Policy Brief | 22.10.2024

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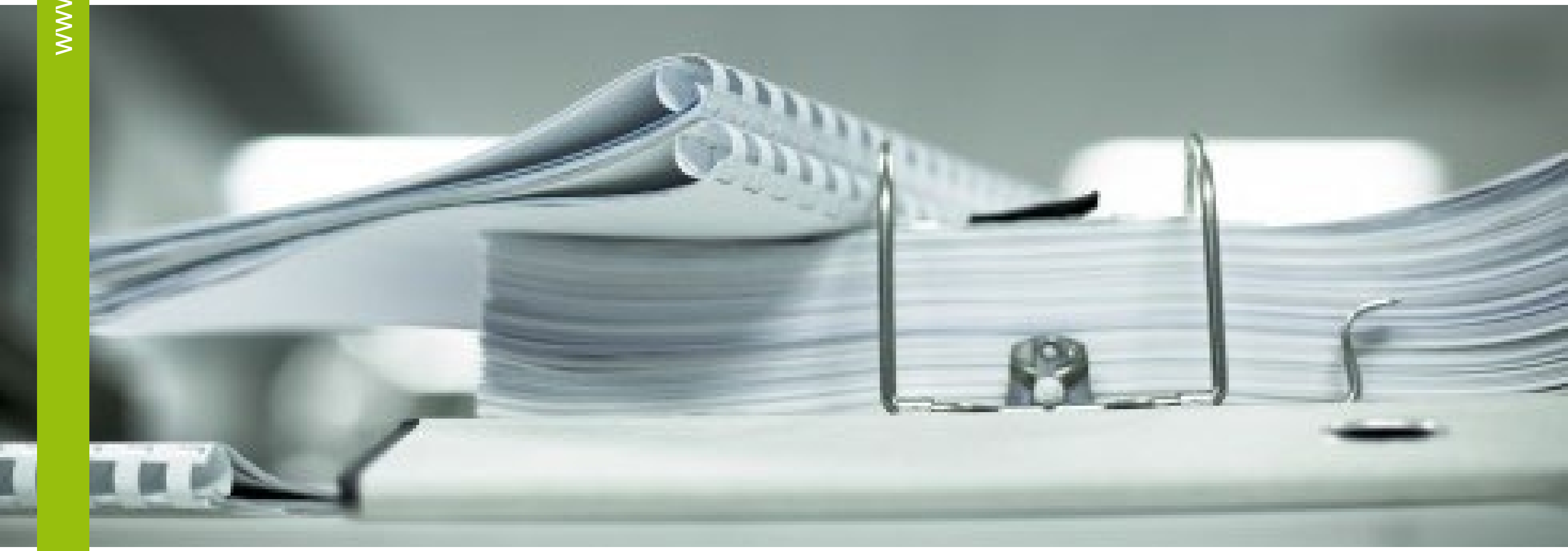

Discussion of the results of the 2040 Impact Assessment

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The European Climate Law (ECL) mandates that the EU Commission must submit a proposal for a 2040 emission reduction target within six months of the conclusion of the Global Stocktake under the Paris Agreement. A target for 2035 must be submitted in the update of the EU's NDC, which is due by COP 2025 at the latest. On 6 February 2024, the EU Commission published three documents: the recommendation for a proposal for the 2040 emission reduction target (EC 2024a), a comprehensive impact assessment (EC 2024c), and an "Industrial Carbon Management Communication (ICMC)" in the document "Towards an ambitious Industrial Carbon Management for the EU" (EC 2024b). Both the recommendation and the ICMC are based on the results of the impact assessment. The proposed target for 2040 is not a concrete legislative proposal. Rather, it serves as a recommendation to the new EU Commission after the elections in June 2024. Neither the proposal, nor the impact assessment discusses the framework of instruments for achieving the target. This paper contributes to the categorisation of the recommendation in the scenario results, compares the scenario results with the recommendations of the European Scientific Advisory Board on Climate Change (ESABCC) and calls for further transparency in the reporting of scenario results with regard to carbon management.

