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The Role of Carbon Capture in Romania's Low-Carbon Economy:

Results of the Annual Decarbonisation Perspective Model for Romania

Luciana Miu

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The Role of Carbon Capture in Romania's Low-Carbon Economy: Results from the Annual Decarbonisation Perspective Model for Romania

A study by

Energy Policy Group (EPG)
Constantin Noica Street 159, Bucharest, Romania
www.enpg.ro, office@enpg.ro

About EPG

EPG is an independent think-tank specialising in energy and climate policy, focusing on the decarbonisation of the Romanian and Central and Southeastern European economies. Founded in 2014, EPG operates as a research institute primarily financed through competitive research grants. Its research aims to promote a constructive, evidence-based dialogue on decarbonisation and economic transformation among decision-makers and the public, both regionally and globally.

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Cover image

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Key findings

- Carbon capture and storage (CCS) will be an essential component of Romania's decarbonisation efforts, particularly for the cement and chemicals sectors.
- Under Romania's obligations under the Net-Zero Industry Act (NZIA), most captured CO_2 will be stored, with less of the gas destined for utilisation.
- According to the ADP model, even under a more relaxed deadline for its NZIA obligations, Romania would need to develop 10 Mt of annual injection-ready CO_2 storage capacity by 2035, and 15 Mt by 2050, to meet the emissions targets outlined in Long-Term Strategy for climate neutrality.
- Given its geological storage potential, Romania is well-positioned to become a CCS hub for Central and Eastern Europe and create new economic opportunities
- CCS infrastructure must be urgently deployed, as the need for CO_2 storage will continue to increase in the decades to 2050.
- To enable CCS projects that contribute to Romania's climate mitigation efforts in a cost-effective way, ambitions must be increased in national strategies, hard-to-abate sectors must be prioritised for CO_2 capture, and the potential for negative emissions through carbon removal projects should be explored.

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Background

The capture, utilisation, and storage of carbon dioxide (CCUS) is increasingly in focus at EU and global levels as a climate mitigation tool. Broadly, CCUS comprises a suite of technologies to capture carbon dioxide (CO_2) from point-source emissions and transport them either for utilisation (such as in the production of synthetic fuels) or for permanent storage in deep geological formations. CCUS technologies are relatively novel and have been sparsely deployed at the commercial scale, compared to other climate mitigation solutions. They are most efficient as a mitigation measure if they capture CO_2 from hard-to-abate industrial processes (such as cement kilns) and prioritise permanent storage of the captured CO_2.[1] CCUS has also been explored as a potential enabler of "negative emissions", by removing atmospheric carbon directly (direct air capture) or indirectly by capturing the CO_2 emissions released from sustainable biomass combustion (bioenergy with carbon capture and storage).

At the EU level, CCUS is increasingly addressed through dedicated and general policies. The Industrial Carbon Management strategy, published in February 2024, is the EU's first-ever strategy setting the direction for the development of CCUS in the Union. It prioritises carbon capture and storage (CCS), with carbon capture and utilisation (CCU) foreseen as being linked to the removal of atmospheric or biogenic carbon. CCUS technologies are also addressed in the EU's Communication on a 2040 emissions reduction target, foreseen to play a role in the deep decarbonisation required to reach a 90% reduction in EU-wide emissions by 2040. Most prominently, the Net Zero Industry Act (NZIA) classifies CCS projects as strategic net-zero projects and sets out obligations for oil and gas producers in EU Member States to contribute to a Union-wide target for injection-ready geological storage capacity of 50 million tonnes (Mt) by 2030.

