LTES LONG-TERM SCENARIOS FOR THE ENERGY TRANSITION

A CAMPAIGN OF THE CLEAN ENERGY MINISTERIAL

IRENA International Renewable Energy Agency

SCENARIOS FOR THE ENERGY TRANSITION

Global experience and best practices

September 2020

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Participating countries in the CEM LTES campaign: Ministry of Mines and Energy/Energy Research Office (EPE) – Brazil, Natural Resources Canada – Canada, Ministry of Energy – Chile, Ministry of Climate, Energy and Buildings – Denmark, Technical Research Centre of Finland (VTT) – Finland, Federal Ministry for Economic Affairs and Energy (BMWi) – Germany, Energy Services Manager (GSE) – Italy, Ministry of Economy, Trade and Industry (METI) – Japan, Mexican Secretary of Energy (SENER) – Mexico, Netherlands Environmental Assessment Agency (PBL) – The Netherlands, Ministry of Energy – Saudi Arabia, Ministry of Energy and Industry – United Arab Emirates, Department for Business Energy and Industrial Strategy – United Kingdom.

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Abbreviations

AFEP: French Association of Private Companies

BEIS: Department of Business, Energy and Industrial Strategy

CEM: Clean Energy Ministerial

CNREC: China National Renewable Energy Center

DEA: Danish Energy Agency

DECC: Department of Energy and Climate Change

EPE: Brazilian Energy Research Office

ETSAP: Energy Technology System Analysis Program

GHG: Greenhouse gas

GSE: Italian Energy Services Manager

IEA: International Energy Agency

IPCC: Intergovernmental Panel on Climate Change

IRENA: International Renewable Energy Agency

KAPSARC: King Abdullah Petroleum Studies and Research Center

LTES: Long-Term Energy Scenarios

LTS: Long-Term Strategies

NDC: Nationally Determined Contributions

NGO: Non-Governmental Organisation

VRE: Variable Renewable Energy

TCFD: The Task Force on Climate-related Financial Disclosures

UNFCCC: United Nations Framework Convention on Climate Change

THIS REPORT AND ITS FOCUS

Long-term energy scenarios (LTES), which have been used for many decades as a vital planning tool for governments, can also serve to guide the transition to a clean, sustainable and increasingly renewable-based energy system. The Long-term Energy Scenarios for the Clean Energy Transition campaign, also known as the LTES campaign was initiated in May 2018 under the Clean Energy Ministerial (CEM) to promote the improved use and development of LTES for the clean energy transition. The campaign is led by the governments of Denmark and Germany, and co-ordinated by the International Renewable Energy Agency (IRENA).

This report assesses a collection of recommendations and country experiences gathered through the activities of the LTES campaign and the LTES Network (IRENA's extension of the LTES campaign to cover non-CEM countries). These activities included over 26 events in 10 different countries and a webinar series with more than 20 experts showcasing examples of the value and effective use of scenarios in governments and technical institutions supporting countries' clean energy transition planning processes.

Discussions also revealed that, in the context of the broad and complex challenges of a clean energy transition, much more must be done to encourage the more effective and extensive use of long-term energy scenarios.

Chapter 1 focuses on strengthening scenario development, highlighting how scenarios can better account for potentially transformational changes. Chapter 2 focuses on improving scenario use, exploring how scenarios can be better used for strategic decision-making by governments and investors. Chapter 3 identifies approaches that can enhance institutional capacity for scenario planning.

This report expands upon the report, Long-term energy scenarios: First-year campaign findings, which collected findings from the first year of the campaign.

KEY FINDINGS AND RECOMMENDATIONS

The following key insights and recommendations for policy makers, identified in discussions to date, can help make the most of using long-term energy scenarios (LTES):

01 Strengthening scenario development

1.1 Establishing a strong governance structure

The clean energy transition will require broad participation and stronger coordination across different government institutions. Examples of strong governance structures exist and can be learnt from.

- **Participatory processes:** consensus can only be attained by opening up the process, making it participatory and inclusive, with a multi-institutional approach. A participatory process creates trustworthy scenarios.
- **Co-ordination amongst LTES entities:** often, there is a range of national institutions involved in scenario development at different stages of planning. Greater co-ordination is needed not only between energy planning agencies and institutions, but also with the climate community.

1.2 Expanding the boundaries of scenarios

Model results are inevitably shaped by the scope of the model itself. To adequately reflect the complexities of the clean energy transition, models and scenarios need to better address new technologies, business models and disruptive innovations.

- **Scenarios for a just, clean energy transition**: it is necessary to investigate the *questions policymakers ask* in relation to the impacts of the clean energy transition on economic growth, employment and welfare; and not the questions *scenario developers want them to ask*. Scenarios can be utilised to guide policymakers on how to achieve a prosperous and inclusive just transition.
- **Accounting for innovation in the energy sector**: the clean energy transition invites disruptive innovation within the energy sector and in all other sectors of the economy. Innovation in decentralisation, digitalisation and electrification of the energy system are the key to a renewable-powered future and need to be better accounted for in clean energy transition scenarios.

02 Improving scenario use

2.1 Clarifying the purpose of scenario-building

Scenarios can be used for different purposes, depending on the context and the goals being pursued. Such distinctions should be clear to avoid misinterpretation of clean energy transition scenarios.

- **Forecasting and backcasting:** forecasting is used to predict future events or trends, or to answer the question: *what it going to happen?* Backcasting can be used to provide potential pathways backwards from a certain goal or target and can assist in determining policies to support the achievement of a goal or ask the question: *how do we get to a certain point in the future?*
- **Building consensus and raising ambition:** scenarios can be a tool to open debate and build consensus around what the future may look like, and to bring stakeholders together. Scenarios can be used to generate debate and raise ambition when developing pathways to be taken to achieve the desired decarbonisation.
- **Conservative and exploratory:** network development and regulatory design need to be considered plausible; therefore, realistic (conservative) scenarios are often preferred. Exploratory analysis is useful for preventing persistent 'business-as-usual' conclusions, raising awareness of opportunities, considering future shocks and challenges, and identifying risk and uncertainty related to the clean energy transition.

2.2 Transparent and effective communication

Transparency ensures the quality of scenarios and builds trust. Scenario assumptions and results need to be clearly communicated in the context of the more complex clean energy transitions and innovative communication methods that are now emerging.

- **Effective communication tools**: communication facilitates the LTES participatory processes and engages important actors whose co-operation is required for achieving the clean energy transition. The insights of scenarios need to be communicated in simple messages that can be understood by non-experts and people who do not deal with scenarios on a regular basis.
- **Transparent and publicly available information**: transparency is required in terms of input data, methodology and assumptions. This allows scenarios to be thoroughly scrutinised and decisionmakers to trace which assumptions drive specific results.

03 Identifying capacity-building approaches

3. 1 Building the right type of scenario capacity in government

The capacity to use scenarios can be created through the use of modelling tools within government institutions. If modelling is outsourced, governments must still ensure they have the capacity to understand the results.

- **Insourcing scenario development capacity**: having a team or agency dedicated to modelling and scenario building is crucial for successful insourcing. Setting an institutional process for regular updates of LTES and engaging with external stakeholders to establish quality assurance, both support the continuity and growth of internal capabilities.
- **Outsourcing scenario development capacity**: successful outsourcing of LTES requires absorptive capacity within government to understand the modelling results. Outsourcing allows access to high-end scenario-building techniques; however full disclosure of scenario data and modelling methodologies is needed to aid understanding and use of scenario results in government.

INTRODUCTION

The clean energy transition:
A challenge for decision makers

The clean energy transition presents an unprecedented challenge for decision makers – particularly energy planners and policy makers – that differs substantially in scope and scale from past energy transitions.

The future energy system could look entirely different from that of the present, with a vast expansion of low-cost renewables, a smarter and much more flexible electricity grid, and considerable increases in the numbers of vehicles and other products and processes that run on electricity. Digitalisation, decentralisation and electrification, supported by innovative policy frameworks and market instruments, are poised to create new business models, change consumer behaviour and radically transform established systems.

The urgent need to reduce greenhouse gas emissions, as outlined in the climate objectives of the Paris Agreement, necessitates deep decarbonisation of the energy sector, which will require a fundamentally different approach to previous strategies that sought to stabilise or halve emissions.

Long-term energy and climate policy formulation and planning pose far more complex challenges than in the past. More than ever, policy makers and investors must make strategic, forward-looking energy decisions that consider new trends and uncertainties in technology, markets and policies. The LTES campaign has outlined a mental model for how LTES can be developed and used for guiding the clean energy transition (see Box 1).

Box 1 THE LTES CAMPAIGN'S MENTAL MODEL FOR HOW LTES ARE DEVELOPED AND USED

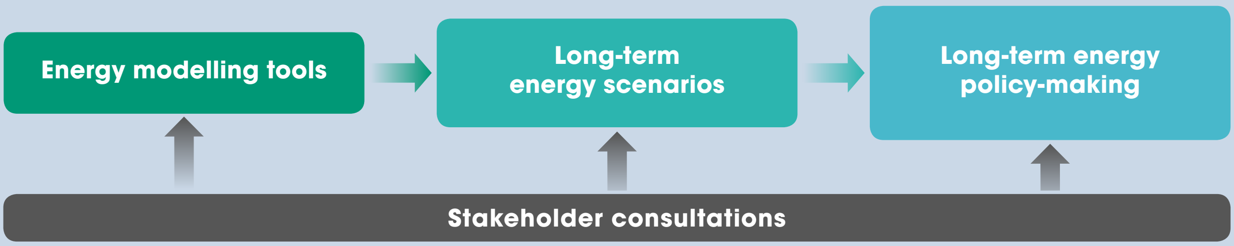
Long-term energy scenarios (LTES) that explore socio-technical pathways over c. 20+ years can help trigger productive national and international policy debates, allowing governments to develop well-informed long-term visions and associated energy policies and strategies.

LTES help governments to prepare for the long-term interventions required by policy goals; they also assist in identifying the short-term challenges and opportunities of achieving the desired sustainable energy future and quantifying the possible impacts of these policies. LTES can also be used to inform recommendations on where to direct investment.

Energy modelling tools are often used to support the development and analysis of LTES. They assist in quantifying the implications of different technological pathways and can improve the understanding of the complexities and interdependencies within an energy system, as well as their connections to other sectors. Meanwhile, the qualitative aspects of scenarios and scenario planning – such as visions and storylines for the future – are formed through stakeholder consultation at various levels (see Figure 1).

LTES are an essential tool for strategic decision making, but the way in which they are developed and used must evolve and improve to fully support the complex clean energy transition. The participating countries and technical institutions of the LTES campaign are exploring ways to ensure this occurs through the various campaign activities undertaken so far.

Figure 1: How scenarios are developed and used: A mental model for the LTES campaign



Long-Term Energy Scenarios for the Clean Energy Transition: The LTES Campaign

Launched at the 9th Clean Energy Ministerial (CEM) in May 2018 and co-ordinated by IRENA, the Long-term Energy Scenarios for the Clean Energy Transition campaign (LTES campaign) aims to promote the wider adoption and improved use of model-based LTES to support and accelerate the energy transition in CEM countries. Key stakeholders involved in the campaign are scenario users within government planning teams and policy-making institutions, as well as scenario developers within government modelling and development teams.

Three focus areas were defined to structure the LTES campaign and systematically organise the information stemming from its activities, as shown in Figure 2. Each area has a specific key question regarding LTES development, use and capacity building.

Through the LTES campaign's activities, the participating CEM countries shared their various experiences of developing and using LTES for official long-term planning purposes. Figure 3 briefly summarises how key institutions in each participant country have utilised LTES.

Figure 2: Focus areas of the LTES campaign and key questions

01	02	03
Strengthening scenario development	**Improving scenario use**	**Identifying capacity-building approaches**
Key Question: How can scenarios be developed to better account for potentially transformational changes?	**Key Question:** How can scenarios be better used for strategic decision-making by governments and investors?	**Key Question:** What approaches can enhance institutional capacity for scenario planning?

Figure 3: How LTES campaign countries are using and developing scenarios

Brazil

Under the co-ordination of the Ministry of Mines and Energy, the Energy Research Office (EPE) published the National Energy Plan to 2030 based on LTES developed by in-house modelling teams at EPE. Between July and October 2020, a new National Energy Plan with a 2050 planning horizon is under public consultation.

Canada

The Canada Energy Regulator (CER) publishes Canada‘s Energy Future based on LTES, while Environment and Climate Change Canada (ECCC) publishes LTES for both international and domestic reporting purposes. Both the CER and ECCC have in-house modelling teams. These activities are supported by data from Statistics Canada and Natural Resources Canada (NRCan).

Chile

The Ministry of Energy publishes a long-term energy planning document every five years with a 30-year time horizon, based on LTES developed by in-house modelling teams. The Ministry also publishes an annual update report detailing trends in the sector and new energy infrastructure. An energy plan is currently under development to meet the country's commitment to Carbon Neutrality by 2050.

Denmark

The Danish Energy Agency (DEA), a government agency under the Ministry of Energy, Utilities and Climate, annually publishes the Danish Energy and Climate Outlook and the Power and Gas Infrastructure Outlook based on LTES developed by its System Analysis Department. The System Analysis Department also produces the National Energy and Climate Plan requested by the European Union.