Key conclusions

- The recommendation corresponds to the mean value of scenarios S2 and S3 of the impact assessment; therefore, a S2.5 scenario is used.
- Except for the use of Direct Air Capture and Carbon Storage (DACCS) and the classification of fossil Carbon Capture and Storage (CCS) from industrial processes, the results for 2040 in the S2.5 scenario roughly fall within the ranges specified by the ESABCC.
- Future scenario results should also show the production of greenhouse gases in addition to gross and net emissions in order to clarify the application of carbon management. Greater attention should also be paid to comprehensible and clear sectoral categorisations so that emission developments in the sectors can be discussed.

Quantitative categorisations

In a document consisting of a few pages only, non-numbered headings should be used.

The recommendation for the 2040 climate target is a **90% reduction in net emissions compared to 1990**. To achieve this target, EU-wide emissions should be less than **850 Mt CO_2-eq.** In addition, the amount of carbon sequestrated from the atmosphere should be limited to **400 Mt CO_2-eq**. This amount is not divided into land-based and industrial sequestration in the recommendation.

In the ICMC, the result of a total carbon capture of approx. **280 Mt CO_2** in 2040, rising to 450 Mt CO_2 in 2050, is regarded as the basis for the upcoming discussions.

The impact assessment presents **three scenarios (S1-S3)**, which all start at the same point in 2030 and reach climate neutrality in 2050. They therefore only differ in terms of the speed of implementation. Furthermore, an alternative scenario is mentioned at various points (**LIFE**), which is to be understood as an addition to the three scenarios and is intended to reflect the effects of lifestyle changes. All scenarios involve substantial but different amounts of carbon capture and storage. It is thus intended that the scenarios provide clear orientation and convey investment security. In particular, the focus is on possible technical developments in new carbon management technologies and new energy sources. Changes in lifestyle, the resulting changes in activity rates and opportunities for sufficiency are only considered to a limited extent in the LIFE scenario. Scenarios S1-S3 assume a largely unchanged continuation of consumption habits and production styles.

The EU Commission's proposed target of a 90% reduction for 2040 lies consistently between the results of scenarios S2 (85-90%) and S3 (90-95%). It corresponds to the lower value of the recommendation of the European Scientific Board on Climate Change (EASBCC) in ESABCC (2023) of 90-95 %. For the quantitative analysis, a S2.5 scenario that reflects the mean values of the two scenarios is examined below.

In the impact assessment, a 90% reduction is presented as only a slight increase in effort compared to a theoretical “baseline”: a reduction of 88% is achieved by 2040 by continuing the existing measures. This means that the planned target achievement is almost entirely realised through the policy instruments. This is based on the assumption that the linear reduction factors in the EU’s Emissions Trading System (ETS) continue to increase, with the ETS-1 cap reaching zero in 2039 and the ETS-2 cap reaching zero before 2045. In contrast to the baseline modelling, however, the scenario calculations do not assume an unrevised continuation of the linear reduction factors. This results in significant quantities of residual emissions from fossil fuels. In the ETS-1 sectors, these add up to a gross total of approx. 200 Mt, i.e. after the capture of CO_2 (see section 3).

The emissions for the **1990 base year** are not shown directly in the documents. Particularly due to the ambiguous determination of emissions from international transport, which are included in the target, an estimate must therefore be made for 1990. This estimate shows that the proposed net reduction of 90% can be translated into a **gross reduction of** approx. **83%.**

The three scenarios S1-S3 start at a common point in 2030. According to the information provided by the impact assessment, gross emissions in 2030 amount to 2,301 Mt CO_2-eq, which corresponds to a reduction of 53% compared to 1990[1]. If the natural and industrial sinks are taken into account based on the information contained in the impact assessment (amounting to -310 and -4 Mt CO_2-eq respectively), it results in a net reduction of **58% compared to 1990 as a starting value**. This reduction is greater than the official target of a net reduction of 55% for 2030, though the entire LULUCF sink of 310 Mt CO_2-eq is taken into account and not the limit of 225 Mt CO_2-eq stipulated in the ECL. This limit would result in a reduction of 56% compared to 1990.

