh conditions.

In Europe, NorthC has taken hydrogen implementation further by deploying fuel cells powered by locally produced green hydrogen at its Groningen data centre to replace conventional diesel backup systems. This makes it one of the first facilities on the continent to operationalise hydrogen as a standby power source.

Hydrogen adoption still faces challenges. Cost, infrastructure, and supply chain development remain hurdles. Green hydrogen production is still relatively expensive compared to traditional fossil fuels. Nonetheless, falling electrolyser costs and growing renewable capacity are gradually improving hydrogen's prospects, but the sector must be supported by strong legislative and financial measures from the EU and its member states – and, of course, internationally. Building the infrastructure and supporting the production of hydrogen will provide us with a crucial tool for managing our data centre expansion.

Hydrogen is no distant vision for data centres. Microsoft and NorthC are just two examples highlighting the technology's potential to grow the data centre sector in a resilient and sustainable manner. With continued innovation, supportive policy, and strategic partnerships, hydrogen could become a cornerstone of the data centre energy transition in the decade ahead.

Scaling up carbon storage – how Europe can lead the world

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In the Norwegian village of Øygarden, on the Bergen coast, the sight of large tanker ships carrying gases and liquids is not uncommon. After all, Øygarden, which sits at the heart of Norway's energy region, is located just miles from the Troll gas field that supplies much of Europe. Yet every four days, a different kind of tanker comes into view, because these tankers, easily noticed due to their bright, purple colour, are not carrying fossil fuels. These tankers are carrying carbon dioxide.

The Longship project, which commenced operations in June 2025, marks a turning point for Europe's emerging carbon storage industry. Over 10 years in the making, Longship, also known by its management company, Northern Lights, aims to store up to 1.5 million tons of CO_2 per year, with investment committed for up to 5 million tons per year, equivalent to roughly half of Brussels' total annual emissions. Collecting carbon from industries around the North Sea, Longship provides a lifeline for European industries seeking to cut their emissions and reach net zero. With carbon prices due to increase rapidly in the coming years, key industries like cement, fertiliser and waste-to-energy have looked to

(C) Northern Lights JV

Longship to take their CO_2 by storing it safely and permanently in rock formations over 2500 metres below the Norwegian seabed.

But as other countries and regions look to advance their carbon storage projects across Europe in the march towards net zero, three structural challenges must be addressed if a functioning European carbon management market is to emerge.

Addressing Europe's regional imbalance

As Europe's CO_2 storage market moves from announcements toward delivery, the near-term reality is tight and uncertain capacity. A recent study assessed 33 million-tonne-scale projects in Europe, assessing their likely delivery in 2030. While expected regional injection capacity is about 60 Mtpa, in the European Union this falls to 39 million tons per year, well short of the Net Zero Industry Act's target of 50 million tons.

But more worrisome is the geographical imbalance of Europe's emergent storage capacity, which is heavily concentrated around the North Sea. Currently, about 90% of expected capacity sits in a small set of countries (notably Norway, the UK, Denmark, and the Netherlands), leaving many emissions-intensive regions with limited or higher-cost access. Southern Europe, which includes central and eastern Europe, holds just 5% of planned storage capacity, most of which is planned to be delivered by the Ravenna and Prinos projects situated in the Italian and Greek offshore, respectively. As a result, many large industrial emitters face the prospect of having little or no credible domestic storage options, creating a practical dependence on cross-border access to North Sea hubs.

Enabling onshore storage

A key barrier to advancing carbon management projects is cost. CO_2 storage costs are highly site-specific, but a clear and consistent cost differential exists between onshore and offshore settings, as a recent study from the Global CCS Institute identified.

The costs associated with onshore storage development are not limited purely to the development of the storage site, because developing and operating storage sites is generally simpler on land, but also since it enables many industrial emitters to access storage capacity located closer to them. This substantial reduction in transport costs could make carbon capture and storage in Europe up to three times cheaper, according to a report from Clean Air Task Force.

