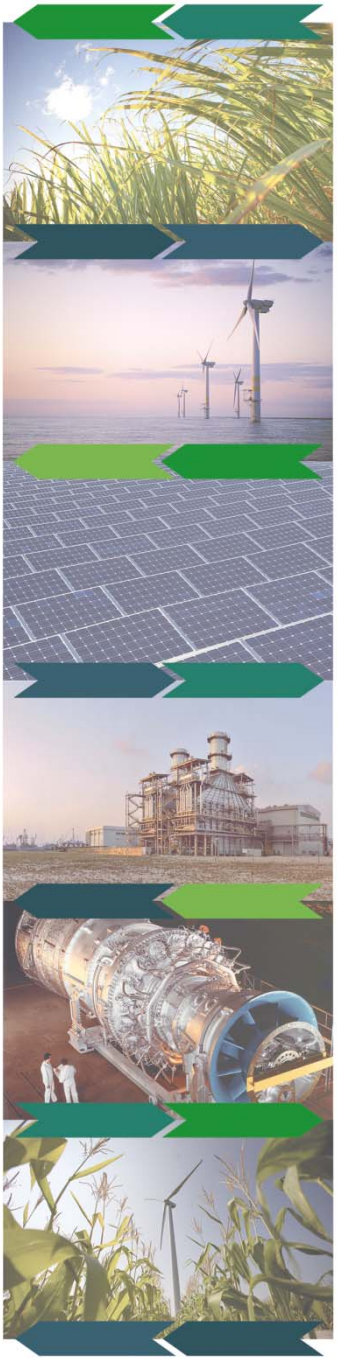
NAVIGATING THE ROADMAP FOR CLEAN, SECURE AND EFFICIENT ENERGY INNOVATION



Policy Brief on

Energy and Climate towards 2050

Four Scenarios

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SET-Nav
Strategic Energy Roadmap

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1 Introduction

Political decision-making involves uncertain future variables. Therefore, in the *SET-Nav* project, we investigate *four alternative scenarios for global energy markets up to 2050*. These four narratives, which are further detailed below, do not attempt to predict the state of the global energy system by the year 2050, but rather bound the range of plausible alternative futures by defining certain trajectories, downside risks, new trends, and 'unknown unknowns' that could significantly affect decarbonisation policy in the years to come. Hence, the present analysis should be read as a means to confront and challenge commonly held perceptions, and thereby contribute to consolidating energy and climate policy in the face of an uncertain future.

The analysis, purposely provocative, aims to make explicit and bring to the forefront of our thinking the diversity of opportunities and challenges that lie ahead of globally concerted attempts to decarbonise the global economy. Relying on a combination of desk research and an expert-based workshop, we have designed (i) a *business-as-usual scenario*, (ii) a worst-case scenario (*'Survival of the Fittest'*), (iii) a best-case scenario (*'Green Democracy'*), and (iv) a surprise scenario (*'ClimateTech'*).

The main conclusions drawn from the overall study find that global energy transition is particularly sensitive to three main forces, namely: the state of international politics which itself is contingent on security matters; the integration of economic and energy-related objectives and incentives; and, finally, the balancing between climate change mitigation and adaptation response types as a means to effect a far-reaching system transformation.

2 Studying scenarios

The modern use of scenario development dates back to the 1950s, when the Rand Corporation submitted a study to the Pentagon outlining the plausible strategies with regards to thermonuclear war. It was, however, further popularised by Shell in the 1970s onwards: The company was prepared for the eventuality of a price shock in 1973 and again in 1981, in part thanks to the work done by its scenario planning team.