The proposed amount of carbon management – **280 Mt CO_2** by 2040 – roughly corresponds to the mean value of the scenario results in S2 and S3. Based on this classification of the mean values of the two scenarios, around 195 Mt CO_2 go into underground storage (CCS) and **85 Mt CO_2** are absorbed and reused in other sectors (carbon capture and utilisation, CCU). The 195 Mt CO_2 in storage are then divided into **134 Mt CO_2** from fossil fuels and **62 Mt CO_2** included in the overall balance as removals. This total is made up of BioCCS and DACCS removals and thus comprise the industrial removals (see also Table 2-1).

Comparison with the recommendations of the ESABCC

In ESABCC (2023), the scenarios analysed for 2040 result in the following ranges in the iconic scenarios (see also Table 2-1):

- Fossil CCS: 50 to 200 Mt CO_2
- Industrial process CCS: 5 to 70 Mt CO_2
- Bioenergy with carbon capture and storage (BECCS) & DACCS: 50 to 200 Mt CO_2
- CCU: 0 to 166 Mt CO_2.[2]

The ranges in selected scenarios are 46-207 Mt CO_2 for BECCS and 0-7 Mt CO_2 for DACCS. The ESABCC assumes maximum carbon management of 425 Mt CO_2 in 2050. The results of the scenarios in the impact assessment are higher than this maximum, at 452 Mt CO_2.

In a S2.5 scenario based on the impact assessment, the amount of fossil CCS – 134 Mt CO_2 – falls within the range of the iconic scenarios, but is around twice as high as in two of the three scenarios. At approx. 200 Mt CO_2 in 2040, the use of fossil CCS in the "mixed option pathway" is around four times higher than in the other two scenarios. In the impact assessment, 62 Mt CO_2 are included as BECCS and DACCS in a S2.5 scenario. This total is made up of 34 Mt CO_2 BECCS and 29 Mt DACCS. The latter is clearly outside the range shown by ESABCC while the use of BECCS is lower.

The CCU assumed in the S2.5 scenario lies exactly in the middle of the range specified by the ESABCC. However, this quantity is used exclusively for the production of e-fuels in the scenarios up to 2040, and only from that year onwards for the production

[1] This already includes the capture of CO_2 from fossil fuels (see discussion below), the amount of which will be very limited at that time.
[2] ESABCC (2023), Figures 18, 24, 25 and 26.

of synthetic materials. This exclusive use for a product that tends to be imported in most scenarios seems questionable.

For the quantitative target, these results could be interpreted in such a way that the total amount of removals, 400 Mt CO_2, includes approx. **60 Mt CO_2 from industrial** carbon sequestration[3]; the **natural sinks** would therefore have to amount to **340 Mt CO_2**. The natural sinks amount to 316/317 Mt CO_2 in the S2 and S3 scenarios respectively and to 360 Mt CO_2 in the LIFE scenario. The 340 Mt CO_2 from natural sinks would therefore be within the scope of the scenarios (and comprise an increase of 30 Mt CO_2 compared to the 2030 target of the LULUCF Regulation). All the values mentioned for the LULUCF sink are within the range of 100-400 Mt CO_2 specified in ESABCC (2023).

Table 2-1 shows the targets for 2040 and the detailed values for carbon management in scenario S2.5 and, where possible, compares these with the recommendations of ESABCC 2023.