Finland

LTES play an important role in climate and energy policy and strategy formulations and impact assessments. Typically, national research organisations, like VTT Technical Research Centre of Finland Ltd. support cross-ministerial work with quantitative modelling of LTES. Currently, new climate and energy strategy formulation is underway to achieve climate neutrality by 2035.

Germany

The Federal Ministry for Economic Affairs and Energy (BMWi) and the German Environmental Agency (UBA) use various LTES procured from research institutions. These LTES usually reflect the renewable energy-related targets of the Energy Concept 2010. The Federal Network Agency (BNetzA) uses LTES as a starting point for transmission grid planning.

Italy

The Ministry of Economic Development (MSE) and the Ministry for the Environment, Land and Sea (MATTM) developed LTES for the Integrated National Energy and Climate Plan (INECP) at the beginning of 2020. The Italian Managers of Energy Services (GSE) supervised the contributions of the national institutions and agencies involved in the process of energy planning.

Japan	The Ministry of Economy, Trade and Industry (METI) co-ordinates the development of the Strategic Energy Plan, which comprises LTES for 2050 using inputs from the expert panel appointed by the government and considering the energy mix from the outlook for 2030.
Mexico	The Federal government has published the National Energy Strategy, in which the vision for 2050 is established based on LTES with 15- and 30-year time horizons developed by in-house modelling teams at the Mexican Secretariat of Energy (SENER).
Saudi Arabia	The Ministry of Energy oversees energy policy to ensure the Kingdom has a sustainable energy mix throughout the clean energy transition. This includes much investment in renewable energy, which is enveloped by the long-term strategic initiative, the National Renewable Energy Program (NREP).
The Netherlands	The Netherlands Environmental Assessment Agency (PBL) publishes the Dutch National Energy Outlook, providing four Ministries (Economic Affairs and Climate; Interior; Infrastructure and Water Management; and Finance) with LTES developed by in-house modelling teams. From 2019 onward, this Outlook will be renamed the 'Climate and Energy Outlook' and will have legal status as reference for policy progress as stated in the new Climate Law.
United Arab Emirates	The Ministry of Energy and Infratsructure launched the National Energy Strategy 2050, informed by LTES developed by in-house modelling teams. It has developed the Future Lab to communicate LTES results to high-level political leaders.
United Kingdom	The Department for Business Energy and Industrial Strategy (BEIS) maintains a national energy system model with a 2050 planning time-horizon in close co-operation with academia to inform policy development – the Clean Growth Strategy is a good example.

LTES

LONG-TERM SCENARIOS FOR THE ENERGY TRANSITION

A CAMPAIGN OF THE CLEAN ENERGY MINISTERIAL

01

STRENGTHENING SCENARIO DEVELOPMENT

1.1 Establishing a strong governance structure

The clean energy transition will require broad participation and stronger co-ordination across different government institutions. Examples of strong governance structures exist and can be learnt from.

The process of LTES development varies widely across different countries and contexts. Some governments have particular steps and outputs stipulated in national law, while others have less formal processes or none at all. The same variations can be seen in the scope of stakeholder involvement and consultation, which differs significantly across jurisdictions.

It has become clear from the LTES campaign's discussions, however, that the clean energy transition requires more co-ordinated and expansive governance of LTES development than in the past, involving a broader set of stakeholders. For example, the emergence of distributed energy sources and smart grid technologies can turn energy consumers into more active participants in the energy system, which will likely increase the prominence of their participation in the LTES development process.

Electrification of new sectors, and the unique geographic and production patterns of renewables such as wind and solar, require better co-ordination among institutions that develop scenarios spanning different temporal granularities and spatial boundaries (e.g. cities and regions). Given that the clean energy transition is inextricably linked with climate policy, better co-ordination is also required across energy and climate scenarios, which often fall under different institutional jurisdictions.

Recommendation 1 delves into two important aspects to establish a strong governance structure gleaned from the LTES campaign discussions – participatory processes with broad segments of society; and co-ordination between entities involved in LTES use and development.

Participatory processes

Consensus can only be attained by opening up the process, making it participatory and inclusive, with a multi-institutional approach. A participatory process creates trustworthy scenarios.

The LTES campaign has identified a range of best-scenario governance practices. Impressive stakeholder consultation is practised in many of the campaign member countries and the process is increasingly opening up to include civil society to build broader consensus for clean energy transition pathways.

Developers and users of scenarios have stressed the benefits of a participatory process for scenarios' legitimacy, acceptance and utility. Brainstorming with a variety of stakeholders on the best- and worst-case scenarios is crucial to create a shared vision of the future, which is vitally important to assess diverse views of the current context and the future. Another benefit from participatory processes, highlighted in the campaign, is that it helps to ensure the energy transition is just and inclusive.

Finland

In Finland, the Government has set an ambitious climate target to become carbon neutral by 2035 and carbon negative after that (Ministry of the Environment of Finland, 2020). The VTT Technical Research Center of Finland Ltd (VTT) has co-ordinated multidisciplinary research projects to create alternative narratives and quantitative scenario assessments to inform the *Energy and Climate Roadmap 2050* (The Ministry of Employment and Economy of Finland, 2014) and *Long Term Energy and Climate Strategies (REF)*. Figure 5 shows the 2-year timeline of the participatory process for the development of the roadmap in 2012-2014. The process was orchestrated by VTT and comprised multiple workshops and a consumer survey with 3 000 respondents providing feedback to finally reach an agreeable set of scenarios for the country. A similar scenario process, but now only six months long, was led by VTT to inform the Long Term Energy and Climate Strategy for 2050 (VTT, 2018). The scenarios were updated in early 2020 to fulfil the climate neutrality targets by 2035, which was set up by the new government in the summer of 2019.

Figure 4: Finland's participatory process for the development of a low carbon roadmap to 2050

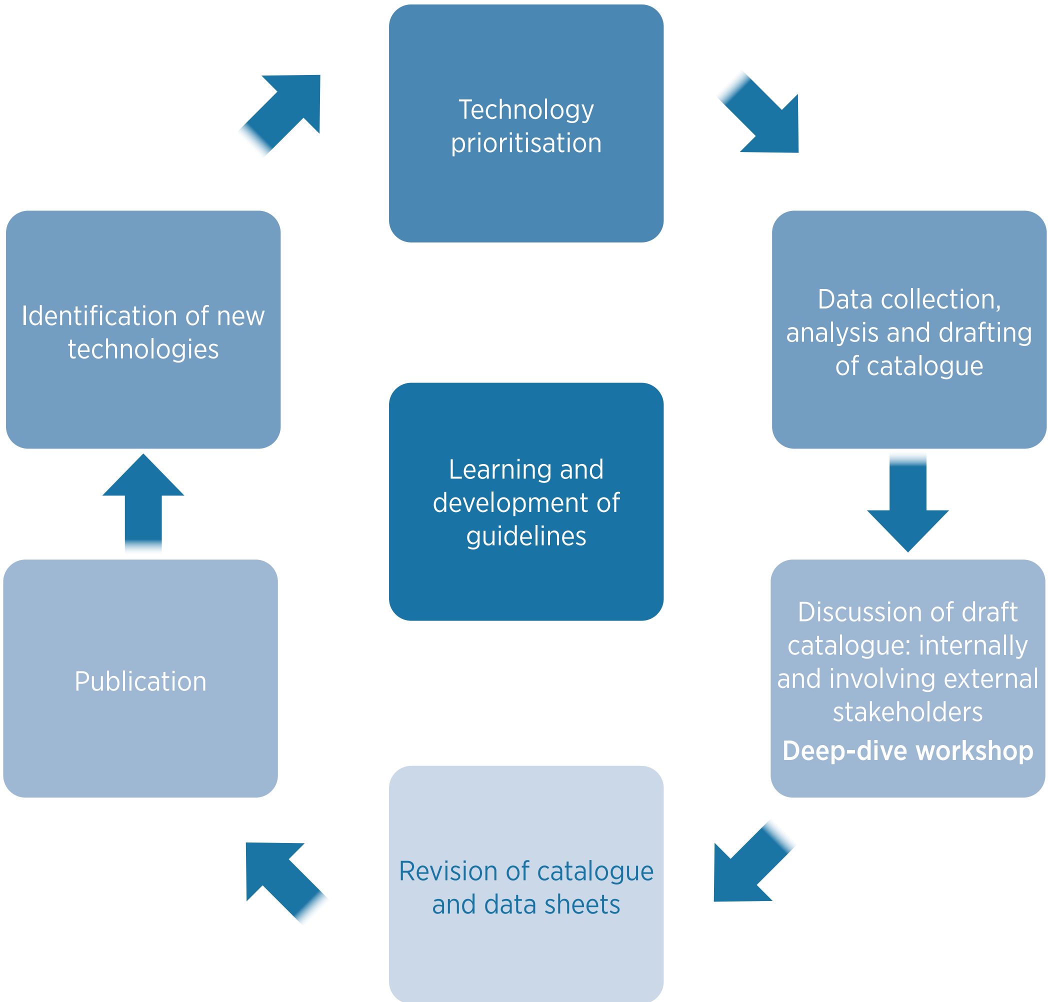
Workshop	First draft	Workshop	Workshop	Workshop	Consumer Survey	Seminar	Final Scenarios
First workshop: future wheel, 30 participants.	**First draft of scenarios:** future tables.	**Projects research workshop:** formulation of 4 basic scenarios.	**Second workshop:** feedback (World Café), 66 participants.	**Third workshop:** feedback ('me-we-us'), 50 participants.	**Consumer survey:** 3 000 respondents providing feedback.	**Final seminar:** feedback provided by 5-expert panel/80 workshop participants.	**Scenario finalised.**

Adapted from the LTES webinar series (VTT, 2018).

Denmark

In Denmark, the Danish Energy Agency (DEA) leads Denmark´s *Energy and Climate Outlook*, an annual technical assessment of how the country´s supply and demand of energy will evolve until 2030 (DEA, 2020a). The methodology behind the scenarios is based primarily on technological costs, as well as rational options and financial viability requirements for players in the energy market. This underlying information is summarised in the DEA's *Technology Catalogues* (DEA, 2020b), which are developed through a participatory iterative process of internal and external stakeholder consultation with experts (see Figure 5).

Figure 5: Denmark's Technology Catalogues development process, including external consultation



Adapted from the 2019 LTES International Forum (DEA, 2019a).

Brazil

In Brazil, the Ministry of Mines and Energy (MME), with the support of the Energy Research Office (EPE), develops two scenario-based studies with different time horizons: Brazil's *National Energy Plan* (PNE) (MME and EPE, 2020, 2007) with a long-term time horizon (2030–2050) and the *10-year Expansion Plan* (PDE) with a time horizon of 2029 (MME and EPE, 2020). In 2020, the MME has defined that the *National Energy Plan* will be published every five years with a horizon of at least 30 years (MME, 2020). The 2050 *National Energy Plan* has been under public consultation between July and October 2020. The public consultation has been open to the public on the MME website (MME, 2019); the consultation concerns: the energy planning agenda; the systemic approach of projections; inter- and intra-sector governance; and how to use the results. Figure 6 shows the three pillars of this participatory process.

Figure 6: The three pillars of the participatory process for the National Energy Plan (PNE) 2050 in Brazil

1 - Participatory and inclusive with a multi-institutional approach

10 workshops **+250** participants of public and private sectors

2 - Guiding work with questions by policy makers

The PNE 2050 was designed to answer **12 guiding questions** prepared by the Brazilian Mnistry of Mines and Energy

3 - Scenarios used as tool to stimulate debate and build consensus

PNE 2050 innovates by proposing a **3-month period** for public consultation and a series of presentations to publicise the content of the plan during this period. This aims to enable stakeholder participation and facilitate consensus building.

Adapted from the IRENA LTES for the Clean Energy Transition in Latin America Workshop (EPE, 2019).