CCUS, and CCS in particular, will be an essential element of Romania's trajectory to reach net zero emissions. Firstly, Romania's cement and chemicals sectors, as well as other hard-to-abate sectors, will require rapid deployment of CCS projects to avoid industrial emissions and continue to operate in a net-zero world. Secondly, under the NZIA, oil and gas companies producing from reserves on Romania's territories will have a substantial contribution to the Union-wide storage capacity target (approx. 9-10 Mt), and will need to prepare several storage sites ready to inject captured emissions by 2030. Thirdly, Romania's geological potential for CO_2 storage could be significant, with theoretical estimates as high as 22.6 giga-tonnes (Gt) CO_2 storage capacity.[2,3] This means that Romania could successfully position itself as a CCS hub for the region, creating new businesses based on the safe and reliable import CO_2

[1] E3G, 2023. Carbon capture and storage ladder.
[2] Clean Air Task Force, 2023. Unlocking Europe's CO_2 storage potential.
[3] These theoretical estimates are highly uncertain and will likely be smaller when accounting for technical and economic potential of storage sites. For example, while theoretical estimates place the capacity of depleted hydrocarbon reservoirs at 4 Gt, more conservative estimates place these around 510 Mt.

emissions from neighbouring states with less storage potential, as is being pioneered by Norway and Denmark.

Romania currently has no dedicated national strategies on CCUS; however, its key national climate strategies both cover CCUS: the Long-Term Strategy for climate neutrality (LTS) (currently in force), as well as the most recent version of the draft revised National Energy and Climate Plan (NECP), include measures to enable the deployment of CCUS technologies. The draft revised NECP, currently in public consultation until the end of September 2024 before official submission to the European Commission, has significantly strengthened its CCUS commitments throughout its development from the initial draft version, first published for consultation in Q1 2024 and subsequently revised to the present version. This includes committing to the elaboration of a National Carbon Management Strategy (2025) and a public fund of €750 million for CCUS projects (including transport infrastructure) by 2027. For comparison, in the initial draft revised NECP, none of these measures were present.

Despite these recent positive signals, both the LTS and the current draft revised NECP forecast the capture of merely 2.58 Mt of CO_2 from Romania's minerals industry (cement, lime, and others – cumulatively responsible for around 8 Mt of CO_2 emissions in Romania) by 2050. Furthermore, there is little clarity on the buildout of CO_2 transport infrastructure, including cross-border transport links, required to reach Romania's CO_2 storage targets and capitalise on the opportunities offered by the development of CCUS projects at scale. To this end, this policy brief presents key takeaways on the potential future of CCUS in Romania, based on a detailed model of Romania's energy system developed by Carbon-Free Europe, Evolved Energy Research, and Energy Policy Group, the ADP model. An analysis of the model's full results is available in a full-length policy paper, alongside a second policy brief on the outlook for clean hydrogen in Romania.

The ADP model

The Annual Decarbonisation Perspective (ADP) model simulates pathways to attain carbon neutrality by 2050 in the EU, under different scenarios.[4] The scenarios are elaborated using a back-casting approach, allowing for an analysis of the intermediate decisions and investments required to meet long-term goals. For Romania, the main scenario relevant for assessing pathways for CCUS is the *reference* scenario,[5] which is constrained by the targets outlined in official strategic documents in March 2024, most prominently Romania's LTS (currently in force) and the initial draft revised NECP, published in Q1 2024 and subsequently

[4] CFE (2023): Carbon Free Europe Annual Decarbonization Perspective 2023.
[5] This scenario is referred to as "LTS-equivalent" in the figures shown throughout this document, as Romania's LTS was the primary strategic document used to develop the scenario. Importantly, this scenario is not an identical representation of the values in the LTS, given the differences emerging from the modelling tools used for the official document compared to the ADP model, which can be related to input data, cost assumption, technological learning curves, sectoral interdependencies, etc.

revised (the draft revised NECP mentioned above).[6] Other relevant scenarios are the *no removals* scenario, which assumes no CO_2 storage on Romania's territory to show the implications of a failure to develop CCS projects, and the *net-zero E+I* CO_2 scenario, where Romania's energy and industry emissions are not offset by natural carbon sinks, resulting in an increased requirement for "technological" carbon sinks, i.e., CCUS. (Table 1).

Table 1. Overview of scenarios implemented in the ADP model.

