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Carbon Budgets Working Group – Final Report Oliver Geden

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Executive Summary

This report focuses on the role of Carbon Dioxide Removal (CDR) in achieving ambitious climate targets, the incomplete representation of CDR methods in modelling frameworks, experience in other EU Member States and potential CDR-related interactions of Irish climate policy with EU climate policy.

Charting out trajectories towards net-zero emissions for Ireland necessarily involves some level of CDR, to counterbalance hard-to-abate residual emissions (e.g. from aviation, agriculture, or some industrial processes). However, any long-term planning is confronted with the fact that only very few CDR methods are represented in models so far, with afforestation and reforestation being the only ones deployed at a meaningful scale, and many 'novel' methods currently at relatively low readiness levels.

GOBLIN and TIM models use considerable amounts of CDR until 2050 and beyond. In GOBLIN, the combined trajectories (gross emissions and gross removals) in the land use, land-use change and forestry (LULUCF) sector seem very optimistic given the experience with declining net LULUCF sinks in other EU Member States, in the face of an already changing climate. On CDR methods beyond forestry, it may be wise to consider emerging options like biochar and enhanced rock weathering, both in future modelling efforts and policy assessment. Deployment of Bioenergy with Carbon Capture and Storage (BECCS) is shown in GOBLIN calculations, but should be reported only in TIM scenarios (in the sectors with BECCS installations), in line with existing National Inventory Reporting.

TIM is using BECCS across all scenarios, but seemingly only in the power sector. In other OECD countries BECCS is discussed and modelled also in the industry sector and in waste incineration plants, which may emerge as real-world options in Ireland as well – as will DACCS (already indicated in the narrative scenario document, and modelled in several countries and for the European Commission). Other novel CDR options are tried and tested in other countries already and may emerge in modelling frameworks soon. But given their currently very low deployment levels around the world (Smith et al. 2024), it is at this point impossible to robustly assess which volumes of CDR could be delivered in which countries at which costs and with which side-effects and/or co-benefits.

Finally, it is foreseeable that the EU will increasingly regulate CDR, e.g. by integrating it into its Emissions Trading System (ETS) I. But beyond more detailed regulation, CDR will also play a role in the 'political economy' of EU climate policy, which may lead to tensions between Irish and EU climate policy, and/or to more stringent obligations for Ireland than currently expected – stemming from the (potential) use of different emission metrics in Ireland and the EU (GWP* vs. GWP100, which will affect CDR volumes needed), future decisions about the basic pillars of EU climate policy (continuation of national Effort Sharing targets vs. Agri-ETS), and EU net-negative emissions targets post-2050.

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Full report

Given that my main expertise covers Carbon Dioxide Removal (CDR) and the European Union's climate policy, my report does focus on these aspects. It combines perspectives on the role of CDR in achieving ambitious climate policy targets, the incomplete representation of individual CDR methods in mitigation modelling frameworks, experience in other EU Member States and potential CDR-related interactions of Irish climate policy with EU climate policy.

Like in any other OECD country or the European Union, charting out trajectories towards net-zero emissions for Ireland necessarily involves some level of CDR. This stems from the simple fact that "the deployment of carbon dioxide removal (CDR) to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO_2 or GHG emissions are to be achieved" (IPCC 2022). A domestic *net*-zero target indicates that there will be residual emissions (e.g. from aviation, agriculture, or some industrial processes) and that anthropogenic removal of CO_2 will be needed to offset these remaining emissions.[1] While in real-world policymaking, CDR deployment planning may follow from considerations about residual emissions stemming from hard-to-transition sectors, in modelling frameworks the sheer existence of considerable levels of CDR at moderate costs can create residual emissions in mitigation trajectories (Lamb 2024), simply because a model chooses the cheaper mitigation option, assuming full fungibility of CDR and emission reductions. At the same time, any planning for achieving national net-zero pathways needs to deal with the fact that only very few CDR methods are represented in models so far, and even fewer – namely afforestation and reforestation (and in some countries also Harvested Wood Products, HWPs) – are actually deployed at a meaningful scale, while many 'novel' methods are currently at relatively low readiness levels (Smith et al. 2024).