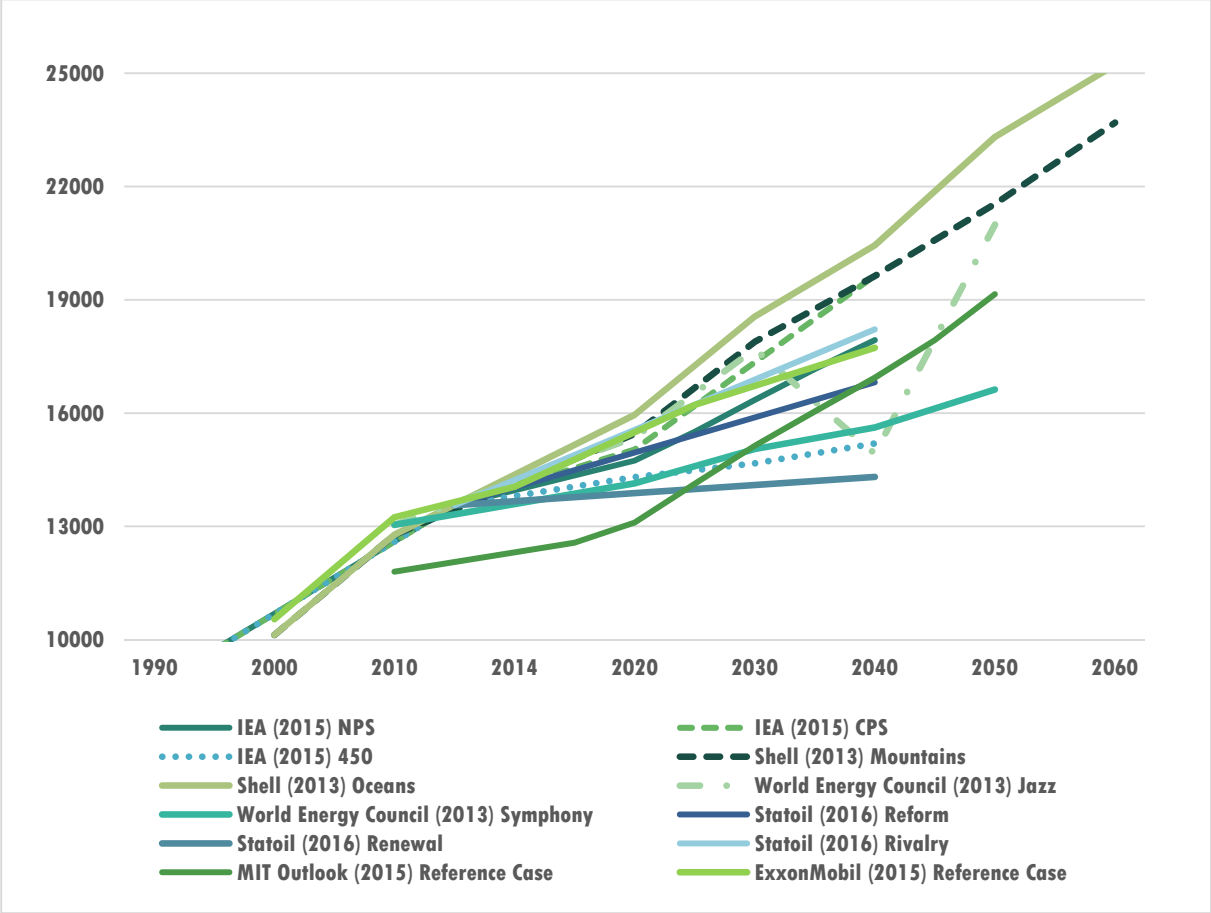

Figure 1: Total Primary Energy Demand across 12 World Outlooks (Mtoe).

Nowadays, one of the most authoritative sources of forward-looking energy analysis is the annual *World Energy Outlook* (WEO), published by the *International Energy Agency* (IEA). It provides a projection of trends in energy demand and supply alongside explanations of their implications for energy security, environmental protection, and economic development. Recent issues of the WEO typically comprise three scenarios: 'New Policies' incorporates all existing and intended policies and measures at the time of publication, while a second scenario, 'Current Policies', only takes into consideration those policies that have already been implemented. Finally, a '450ppm' scenario looks at the necessary policies and measures for achieving the 2-degree Celsius target.