Scenarios	Description
Reference scenario	Based on official targets of Romania's strategic documents, most prominently the "RO Neutral" scenario from Romania's LTS (subsequently adopted and re-iterated in the draft initial NECP), reaching 99% economy-wide emissions reductions by 2050, relative to 1990.
No hydrogen in the mobility sector	Mimics the *Reference* scenario, but includes a reduced role (substituted for direct electrification) of hydrogen in the transport sector.
No removals	Mimics the *Reference* scenario, but excludes any geological storage of CO_2 in Romania.
Constrained renewable siting	Mimics the *Reference* scenario but with a reduced ability to build onshore wind and solar based on more stringent siting restrictions.
Constrained renewable siting + No unplanned nuclear	Mimics the *Constrained renewable siting* scenario with a constraint on future nuclear reactor buildout.
Net-zero E+I CO_2	Mimics the *Reference* scenario, but includes a net-zero target by 2050 for energy and industrial CO_2 emissions and a constraint on using Romania's land sink to offset positive energy emissions.
No gas power	Mimics the *Reference* scenario, but excludes any new build of gas power and the retirement of existing capacity by 2050.
Nuclear cost reduction	Mimics the *Reference* scenario but assumes lower costs of nuclear power production (€102/MWh in 2030 and €58/MWh in 2050, compared to €120/MWh in 2030 and €115/MWh in 2050 in the *Reference*).

Source: Evolved Energy Research, 2024.

[6] Compared to the LTS and the initial draft revised NECP, on which the ADP modelling is based, the current version of the revised NECP does not include substantial changes to the quantitative targets relevant to CCUS, which would affect the results of the model.

CCS: the main projected driver of Romania's carbon management

CO_2 capture from industry is projected to increase significantly. To meet Romania's emissions targets, the ADP model shows a significant increase in the capture of CO_2 from industry, primarily destined for geological storage driven by Romania's NZIA obligation, in all scenarios aside from *no removals* (Figure 1). Even under the assumption of a later target for meeting this obligation, most scenarios show that Romania would still need to develop 10 Mt of CO_2 storage capacity by 2035. If this capacity is assumed to be developed at a steady pace, the modelling results show that Romania would need to have 6.4 Mt of injection-ready storage capacity by 2030. As this is likely not likely to be technically achievable, Romania must prepare for a massive deployment of CCS projects in the early 2030s.

Most of Romania's captured CO_2 will be geologically stored. All model scenarios show that under Romania's NZIA obligations, captured CO_2 is stored, rather than utilised. However, the very low contribution of CO_2 utilisation in the *no removals* scenario, where no CO_2 storage is included, indicates that even in the absence of a storage target, the contribution of CCU to Romania's carbon management would be minor.

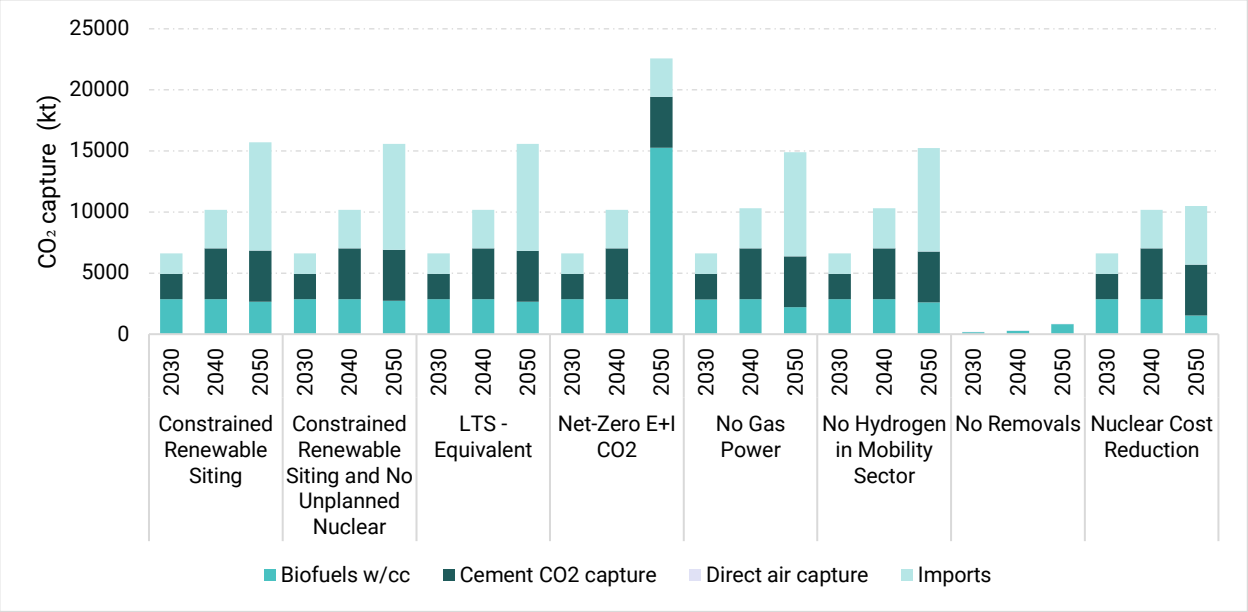
Both domestic and imported CO_2 would be stored in Romania. Of the CO_2 stored in Romania in most scenarios in the 2030s, an approximately equal share would come from the domestic cement industry, imports, and biofuels production (enabling so-called "negative emissions" if a sustainable source of biomass is used).