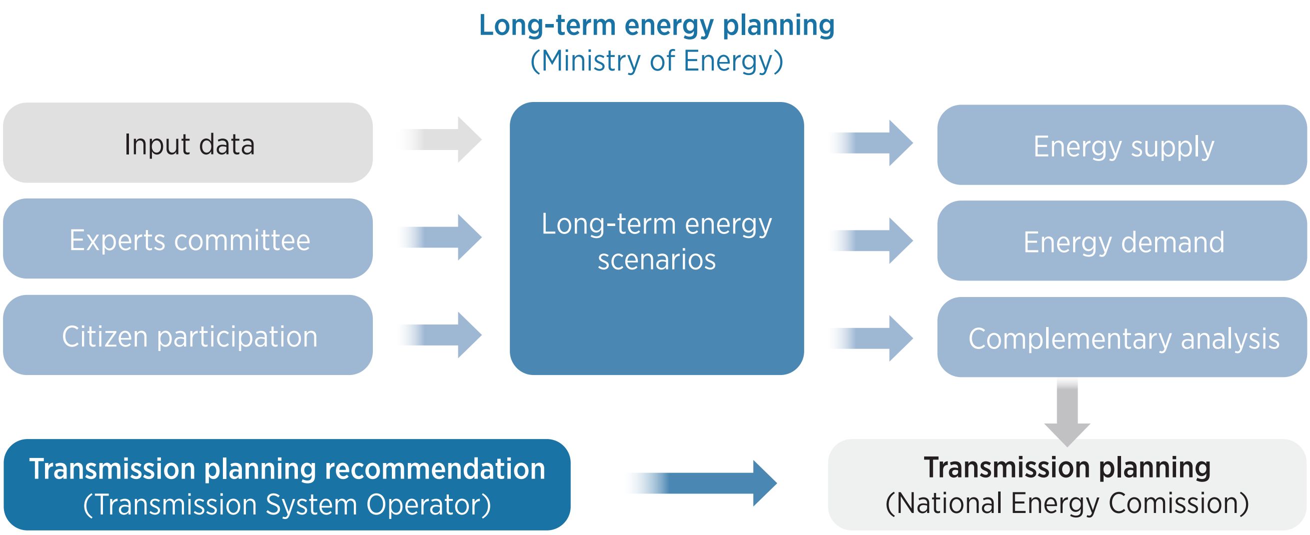
United Kingdom

In the United Kingdom (UK) the power system operator, National Grid, produces the *Future Energy Scenarios* (FES) publication with a horizon of 2050 (National Grid ESO, 2020a). During 2019, National Gird engaged widely with stakeholders to discuss with them the design of the 2020 FES and collect feedback. Almost 600 individual stakeholders representing 548 unique organisations from nine different stakeholder categories like 'energy industry', 'innovators' and 'regulators', participated in the process. The "Shaping FES 2020" call for evidence was shared with a community of stakeholders of nearly 6 500 people, providing the opportunity for all to provide evidence and insight on specific subjects (National Grid ESO, 2020b).

Chile

In Chile, the Ministry of Energy of Chile incorporates citizen participation in every step of its long-term energy planning process, including the development of LTES (Ministerio de Energía de Chile, 2018a). For scenario development, the Ministry uses the Delphi method – developed as a systematic, interactive forecasting method which relies on a panel of experts and multiple rounds of questionnaires (Ministerio de Energía de Chile, 2019a). Figure 7 represents Chile's long-term energy and transmission planning governance structure, in which inputs from an experts' committee and citizen participation are used to develop long-term energy scenarios.

Figure 7: Chile's long-term energy and transmission planning governance structure

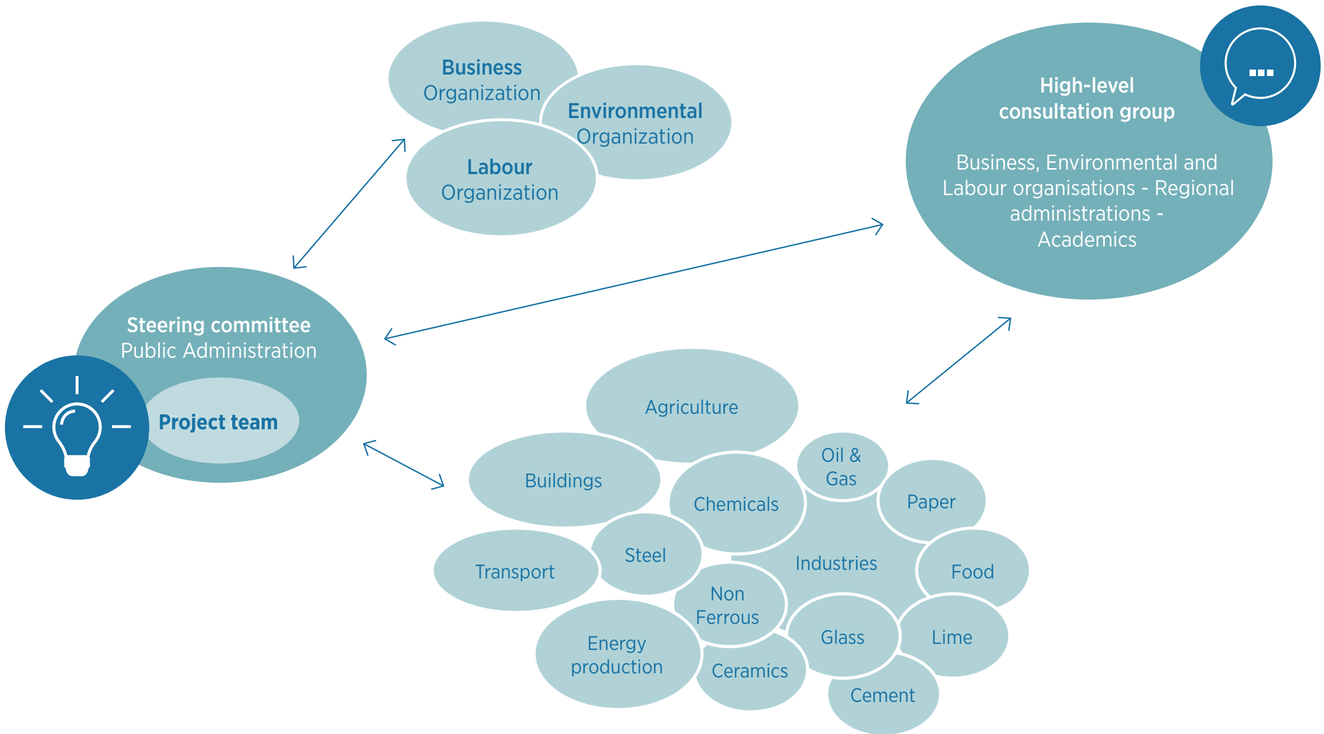


Adapted from the LTES webinar series (Ministerio de Energía de Chile, 2018b).

Belgium

In Belgium, the Federal Government used a two-fold participative and iterative process to develop LTES scenarios (Climact and VITO, 2016), which were based firstly on the development of an energy accounting calculator – as seen in the report *Low Carbon Scenarios for Belgium by 2050* (Belgian Federal Public Service Health, Food Chain Safety and Environment, 2013) – and secondly on discussions with a broad range of stakeholders. The participatory engagement was led by a federal steering committee and required over 30 meetings with over 150 people over a period of two years (IRENA, 2020a). Figure 8 shows the stakeholders involved in the process – namely business, environmental and labour organisations; a high-level consultation group including regional administrations and academics; and a large group of stakeholders from the industrial sector.

Figure 8: Belgium's participative process for low carbon scenarios by 2050



Adapted from the 2nd LTES International Forum
(Federal Public Service Health, Food Chain safety and Environment, 2020).

South Africa

In South Africa, the National Integrated Resource Plan 2019 (IRP 2019) provides a roadmap for the future energy landscape which guides future energy infrastructure investments and policy development (Republic of South Africa, 2019). The policy-adjusted IRP 2019 integrated public comments and updated the draft IRP 2018 report (Republic of South Africa, 2018). The update process began with public consultations on the assumptions, after which, several supply- and demand-balancing scenarios were modelled, simulated and analysed. Following Cabinet approval, the Draft IRP 2018 report was published in August 2018 for public feedback for a period of 60 days. Public submissions for the draft IRP 2018 varied from statements of opinion to substantive inputs with supporting data. The number of submissions received was 5,929, of which 242 were substantive comments inclusive of discussions and, at times, supported by facts, data or references. Key issues raised included assumptions regarding demand forecast and growth, costs, risks around gas-to-power generation, nuclear capacity, distributed generation, and the role of coal and hydropower in the matrix (Republic of South Africa, 2019).

Italy

In Italy, a two-stage consultation approach was adopted to elaborate long-term energy scenarios for the Integrated Energy and Climate Plan for 2030 (INECP), (MISE et al., 2019). The first stage included the engagement of more than 70 experts from the public and private sectors, academia, TSOs and DSOs and non-profit organisations. The activities performed in this initial stage were focused on four main areas: i) developing a database for economic, social and environmental variables; ii) technical and economic characterisation of energy demand and supply and likely evolution of technologies; iii) development of reference and policy scenarios and sensitivity analysis; and iv) the choice of a synthetic set of cost–benefit indicators. In the second stage, only public institutions were involved. The latter working group developed the INECP by defining objectives, trajectories and measures for each one of the five dimensions of the Energy Union (decarbonisation; energy efficiency; energy security; research, innovation and competitiveness; and an internal energy market), (European Commission, 2020) and built national scenarios around the key variables provided by the European Commission (European Commission, 2016).

Global

In the global context, the World Energy Council has been expertly facilitating the participatory design, development and effective use of plausibility-based global energy scenarios for more than two decades, drawing on the deep energy expertise of its diverse global community in nearly 90 countries, represented by more than 3 000 organisations across the entire energy value chain and its sectors. The World Energy Council engages with diverse stakeholders – firms, policy makers, the public sector, consumers – in every stage of the process. Figure 9 shows the multi-step process of scoping, building and using scenarios. The most recent set of long-term scenarios – World Energy Scenarios to 2040 (World Energy Council, 2019a) – explore the new context of demand-driven disruption and explore innovation turning points in energy transition pathways. Throughout the process of building and updating these, more than 20 seminars and more than 120 interviews were conducted across different regions.

Figure 9: The World Energy Council's scenario-building process

1 Scoping	• Orientation workshop. • Deep-dive interviews with leaders in energy and beyond. • Horizon scanning – insights from WEC Issues Monitor, Energy Trilemma Index, innovation briefs. • Global scenarios comparison/review to benchmark Council scenarios to peers.
2 Building Narratives	• 100+ exploratory interviews with global energy leaders focused on 14 themes. • Regional workshops in Paris, Berlin, Tallinn, Abu Dhabi and elsewhere. • 2-day global scenarios weaving workshop. • Building narratives.
3 Qualification / Iterating	• Conducting illustrative quantification. • Iterating between global narratives, systems maps and comparative analysis. • Development of application tools.
4 USING	• Launch. • Wide use of scenarios for decision making during uncertainty. • Regional/sectoral/thematic 'deep-dives'.

Further to the above practices of government and technical institutions facilitating stakeholder participation in the LTES development process, academic and research institutions have also organised activities to engage stakeholders in the process, as can be seen in Box 2.

Box 2: FACILITATING LTES PARTICIPATORY PROCESSES WITH CITIZENS AND POLITICIANS THROUGH ACADEMIC INSTITUTIONS

Academic institutions involved in developing energy scenarios have collaborated with government institutions to facilitate participatory processes to engage policy makers and other stakeholders in the development and use of LTES for agenda-setting and decision-making.

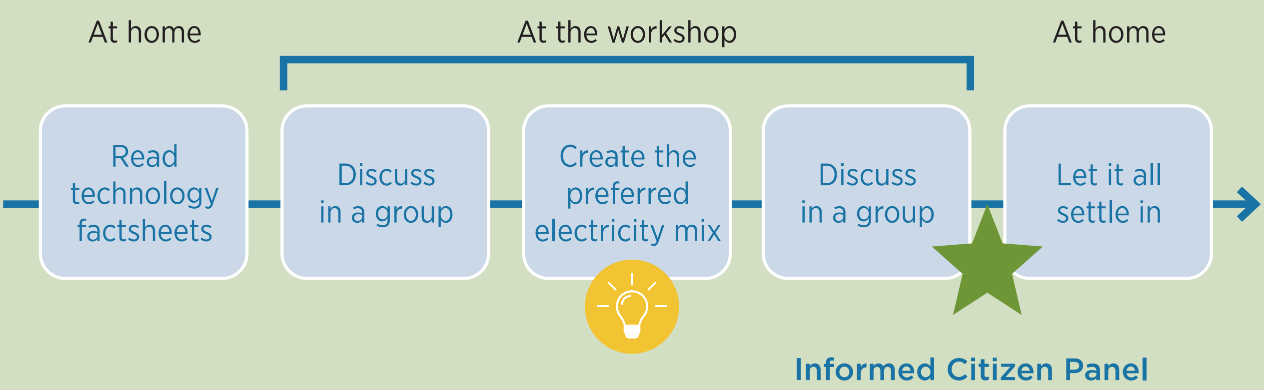
Denmark

In Denmark, the Technical University of Denmark (DTU) created a participatory process for politicians to interact with energy scenarios through a "model lab" exercise in 2019 (DTU, 2019). This was an adaptation of the US White House 'war room', i.e. a closed meeting with targeted politicians and other stakeholders, the concept being that the meeting cannot be terminated until a decision is reached (Kinsella, 2007). The DTU model lab exercise discusses policy designs as scenarios, which are then modelled in real time and the results presented to participants in the war room, who can immediately compare the results with their expectations and targets and re-evaluate the policies.

Switzerland

In Switzerland, after the Fukushima nuclear accident in Japan, the Federal Council initiated the *Energy Strategy 2050* to phase out nuclear power and to increase the uptake of renewable energy and efficiency (DETEC, 2018). Among multiple LTES-studies to inform the strategy, the University of Geneva (UNIGE) developed a participatory process specifically designed to engage with citizens (non-energy experts). The 'informed citizen panel' consisted of 79 citizens, who participated in a series of home activities and workshops to develop a set of scenarios in line with their expectations and knowledge acquired through technology factsheets (Trutnevyte et al., 2019) including large dams, large run-of-river, and small hydropower; (2 and the interactive online tool Riskmeter[1] (Dubois et al., 2019; UNIGE, 2019; Volken et al., 2018). The process of the 'informed citizen panel' is represented in Figure 10.

