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ECEMF Policy Brief: Insights on EU2040 targets

based on a model intercomparison exercise of EU Climate Neutrality Pathways

Introduction

The EU's 2040 emission reduction targets are an important milestone for the transition towards climate neutrality in 2050. They bridge the gap between the measures currently implemented for 2030 and the long-term ambition of Net Zero greenhouse gas (GHG) emissions in 2050, and play a vital role in aligning the expectations and investment strategies by all stakeholders that contribute to the transformation.

The European Climate and Energy Modelling Forum (ECEMF) project funded by the EU Horizon 2020 research programme is ideally suited to provide information for a sound identification of the EU 2040 targets. It recently concluded the first round of a multi-model intercomparison of the EU's climate neutrality target, in which both integrated assessment models and energy supply models developed quantitative pathways that explore how the EU can achieve its targets set in the EU climate law.

This policy brief presents insights on overarching and sectoral transformation milestones to be reached by 2040 in pathways towards climate neutrality in 2050.

Key insights

1. The modelled pathways show average EU GHG emissions reductions in 2040 (vs 1990 levels) of 86% (interquartile range across the models: -85% to -87%, full model range: -84% to -89%)[1]. Optimal 2040 emission reductions thus require increased ambition compared to a straight line reduction from 2030 to 2050.

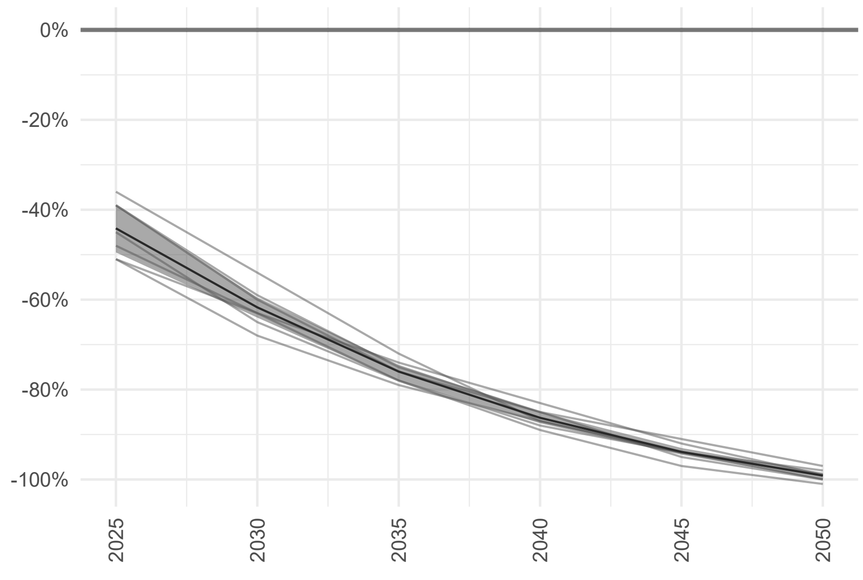

Figure 1: EU GHG emission reductions compared to 1990 for the years 2025-2050 based on modelled scenarios. The thick line represents the average value, shaded areas the interquartile range, and the thin lines show individual model results.

[1] These values refer to total GHG emissions including all bunker fuels. Other analyses, such as the recent report by the EU Scientific Advisory Board on Climate Change, chose to only include intra-EU bunker fuels in their GHG reduction metric. Using a "only intra-EU bunkers" metric would likely increase the ECEMF GHG reduction values by 2-3 percentage points so that the full model range would be about -86% to -92%.

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2. Decarbonization of the electricity sector is achieved before 2040, and is mainly based on the rapid expansion of wind and solar power, which together provide 68% of the EU's electricity generation by 2040 (interquartile range: 63-69%). This is achieved by a fast scale-up of wind and solar energy, which jointly increase almost six-fold from 2020 to reach 3600 TWh/yr by 2040 (interquartile range: 4 to 7-fold increase to 2800 to 4400 TWh/yr). Solar power increases more than 9-fold to 1400 TWh/yr (interquartile range: 7 to 10-fold increase to 1100 to 1500 TWh/yr), while wind power increases 5-fold to 2200 TWh/yr (interquartile range: 4 to 6-fold increase to 1800 to 2600 TWh/yr). When including the contribution from hydro, biomass and geothermal power, the share of renewable electricity in the power sector increases to 85% (interquartile range: 82-90%)

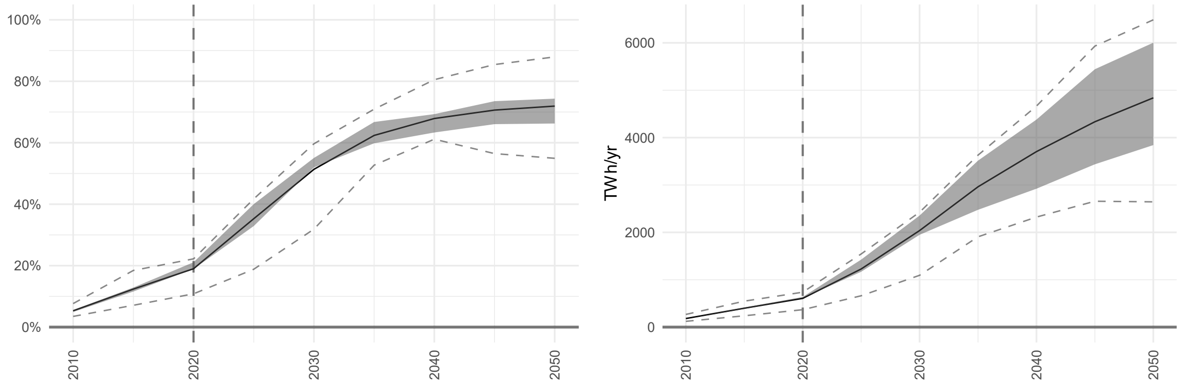

Figure 2: Share of wind and solar power in total electricity generation for EU 27 & UK (left). Total electricity generation from wind and solar for EU27 & UK (right). Continuous lines represent average values, shaded areas the interquartile range, and dashed lines the highest/lowest values.