CO_2 storage is projected to ramp up in the late 2040s. In most scenarios, imports nearly triple between 2045 and 2050, and are the driver of the overall increase in CO_2 storage development, which will reach 15 Mt/year by mid-century (Figure 1, Figure 2). Importantly, the overall quantity and composition of stored CO2 remain the same, even in scenarios with land constraints on renewable deployment. This shows that the model does not find it cost-effective to capture carbon from fossil-based energy production, even when renewables buildout is constrained.

If Romania's land sink fails to absorb CO_2, the need for negative emissions will increase dramatically. In the scenario where Romania cannot use its land sink for offsetting emissions, the total amount of technological CO_2 storage is significantly higher than in other scenarios (22 Mt/year in 2050 compared to 15 Mt), primarily supplied by CO_2 captured from biofuels production to create negative emissions.

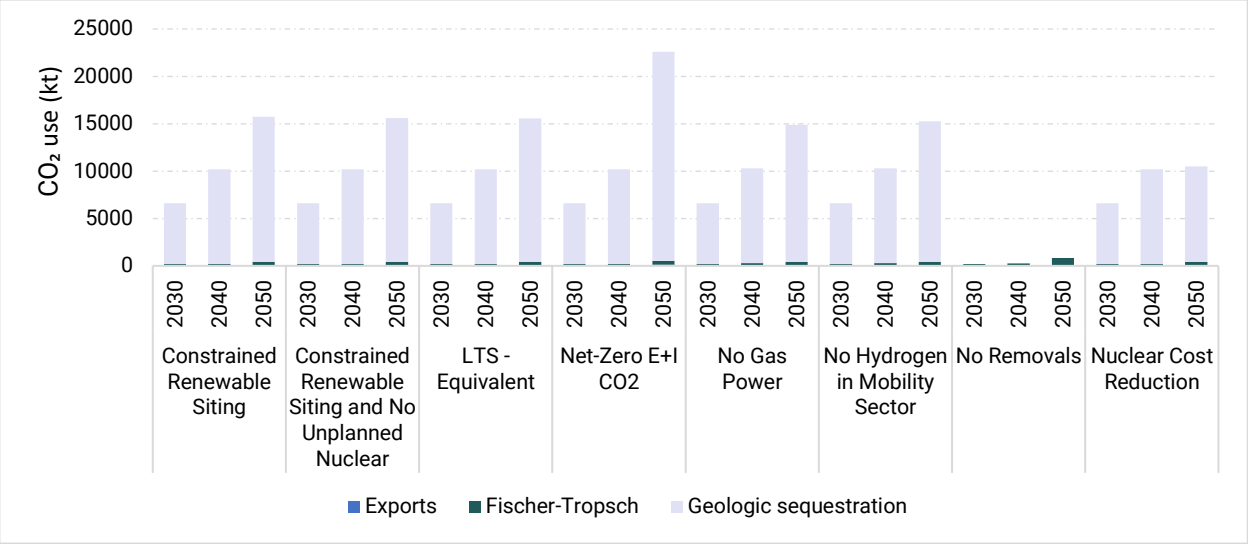
Domestic CO_2 transport and storage infrastructure will need to be rapidly deployed. For a theoretical cost-optimal deployment of CCS, biofuels with carbon capture would need to be developed as early as 2025. While this is not technically feasible, it showcases the urgency for creating the necessary enabling conditions. CO_2 transport and storage infrastructure on Romania's territory would need to be developed well before 2035, to enable the capture and storage of at least 3 Mt of emissions from Romania's cement producers in 2035.

