

Can the World Achieve Carbon Neutral Energy Balances?

Jonathan Stern*

Introduction

Given the climate crisis repeatedly confirmed by the scientific community, most recently in the 6th Assessment Report (Working Group 1) of the International Panel on Climate Change (IPCC), the urgency to reduce greenhouse gas emissions from the energy sector has increased significantly. Around 40 countries have made pledges to reduce their emissions to net zero (ie carbon neutrality) by 2050 (2060 in the case of China), which account for 40% of the global population, 70% of global GDP and around 75% of CO₂ emissions.

In May 2021, in response to a request by the organisers of the November 2021 COP26 meeting, the International Energy Agency (IEA) produced a report, ‘Net Zero by 2050 – a roadmap for the global energy sector’. The IEA’s net zero energy (NZE) scenario is a modelled pathway which sets out actions which need to be taken if NZE is to be achieved by 2050. The study has provoked strong responses by critics, notably by the Saudi Arabian Energy Minister who was quoted (Financial Times, June 5/6 2021) as saying, “Whoever put that scenario [together] is not in touch with reality”. However, it is not clear whether such critics are saying that NZE by 2050 is impossible, or whether the IEA have chosen the wrong modelling assumptions to achieve this outcome.

Required Milestones to Achieve NZE by 2050

Although the focus of net zero tends to be 2050, it is clear that unless certain milestones are achieved by 2030 it will be almost impossible to ‘catch up’ with emission reduction targets because the ‘carbon budget’ (ie the emissions which will already be in the atmosphere) necessary to ensure the limitation in global temperature increase, will have been exceeded, and because the lead times necessary to achieve key milestones for 2050 are measured in decades. Some of these milestones are:

- From 2021: no new oil and gas fields should be approved for development (although existing fields and extensions of those fields can continue); no new coal mines or mine extensions should be approved; no new unabated coal plants should be approved for development.
- By 2025 no new sales of fossil fuel boilers.

* Distinguished Research Fellow and Founder Natural Gas Research Programme, Oxford Institute for Energy Studies, UK/ Distinguished Fellow, IEEJ

- By 2030: all new buildings should be zero-carbon ready; 60% of global car sales should be electric; unabated coal plants should be phased out in advanced countries; more than 1000GW of solar and wind power plants should be built every year.

**Table 1 Required Carbon Prices in Advanced and Emerging Economies
(Real US\$ 2019/tonne/CO₂)**

| | 2025 | 2030 | 2040 | 2050 |
|--------------------|------|------|------|------|
| Advanced Economies | 75 | 130 | 205 | 250 |
| Select EMDEs* | 45 | 90 | 160 | 200 |
| Other EMDEs | 3 | 15 | 35 | 55 |

*includes China, Russia, Brazil and South Africa

Source: IEA (2021), *Net Zero by 2050*, Table 2.2

In order to achieve these milestones, carbon prices need to increase significantly from current levels in both advanced and emerging and developing economies (EMDEs) as shown in Table 1. Very few advanced countries have carbon prices which are close to \$75/tonne currently, and which need to be 70% above that level in 2030, and only a few EMDEs (eg China and South Africa) have carbon price regimes.

Fossil Fuel Production and Exports

One of the most controversial milestones is the requirement there should be no new fossil fuel development. The most immediate impact is on global coal production which falls by more than 50% in the 2020s. By 2030, oil production has fallen by 20% and by 2040 it is less than half the 2020 level. Table 2 shows that as demand falls, prices also fall and supply becomes concentrated in the lowest cost producers. This results in OPEC's share of global production rising to nearly 40% in 2030 and above 50% in 2050. Natural gas production is more resilient falling by only 12% by 2030 with the most immediate impact on global LNG trade which is 50% below 2020 levels by

Table 2 Oil and Gas Prices to 2050 (Real US\$ 2019)

| | 2019 | 2020 | 2030 | 2040 | 2050 |
|---------------------------|------|------|------|------|------|
| Crude Oil (US\$/bbl) | 91 | 37 | 35 | 28 | 24 |
| Natural Gas (US\$/mmbtu): | | | | | |
| United States | 5.1 | 2.1 | 1.9 | 2.0 | 2.0 |
| European Union | 8.7 | 2.0 | 3.8 | 3.8 | 3.5 |
| China | 7.8 | 5.7 | 5.2 | 4.8 | 4.6 |
| Japan | 12.9 | 5.7 | 4.4 | 4.2 | 4.1 |

Source: IEA (2021), *Net Zero by 2050*, Table 2.1

2030 and 80% by 2040. This is largely due to most projects being unable to compete at the import prices (for Europe, Japan and China) of less than \$5/mmbtu shown in Table 2, which should be of concern to promoters of new LNG projects. Natural gas producer income falls by 36% in the 2020s compared to the previous decade but remains relatively stable thereafter. By contrast a combination of falling demand and the prices in Table 2 greatly impact the income (and potentially also the political stability) of oil producing and exporting countries, which falls by 55% this decade and continues to fall sharply over the following two decades.