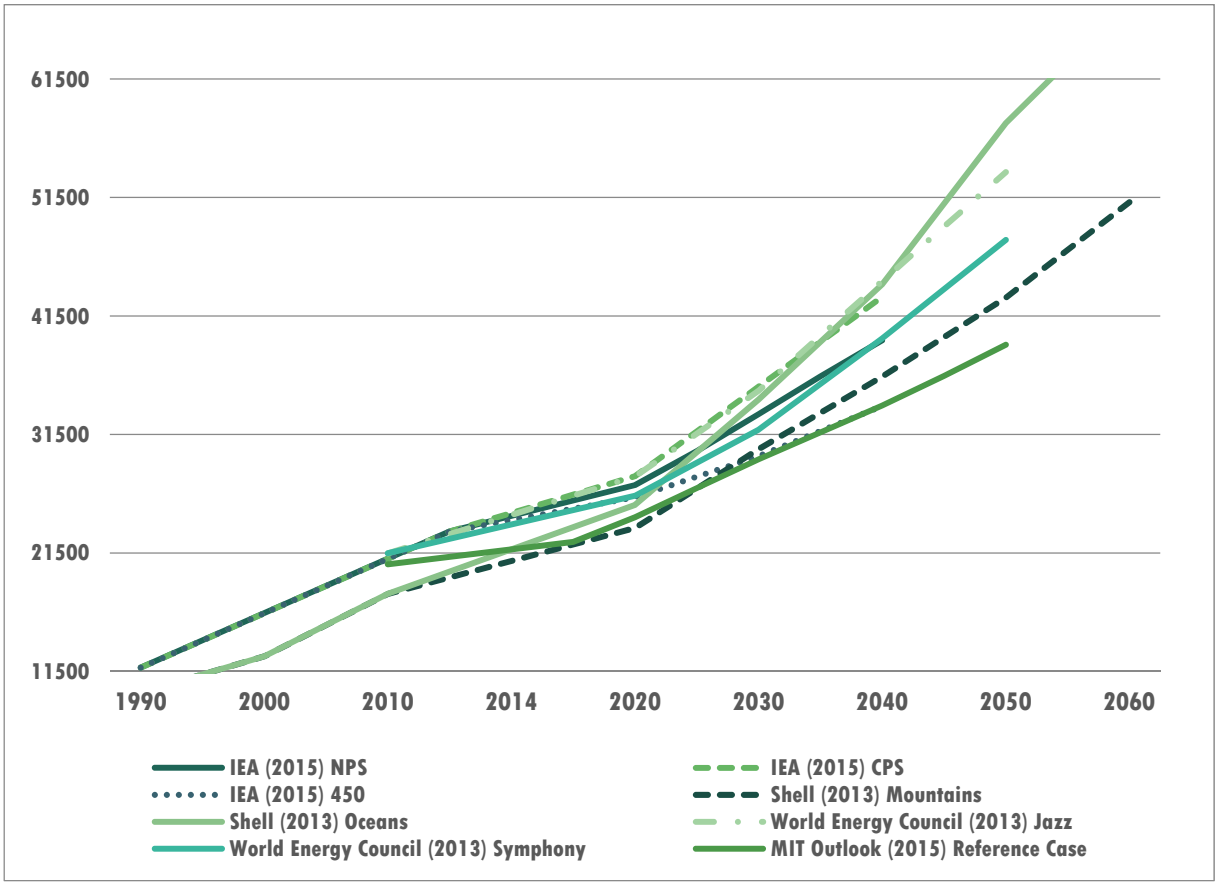

Figure 2: World Electricity Generation across 8 World Outlooks (TWh).

Several international oil companies also issue their own energy outlooks, projecting several decades ahead. *Shell* continues to periodically publish its scenarios for the global energy future, which, in the latest scenario study made public under the title 'New Lens', are mainly driven by the degree of rigidity and centralisation of the overall decision-making apparatus. For several years, *Statoil* has also been publishing a yearly scenario-based outlook, which very much follows similar principles as the WEO, with three scenarios inspired by the principles of 'reform', 'renewal', and 'rivalry'. *BP* and *ExxonMobil* are other examples of oil companies that produce their own outlooks, although these often rely on a single baseline projection.

In recent years, the generation of scenarios for the world energy system has also been widely popularised among other non-state actors, such as interest groups or research institutes. *The World Energy Council* (WEC) has, based on a mix of qualitative foresight analysis and quantitative modelling, produced two scenarios. These are 'Symphony' and 'Jazz', which are driven by a dichotomy between coordinated and uncoordinated energy and climate policy. Finally, the *Massachusetts Institute of Technology* (MIT) also provides a yearly single reference case which assesses the pledges made by the signatory countries at the Paris 2015 summit.