Figure 1. CO_2 capture in Romania under the ADP model.



Source: Evolved Energy Research and EPG, 2024.

Figure 2. CO_2 utilisation and storage in Romania under the ADP model. The "Fischer-Tropsch" label refers to the utilisation of CO_2 for the production of synthetic hydrocarbons.



Source: Evolved Energy Research and EPG, 2024.

CCU plays only a small role across scenarios

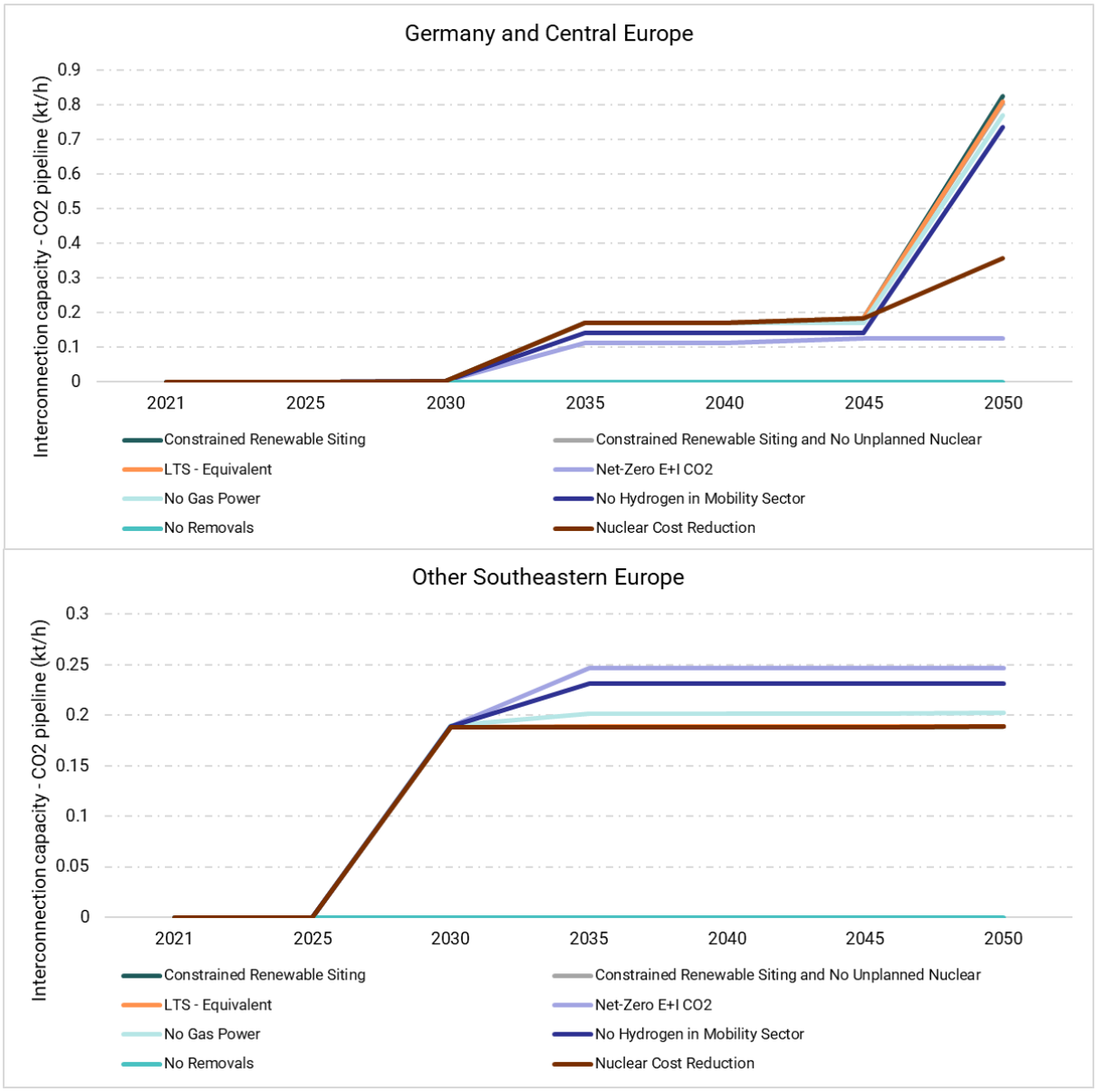
Even in the absence of a storage obligation, CO_2 utilisation pathways cannot use all the carbon that needs to be captured in Romania. In a scenario in which domestic geological sequestration is not possible, CCU would still make a very small contribution to Romania's carbon capture pathways. This shows that even assuming a decision not to invest in CCS at all, only minor amounts of CCU would develop cost-effectively, primarily in the Fischer-Tropsch pathway of producing synthetic hydrocarbons (including e-fuels) from hydrogen and captured CO_2. The reason behind this is that hydrogen would be most cost-effectively deployed as a direct fuel for industry and transport.