Technologies and Modelling

The progress made with low and zero carbon technologies will clearly be very important for the achievement of NZE. The IEA also stresses the importance of consumer behaviour not only in relation to changes in lifestyle (such as personal transport and household heating choices) but also active involvement in efficiency investment and curbing wasteful consumption. For the industry and agriculture sectors, the importance of improving the collection and recycling of plastics, and increasing the efficiency of fertilisers, are key metrics. Overall, the importance of electrification in industry, transport and buildings, and the use of hydrogen in ‘hard to electrify’ sectors increases significantly.

The NZE scenario was benchmarked against 18 net zero scenarios assessed by the IPCC along different technology parameters. This is important because the selection of technologies and the speed of their development will determine much of cost and difficulty of achieving the desired level of greenhouse gas reduction targets. In comparison to the assumptions in the IPCC scenarios, NZE is: very low in relation to CCUS, direct air capture and bioenergy; moderately low in relation to total final energy consumption; and relatively high in relation to the share of hydrogen and wind and solar in total final consumption.

Although modern bioenergy increases significantly to compensate for the phase-out of traditional biomass, this is not significant in comparison to the IPCC scenarios. Carbon capture, utilisation and storage will be a very important technology for the success of any NZE target. By 2030, 1.7 billion tonnes of CO₂ will need to be captured globally, increasing to 7.6 bn tons by 2050, compared with just 40mt being captured and stored currently. Of the 2030 figure, 80% needs to be captured from fossil fuel production and processes, most of the rest from bioenergy and only 5% from direct air capture. If CCUS fails to achieve these levels – and growth in nuclear power generation is similarly modest – this would require an additional 2000-3000GW of renewable energy by 2030-2050. Hydrogen development relies on fossil fuels (some with CCUS) until 2030 when ‘power to gas’ (green hydrogen via electrolysis) begins to take off. By 2040, the majority of hydrogen production is from electrolysis, and more than 60% by 2050 with CCUS applied to all fossil-based production.

Investment Requirements and Impact on Household Energy Bills

By 2030, NZE sees a requirement for \$5 trillion of investment – more than twice the level spent during 2016-20 – falling only marginally to \$4.5 trillion by 2050. From a sectoral perspective, the majority of this investment in the first two decades is required for electricity generation and infrastructure, but with transport progressively increasing its share over the decades. In terms of technology investment, electrification, electricity systems and efficiency take the majority shares, with hydrogen only becoming important post-2030. Electricity network investment is 3-4 times higher compared to 2020, 60-70% of this being due to increased demand.

Household energy bills are projected to fall significantly in advanced economies both in absolute terms and in relation to share of income. In 2030 this is counterbalanced by the investments which will be required in electrification and efficiency, but by 2050 there is a net fall in household energy expenditure despite investment remaining relatively constant. In emerging and developing economies, energy bills per household increase substantially both in absolute terms and as a share of disposable income. A policy of requiring consumers to pay for efficiency improvements may prove politically contentious, and governments may choose to subsidise a large part of household energy efficiency refurbishment and electrification investments through taxation. But as consumers see the benefits of lower bills due to efficiency improvements, such policies may become increasingly popular.

Conclusions: the Importance of Government Policy

It is important to remember that the IEA NZE study is not intended to be a forecast of what will happen. It is an illustration of one possible pathway (but not the only one) showing what needs to happen if the world is to achieve net zero energy emissions by 2050. Returning to the question posed in the title of this article: “Can the world achieve carbon neutral energy balances?” This overview suggests that it is possible, but very difficult without revolutionary changes in the way the world uses energy and organises energy production and consumption. A large part of those revolutionary changes will need to be driven by government policies. Governments have signed up to pledges – either related to the Paris Agreement (COP 21) or achieving net zero emissions by 2050 – and must urgently demonstrate that they are on track to meet the interim targets they have set for 2030. Meeting 2030 targets will be essential if global net zero by 2050 is to remain a credible aspiration.

Writer's Profile

Jonathan Stern

Professor Stern is a Distinguished Research Fellow and founder of the Natural Gas Research Programme at the Oxford Institute for Energy Studies (OIES). He holds professorships at the University of Dundee and Imperial College, London; and fellowships at the Energy Delta Institute and the Institute of Energy Economics, Japan.