Table 2-1: Proposal for 2040 and its interpretation compared with the ESABCC recommendations

	Proposal, specified and interpreted		S 2.5	ESABCC recommendation
	[Mt CO_2-eq]	[% vs 1990]	[Mt CO_2-eq]	[Mt CO_2-eq]
Net emissions	**450**	**-90%**	**467**	-90% to-95%
Gross (after fossil CCS)	**850**	-83%	**846**	
Removals	**-400**		**-379**	
LULUCF	-340		-317	100-400
Industrial	-60		-62	50-200
Carbon management	**280**		**284**	425 (for 2050)
CCS_ Underground storage	195		**196**	
Fossil CCS	134		**134**	50-200
Power generation	37		37	
Industrial processes	97		97	5-70
BioCCS & DACCS	62		**62**	50-200
BioCCS	34		34	46-207
DACCS	29		29	0-7
CCU	85		**88**	0-166

Note: With a view to carbon management, CO_2 sequestration includes only the effects of BioCCS and DACCS; the values correspond to the industrial sinks in the upper section. The values in the lower section are calculated from the scenario results; the upper section shows rounded targets.

Source: ESABCC 2023; impact assessment and authors' own calculations

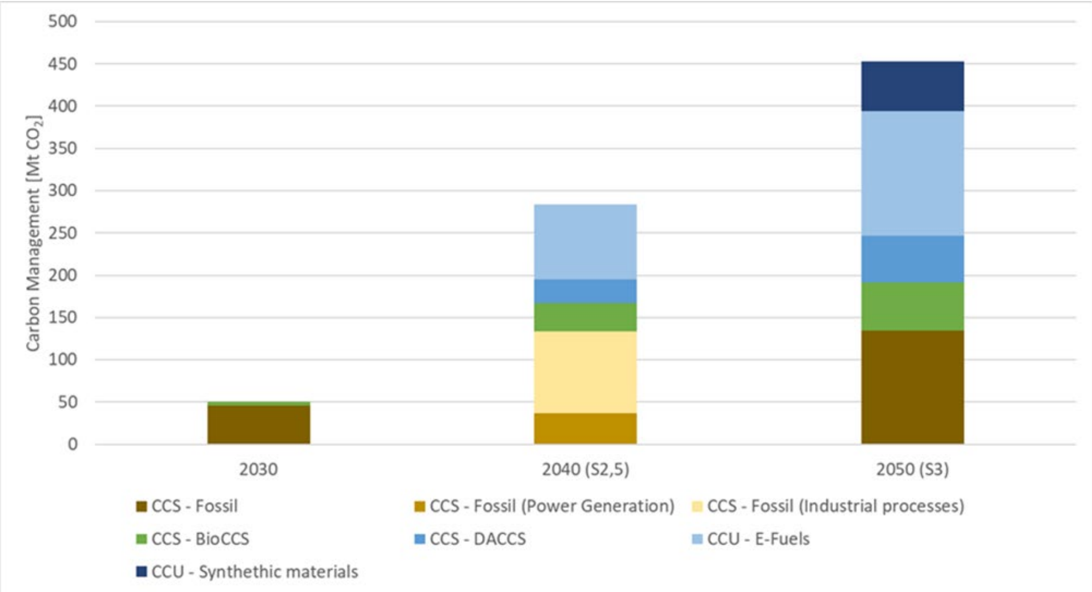
The three scenarios S1-S3 differ primarily with a view to carbon management levels in 2040, i.e. the speed at which carbon capture, storage and utilisation are expanded. The use of hydrogen also increases significantly from S1 to S3, primarily as a result

[3] This corresponds to the value for DACCS and BECCS as rounded targets, based on the calculated 62 Mt CO_2.

of the increased use of hydrogen for e-fuel production. For many other key points of the energy system, the results of scenarios S1-S3 are very similar.