The GOBLIN and TIM models do use considerable amounts of CDR until 2050 and – in the case of GOBLIN – beyond. Not considering myself an expert on practices and processes in the land use, land-use change and forestry (LULUCF) sector, I am not in the position to scrutinize the assumptions around the various afforestation levels and types of improved forest management practices modelled in GOBLIN. However, I want to note that the combined LULUCF trajectories (gross emissions and gross removals) seem very optimistic for a country that traditionally has been a net LULUCF emitter while those EU Member States that have traditionally been net removers (most of the EU27) are, in the face of an already changing climate, now struggling in keeping a net LULUCF sink (which is mainly a result of removals via forestry), regardless of a very ambitious overall EU LULUCF target for 2030 (Pilli et al. 2022). Of course, the net LULUCF values achievable in Ireland will also depend on the gross emissions trajectory, not the least influenced by levels of peatland rewetting (which is first and foremost an emissions reduction measure that will lead to removals

[1] Methods for the removal of other greenhouse gases are being proposed in the scientific literature but are generally at a much earlier stage of development. Removing gases like methane or nitrous oxide is particularly challenging because, although powerful greenhouse gases, they are present at very low concentrations in the atmosphere. Counterbalancing residual non-CO_2 emissions with CO_2 removal (with calculations based on emission metrics like GWP100) leads to net-zero CO_2 emissions being reached considerably earlier than net-zero GHG emissions.

only in the very long-term). On CDR methods other than afforestation/reforestation/HWPs it may be wise to consider emerging options like biochar (as soil amendment) and enhanced rock weathering on land already in the accompanying advice (with an educated guess how their inclusion could influence sectoral trajectories), since these may become real-world options in Ireland in the mid-term (like currently already in Denmark), and part of mitigation modelling frameworks (representation of enhanced weathering can already be observed in some global Integrated Assessment Models, with biochar following suit). Finally, I note that removals achieved through the deployment of Bioenergy with Carbon Capture and Storage (BECCS) are shown in GOBLIN calculations, probably to highlight the role of a national bioeconomy for future net emissions trajectories. However, in standard National GHG Emissions Inventory Reports under the United Nations Framework Convention on Climate Change (UNFCCC), removals via BECCS would be shown in the sectors where BECCS facilities are installed, usually Energy and Industry. Therefore, the removals via BECCS should only be accounted for in TIM scenarios, even if this means that the use of BECCS may create a disbenefit in the LULUCF sector (stemming from biomass harvesting), at least if the biomass used in BECCS installations would only be sourced in Ireland (which seems to be a set assumption in both GOBLIN and TIM, which should be made explicit).

TIM is also making use of CDR, namely (considerable levels of) BECCS in the power sector across all scenarios, which seems to be the only representation of BECCS in the model. In other OECD countries the use of BECCS is politically discussed and explicitly modelled also for installations in the industry sector (e.g., via bioenergy input in cement clinker production with CCS, or pulp and paper production with CCS) and in 'waste-to-energy' (= incineration) plants where biogenic material can make up half of the waste treated. If some of these options represent real-world possibilities in Ireland it should be mentioned in the advice that these may emerge in the future, combined with an educated guess how their inclusion could influence modelled sectoral trajectories. At this point, these options are not less realistic at this point than the widespread application of BECCS in power stations. So far, DACCS isn't included in TIM, but as mentioned in the narrative document, it is the obvious next candidate, since relatively easy to represent in standard mitigation modelling (and done in several countries and for the European Commission already). But even BECCS and DACCS (coming with extremely different effects for the energy sector) will not be the only future CDR options beyond LULUCF, so it would be important to mention in the accompanying advice (even if not directly relevant for modelling Carbon Budgets 3&4) that CCS-based CDR currently acts as a proxy for a broader group of CDR options, some of which will emerge in modelling frameworks and/or in the real world – although it is not always clear yet in which sectors these removals (e.g. from biochar in construction materials, biogenic CO_2 in cement aggregates, mineralization of biogenic CO_2 in wastewater treatment) would be reported/accounted for. Given their currently very low deployment levels around the world (Smith et al. 2024), it is at this point impossible to robustly assess which volumes of CDR could be delivered in which countries at which costs and with which side-effects and/or co-benefits. Therefore, it would be prudent not to overestimate near- to mid-term CDR potentials but at the same time strategically invest in research, development and demonstration (Nemet et al. 2023), in an internationally coordinated manner (Schenuit et

