

CHAPTER 1 THE ENERGY TRILEMMA FOR NET ZERO 2050

Norazana Ibrahim and Asiah Nusaibah Masri

1.1 INTRODUCTION

The global pursuit of net zero emissions by 2050 has emerged as one of the most critical challenges of the 21st century. With climate change increasingly affecting economies, societies, and ecosystems, there is mounting pressure on countries and industries to transition to cleaner, more sustainable energy systems. However, this transition presents numerous complexities, particularly when addressing the “energy trilemma” which is the need to simultaneously ensure energy security, environmental sustainability, and economic affordability.

The energy landscape is undergoing a significant transformation. Countries worldwide have committed to reducing their carbon footprints through frameworks such as the Paris Agreement, with many aiming for net zero emissions by 2050. This ambitious target involves balancing the amount of greenhouse gases released into the atmosphere with those removed via carbon capture technologies and natural processes.

This energy transition is propelled by advancements in renewable energy technologies such as solar, wind, hydropower and alongside improvements in energy storage, efficiency, and carbon capture and storage (CCS). Governmental and international organizations have implemented policies and funding initiatives to promote and accelerate

this transition. However, despite the progress, fossil fuels continue to dominate the global energy mix, comprising around 80% of the world's primary energy consumption as of 2021 (International Energy Agency [IEA], 2022).

In many developing economies and fossil-fuel-dependent regions, the shift away from carbon-intensive energy sources create significant economic and social challenges. This disparity in energy transition readiness highlights a global imbalance, with developed nations advancing in clean energy adoption while developing countries face hurdles in accessing the necessary technology and financing for decarbonization.

The journey to net zero is fraught with challenges, and the energy trilemma underscores the conflicting priorities that must be balanced by policymakers, industries, and societies. These challenges include energy security, environmental sustainability, and economic affordability.

Achieving net zero emissions by 2050 will require not only rapid deployment of current clean energy technologies but also the development and widespread adoption of new innovations. While existing technologies can deliver most carbon dioxide (CO₂) reductions by 2030, nearly half of the reductions needed by 2050 will rely on technologies that are still in the prototype or demonstration phase, particularly in heavy industry and long-distance transportation.

Figure 1.1 illustrates annual CO₂ emissions savings in the net zero pathway relative to 2020. It is clear that significant reductions in emissions are crucial for reaching net zero by 2050. The pathway outlined suggests that the bulk of emissions savings comes from various technological advancements and sectoral transformations, with a progressive reduction trend over the years.

Key contributors to these emissions savings include the deployment of existing low-carbon technologies, the development and commercialization of innovations like advanced batteries, hydrogen electrolyzers, and carbon capture technologies, as well as policy-driven changes in industrial and energy sectors. The reduction trajectory emphasizes the necessity for rapid

advancements in technology, large-scale infrastructure development, and a shift in energy systems to cleaner alternatives.

These findings align with the International Energy Agency's (IEA) report on the roadmap for achieving net zero by 2050, which emphasizes that by 2030, nearly half of the required CO₂ reductions will need to come from technologies still in the prototype or demonstration stage. Additionally, the continued scaling up of renewable energy sources, coupled with significant R&D investments, will be essential to maintain the pace needed to achieve these emissions reductions (IEA, 2021).

Implementing clean energy transformations may be challenging, so decisions must be transparent, fair, and cost-effective. Governments need to ensure that energy transitions are inclusive and people-centred. In emerging markets and developing economies, household energy costs are expected to rise slightly as more people gain access to energy and demand increases. To ensure energy remains affordable, policies like tax credits, loans, and targeted subsidies should be used to support low-income households.

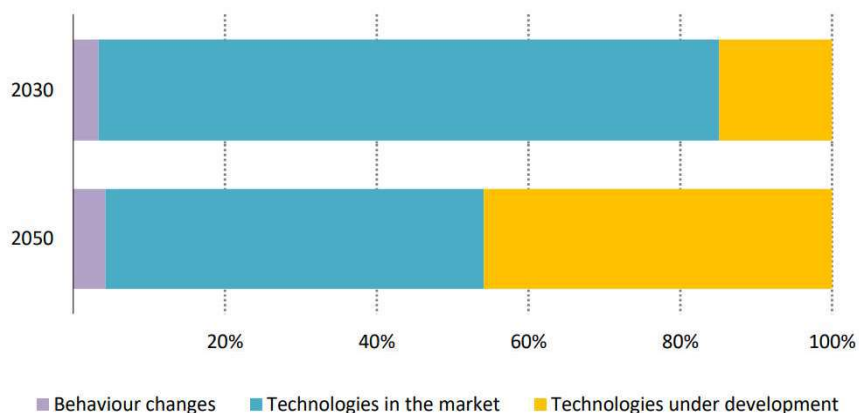


Figure 1.1 Annual carbon dioxide emissions saving in the net zero pathway, relative to 2020 (Source: IEA, 2021)