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Carbon commitment analysis of primary energy in national policy projections and energy system alternatives, with and without carbon capture or carbon dioxide removal

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National Energy and Climate Plans (NECPs) currently being developed by EU member states will be required to contribute to fulfilling the temperature objectives of the Paris Agreement (PA). Scientifically, the PA temperature objectives directly equate to limiting future cumulative CO_2 emissions within a global carbon budget (GCB) range. Policy and modelling increasingly includes options to abate fossil fuel (FF) emissions using carbon capture and storage (CCS) or to enable carbon dioxide removal (CDR), through bioenergy with CCS (BECCS) or other negative emissions technologies (NETs). Therefore, including these options, it is critically important to undertake carbon commitment analysis of the cumulative national CO_2 emissions due to planned or projected, energy and land use (LU) pathways, relative to estimates of an equitable national carbon quota (NCQ) based on a PA-aligned global carbon budget (GCB). Despite this need, cumulative CO_2 pathways and indicative NCQs are commonly absent from energy system analyses and policies, and energy and land use are often addressed relatively independently. Therefore, we developed a simple spreadsheet model ("Anthem") to present coarse-grained, carbon commitment analysis of primary energy supply for existing national policy projections and modelled alternatives, including CCS and CDR. In principle, this open source model can be used at global or regional level or for any specified nation. Here we apply it to Ireland's policy projections and alternative energy system futures from 2020, with and without potential CCS or CDR. Previously we estimated a prudent and minimally equitable, PA-aligned, Irish NCQ as 378 $MtCO_2$ from 2015 onward (McMullin et al, forthcoming). We find that current policy projections, with continued high fossil fuel use, overshoot this NCQ as early as 2025 and rapidly accumulate carbon debt, tacitly commiting to rapidly achieving large scale CDR. Avoiding overshoot would require immediate radical reductions in unabated FF use (>95% by 2025) and result in a near-term energy trough until progressive deployment of variable renewable and sustainable bioenergy might again increase energy availability. Substantive CCS to enable FFCCS and CDR becoming available as early as 2025 would still not avoid an energy trough, but would enable more rapid rebound in energy availability as large scale FFCCS is added to low carbon energy supply. NCQ overshoot already appears inevitable for Ireland but then limiting future carbon debt within plausibly achievable CDR deployment still requires urgent measures to cut unabated FF combustion and ongoing LU CO_2 emissions without delay. Our model shows that annual and cumulative CCS CO_2 storage from FF and CDR required to return to the NCQ can approach 1000 $MtCO_2$. Given significant investment and uncertainty costs of CCS and NETs, our NCQ-constrained modelling shows that delaying radical reductions in FF and LU emissions likely results in increasingly costly tradeoffs between near-term energy availability and negative emissions requirement – assuming good faith commitment to the Paris Agreement objectives.