A CCU-only scenario would force changes in the industrial energy mix. Aside from a change in Romania's carbon management pathways, the *no removals* scenario results in a small increase in Romania's overall hydrogen demand; by 2050, this reaches 433 ktoe for e-fuels production, out of a total of 2.08 Mtoe, compared to 1.88 in the *reference* scenario. This is also linked to a proportionately higher penetration of solar, offshore wind, and nuclear energy. However, the mix in industrial heat vectors shows a more pronounced shift: after 2030 there is a higher rate of electrification (using heat pumps), in the *no removals* scenario compared to the *reference* scenario. This additional electrification primarily displaces fuel boilers, electric boilers and biofuels with carbon capture, but would do little to address the issue of process emissions.

Romania as a regional CO_2 storage hub

Romania can position itself as a hub for geological CO_2 storage. The ADP model results show that Romania's NZIA obligations could make it an important geological CO_2 storage hub. In the modelled reference scenario, a small but steady flow of CO_2 imported from south-eastern Europe (0.85 Mt of CO_2 in 2035 and 0.93 Mt by 2050) accompanies a drastic increase in imports from Central Europe (including Germany) (0.72 Mt in 2035 and 5.8 Mt in 2050).

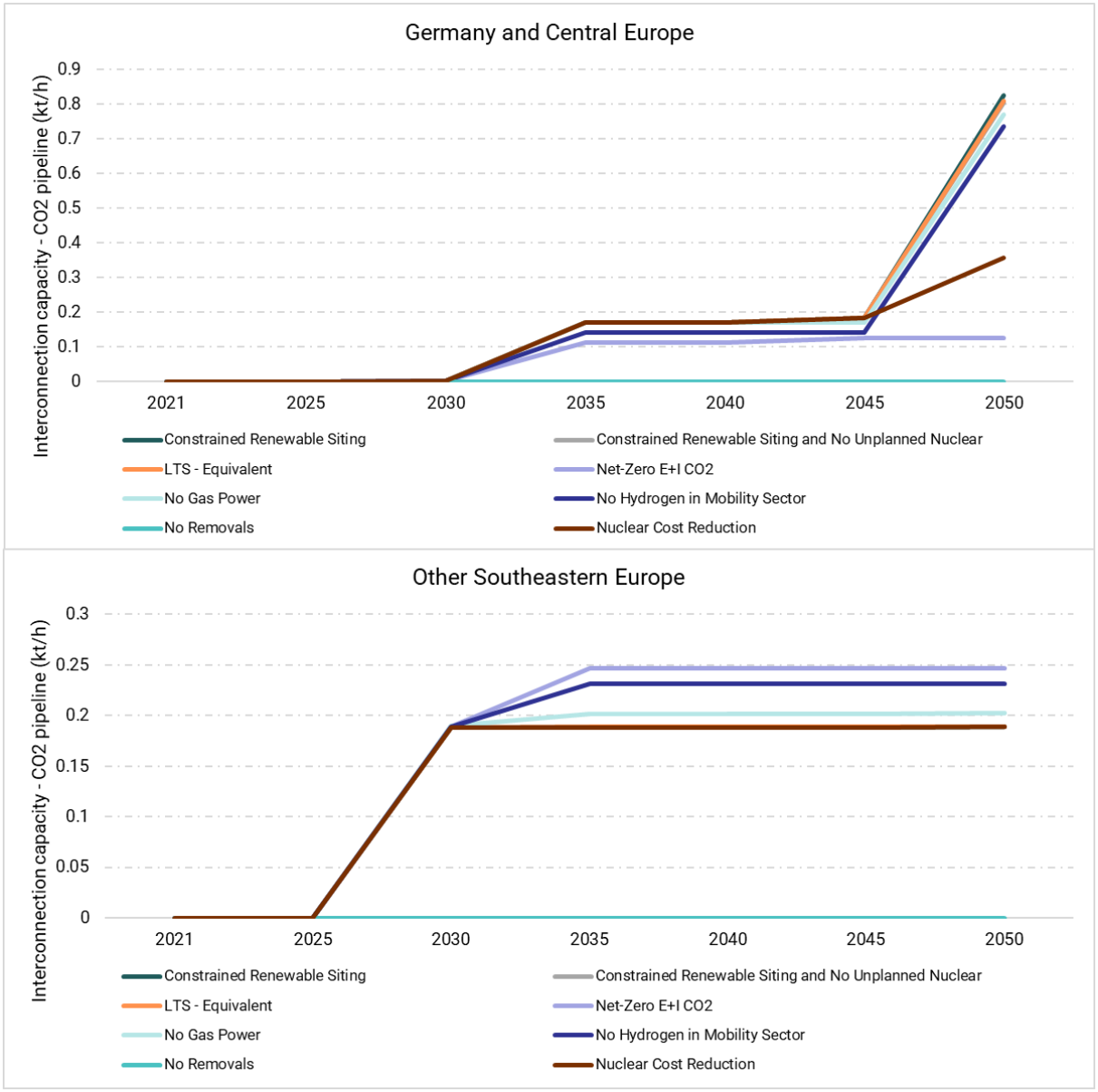
Infrastructure buildout for cross-border CO_2 transport will be essential. In the reference scenario, CO^2 transport and storage infrastructure should be developed promptly to cement Romania's position as a regional CCS hub. In the near term, cross-border pipelines to south-eastern Europe could develop learnings on infrastructure buildout, scaling up in the longer term with pipelines to central Europe and beyond and reaching capacities of 810 tonnes CO_2/hour by 2050, with rapid construction between 2045 and 2050 as demand for CO_2 storage capacity is projected to surge (Figure 3. Cross-border CO2 pipeline capacities.



Source: Evolved Energy Research and EPG, 2024.

).[7]

Figure 3. Cross-border CO_2 pipeline capacities.