The primary barrier to onshore storage development in Europe is political. In many countries with large industrial emissions, such as Poland and Italy, onshore storage is outright banned, while in Germany, it is left to federal states to determine whether they want it, or not. But in other EU member states, change is being felt. In Denmark, Hungary, Romania and Bulgaria, onshore storage projects are already under development with the first permits due to be issued in 2026.

For member states that continue to avoid the issue, the underlying question is increasingly stark: do you want your industries to shut down due to a lack of carbon storage infrastructure, or not?

Sharing knowledge

While Europe's CO_2 storage sector is only now gaining momentum, the practice itself is not new. Data from the London Register of Subsurface CO_2 Storage, an initiative co-ordinated by Imperial College London which aims to verifiably quantify all CO_2 storage injection globally, shows that despite Europe having over 30 years of experience with subsurface CO_2 injection, just 2% of global volumes have been stored in Europe.

Nevertheless, experience has shown that knowledge sharing is key to getting things going. In December 2025, Denmark issued its first-ever CO_2 storage permit, providing a green light for the Greensand project. This milestone came just over four years after carbon capture and storage first received formal political recognition in the country.

The Danish experience shows that while Europe is behind, it can catch up quickly. Doing so means we should also learn from the rest of the world, particularly from decades of experience in the United States, Canada, and Norway, and translate these learnings to other regions. The evidence is clear that large-scale CO_2 storage globally is necessary to meet climate targets. The challenge now is for Europe to demonstrate that it can deliver at a scale not yet achieved.

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From hands-off to hands-on: The need for a **European regulatory framework** for **CO_2 transport infrastructure**

The European Commission has stated that to achieve the goal of climate neutrality by 2050, within the same timeframe, up to 300 million tonnes of CO_2 will need to be captured, transported, and permanently stored on an annual basis. Transporting and storing CO_2 in the volumes envisioned will require an extensive network of cross-border pipelines, shipping terminals and geological storage sites. To achieve this, Bellona strongly believes that that the EU must quickly agree on a new regulatory framework which obliges cross-border planning and coordination, prevents market failures and supports public/private investment through targeted risk management solutions.

The ongoing EU legislative initiative on CO_2 transportation infrastructure and markets, due for adoption in late 2026, represents an opportunity to address these issues, but only if the framework's design considers the current market dynamics of the nascent industry. Done right, the initiative has the potential to set structured and predictable approaches to ownership structures, third-party access procedures, fair and transparent tariff mechanisms and clear expectations for regulatory oversight by competent authorities. European coordination, together with a harmonised approach to managing investment risk can help to minimise the costs to European industry and in turn the societal cost associated with CO_2 abatement.

European Coordination of CO_2 transport and storage infrastructure is vital

Despite a clear identification of the European Commission of the need for cross-border CO_2 transport, there is currently no EU-level coordination or planning of CO_2 pipeline or storage infrastructure. Despite endorsing 14 vital Projects of Common Interest (PCIs) in 2025, Europe risks a fragmented mess of duplicate pipelines, unused capacity, and stranded industrial clusters. In addition, uncoordinated build-out invites inefficiency. Multiple planned pipelines chasing the same emitters inflate costs, strain spatial planning, and undermine investor confidence. Without a master plan syncing capture, transport, and storage timelines, CCS will stall.

Regulation is not only about tariffs; it can also be a planning tool. Anchoring this planning in a regulatory regime that rewards anticipatory, least cost buildout can avoid a patchwork of overspecified private lines that later need expensive retrofitting or consolidation.

Other major European pipeline infrastructure networks have European Networks of Transmission System Operators (TSOs), ENSTO-G[1] (gas), ENTSO-E[2] (electricity) and ENNOH[3] (hydrogen). These bodies ensure coherent, secure infrastructure by harmonising national plans, assessing scenarios, and evaluating cross-border projects against transparent criteria. CO_2 networks warrant a parallel structure. Operating independently under ACER supervision and Commission approval, an 'ENTSO-C' or 'ENNOC' would align national roadmaps, develop EU-wide corridor plans incorporating multimodal transport, and enforce conformity checks on major expansions to prevent duplication.

