Modelling Net Zero and Sector Coupling: Lessons for European Policy Makers

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1. Motivation

Net Zero (NZ) is the name given to the policy target of reducing to zero (net) GHG emissions across the economy. In March 2020 the European Commission proposed a European Climate Law aimed at legislating for Net Zero across the European Union, this has recently (as of June 2021) become law having passed through the European Parliament and Council. While the prospects for electricity decarbonisation to 2030 are promising, the necessity of deep decarbonisation of the entire energy system by 2050 remains challenging.

Sector coupling is commonly understood as integrating the energy consuming sectors (such as buildings, transport, and industry), and optimising them with the energy supply sector. The joint decarbonisation of the electricity and gas sectors is seen as critical to the achievement of the NZ target in the European Union and the UK. What a NZ implies for energy and environmental policy can be clarified by appropriate energy system modelling.

2. Short account of the research

This paper seeks to discuss some of the policy implications which arise from the modelling of Net Zero GHG emissions in 2050 within a sector coupling approach. We draw on a major study of the EU-UK energy system in 2050 produced by the Centre for Regulation in Europe (Chyong et al., 2021), which involved stakeholders from both electricity and gas sectors in a year-long modelling exercise of the European energy system. While no model of the future is an accurate forecast, an optimisation model of the Net Zero energy system is very helpful in clarifying the role the modelled technologies might play in a future energy system under binding government policy targets. What our modelling highlights is that the achievement of Net Zero depends on the massive scale up of variable renewable electricity, biomethane, hydrogen and carbon capture and storage (CCS) technologies.

As with all scenarios, our modelling is not a prediction about the future, and we are not saying a priori that our reported scenarios are absolutely likely to come about or that any one scenario is more likely than another. We report our NZ scenario and our 90% GHG reduction scenario (relative to 1990) and show very significant changes to the European energy system relative to today. Our modelling allows us to discuss the potential magnitudes of future electrification, use of hydrogen, use of biomethane and the extent of carbon capture (with and without storage) to be explored. Specifically, the modelling produces magnitudes for the amount of sector coupling, which we take to encompass power-to-hydrogen (power-to-H2) as well as synthetic methane and synthetic diesel produced by combining hydrogen and CO_2 captured from bio-energy (i.e. e-gas and e-liquid).

3. Conclusions for Policy makers

Our modelling highlights the following conclusions for policy makers and policy making.

The continuing roll out of renewable electricity supply (RES-E) is essential to any deep decarbonisation scenario and the required rate of roll out of wind is much higher than has previously been achieved. A striking consequence of the increased reliance on a renewables-based electricity system is that a substantial increase in electricity trading is envisaged.

Depending on relative costs and the depth of decarbonisation, electricity is required to be transformed into carbon-neutral gaseous or liquid fuels, which implies significant transformation losses com-

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pared to the route of direct electrification. Bio-energy with carbon capture and storage (CCS), otherwise known as BECCS, is an essential NZ technology as a source of negative emissions. Achieving NZ with this technology requires a large increase in the use of biomass. Hydrogen and biomethane have key roles in each of our NZ scenarios, given our currently available/envisaged technologies out to 2050, provided that the large increase in biomass availability turns out to be sustainable.

Fossil fuel prices do continue to make potentially significant differences, especially in determining the relative quantities of hydrogen produced from electrolysis (green hydrogen) vs. from steam reformation of methane with carbon capture and storage (blue hydrogen).

The successful scale-up of multiple technologies supported by appropriate policies will be critical for the achievement of any of our Net Zero scenarios. Scaling up new industries over which different EU member states have different preferences means that policy should both encourage learning from experimentation and harmonisation of arrangements across the EU. What our NZ scenarios show is that some massive scaling up of currently nascent technologies – e.g. hydrogen, CCS, biomethane - is part of Net Zero under a wide range of cost assumptions. While there may be lots of small injections of locally produced hydrogen, this is not enough on its own in any of our Net Zero scenarios. Our detailed modelling assumes that there are separate methane and hydrogen networks in 2050.

Finally, net zero raises big future issues as to how costs will be allocated to consumers.

Overall, net zero in Europe remains an extremely technologically challenging policy goal, involving the roll out of multiple new technologies at scale in a 30-year time frame. It requires policy to deliver three times the carbon reduction achieved in the last 30 years. Modelling clearly shows that wholesale failure to scale up any one of the key technologies on which our Net Zero scenarios depend – RES-E, biomethane, hydrogen or CCS – will fundamentally block the path to Net Zero, necessitating a currently unforeseen technological break-through. This is in addition to the fact that modelling shows the necessity of the extension of the single market in electricity and assumes uniformly high carbon prices and deep improvements in energy efficiency relative to business as usual.