Figure 2-1 shows the development of projected carbon management for 2030 to 2050. For 2040, scenario S2.5 is used, i.e. the recommended scenario as the mean value of scenarios S2 and S3. Between 2030 and 2040, the total amount of carbon management increases from 50 Mt CO_2 to more than 275 Mt CO_2. It is striking that the planned quantities for fossil CCS hardly increase at all between 2040 and 2050, while BioCCS, DACCS and CCU for e-fuel production in particular increase sharply during this period and the production of synthetic materials is added. It should be noted that in 2040 in the S2.5 scenario, a large share of the carbon used for e-fuel is removed by direct air capture; consequently, DACC technologies are used for a total of 70 Mt CO_2. This figure seems particularly high in view of the high costs still expected for this technology in 2040.

Figure 2-1: Development of carbon management in scenario S2.5



Source: Authors' own diagram based on (EC 2024c)

New transparency regarding carbon management

The impact assessment shows a new transparency with regard to the new carbon technologies, which raises questions about the results in earlier publications.

A clear distinction is made between "Carbon Management," "Carbon Capture (CC)" and "Carbon Storage (CS)". These are elements whose effect on the emissions balance is completely open. In addition, there is "Fossil CCS" as a zero-emission technology, "BioCCS + DACCS" as negative emission technologies[4] and "Carbon Capture and Utilisation (CCU)". For the latter, different storage periods (short/long-term) need to be taken into account with a view to the overall balance. The Industrial Carbon

[4] For wood-based BECCS, however, this actually only applies in the long-term integral. Biochar is not shown separately because it is assumed that all products of the pyrolysis of biomass during the production of biofuels are gaseous and are captured. Other industrial removal technologies are not taken into account (see p. 150 of EC 2024e).

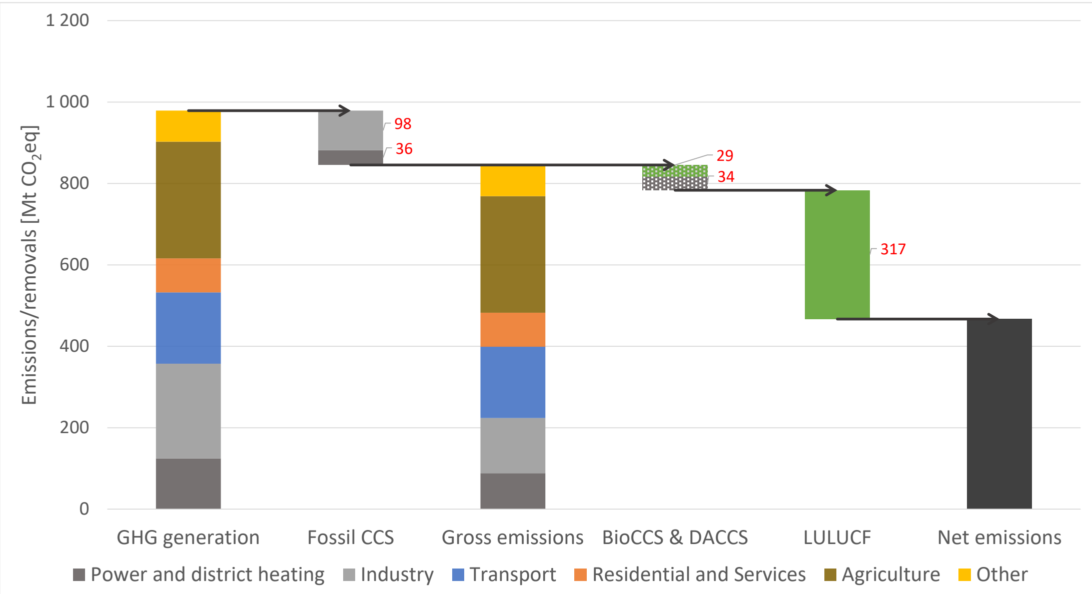
Management Communication shows amounts for the necessary infrastructure expansion.

In all scenarios, **CCU** is **only used for e-fuel production** up to 2040. Only from that year onwards is CCU used to produce materials. It is not clear from the results reported (in tabular form) which sectors apply CCU, particularly in terms of carbon extraction. As CCU will only be used for e-fuel production up to 2040, no carbon storage periods in products need to be taken into account until then. No storage in products for materials has probably been included up to 2050 either; this can be regarded as a **conservative approach**.