Enforcement and oversight is needed to prevent market failures

Initially, EU Member States with an interest in CCS took a laissez-faire approach towards the ownership of CO_2 transport and storage infrastructure, allowing market players to take the lead and make commercial agreements in a largely unregulated environment. Whereas giving the market room to take initiative and develop innovative business models is highly desirable, this is not without risk.

In 2022, in the Port of Rotterdam, the prospective emergence of a fully vertically integrated CO_2 transport and storage project, offering bundled transport and storage services, created considerable distrust amongst potential users who had to negotiate directly with their competitors, most of whom considered the project initiators to have an unfair market position. A subsequent independent economic evaluation commission by the Dutch government, confirmed that the project initiators indeed held an effective national monopoly on the provision of CO_2 transport and storage services in the region, and recommended stronger regulatory oversight on market developments and transport and storage tariffs in the Netherlands.[4]

Intentional or not, the example from the Netherlands highlights that structural ownership unbundling of CO_2 pipelines from capture and storage, should be treated as the default for Europe's emerging CO_2 networks, but applied through a differentiated, pragmatic framework that reflects the diversity of transport configurations. Large pipelines through industrial clusters or built with significant marketable capacity clearly warrant strict ownership separation to prevent vertically integrated players from locking out rivals and distorting tariffs. By contrast, point-to-point links from one capture site to one storage facility does not justify the same regulatory intervention.

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1 European Network of Transmission System Operators for Gas

2 European Network of Transmission System Operators for Electricity

3 European Network of Network Operators for Hydrogen

4 Mulder, M. 2024. University of Groningen. marktordening-ccs-mulder-cenber-policy-paper-14.pdf (in Dutch)

Such examples of market failures haven't gone unnoticed, with other Member States currently taking a more hands-on regulatory approach. Most recently Denmark and the Flemish region of Belgium have passed legislation on ownership and tariffs around CO_2 transport pipelines, with France in an advanced stage of preparation. But these isolated, disparate approaches to regulation presents another risk, that a patchwork of various regulatory frameworks constrains the emergence of an EU market. The new legislative initiative must act to ensure a harmonised approach, while respecting existing Member States legislation.

Managing risk and enabling private investment

The majority of CO_2 infrastructure is currently being financed through tailormade commercial structures, blending carbon contracts for difference, grants and state support on a project-by-project basis. Whereas this approach may be enough for the first wave of smaller projects, it will not scale to the hundreds of megatonnes per year of capacity that the European Commission envisages.

Pure commercial investment is considered challenging, as the risk profile of CO_2 infrastructure is dominated by policy and demand uncertainty rather than conventional construction risk. Emitters' capture investments depend on future ETS prices, CBAM design, and product-market demand, all of which sit largely outside the operator's control. Investors require predictable tariff logic and a low-risk pathway to returns.

Economic regulation of CO_2 transport infrastructure offers a powerful lever to unlock private investment without the use of endless subsidies. The UK's regulated asset-base (RAB) approach has opened the door to low-cost institutional capital, hungry for long duration, inflation linked infrastructure exposure. The result is not socialisation of all risk, but a risk sharing compact: investors accept lower upside in exchange for credible protection from catastrophic downside.

By establishing clear, predictable rules - such as cost-reflective tariffs, third-party access procedures, and public/private risk-sharing mechanisms, the new EU legislative initiative can set the foundations for a sufficient, timely and efficient CO_2 market.

CCS & the Ravenna Project

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Although fossil fuels are the largest contributor to climate change, they are not the only source of greenhouse gas (GHG) emissions. In industry, energy-related emissions constitute the largest share of GHGs embedded in products. However, emissions from Industrial Processes and Product Use (IPPU) - arising from chemical or physical transformations and the use of man-made GHGs in products - should not be overlooked. In 2023, IPPU accounted for about 9% of total EU emissions, ranking as the third-largest source after energy and agriculture. The rise of Industrial Carbon Management on the climate agenda reflects the recognition that decarbonising industry requires addressing more than just energy use.

Advanced recycling, resource efficiency, closed-loop material use and industrial symbiosis are critical for cost-efficient industrial decarbonisation - reducing upstream GHG impacts while enhancing strategic autonomy. Yet residual emissions remain, particularly in Energy-Intensive Industries (EIIs) such as cement and chemicals. Even with energy and material substitution, some emissions are unavoidable - this is where a targeted use of Carbon Capture and Storage (CCS) can play a limited role.