Figure 10: Switzerland's informed Citizen panel process developed to design LTES



Adapted from the 2019 LTES International Forum (Dubois et al., 2019; UNIGE, 2019).

1 Available at: www.riskmeter.ch

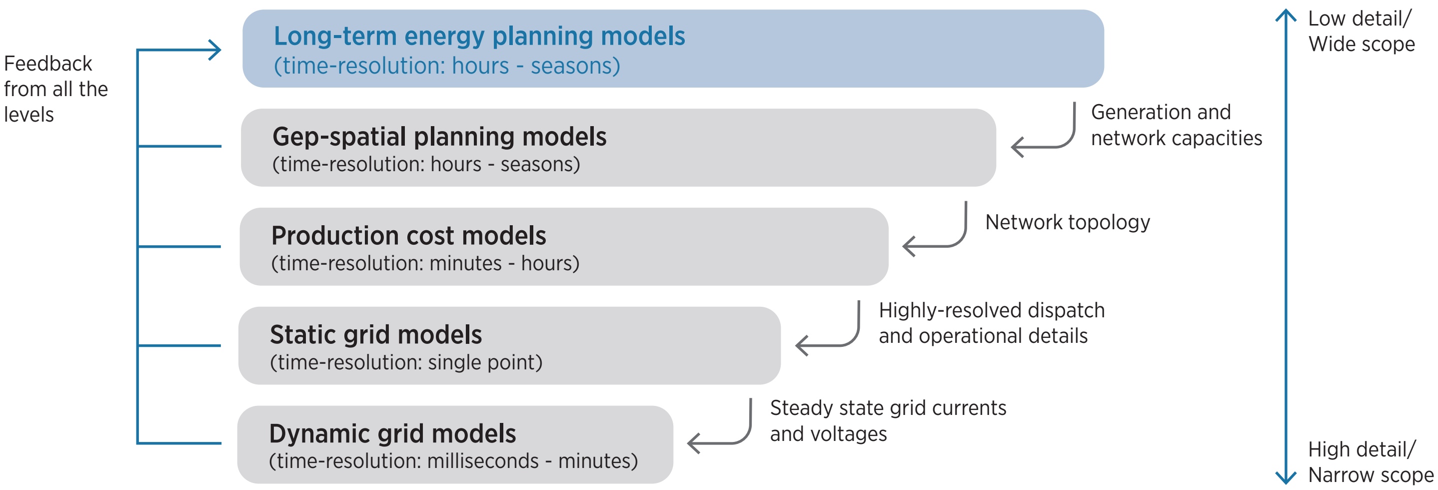
Co-ordination among LTES entities

Often, there is a range of national institutions involved in scenario development at different stages of planning. Greater co-ordination is needed not only between energy planning agencies and institutions, but also with the climate community.

Within a national government, the methodology and governance relating to LTES may vary greatly according to the objectives and conditions of different institutions. Looking at individual LTES in isolation risks misinterpretation and misalignment amongst entities. Co-ordination among institutions can, for example, direct individual LTES to approach the same question from different angles, and thus derive comparable and meaningful conclusions.

The need for a first level of co-ordination in the context of the clean transition was observed between the institutions developing official LTES and institutions conducting technical studies for different segments of the power system, in particular when planning for high shares of variable renewable energy (VRE). Figure 11 provides a visual representation of how VRE properties impact different power system properties and the planning stages in which these issues are taken into account – most likely by different institutions involved in the generation, transmission and distribution of electricity.

Figure 11: The systematic interaction and feedback channels between institutions involved in the planning process



Source: (IRENA, 2017a).

A second level of co-ordination revealed in LTES campaign discussions is that between institutions from different sectors developing scenarios. The campaign has revealed disconnects between the climate community that is responsible for setting climate targets and the energy planners who have experience with energy scenarios and models. The campaign has recognised, through discussions, the importance for aligning LTES with climate targets – for example, with Nationally Determined Contributions (NDC) – in order to avoid infrastructure lock-ins due to myopic visions and a widening emissions gap (UNEP, 2019). IRENA analysis has shown that national LTES tend to be more ambitious than NDCs and are sometimes contradictory (IRENA, 2019).

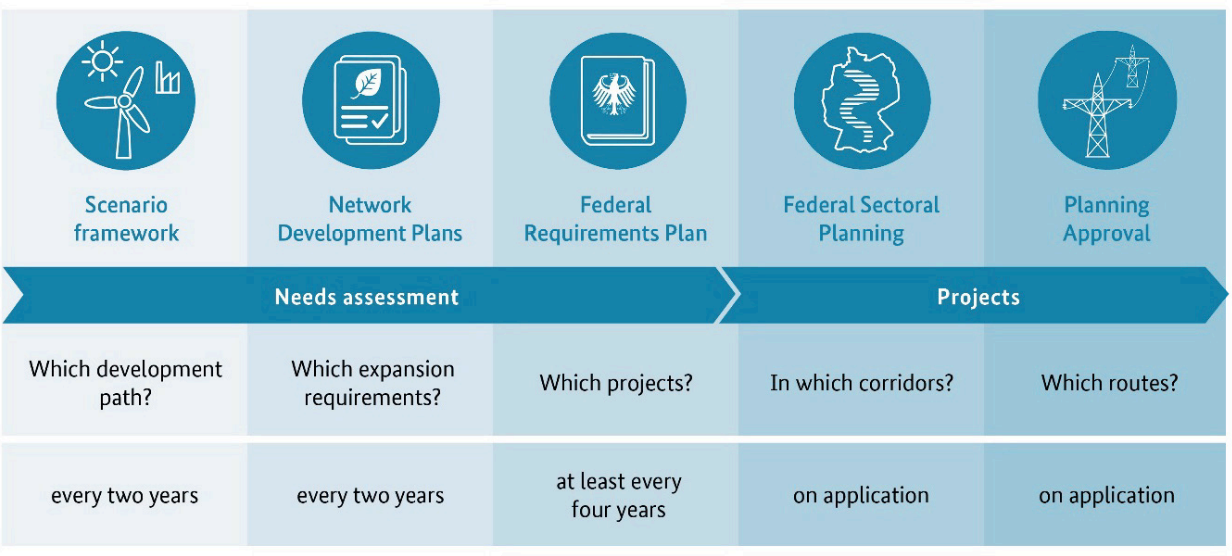
An additional level of LTES co-ordination highlighted by the campaign is between federal and central governments, and national and regional governing bodies. Co-ordination for LTES development in these different jurisdictions can be complicated, as these can depend on different types of energy resources for their future development. In order to overcome this difficulty, discussions suggested bottom-up and top-down co-ordination. The concept of regional co-ordination is not just a physical one, but a geographical and bilateral concept that could include integration of factors of commonality. LTES could be a tool utilised to consider regional diversities and serve them.

Germany

In Germany, the biannual transmission expansion planning process is co-ordinated between the Transmission System Operators (TSO) and the Federal Network Agency (Bundesnetzagentur). Every four years the German Parliament decides on priorities for future transmission investment (Bundesnetzagentur, 2017). First, the TSOs draw up a draft scenario framework. The scenarios take account of all factors relevant to the development of transmission network infrastructure, including assumptions about developments in power production, consumption and about ongoing investments in networks. The scenarios incorporate the status quo and developments in Europe, and therefore ensure alignment with ENTSO-E's scenarios leading to the formulation of the TYNDP (ENTSO-E, 2020). The regulator publishes the draft scenario framework and gives the public the opportunity to comment on it (over 660 individuals from eight stakeholder categories participated in the latest round), (Bundesnetzagentur, 2020a). The consultation process continues with the Bundesnetzagentur assessing the input from all stakeholders and closes with an official confirmation of the scenario framework.

Next, the Network Development Plan (NDP) itself is developed. The TSOs use the scenario framework to model the network expansion requirements for the next ten to fifteen years (the latest for 2021–2035), (Bundesnetzagentur, 2020b). Using the approved NDP as evidence, every four years the regulator proposes amendments to the Federal Requirements Plan by submitting a list of new transmission investments to Parliament. The Federal Requirements Plan determines the need for specific transmission investment as part of subsequent permitting steps (Federal Sector Planning and Planning Approval). This five-step co-ordination process of LTES development and transmission network planning is depicted in Figure 12. Co-ordination amongst entities using and developing scenarios prevents push-backs and therefore speeds along the network expansion process required for wind and solar PV capacity expansion in Germany.

Figure 12: German co-ordination process for transmission expansion scenarios, planning and permitting



Adapted from the 2nd LTES International Forum (Bundesnetzagentur, 2017).

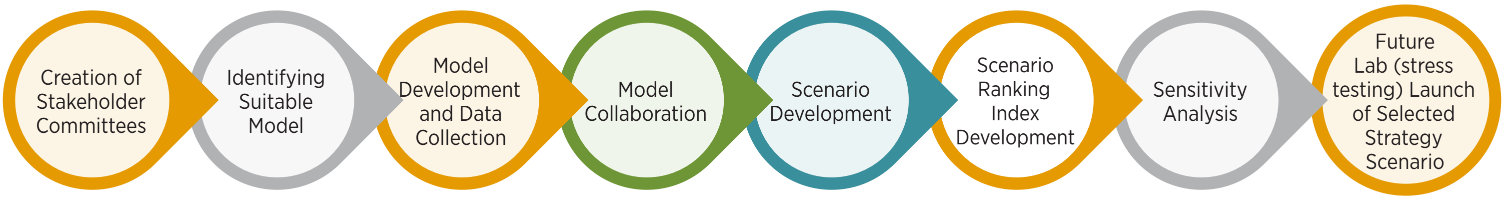
Italy

In Italy, an inter-institutional approach has been adopted to ensure the alignment of energy stakeholders for elaborating energy scenarios and plans. An interdisciplinary working group was set up in 2016 under the co-ordination of the Presidency of the Council of Ministers, which later passed the co-ordination to the Ministry of Economic Development, which is responsible for energy scenario policies. The working group for the elaboration of the Integrated National Energy and Climate Plan for 2030 (MISE et al., 2019) and of the Long-term strategy 2050 (MISE and MATTM, 2017) was coordinated by the state company, GSE (the Italian Manager of the Energy Services), upon request of the Ministry of Economic Development. The Ministry of Foreign Affairs and International Co-operation also plays a relevant role by leading dedicated policy boards for energy and climate diplomacy, which are periodically engaged to provide updates and policy inputs on relevant issues at a national and international level, with the involvement of the public and private sectors.

United Arab Emirates

In the United Arab Emirates, the Ministry of Energy and Infrastructure is the leading institution for energy planning and use scenarios to inform their first *National Energy Strategy 2050* (Ministry of Energy and Infrastructure, United Arab Emirates, 2017). Figure 13 illustrates the development process of the strategy, which involved a collaborative approach with the creation of a team representing all communities and local governments in the UAE. This co-ordination step was carried out before starting data collection and modelling activities, and after obtaining the final scenario results. Since the UAE has a federal structure, where policies and regulations are set at a local level, it is crucial to have strong stakeholder collaboration and validation for the results to be accepted (UAE Ministry of Energy and Infrastructure, 2019).

Figure 13: UAE Energy Strategy 2050 development process

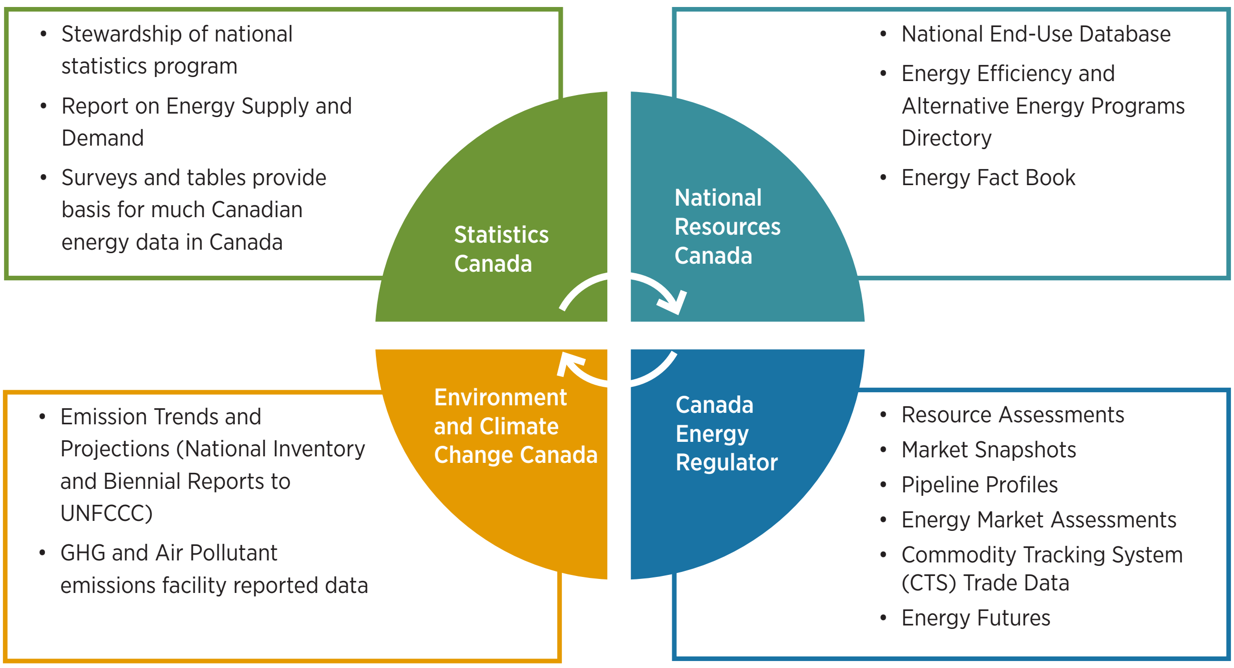


Adapted from the LTES webinar series (Ministy of Energy and Infrastructure , United Arab Emirates, 2019)

Canada

In Canada, there are four organisations within the federal government that play a role in the collection and analysis of data for, and the modelling of, LTES. These institutions co-ordinate their efforts through the Federal Energy Information Framework to develop a suite of energy information products (see Figure 14). The Canada Energy Regulator (CER) is responsible for the flagship series, *Canada's Energy Futures,* which explores how possible energy futures might unfold over the long term (CER, 2019a). The federal level scenarios developed in this series are used to inform policymaking at the Ministry of Natural Resources (NRCan); however, provinces and territories also produce information products to complement federal scenario work, given their significant autonomy in many sectors, including energy and carbon pricing (NRCan, 2019).