al. 2024). Finally, the use of a backstop for missing mitigation solutions may be necessary for now. But since the €2000/tonne threshold is much higher than existing non-BECCS CDR options even today, it would be important to hint towards likely effects of an integration of more mitigation options (CDR, or SAFs, or else) in scenarios, for currently assumed exceedance levels for Carbon Budgets 1-4, or 'payback' from net-negative Carbon Budgets post-2040.

Finally, on the EU context in relation to CDR. It is obvious that CDR will need to be integrated in the Emissions Trading System (ETS) I (covering the power sector and heavy industry), since there will be now new allowances issued from the end of the 2030s, while reaching zero industrial process emissions is not feasible in some sectors (like cement or lime) even with CCS – for which several approaches exist (Sultani et al. 2024). The regulatory framework will be negotiated after the agreement on the economy-wide EU 2040 target, when the European Commission will present an updated legislative package for the 2030s. Beyond detailed regulatory issues, CDR will also play a role in the 'political economy' of EU climate policy. Like in most EU Member States, the Irish climate policy debate uses the vision of reaching net-zero (CO_2 or GHG) emissions as long-term focal point. A temperature assessment of selected Irish carbon budget scenarios based on emission metrics other than GWP100 (like GWP*) may show that net-zero GHG emissions are not necessarily needed to comply with national obligations. However, it should be taken into account that EU climate policy frameworks may lead to more stringent obligations for Ireland, in three dimensions.

1) It is unlikely that the EU will shift from GWP100 to any other emissions metric. This is obviously a burden for a country with much higher-than-average methane emissions from livestock, a feature persisting in all GOBLIN scenarios. While Ireland is free to make additional use of GWP* in national reporting & accounting, it is obliged under the 'Paris rulebook' to use GWP100 as a standard in international reporting. Under current scenarios, reaching net-zero GHG under GWP100 will require very high amounts of CDR from Ireland. Alternatively, Ireland could try to reach net-zero GHG emissions under GWP* or pursue a net-zero target only for long-lived GHGs, similar to the approach currently taken by New Zealand. Since the EU's net-zero GHG target for 2050 is defined as a 'union-wide' target in the EU Climate Law, this would be possible in principle. But if Ireland would effectively plan to stay above net-zero GHG (under GWP100) in 2050, this would at least implicitly require that other EU Member States reach net-negative levels to counterbalance Irelands net-positive emissions (Geden/Schenuit 2020), a scenario that is likely to be contested by other Member State governments.

2) What looks like a hypothetical option now will largely be affected by the evolution of the EU's climate policy pillars post-2030. If the Effort Sharing pillar for sectors beyond the ETS-I would stay in its current form (despite the introduction of the ETS-II for some of the sectors currently covered by national targets under the Effort Sharing Regulation, ESR, namely transport and buildings) then staying net-positive because of significant levels of agricultural non-CO_2 emissions would need to take the form of a negotiated outcome in future rounds of national ESR target setting. But if the Effort Sharing pillar would be dismantled, and an ETS-III for agricultural emissions were to complement ETS-I and ETS-II (as discussed within in the European Commission) then staying above net-zero in 2050 as

an individual Member State would not be as visible anymore, because it would not take the form of a national target negotiated a decade in advance. Still, if Ireland were to aim to stay above net-zero GHG emissions in 2050, other Member States would need to be below net-zero.

3) Regardless of the 2050 GHG emission levels (under GWP100) that Ireland will eventually aim for, it is likely that European climate policy will not end with focusing on net-zero GHG emissions. The EU Climate Law already foresees net-negative GHG emissions for the period after 2050, so far without any further quantification. It can be expected that in global climate negotiations, already existing demands for OECD countries to go net-negative will intensify in coming years (Mohan et al. 2021; Schenuit et al. 2024), which may force the EU to further increase its ambition – which would affect Ireland's trajectory as well.

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