With global temperatures already exceeding the 1.5 °C threshold set by the Paris Agreement, CCS would deliver only a marginal contribution. Currently, the only commercially viable use of CO_2 injection is to support fossil fuel extraction - the sole context in which CO_2 storage has historically proceeded without public funding. Outside this setting, CCS remains expensive and unlikely to become significantly cheaper. Its deployment would entail higher operating costs for connected industries and risk diverting investment from more effective decarbonisation options. Industrial decarbonisation should therefore prioritise electrification, circularity, efficiency, sufficiency, and demand-side measures. Combined with material substitution and process electrification, these approaches are often more cost-effective and could substantially reduce - if perhaps not eliminate - the need for CCS.

CO_2 should be treated as a regulated waste stream rather than a commodity. If carbon gets captured, permanent storage should be the default option, unless the CO_2 can be securely bound in products for centuries. CCS projects typically claim capture rates of 85–90%, leaving 10–15% of emissions unaddressed. Achieving higher capture rates becomes increasingly costly, and pilot projects worldwide have often fallen short, sometimes capturing only around 50% of emissions.

Greater transparency is essential to verify actual capture rates and ensure they consistently achieve at least 90% to deliver meaningful climate benefits.

CCS also requires additional energy for capture, compression and transport, reducing net efficiency. Even if powered by renewables, this energy may be better used to directly electrify industrial processes. In practice, it means that CCS makes industries more energy-intensive without transforming their core operations.

In Italy, the Ravenna CCS project from SNAM and ENI faces concerns over extremely high costs and uncertain demand. Estimated costs for CO_2 injection and storage are €150–250 per tonne and the demand for the infrastructure remains unclear. Cost-effective alternatives may not have been fully explored in the area. While technically ambitious, its commercial feasibility and prioritisation over more efficient decarbonisation strategies are uncertain.

While proponents argue that the Ravenna CCS project could immediately capture up to 90% of CO_2 emissions. Among suggested

applications regrouped as EIIs, rise also thermal power plants. An obscene idea. Applying CCS to thermal power plants is particularly illogical: it would require continuing to burn fossil fuels to generate electricity that is already costly, while piling up additional operational costs for capturing CO_2. The resulting electricity prices could destabilize markets based on marginal-cost pricing, whereas the same investment could more effectively decarbonise the energy system through renewables and storage solutions.

The project also claims that it will create a "sustainable ecosystem" and up to 45,000 jobs. This is misleading. While construction may generate temporary employment - as any infrastructure project - operational-phase jobs are limited and public funds used for CCS could achieve far greater climate and social benefits if redirected to projects that are cheaper, more scalable, and directly reduce emissions in communities impacted by industrial activities.

The project's use of only 10% of existing gas infrastructure highlights the risk of underutilisation. Given the extraordinarily high cost of €38.4 billion over the project lifetime, this limited adaptation makes the project vulnerable to becoming a stranded asset. Moreover, the projected 16 million tonnes of CO_2 captured annually depends entirely on which facilities choose to connect, leaving substantial uncertainty about actual performance.

The boasted €79 billion in economic benefits largely reflects maintaining existing industrial processes rather than creating additional value, and the same funding could instead partially or fully decarbonise using commercially available, cost-effective technologies.

In short, the Ravenna CCS project is technically ambitious but economically risky and environmentally marginal compared to available alternatives. It provides limited justification for diverting substantial public or private resources from more efficient decarbonisation pathways.

CCS should only be used as a complementary measure for unavoidable emissions and must never support fossil fuel extraction or use. Infrastructure must be safe, with robust monitoring and contingency protocols to prevent long-term environmental or public health risks. Capture rates should be publicly reported, monitored and enforceable to avoid misleading claims. The oil and gas industry must take responsibility for its climate impacts and fund the long-term management of storage sites. Any financial support should come from private investors and be guided by strict enforcement of the polluter-pays principle and extended producer responsibility. Finally, EU funds should not subsidise CCS where more cost-effective, reliable and commercially scalable decarbonisation options exist.