Figure 14: Canada's Federal Energy Information Framework

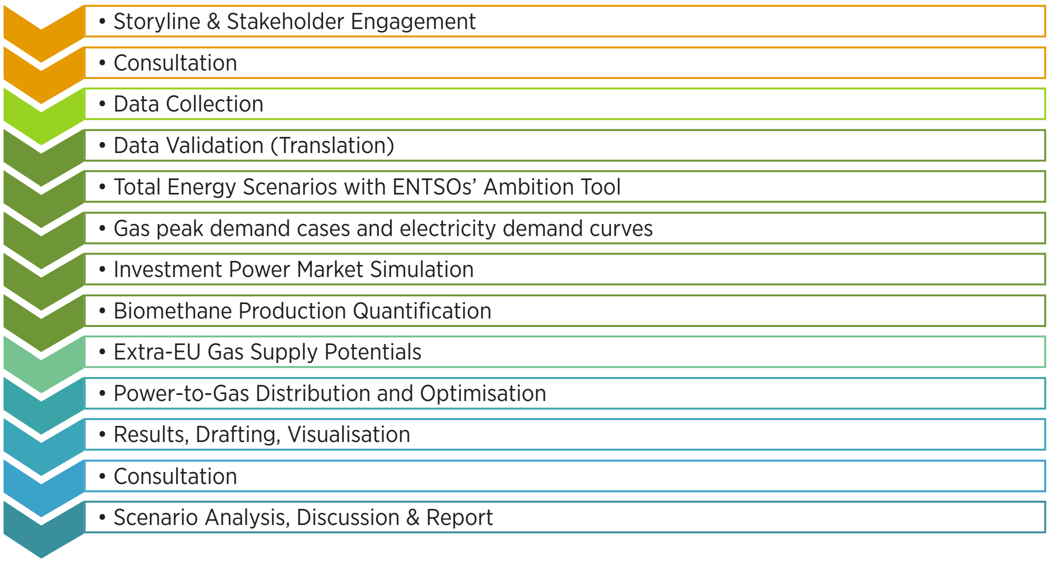


Adapted from the LTES webinar series (NRCan, 2019).

Global

In Europe, the European Network of Transmission System Operators for electricity (ENTSO-E) and gas (ENTSOG) conducted a joint Scenario Report (ENTSO-E and ENTSOG, 2020a) – the second report of its kind to involve the two ENTSOs working closely together to develop European-focused scenarios. Co-ordination between these two entities for cross-sectoral scenario development combines the expertise of gas and electricity TSOs. The work provides a basis to allow assessment for the European Commission's Projects of Common Interest (PCI) list for energy, as the ENTSOs progress to develop their Ten-Year Network Development Plans (TYNDPs) (ENTSO-E, 2020). Building upon the experience of previous scenarios, the joint scenarios combine ENTSOG's and ENTSO-E's methodologies and allow for the development of new joint methodologies (ENTSO-E and ENTSOG, 2020b). Figure 15 shows the steps taken to co-ordinate and develop the joint scenario report. ENTSO-E and ENTSOG co-ordinated with each other and also with the environmental NGOs, Renewable Grid Initiative (RGI) and Climate Action Network (CAN) Europe, to set the carbon constraints for their ambitious decarbonisation scenarios by 2050 (European Parliament, 2019).

Figure 15: Scenario-building steps for the ENTSO-E and ENTSOG joint scenario



Source: (ENTSO-E and ENTSOG, 2020b).

Global

In Latin America, the United Nations Economic Commission for Latin American and the Caribbean (ECLAC) has been advocating regional integration, with the Regional Energy Planners Forums being thematically aimed 'towards sustainable regional integration' based on the complementarity of renewable energy (CEPAL, 2019). Forums such as this – where national energy planners can meet, and exchange scenarios and planning experience – foster the co-ordinated development of regional LTES. The Inter-American Development Bank (IDB) and the World Energy Council have led regional scenario studies for Latin America (IDB, 2017; World Energy Council, 2017), and concluded that isolated energy planning and scenario development misses opportunities for higher trade and economic deployment of VRE, and hence limits the speed of the energy transition.

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1.2 Expanding the boundaries of scenarios

Model results are inevitably shaped by the scope of the model itself. To adequately reflect the complexities of the clean energy transition, models and scenarios need to better address new technologies, business models and disruptive innovations.

The energy transition is no longer solely concerned with specific technology or cost evolutions, but now also involves managing structural change. Many innovations are coming together, both within and around the energy sector, such as digitalisation, decentralisation and electrification. The means by which these innovations will be fully developed and deployed remains uncertain, and unexpected breakthroughs may occur. Unconventional non-energy players are also increasing their interaction with the energy sector (e.g. by facilitating prosumer activity), making the supply side harder to distinguish from the consumer side.

Representing such disruptive innovations and dramatic social changes in LTES remains a challenge. It is important not only because the boundaries of a given energy model determine the results, but also because the comparability of LTES can be hindered by vastly different or unclear model boundaries. Throughout the campaign's discussions, experts stressed that innovation and socio-economic features of the energy transition are not being well reflected in LTES, and therefore LTES are likely to struggle to provide guidance to policymakers and hinder a just and inclusive transition.

Scenarios for a just, clean energy transition

The campaign unveiled the importance of investigating questions from policymakers in relation to the impacts of the clean energy transition on economic growth, employment and welfare. Scenarios can be utilised to guide policymakers on how to achieve a prosperous and inclusive just transition.

A recurring discussion topic was the socio-economic footprint of the clean energy transition and how these impacts differ depending on the policymakers' actions today in relation to the transition. An important concept is that there will be "winners" and "losers" of the clean energy transition, thus policymakers are interested in identifying these groups in order for policy to adhere to the principle of equity; a just transition should leave no one behind (IRENA, 2020b). Campaign discussions highlighted that it is necessary to answer the questions *policymakers ask* and not the questions *scenario developers want them to ask*. The recent COVID-19 pandemic has drawn renewed attention from policy makers on sustainable development pathways for a green recovery.

Box 3 discusses the impact of the COVID-19 pandemic and the role of LTES in times of such change and uncertainty in furthering the clean energy transition.

Germany

In Germany, the coal phase-out may cause unemployment in the coal industry. In January 2019, following an lengthy consultation process, a government-appointed commission proposed a total phase-out of coal in Germany by 2038 (BMWi, 2019). The phase-out plan included a €40 billion economic package offered to affected coal regions, including alternative industry investment projects and state aid for coal workers (UNEP, 2019). Traditional scenarios that usually leave out complex socio-economic aspects can only inform on the macroeconomic suitability and technological viability of the energy transition. Hence, the German experience reveals the need for integrating socio-economic analysis into LTES analysis to guide policymakers in the realistic impacts, consequences and timelines of a just transition (BMWi, 2020).

Finland

In Finland, the VTT Technical Research Center of Finland Ltd (VTT) develop national LTES and perform scenario analysis for the clean energy transition (VTT, 2020). Figure 16 presents the scenario modelling framework to study the impacts of long-term energy policies, which has been used in collaboration with other national research institutes (VTT, 2018). As can be seen, in addition to energy systems, LTES policy analysis includes impacts on the national and regional economies, on land use and forests (particularly important for Finland's greenhouse gas mitigation and the whole economy), and on matters of the environment. This inclusion of multiple sectors translates into a broader scope for LTES and different research disciplines are accounted for – not to mention important socio-economic aspects that are specifically taken into account, such as the impacts on environment, nature, air, emissions and therefore public health.

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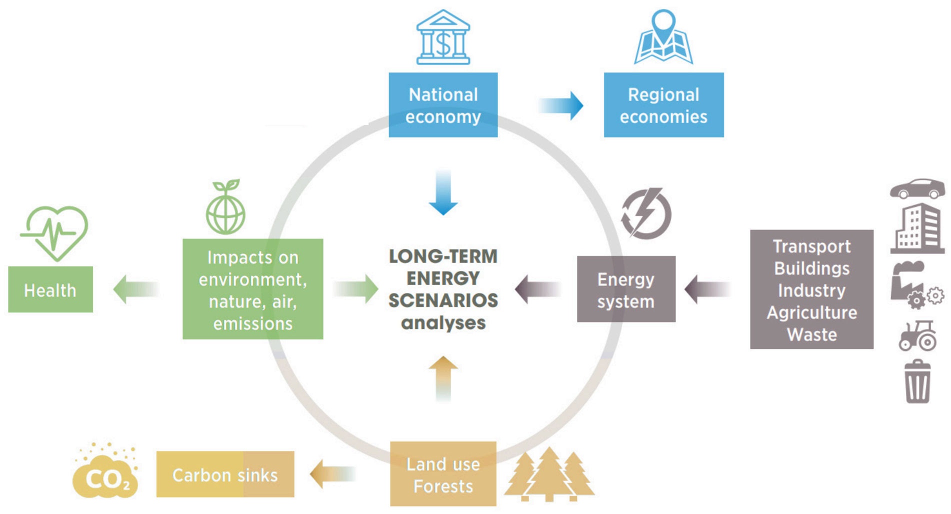
Figure 16: Finland's scenario modelling framework to study the impacts of long-term energy and climate policies



Adapted from the LTES webinar series (VTT, 2018).

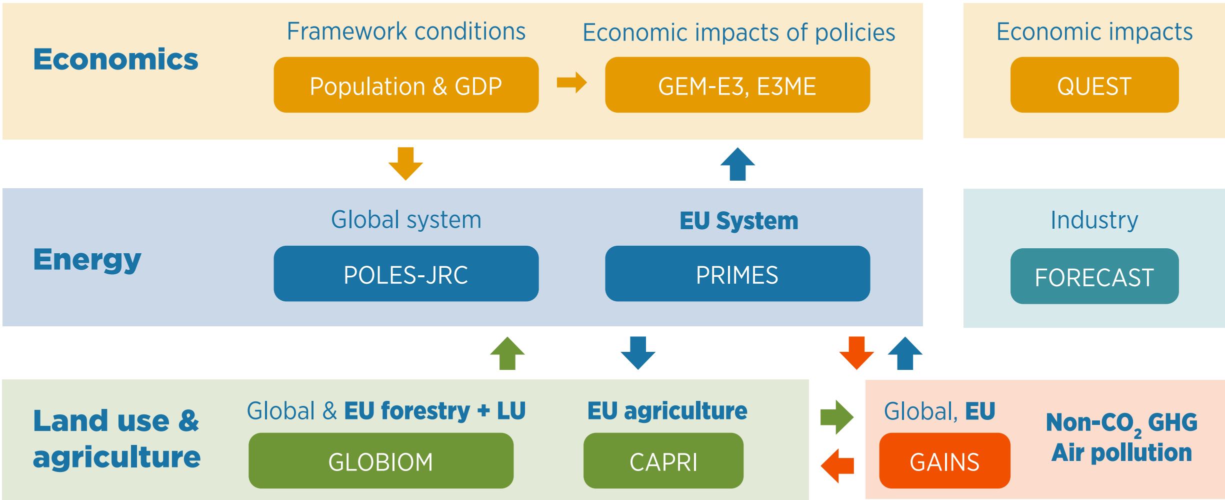
Global

In Europe, the European Commission´s scenario study A *Clean Planet for all: A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy*, presented scenarios to 2050 that consider the interaction of the economy, energy, land use and agriculture, and non-CO_2 GHG and air pollution (European Commission, 2018). Figure 17 showcases the modelling suite for this integrated scenario approach, with a wider perspective accounting for important aspects of a just and inclusive clean energy transition. Specific models are used to capture the economic impacts of policies on jobs, productivity and economic growth at the EU level, in close connection to models that represent the conditions at the global level and feedback loops between sectors.