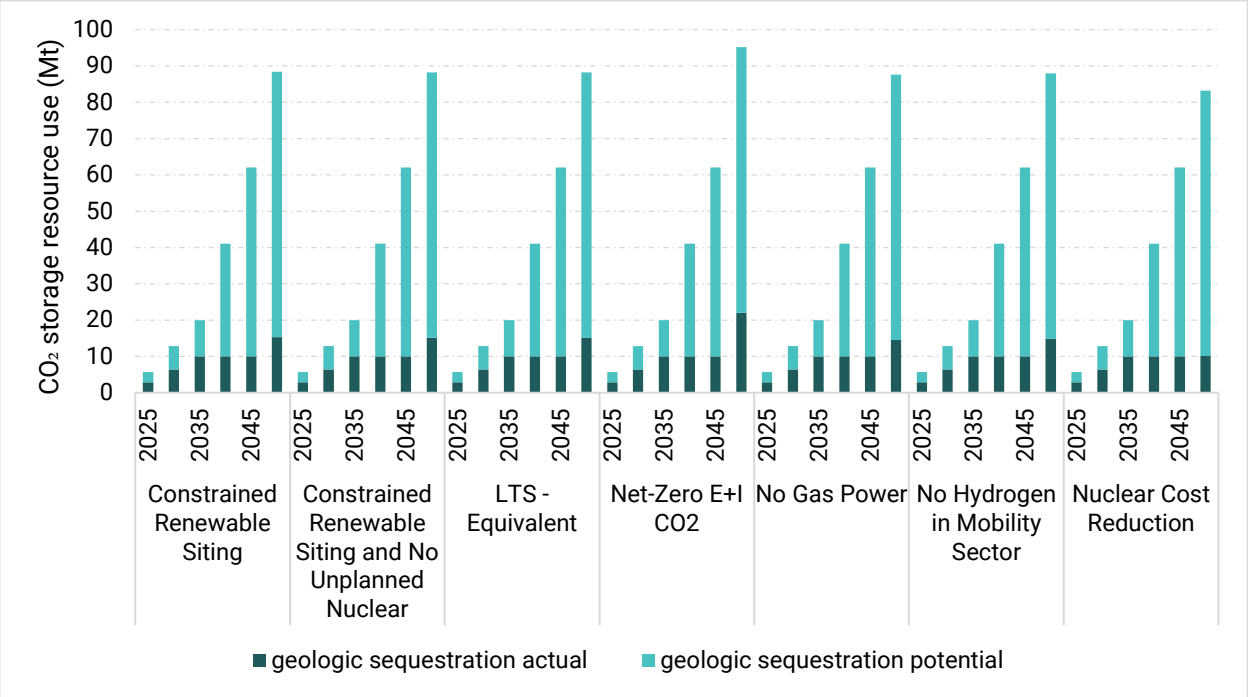


Source: Evolved Energy Research and EPG, 2024.

[7] Under the "nuclear cost reduction" scenario, it is assumed that other Member States will choose to not export their captured CO_2 and use it for e-fuels production, given the lower cost of electricity.

Even under ambitious CCS scenarios, Romania would only be exploiting a small amount of its total storage potential. Despite Romania's apparently daunting CO_2 storage targets, storage development under most scenarios only makes use of a minor part of Romania's theoretical storage potential (Figure 4). A robust evaluation of this storage potential will be required to sharpen the focus of planning for CCS deployment in Romania.

Figure 4. Resource utilisation levels of geological CO_2 storage capacity. This assessment uses a conservative estimate for Romania's total storage capacity (7.5 Gt total saline aquifer storage capacity, assuming 100 years of injection).



Conclusions and recommendations

Romania has significant CCS potential, which can support **the deep decarbonisation of hard-to-abate industry,** enable **negative emissions**, and position Romania as a **regional CCS hub**. The ADP model scenarios show a nearer-term and more ambitious buildout of CCS projects would be necessary than foreseen in Romania's national climate strategies. The role of CO_2 imports increases significantly in the long term and requires detailed **planning of investments in infrastructure**, including cross-border pipelines, particularly to central Europe and beyond. This in turn will require a robust regulatory framework, cooperation between storage providers and emitters to determine cost-optimal CCS project locations, and a better appraisal of regional- and local-level storage potential.

Several key recommendations emerge from the main findings of this analysis:

1. **Carbon capture and storage ambitions must be significantly increased**. Romania's climate strategies, including any forthcoming National Carbon Management Strategy, must strengthen their near-term CO_2 storage targets, including a detailed assessment of CO_2 supply sources to ensure the bankability of storage sites.
2. **Hard-to-abate sectors are a priority.** For domestic capture, industrial emissions must be prioritised. The ADP model sees no role for CO_2 capture from the energy sector, and only a transitional role for blue hydrogen production. CCU is only minorly deployed.
3. **Interconnection capacity must be strengthened**. There is a significant gap between the ADP projections for CO_2 cross-border transport build-out and the lack of information on this topic in national climate strategies. Early-stage commitments and strong management of international transport challenges, like CO_2 quality standards and tariffs, must support the lengthy planning process for cross-border CO_2 pipelines.
4. Romania must **explore its negative emissions potential without over-reliance on natural carbon sinks**. The ADP model shows a contribution of biofuels with carbon capture to developing Romania's CCS project pipeline, which would avoid an over-reliance on its natural carbon sinks, which may be susceptible to the increasingly palpable effects of climate change.
5. National climate strategies should commit to **a deeper and objective analysis of Romania's carbon market potential**, identifying the cost-optimal pathways for deploying CCS without compromising emission reduction activities.

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