Beyond Mapping: **Turning Europe's CO_2 Storage Knowledge** into **Climate Action**

EuroGeoSurveys, the Geological Surveys of Europe *

The Geological Surveys of Europe

Europe's ambition to achieve climate neutrality relies not only on reducing emissions, but also on managing the carbon dioxide that cannot be avoided. This means that developing a credible pipeline of CO_2 storage projects is essential.

Geological CO_2 storage is a necessary component of Europe's decarbonization strategy. From a (geo)scientific and technical perspective, research and operational experience demonstrate that CO_2 can be injected and retained securely in geological formations over very long timescales. The core scientific question—***can CO_2 be stored securely underground?*** —has been convincingly answered.

Long term security of CO_2 storage is assured through management, monitoring, reporting, and verification processes in line with the European CO_2 Storage Directive; including thorough site characterisation; assessment and management of risks; and well integrity standards.

The challenge Europe now faces is of a different nature. As large-scale deployment must accelerate to meet industrial and climate targets, the key bottleneck is the availability of **trusted and comparable geoscientific data** that supports decisions by policymakers, regulators, and investors. Scaling CO_2 storage from individual projects to a pan-European system requires a shared understanding of where geological opportunities for secure storage exist, how mature they are, and how projects can be developed responsibly and efficiently.

In this context, the pan-European CO_2 Storage Atlas, developed by EuroGeoSurveys in the Geological Service for Europe (GSEU) project and available through the European Geological Data Infrastructure (EGDI), represents an important step, providing a standardized and harmonized overview of potential storage resources across Europe. Underground CO_2 storage assets can be viewed within a consistent European framework, bringing together the latest data from national assessments and building on predecessors of the atlas (e.g. CO_2Stop). Alongside underground CO_2 storage potential, EDGI brings the additional value of a harmonized overview of multiple uses including hydrogen storage potential, and resources such as groundwater and critical minerals, supporting holistic strategies for use of the subsurface to achieve Europe's sustainability goals.

The current Storage Atlas is not an end point. Its real value lies in how it will evolve through the efficient addition of new data to de-risk storage prospects and functionalities to support investor decisions. To support Europe's Industrial Carbon Management Strategy, the CO_2 Storage Atlas must become a **living infrastructure, and one of the pillars of the future permanent Geological Service for Europe**, capable of translating geological knowledge into operational and policy-relevant insights.

One direction of value propagation lies in alignment of the Storage Atlas with emerging data transparency requirements under the Net-Zero Industry Act (NZIA). The NZIA introduces a new policy environment in which industrial planning, permitting, and investment decisions increasingly depend on clear visibility of infrastructure capacity, timelines, and constraints. Storage resources identified in the Atlas will need to be connected to future data releases and regulatory processes foreseen under NZIA. Static information products are unsuitable for this task. What is required is a flexible data platform that can be easily updated with new data and integrated into broader industrial and policy workflows. The Storage Atlas and EGDI will serve as a gateway—linking subsurface knowledge to Europe's emerging governance framework for carbon management.

A second, and equally important, direction concerns the extension of the Atlas beyond capacity mapping towards **decision support for investability**. Geological storage capacity, while essential, does not automatically translate into viable storage projects. Investors and policymakers must assess a wider set of parameters: remaining uncertainties, financial opportunities, risk mitigation options, regulatory readiness, and the likely trajectory from exploration to operation. Without this additional layer of information, large volumes of theoretical capacity remain disconnected from real-world deployment. The Atlas provides insights into technical readiness of storage opportunities using an established Storage Readiness Level system (Akhurst et al., 2021) to communicate what is needed to move from opportunity to operation. The pace and scale required for CO_2 storage deployment demand tools that help distinguish between long-term potential and near-term opportunities, enabling resources to be prioritized effectively.

Regulatory alignment and investability assessment share a common requirement: **long-term governance of information**. CO_2 storage is, by nature, a multi-decadal undertaking. Storage sites are characterized over years, developed gradually, operated for decades, and monitored well beyond closure. Each project brings new learnings. Without responsibility for maintaining and governing subsurface geoscientific data, even the most sophisticated tools will lose relevance.