In a global context, the International Labour Organisation (ILO) created a Green Jobs Assessment Model (GJAM) capable of assessing clean energy transition policy impacts on societal and employment outcomes, as well as on economic environmental performance (ILO, 2019). The ILO´s analysis showed that a 2-degree scenario will have a global net job creation of 18 million by 2030[2] (ILO, 2018). The ILO has also made available an open source methodology for countries to measure and model the social and employment outcomes of climate and sustainable development policies (ILO, 2017).

2 Percentage difference in employment outcomes between the IEA 2°C and 6°C scenarios by 2030.

Figure 17: The European Commission modelling suite for integrated modelling of the economy, energy, land use and agriculture, and air pollution



Adapted from the LTES webinar series (European Commission, 2019).[3]

Box 3: LTES FOR THE CLEAN ENERGY TRANSITION IN LIGHTOF THE COVID-19 CRISIS

The impacts of COVID-19 on the global economy and the resulting fall in oil prices in early 2020 serve as reminders of how unforeseen factors can disrupt both actual trends and planned processes. These developments confirm the importance of the close interconnections between the energy system and the wider economy.

The health, humanitarian, social and economic crises triggered by the COVID-19 pandemic could either slow or accelerate the transition pathways of our societies. Much will depend on how countries respond in terms of economic stimulus. The COVID-19 crisis has triggered the preparation of vast economic incentive packages – representing possibly the largest structural economic investment in decades. There is a serious risk that some countries may see conventional energy investments as a more attractive route to recovery than the energy transition.

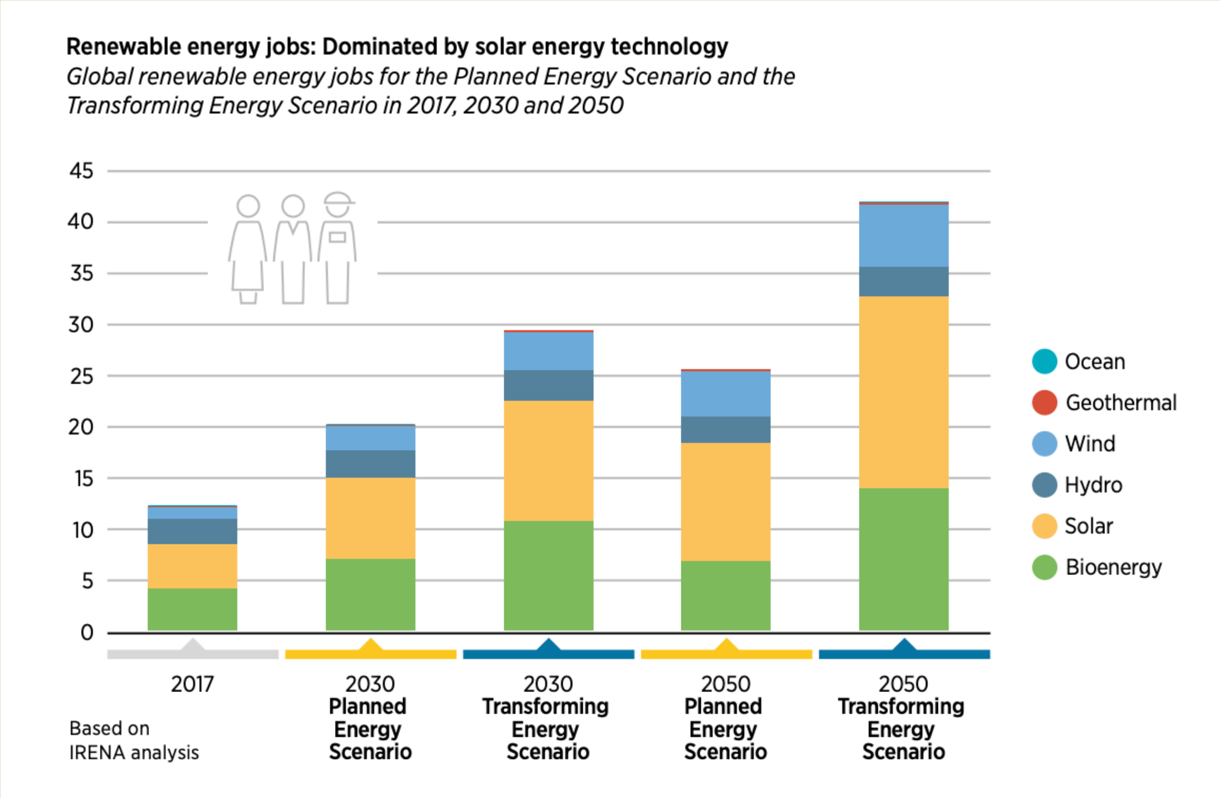
Insights gained through the LTES campaign so far have been reflected in the recent *Policy Briefs in support of the High-Level Political Forum 2020: Accelerating SDG 7 Achievement in the time of COVID-19,* released on 4 June 2020 at the United Nations (UN, 2020). The key message conveyed was that "LTES can demonstrate the superior socioeconomic and environmental outcomes of targeting sustainable energy transition pathways in terms of investment and job creation opportunities and resulting increased resilience of the population and the economy. Scenarios can also expose the risks of stranded assets and inform policy makers as to which policy options and criteria can be applied to [aid] recovery".

3 General Equilibrium Model for Economy - Energy - Environment (GEM-E3), Energy-Environment-Economy Macro Econometric Model (E3ME), question answering model (QUEST), Prospective Outlook on Long-term Energy Systems inhouse model created by the JRC (POLES-JRC), Price-Induced Market Equilibrium System model (PRIMES), forecast model FORECAST, Global Biosphere Management Model (GLOBIOM), Common Agricultural Policy Regional Impact Analysis model (CAPRI) and Greenhouse gas – Air pollution Interactions and Synergies model (GAINS).

IRENA´s *Post-COVID Recovery* report (IRENA, 2020c) offers practical advice on key investment and policy decisions for the crucial post-COVID recovery. It is rooted in the comprehensive long-term energy transformation strategy provided by IRENA's first Global Renewables Outlook *2050* (IRENA, 2020b), which not only portrays the futuredevelopment of regional and global energy systems but carries out a thorough assessment of the socio economic footprint of the transition – namely on welfare, GDP and jobs.

According to the *Global Renewables Outlook 2050* (IRENA, 2020b), a Transforming Energy Scenario (TES)[4] would lead to almost 42 million jobs in the renewable energy sector, as can be seen in Figure 18. This jobs figure is almost 70 percent more than under a Planned Energy Scenario[5] and 3.5 times greater than the present-day total (12.5 million). New jobs in transition-related technologies and sectors are expected to outweigh job losses in fossil fuels and nuclear energy. Solar energy technology and bioenergy would dominate the renewable energy job market.

Figure 18: Global renewable energy jobs for the Planned Energy Scenario and the Transforming Energy Scenario in and 2050



Source: (IRENA, 2020b)

4 The "Transforming Energy Scenario (TES)" describes an ambitious, yet realistic, energy transformation pathway based largely on renewable energy sources and steadily improved energy efficiency (though not limited exclusively to these technologies). This would set the energy system on the path needed to keep the rise in global temperatures to well below 2 degrees Celsius (°C) and towards 1.5°C during this century.

5 The "Planned Energy Scenario (PES)" is the primary reference case for this study, providing a perspective on energy system developments based on governments' current energy plans and other planned targets and policies (as of 2019), including Nationally Determined Contributions under the Paris Agreement, unless the country has more recent climate and energy targets or plans.

Accounting for innovation in the energy sector

The clean energy transition invites disruptive innovation within the energy sector and in all other sectors of the economy. Innovation in decentralisation, digitalisation and electrification of the energy system are the key to a renewable-powered future and need to be better accounted for in clean energy transition scenarios.

Many of the recent or emerging trends underlying the clean energy transition are not well reflected in – or are absent from – LTES, due primarily to gaps in the current capability of modelling tools. For example, consumer behaviour such as maximising self-consumption from rooftop solar PV systems by connecting with residential battery storage and electric vehicles was simply not in the minds of model designers 20–30 years ago.

The hydrogen economy, and the way in which it may co-evolve with electricity infrastructure, remains largely absent from current techno-economic modelling. Today's scenarios also likely underestimate the growth of variable renewable energy and sector coupling (in transport, buildings and industry).

Box 4 discusses the landscape for such innovations to facilitate Variable Renewable Energy (VRE) integration.

Box 4: THE LANDSCAPE OF INNOVATIONS FOR FACILITATING THE INTEGRATION OF VARIABLE RENEWABLE ENERGY

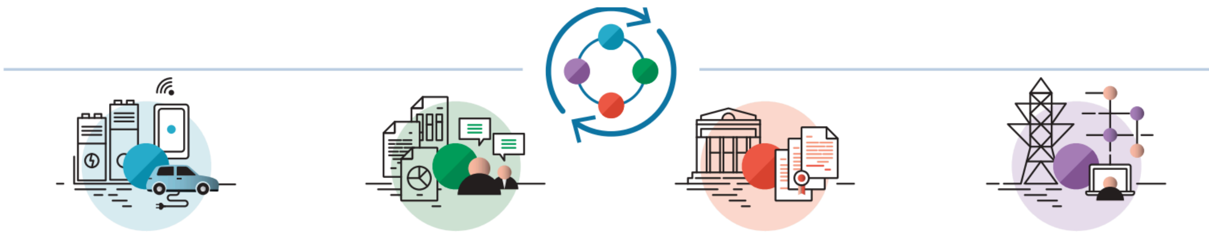
While proper long-term energy planning and scenarios can address system flexibility by identifying complementarity between variable renewable energy (VRE) and the electrification of end-use sectors, many other innovations to integrate a high share of VRE are also emerging and are being implemented worldwide. IRENA has identified a suite of 30 such innovations across four key dimensions of the world's power systems (IRENA, 2019a), see Figure 19.

As the VRE share grows in a power system, innovations become key to unlocking synergies and reducing overall system costs. Not all innovations will necessarily be applicable immediately and strategies to deploy particular sets of innovations are naturally country- and context-specific. Their benefits will depend on aspects such as the rate of electricity demand growth, the level of existing grid interconnectivity and the spread of domestic natural resources, among others.

For this reason, countries exploring how to facilitate the integration of VRE through LTES may include "flexibility assessments" in addition to the traditional long-term capacity expansion modelling. Such assessments can dig deeper into the feasibility of innovation in the energy system to gauge when and where more specific flexibility measures could be taken to support national clean energy transition plans. IRENA provides a user-friendly tool for precisely this purpose – assessments with the flexibility tool "FlexTool" reflect full power system dispatch and offer a detailed view of flexible generation options, demand flexibility and energy storage, along with sector-coupling technologies like power-to-heat, electric vehicles and hydrogen production through electrolysis (IRENA, 2018a). The IRENA FlexTool is currently the only publicly and freely available (open-source) tool of its kind and can be found along with detailed training materials for use on the IRENA website.

The National Renewable Energy Lab (NREL) conducted the study, Power Sector Transformation Pathways to explore objectives, factors and technology innovation to inform power sector pathway decisions with a time horizon of 2050 (NREL, 2020a). Through expert analysis, the study identified innovation in technologies that are most likely to have a major impact on the power sector. Figure 20 represents potential technology disruptions relevant for distributed energy resources (DER) and bulk power transformation, based on current expectations of the number of years until they penetrate the market as well as their potential impact for transforming the power sector.