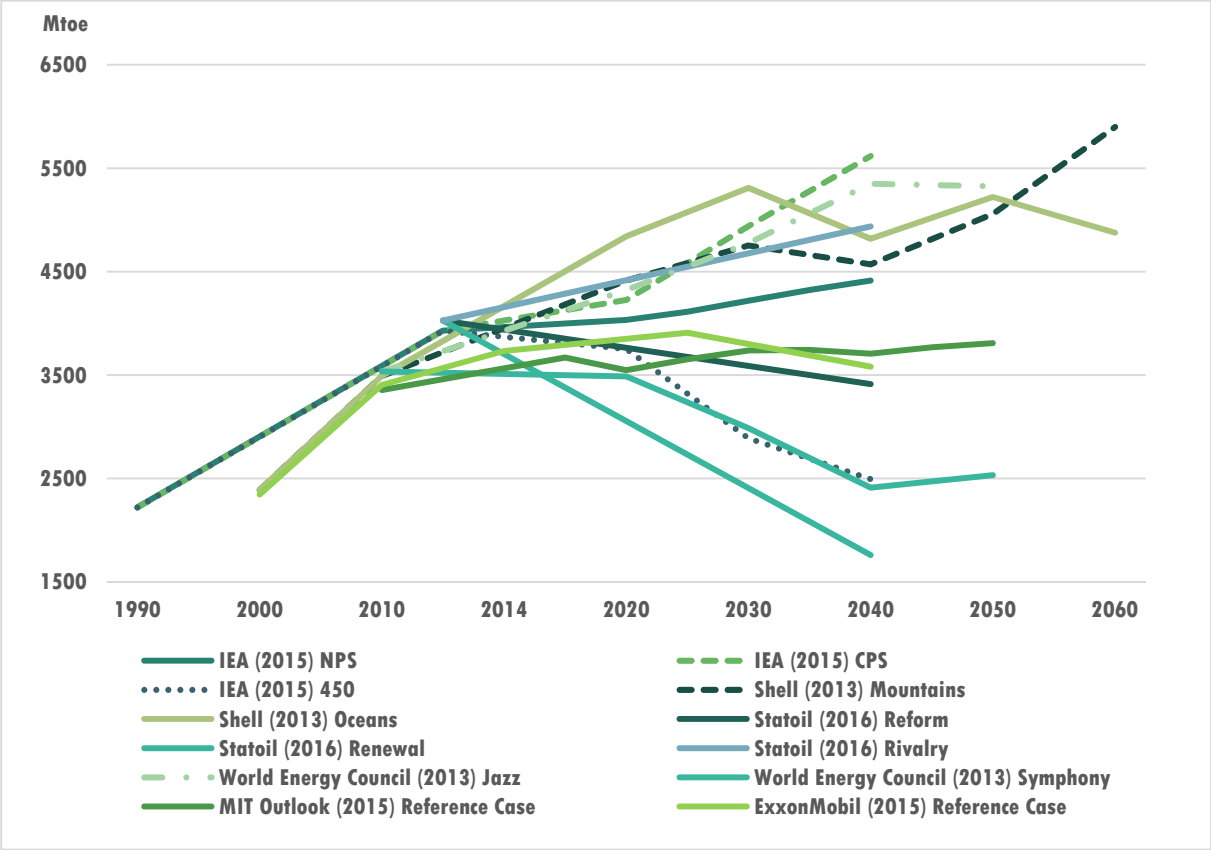

Figure 3: World Coal-Demand across 12 World Outlooks (Mtoe).

Although each organisation makes long-term energy projections using their own model assumptions and historical databases, it appears that, on aggregate and especially for certain variables such as world energy demand and renewable electricity generation, the results shown vary only little in scope. However, the permanence of several key uncertainties characterising the global energy system suggests that other plausible alternative futures exist outside of this restricted range and can bring additional insights to the consumer of these 'classical' scenarios.

3 Developing Scenarios

Scenario development attempts to compensate for two common errors in decision-making: **underprediction** and **overprediction**. It does so by dividing our knowledge into (i) things we are certain about and (ii) things we are uncertain about, i.e. the unknowable. Developing the scenarios presented hereafter was based on three fundamental steps:

a) *identifying* key drivers;
b) *generating* mutually exclusive scenarios, and;
c) *defining* indicators that reveal which future actually emerges.

The first two steps were carried out in an experts-based workshop, in which experienced practitioners, analysts, and academics from relevant sectors gathered to uncover critical uncertainties and driving forces of the energy system. Led by a specialist scenario-workshop facilitator, participants constructed initial scenario themes.

Following the workshop, through extensive desk research, the material collected was elaborated and processed. First, scenarios were checked for consistency and plausibility, and weighted depending on their relevance. Then, remaining scenarios were clustered and re-examined, resulting in the consolidation of a final set of four internally consistent, wide-ranging scenarios. Finally, separate research also led to the elaboration of storylines for each of the four scenarios, while indicators were defined by generating several objective and observable hypotheses for each alternative scenario. These indicators can provide an early warning of the direction in which the future is heading.

This qualitative scenario development can be taken another step further: The information in each scenario can be parametrised and used to inform quantitative models. These models formalise certain interactions and provide numerical values that enable a systematic comparison of the scenarios among themselves and with other studies. Although such scenarios do not require complex computer models to provide values, nearly all contemporary energy scenario studies do. Scenario practitioners and consumers alike should, however, be aware of the risk that results can easily be distorted or miscommunicated if not carefully understood, since they depend on model types and the selection of model levers.

4 Introducing scenarios

We have developed four – rather extreme – scenarios for the global energy market towards 2050, using techniques of foresight analysis as described above. These are:

Business-as-usual: The prolongation of (geo-)political tensions diverts resources and interest from climate issues, such that COP21 is widely respected and fulfilled but not succeeded by more ambitious aims. Increasing, carbon-intensive energy demand, especially driven by the developing world, can only partly be offset by progress towards decarbonisation in emerging economies and the EU. The pace of global energy transition only starts to accelerate towards 2030, but these efforts fail to remain under the 2-degree Celsius threshold, leading to an intensification of localised climate change-related catastrophes toward the end of the period.