This is why a long-term institutional perspective is indispensable. A Geological

Service for Europe (GSE) has been proposed to ensure continuity, transparency, and trust in the management of Europe's geological knowledge. By providing a stable framework for data curation, harmonization, and access, such a public service would allow products like the Storage Atlas to remain up-to-date and authoritative over time. And it would anchor subsurface information within a public-service mandate, ensuring that strategic decisions are supported by robust and openly accessible evidence.

Europe already possesses the geoscientific expertise and geological potential needed for large-scale CO_2 storage. The next phase depends on converting that knowledge to support durable decision-making. Moving beyond mapping is therefore not a technical refinement, but a strategic necessity. If Europe succeeds in this transition to a net zero future, the Storage Atlas will not simply document the subsurface, it will actively shape Europe's pathway to climate neutrality.

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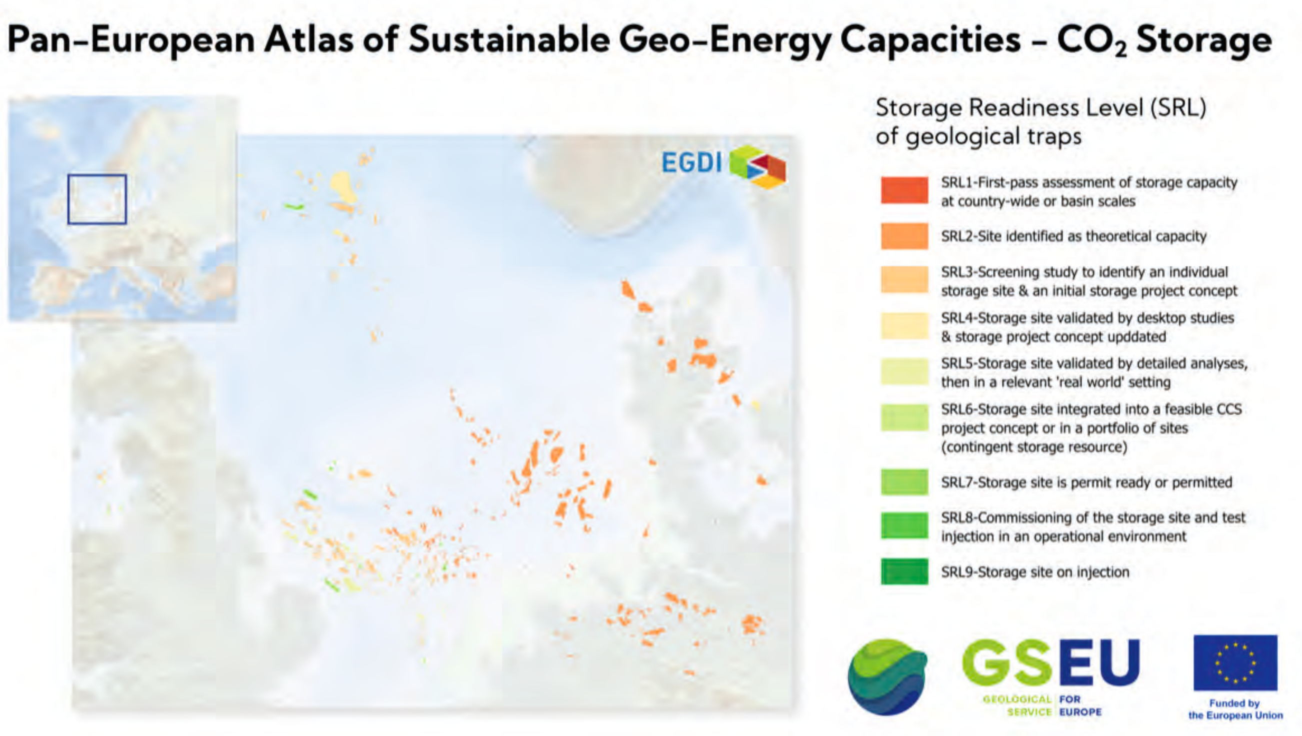