Figure 19: The landscape of innovations to integrate variable renewable energy



ENABLING TECHNOLOGIES

1 Utility-scale batteries
2 Behind-the-meter batteries

3 Electric-vehicle smart charging
4 Renewable power-to-heat
5 Renewable power-to-hydrogen

6 Internet of things
7 Artificial intelligence and big data
8 Blockchain

9 Renewable mini-grids
10 Supergrids

11 Flexibility in conventional power plants

BUSINESS MODELS

12 Aggregators
13 Peer-to-peer electricity trading
14 Energy-as-a-service

15 Community-ownership models
16 Pay-as-you-go models

MARKET DESIGN

17 Increasing time granularity in electricity markets
18 Increasing space granularity in electricity markets
19 Innovative ancillary services
20 Re-designing capacity markets
21 Regional markets

22 Time-of-use tariffs
23 Market integration of distributed energy resources
24 Net billing schemes

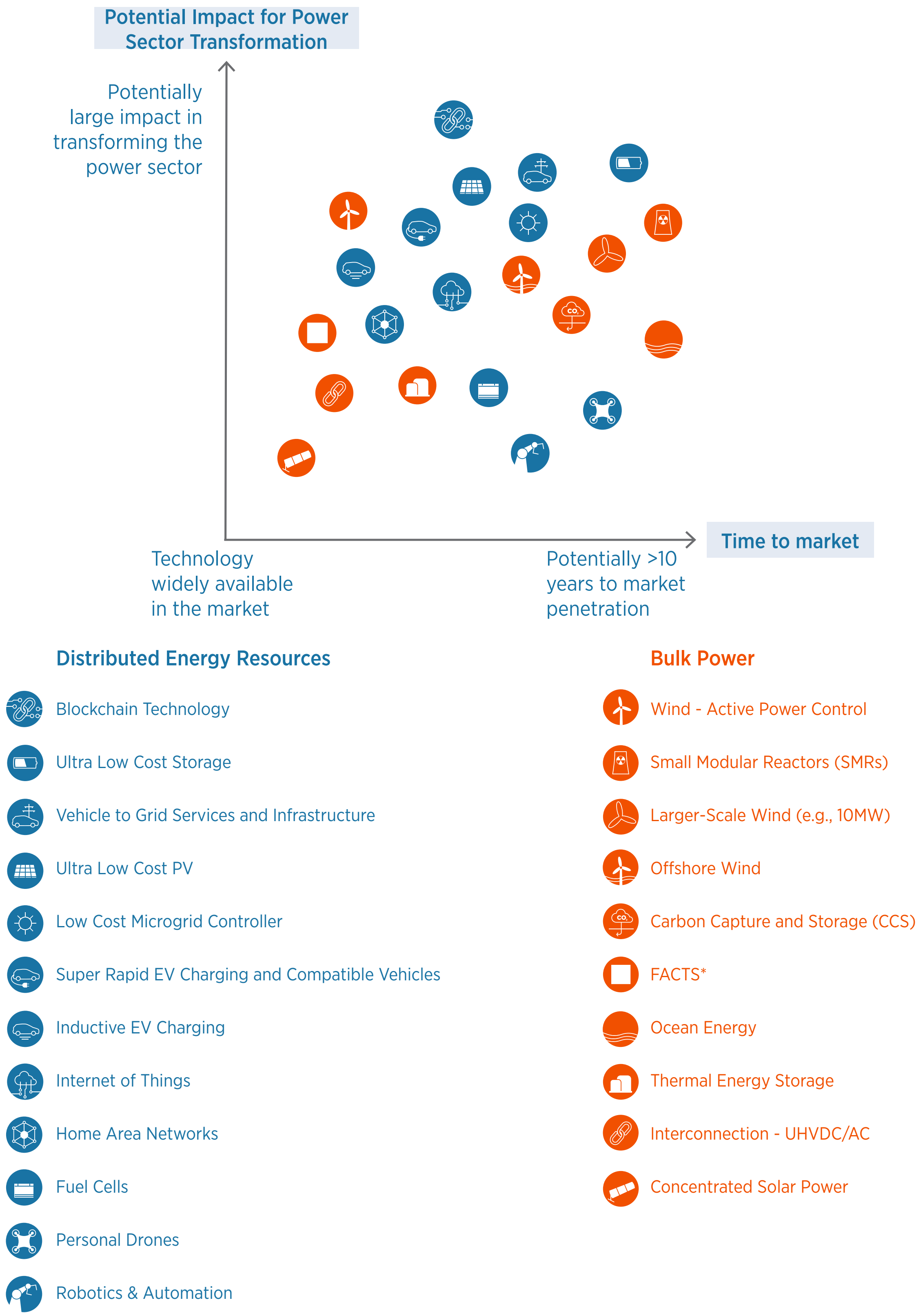
SYSTEM OPERATION

25 Future role of distribution system operators
26 Co-operation between transmission and distribution system operators

27 Advanced forecasting of variable renewable power generation
28 Innovative operation of pumped hydropower storage

29 Virtual power lines
30 Dynamic line rating

Figure 20: NREL illustrative view of disruptive technologies for distributed energy resources and bulk power transformation



Adapted from The Second IRENA LTES International Forum (NREL, 2020a).

Although many disruptions are unforeseeable, planners are concerned that those that are on the radar now are still excluded from models, therefore limiting scenarios' insights and neglecting investment requirements. Discussions in the campaign touched upon the question of capturing innovation on two fronts: firstly, showcasing experiences that are taking stock of the landscape of innovations (see Box 4); and secondly, improving the understanding and modelling of innovation in LTES (see Box 5).

Japan

In Japan, The Ministry of Economy Trade and Industry (METI) has overall responsibility for energy policy, scenario development and modelling, including responsibility for the *5th Strategic Energy Plan* (METI, 2018). The scenarios used in the plan have a time horizon of 2050; however, the long-term analysis is primarily for a shorter-term strategy to 2030. The analysis provides an energy mix target for 2030 and identifies the challenges for achieving the energy transition and decarbonisation for 2050. The 2030 energy demand and supply targets are pre-emptively decided, based on safety, energy security, efficiency and the environment, and the analysis looks at how this could be achieved. For the long-term outlook for 2050, a forecast with a high level of probability is difficult because it involves the potential and uncertainty of technological innovation, and the lack of transparency regarding changes in conditions. For this reason, METI take the approach of using multiple-track scenarios under which ambitious targets are set but priorities are always decided based on the latest information. The multiple-tracked scenarios pursue all options, including renewable energy, hydrogen and Change to Carbon Capture and Storage, and nuclear power.

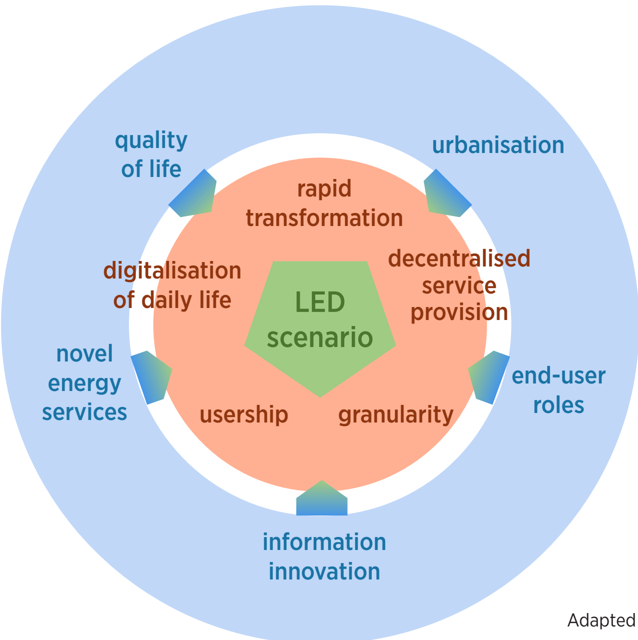
Italy

In Italy, one of the main dimensions of the Italian INECP is represented by research and innovation (MISE et al., 2019) aimed at developing product and process technologies for the energy transition, while favouring the context in which these innovations are implemented. For this purpose, the Italian Ministry of Economic Development has created two levels of governance: a first level, with a task force of ministries responsible primarily for doubling public funds; and a second level, with an 'operational' task force represented by the main public research organisations. In this framework, the research and innovation action within the context of LTES has focused on: i) architecture and management models for electricity networks – integration of non-programmable renewable, self-production, storage, energy communities and aggregators; and ii) models and tools to facilitate the use of electric vehicles in transport (MISE et al., 2019).

Global

In a global context, as part of the Low Energy Demand (LED) project led by the International Institute for Applied Systems Analysis (IIASA), the Tyndall Centre for Climate Change Research studied *Low energy demand scenario for meeting the 1.5 °C target of the Paris Agreement and sustainable development goals (SDG) without negative emission technologies* (Grubler et al., 2018). The study showed that innovations in the type of energy services drive structural changes in intermediate and upstream supply sectors. In Figure 21, the blue wheel encompasses the big picture innovations in demand, such as quality of life and urbanisation; the inner brown circle reflects the more specific ways in which demand will be shaped, such as digitalisation of daily life and decentralised service provisions. The scenario projects energy demand in 2050 to be 40 percent lower than today's, meeting the 1.5°C climate target as well as many sustainable development goals without relying on negative emission technologies, such as Direct Air Capture and Bio-Energy with Carbon Capture and Storage, which are divisive in the renewable energy and environment community.

Figure 21: Drivers of future innovation for a low energy demand scenario

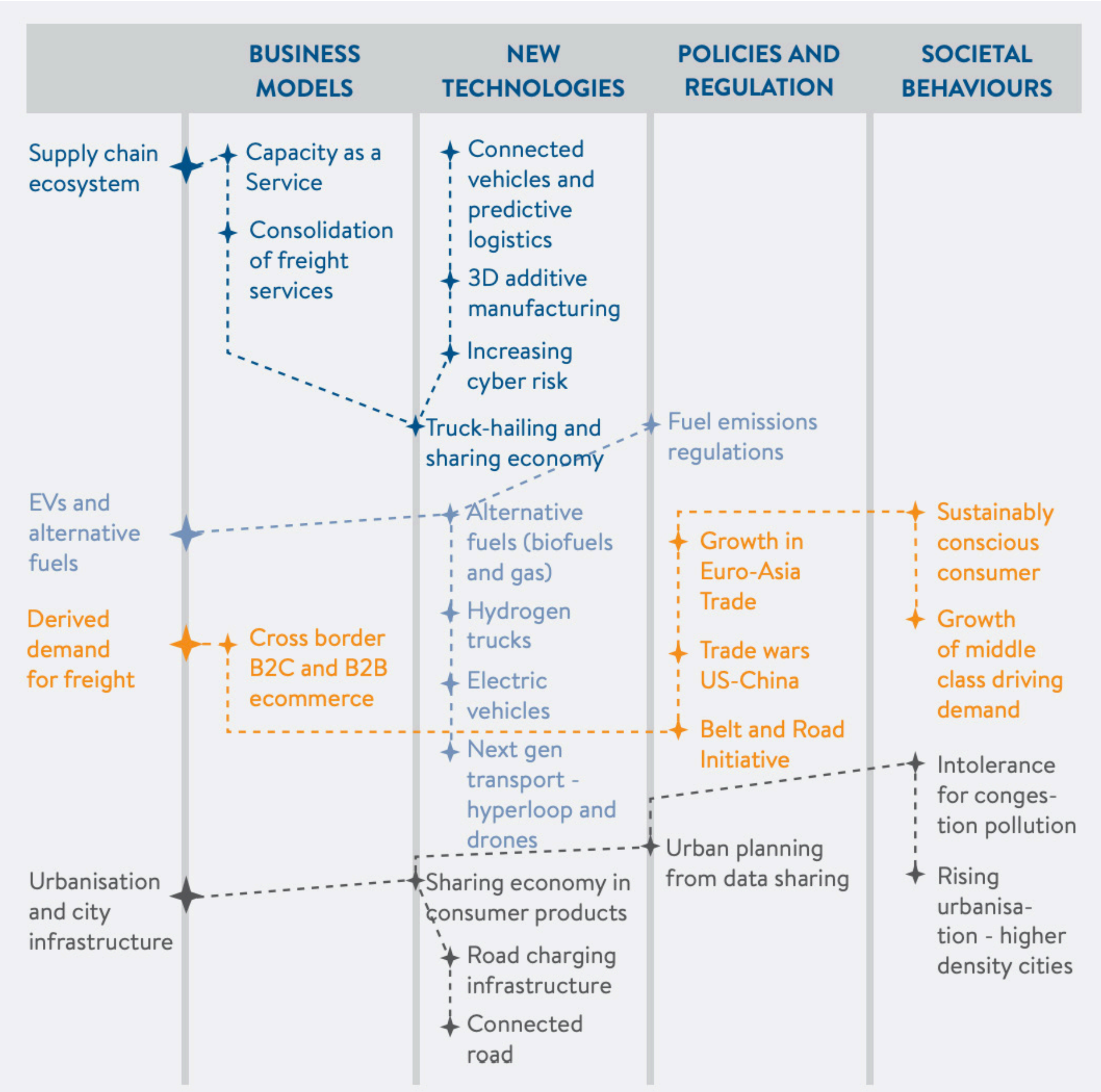


Adapted from The Second IRENA LTES International Forum (Tyndall Centre, 2020).

Global

The World Energy Council recognises that a new era of disruptive innovation – with the potential for effecting rapid changes to the whole energy system – is unfolding. "Disruption-as-usual" involves a combination of technology and non-technology innovation and fundamentally new business models, contrasted with the "business-as-usual", improvement of the baseline/underlying system's historic trend. The World Energy Council report *Designing for Disruptions* (World Energy Council, 2019b) describes the new phenomenon using a "Constellation of Disruptions" (CoDs) framework for explaining the combinatorial effects of innovations – in technology, society, business and policy – that are emerging from within and beyond the energy sector to reshape the energy system. An example of a constellation provided in the report is 'commercial mobility' (that is, commercial fleets and road freight), where a number of individual high-impact emerging disruptions were identified (see Figure 22). Understanding the CoDs approach and using it as a tool, enable ecosystem leaders to identify where disruption-driven opportunities may arise and to explore what implications they might have for the energy sector and capturing new and shifting value. The World Energy Council's latest global scenario publication considers innovation pathways to 2040 as one of the main drivers guiding the energy transition of the future (World Energy Council, 2019a).

Figure 22: The World Energy Council's Constellation of Disruptions in Commercial Road Fleets



Source: (World Energy Council, 2019b).