Survival of the Fittest: Low diplomatic and economic cooperation between the large regional powers brings international climate policy to a halt, albeit isolated initiatives for the deployment of renewable energy for satisfying national energy agendas. The carbon budget is filled towards the end of the 2020s, leading to an intensification of climate-change-related catastrophes and large-scale crises. These new crises and the resulting tensions furthermore hinder government responsiveness in many host countries, thereby drastically delaying even further any concerted adaptation measures and increasing their costs.

Green Democracy: Supported by a stabilisation of international relations and greater economic cooperation, global energy transition accelerates due to support from various forms of bottom-up processes. Cities, non-state actors, and individuals play a noticeably more significant role in the deployment of renewable energy sources and energy-efficient technologies. More generally, a greater integration of energy and climate policy with other economic and social objectives takes place and enables governments to tackle energy poverty, while the 2-degree Celsius threshold is respected and climate change has only localised impacts in the medium-run.

ClimateTech: Decarbonisation efforts weaken as decision-makers anticipate promising technological advances, particularly in the field of geo-engineering, that are considered sufficient for delaying the overrun of the carbon budget. Technologies such as carbon capture and storage and solar radiation management are deployed around 2030 and enable better control over carbon emissions in the long-run, despite environmental complications. However, they only buy time for developing structural solutions based on low carbon-emitting energy sources which is why the dual-need for climate change mitigation and adaptation arises.

5 Conclusion and policy takeaway

While the IEA scenarios have become the point of reference in the international energy sector, they need to be complemented with additional studies that can highlight the opportunities and risks associated with taking a particular pathway. In this regard, the main takeaway points from our study are:

- *International relations and the state of security are strongly tied to the renewable energy transition in the long-run.* Regional conflicts and resulting human crises have fuelled the re-emergence of protectionist policies and represent a risk not only for European integration, but also for the effectiveness of the Union's energy and climate policies in the absence of multilateral climate cooperation. However, as some recent examples have shown too, greater cooperation between countries in the form of investments as well as technological and financial transfers could well spur a new dynamic for international climate policy.

- *Energy transition needs to be integrated with wider economic objectives, such as poverty alleviation, infrastructure modernisation, or private investment.* While that relationship appears to already hold in today's world, it is easily strained by political tensions and protectionist policies. Growing demand from the developing world, for instance, can easily jeopardise mitigation efforts, if a major coordination between economic and energy-related objectives is absent. The 'Green Democracy' storyline, however, conversely highlights the opportunities to be seized by combining these incentives.

- *It is crucial to develop an inclusive approach to policy-making that combines both mitigation and adaptation options.* Adaptation technologies are not necessarily risk-free, and failure to adopt a comprehensive approach could very well lead to new environmental, societal, and political problems that would further hinder the global energy transition. At the other end of the spectrum, balancing the use of both options can encourage new investments, stakeholders, and more dynamic relationships between the relevant actors.

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About the project

SET-Nav aims for supporting strategic decision making in Europe's energy sector, enhancing innovation towards a clean, secure and efficient energy system. Our research will enable the European Commission, national governments and regulators to facilitate the development of optimal technology portfolios by market actors. We will comprehensively address critical uncertainties facing technology developers and investors, and derive appropriate policy and market responses. Our findings will support the further development of the SET-Plan and its implementation by continuous stakeholder engagement.

These contributions of the SET-Nav project rest on three pillars: modelling, policy and pathway analysis, and dissemination. The call for proposals sets out a wide range of objectives and analytical challenges that can only be met by developing a broad and technically-advanced modelling portfolio. Advancing this portfolio is our first pillar. The EU's energy, innovation and climate challenges define the direction of a future EU energy system, but the specific technology pathways are policy sensitive and need careful comparative evaluation. This is our second pillar. Ensuring our research is policy-relevant while meeting the needs of diverse actors with their particular perspectives requires continuous engagement with stakeholder community. This is our third pillar.

Who we are?

The project is coordinated by Technische Universität Wien (TU Wien) and being implemented by a multinational consortium of European organisations, with partners from Austria, Germany, Norway, Greece, France, Switzerland, the United Kingdom, France, Hungary, Spain and Belgium.

The project partners come from both the research and the industrial sectors. They represent the wide range of expertise necessary for the implementation of the project: policy research, energy technology, systems modelling, and simulation.