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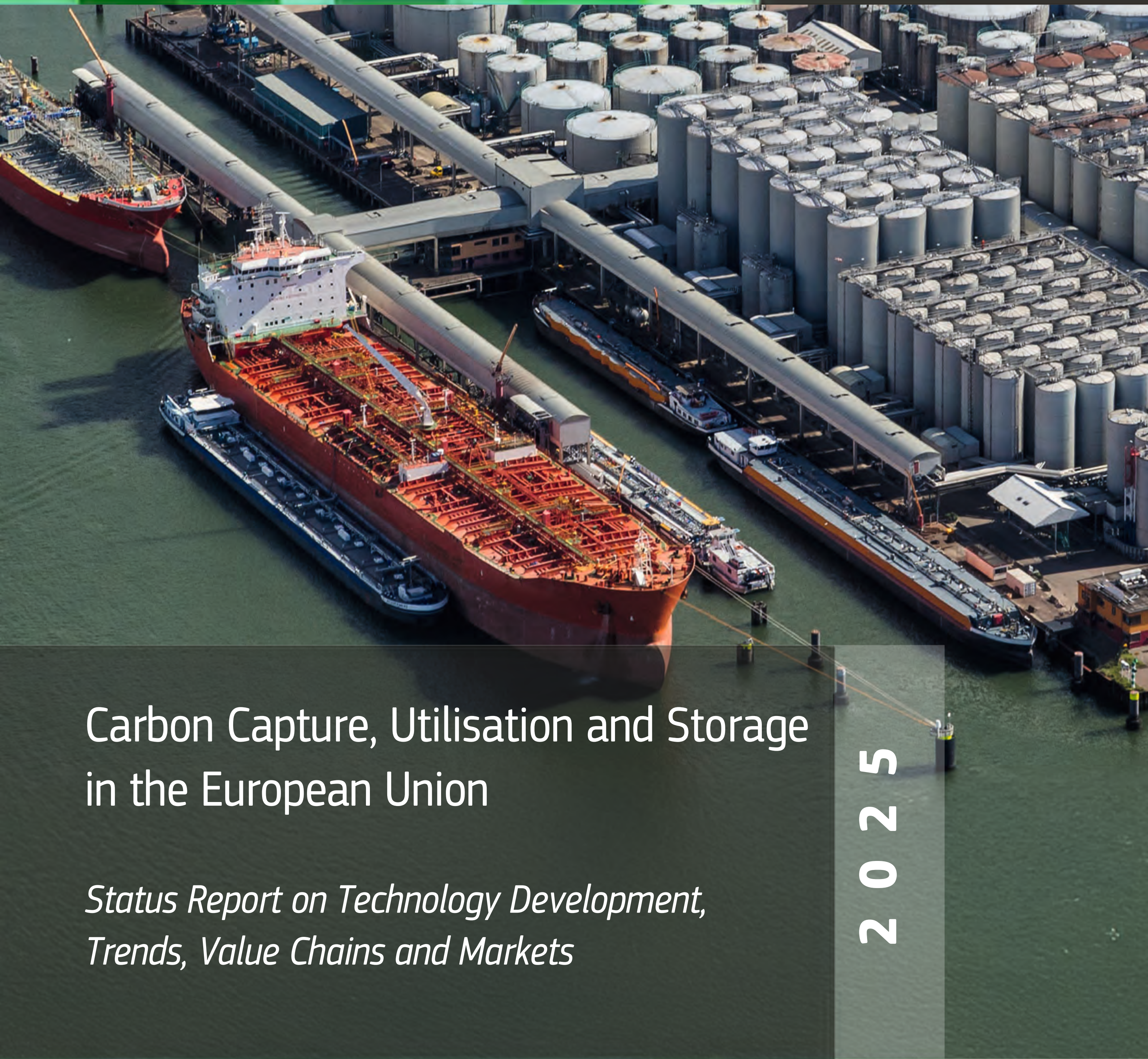

Carbon Capture, Utilisation and Storage in the European Union

Status Report on Technology Development, Trends, Value Chains and Markets

2025


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