When analysing the tables of results, it is noticeable that the specified **gross emissions** show the situation after the use of fossil CCS. The actual volume of greenhouse gases is thus not shown transparently. It is only indirectly possible to allocate fossil CCS to the sectors, i.e. by comparing different tables and diagrams, some of which use categories inconsistently or unclearly. Figure 11 (Annex 8) of the Impact Assessment shows values of 136 Mt CO_2 of fossil CCS in industrial processes and 33 Mt CO_2 of fossil CCS from energy generation for the S3 scenario.

Figure 3-1 shows the overall balance of emissions for scenario S2.5 in the form of a waterfall chart. The quantities of fossil CCS and the industrial and natural sinks are shown transparently. The difference between the volume of greenhouse gases and the net emissions is also shown.

Figure 3-1 Waterfall chart of GHG production to net emissions (scenario S2.5)



Source: Authors' own diagram

When the tables of gross and net emissions are compared, it becomes evident that BioCCS and DACCS are applied in the "Power and district heating" and "Other energy" sectors. The **net emissions of these sectors therefore include industrial removals** and thus significantly distort the sectoral results.

These two elements prevent a meaningful discussion of the results that are directly presented. Additional analyses, or an examination of the energy inputs for carbon technologies, are therefore necessary to gain an overview of the actual greenhouse gas emissions in the sectors.

Table 3-1 summarises the sectoral information for scenario S2.5. The gross emissions for 2030 comprise a reduction of 53% compared to 1990. Taking into account the LULUCF sink of 310 Mt CO_2 in the LULUCF Regulation and the industrial sink from BioCCS of 4 Mt CO_2 in Table 5 of the IA, there is a 58% reduction in net emissions compared to 1990. This corresponds to a reduction of 41% compared to 2015. In the S2.5 scenario, gross emissions fall by 57% in the decade between 2030 and 2040.

Table 3-1 Sectoral developments in scenario S2.5

Mt CO_2 eq		2015	2030		S 2,5 - 2040			
		Gross	Gross	Gross 2030 vs 2015	GHG generation (before fossil CCS)	"Gross"- GHG emissions (after fossil CCS)	Net GHG emisions	GHG generation % vs. 2030
Total GHG Emissions (target scope)		**3914**	**2301**	**-41%**	**979**	**846**	**467**	**-57%**
Power and district heating (net includes BECCS)		1031	339	-67%	70	33	-1	-79%
Other Energy sectors (energy branch and DACCS)*		237	133	-44%	56	56	28	-58%
Industry (Energy)		605	232	-36%	85	85	135	-64%
Industry (Non-Energy)			157		148	51		-6%
Domestic Transport		780	583	-25%	132	132	132	-77%
Residential and Services		519	221	-57%	84	84	84	-62%
Other Non-Energy sectors		130	56	-57%	26	26	26	-54%
International transport (target scope)	*Intra-EUaviation*	107	43	5%	29	29	29	-34%
	Intra-EUnavigation		25		5	5	5	-80%
	50% extra-EUmaritime MRV		44		10	10	10	-77%
Agriculture		385	361	-6%	287	287	287	-21%
Waste		120	87	-28%	55	55	52	-37%
LULUCF net removals		-322	-310	-4%			-317	

Source: Authors' own compilation

This table clearly shows that even in the ambitious scenarios S2 and S3, a significant amount of emissions would still fall under the ETS 1. For the COM's proposal, considered as the mean value of S2 and S3 (S2.5), the amount would be approx. 200 Mt CO_2-eq if the usual ETS shares are applied to the emissions of the individual sectors. By this logic, approx. 330 Mt CO_2-eq would be generated within the ETS and 130 Mt CO_2 would be removed from the ETS by CCS.

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