3. Direct electrification based on a decarbonized electricity sector is the cornerstone of climate neutrality. Electricity becomes the main energy carrier, doubling its share compared to 2020, so that it provides on average 41% (interquartile range: 37 to 45%) of final energy by 2040 (including bunker fuels). This will require a fast upscaling of electric vehicle and heat pump sales to shift large shares of mobility and heating provision to electricity.

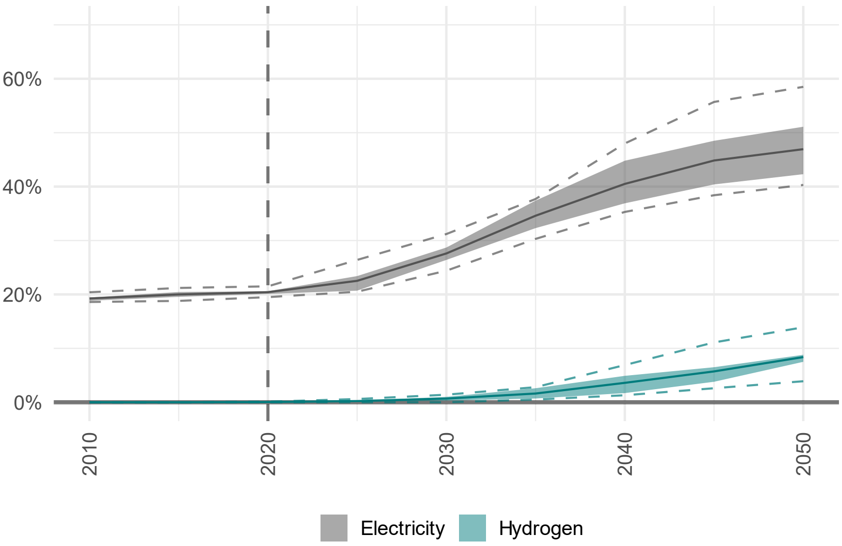

Figure 3: Share of electricity (grey) and hydrogen (turquoise) in final energy demand for EU 27 & UK (including bunker fuels). Continuous lines represent average values, shaded areas the interquartile range, and dashed lines the highest/lowest values.

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4. Carbon Capture and Storage (CCS) reaches maturity and is deployed at industrial scale. Carbon capture is scaled up to 305 MtCO2 on average (interquartile range: 215 - 376 MtCO2) by 2040. This would represent a four-fold increase over the 2030 target of 50 MtCO2 stated in the Net-Zero Industry Act, which will likely require tremendous efforts given the mixed track record of CCS project implementation over the last decade.

5. Hydrogen final energy demand is scaled up to reach 1.2 EJ/yr (interquartile range: 0.5-1.7 EJ/yr), equivalent to 16 Mt H_2 (interquartile range: 4-18 Mt H_2) in 2040. This amounts to 3% of total final energy use in that year.

Besides its use as final energy carrier in industry, transport or buildings, hydrogen is in these scenarios also used to produce other energy carriers. Total hydrogen use (including hydrogen that is further converted into e-Fuels or electricity) reaches 1.8 EJ/yr in 2004 (interquartile range: 0.5-2.0 EJ/yr), equivalent to 15 Mt H_2 (interquartile range: 4-17 Mt H_2). It is interesting to note that none of the models goes beyond 7 Mt H_2 use in 2030, thus staying far below the REPowerEU target of using 20 Mt H_2 by 2030, 10 Mt of which should be produced within the EU.

Methods:

This study reports on the first round of a model intercomparison exercise on the EU's climate neutrality target, using several integrated assessment models and energy supply-side models to develop quantitative pathways that explore how the EU can achieve its targets.

- Analysis is based on scenario from the following models: IMAGE 3.2, LIMES 2.38, MEESA 1.1, OSeMBE 1.0.0, PROMETHEUS 1.2, REMIND 3.2, TIAM-ECN 1.2, WITCH 5.0.
- The full-system models were tasked to reach Net Zero GHG emissions in 2050 while respecting the 2030 GHG emission reduction target. The models should achieve this based on a mix of carbon pricing and additional climate policies by the discretion of each modelling team.
- Three supply-side models were given CO2 emission targets for the electricity/electricity and heat sectors that were in line with the results from the full-system models, to determine in more detail the power sector transformation compatible with the overall Net Zero target.
- For LULUCF emissions, different accounting paradigms exist between the UNFCCC and the integrated assessment modelling community (also known as the "Grassi issue"). Accordingly, for each model a LULUCF offset was calculated to make the modelled 2015-2020 average LULUCF emissions match with the historic 2015-2020 average, and this offset was applied throughout the modelling horizon

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