As these examples illustrate, many countries are strengthening the development of LTES by establishing strong governance structures and expanding the scope of LTES. LTES development governance is aided by co-ordination among entities (namely those in the energy sector and climate community) and also by creating wide-reaching participatory processes for public consultation (involving academia, civil society and the private sector). This reflects on the depth and breadth of the energy transition and the need for larger sectors of society and the economy to engage as active players in the scenario development process.

Countries and institutions are also expanding the scope of their scenarios to include features, concepts and narratives particular to the clean energy transition. The clean energy transition will bring structural changes that will lead to societal and economic impacts that need to be planned and discussed to ensure the transition is just. LTES are a tool to explore these impacts and can be used to advise government beyond the technological demands of the transition. Expanding the scope of scenarios will require an expansion in the scope of models to include digitalisation, decentralisation and other new and innovative interactions between suppliers and consumers, and other sectors such as land, economy, transport, air pollution and health.

Box 5: IMPROVING THE UNDERSTANDING AND MODELLING OF INNOVATION IN LTES

During the 74th IEA ETSAP[6] Workshop, a collaborative ETSAP–IRENA–CEM session on "Innovation in long-term energy scenarios" was organised with the aim of bringing together innovation practitioners and experts within the energy systems modelling community (IEA-ETSAP, 2018). The two open questions explored in the workshop were: *how well do models capture the role of innovation?* and *how should the impact of disruptive technologies and innovation solutions be represented?*

Innovation has been traditionally represented in energy models via specific parameters – such as costs (learning curves) and technology technical parameters – but a reflection on the impact of other innovation elements is missing (IEA, 2018). Innovation is traditionally introduced in an exogenous and simplistic way and is applied on few technologies, while missing the comprehensive picture, which leads to biased results.

Discussion with experts during the workshop underlined the main points that would help energy system models, and therefore scenarios, to become more relevant for business planning and policy making under large innovation-related uncertainties. The following actions were suggested:

1) Include:

- Different time horizons with alignment to different business cycles or political electoral cycles.
- Near-term measures and transition strategies.
- Co-production between resources, e.g. future bio-fuel plants, co-electrolysis and bioenergy.
- Speculative technologies, even if controversial.

2) Adopt:

- Stochastic and probabilistic methods (e.g. Montecarlo analysis setup).
- Black swan scenario/unknown-unknown scenario.
- Wide spread of scenarios with contrasting scenarios.

3) Combine with:

- Historical lessons, i.e. what went well, and what did not.
- Use of historical innovation examples to illustrate the dynamics.
- Different modelling approaches to provide complementary insights on similar scenarios.
- Better visualisation of results: illustrating the required technologies, resource constraints and sector linkage.

4) Clarify:

- Scenarios that are not predictable but indicative and based on system constraints and assumptions.
- The uncertainties associated with the scenarios analysed and appropriate means to overcome them.

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6 The Energy Technology Systems Analysis Program (ETSAP) is a Technology Collaboration Programme within the International Energy Agency: https://iea-etsap.org/

02

IMPROVING SCENARIO USE

2.1 Clarifying the purpose of scenario building

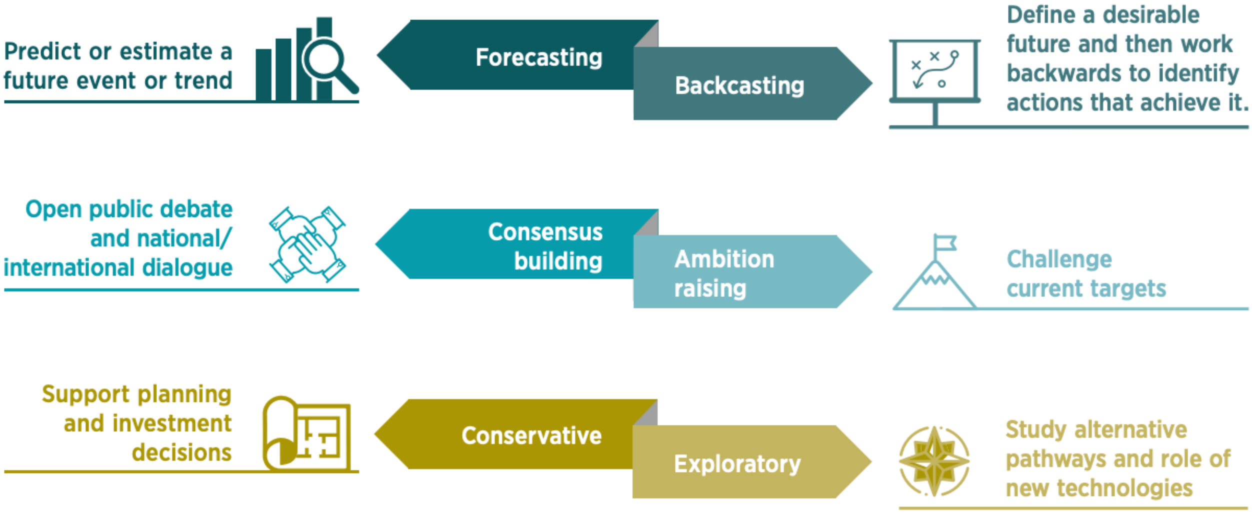
Scenarios can be used for different purposes, depending on the context and the goals being pursued. Such distinctions should be clear to avoid misinterpretation of clean energy transition scenarios.

Although the inherent purpose of a scenario is to portray a vision of the future, expectations as to what scenarios can provide and how they are used can vary significantly depending on the context; this must be well-understood in their application. While some policymakers might expect scenarios to provide forecasts and a clear answer to a policy question, others use them to inform choices by exploring future uncertainties.

Discussions during the LTES campaign indicate a clear consensus among those who develop scenarios that exploring uncertainties is becoming increasingly important as the clean energy transition progresses. The campaign has found that conservative scenarios tend to be used for infrastructure planning (such as that undertaken by public utilities) while more exploratory scenarios tend to remain as academic exercises to explore more radical or even extreme transformations. Such distinctions are useful in better understanding scenario insights.

Most scenarios developed by the LTES campaign participants fall somewhere in the middle of the conservative–exploratory spectrum. In the context of national policy making, using scenarios for consensus building through an open and participatory process is critical; in other contexts, scenarios can be used to pursue a specific agenda and raise ambitions. While consensus-building processes may appear to limit the role of ambitious views, experience from LTES campaign members shows that civil society often demands a cleaner energy future – thus, an open and participatory process may result in higher ambitions. Figure 23 shows three *polar pairings* of LTES uses that have been identified throughout the campaign's discussions as being employed for planning for the clean energy transition.

Figure 23: Types of uses of LTES for planning the clean energy transition



Forecasting and backcasting

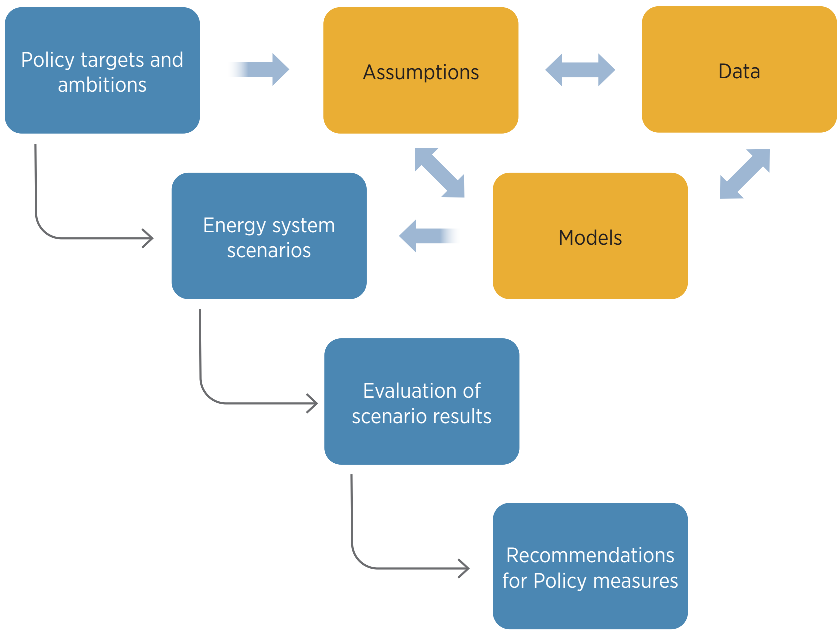
Forecasting is used to predict future events or trends, or to answer the question: *what is going to happen?* When employing scenarios to this end, the decision makers and decisions are already reflected within the scenario. During the campaign, we found few governments using scenarios as forecasts, presumably because the planning horizon is much farther, making forecasts harder to predict. However, the majority of decision makers ask for forecasts to make investment decisions; but the scenario community usually does not produce such outputs. Private industries seem more prone to using scenarios in the forecasting context (BP, 2019; DNV GL, 2019; Shell, 2008; Siemens Gamesa, 2020). See Box 6 for a discussion on private companies' use of scenarios.

Alternatively, backcasting can be used to provide potential pathways backwards from a certain goal or target and can assist in determining policies to support the achievement of goals, or asking the question: *how do we get to a certain point in the future?* This question is aimed at getting the best possible understanding of what implications certain decisions have for the future ('what-if' questions), and is thought to be the most prominent type answered in the scenario modelling community to see which measures may cost-effectively lead to a particular future.

China

In China, the State Grid Energy Research Centre (SGERI) develops scenarios that guide policymaking; for example, scenarios that help the National Energy Administration to set targets for renewable energy capacity expansion. Internally, scenarios also assist SGERI in planning China´s large-scale energy base, as well as mid- and long-term capacity expansions of cross-regional transmission lines (SGERI, 2019; SGERI et al., 2017). The China National Renewable Energy Centre (CNREC) applies LTES to policy-making for the clean energy transition, resulting in the publication of annual energy outlooks (NDRC and CNREC, 2019). LTES are used as recommendations for policy measures on how to reach China's ambitious targets of remaining below 2-degrees of temperature rise by having a clean, low-carbon, safe and efficient energy system by 2050, as laid out in the 13th five-year plan (Central Committee of the Communist Party of China, 2016). Starting from these targets CNREC utilises backcasting LTES analysis for the annual energy outlooks, asking how to achieve these long-term targets. This backcasting approach is accompanied by a forecasting approach that considers the current stated policies in order to determine additional policy requirements to realise the clean energy transition. Figure 24 represents the framework for this analysis, which includes an iterative process to define scenarios from targets using assumptions, data and models.

Figure 24: China's use of LTES resulting in recommendations and policy measures for the energy transition



Adapted from the LTES webinar series (CNREC, 2019).

Building consensus and raising ambition

The campaign's discussions with stakeholders have emphasised the fact that scenarios cannot predict the future; however, they can be a means to open debate and build consensus around how the future may look, and to bring stakeholders together. In the context of the clean energy transition, scenarios can be used to generate debate and build consensus over the pathways to be taken to achieve the desired level of decarbonisation. However, there is concern that stakeholder consensus limits ambition, since they must make room for compromise and diverging perspectives; such compromise could lead to half-baked solutions and slow down the speed of the clean energy transition. Some institutions overcome this concern by using ambition-raising scenarios to challenge current targets or to determine the preferred transition pathway that informs national energy plans (i.e. using normative scenarios rather than scenario outlooks or plausible scenarios).

The Netherlands

In the Netherlands, the Netherlands Environmental Assessment Agency (PBL) is responsible for harmonising national and regional energy planning towards achieving the clean energy transition. PBL produces an annual publication, the *National Climate and Energy Outlook*, with the time horizon of 2030–2035 (PBL, 2019a). Further to this, PBL develops scenarios and options to consider to support the implementation of climate legislation and consensus building amongst wider stakeholders, including provinces and municipalities; this includes support for regional strategy development (PBL, 2019b). PBL built a simple model to represent different types of decision makers with different time horizons and cost considerations in order to provide ease in exploring different options to achieve the clean energy transition; the purpose is to aid strategists in analysing their policies by acting as a reference point, in order to standardise and compare, and therefore build consensus (PBL, 2018).

Global

In Europe**,** IRENA performed scenario analyses for the European Union (IRENA, 2018b) – based on Renewable Energy Roadmaps (REmap) analysis and in co-operation with the European Commission – which found that by 2030 Europe could supply 50 percent of electricity from renewables. These findings contributed to the decision of the European Council to establish a new, more ambitious target of 32 percent of energy from renewables by 2030 (European Parliament, 2018). Other examples of LTES culminating in energy policy ambition-raising can be found in Portugal, UK and Ireland (Chiodi et al., 2015; UCC and IEA-ETSAP, 2019). For example, the scenario work done by the International Energy Agency (IEA) Energy Technology Systems Assistance Programme (ETSAP) in Ireland in conjunction with the University College Cork (UCC) has resulted in ambition-raising within formal policy such as the 2015 Climate Action and Low Carbon Development Act (Government of Ireland, 2015) and the 2014 negotiation with the EU on 2030 targets (DCCAE, 2020).

Conservative and exploratory scenarios

The campaign observed that most government agencies are naturally conservative. For instance, the network development and regulatory design required for the clean energy transition, must be considered plausible and therefore realistic (conservative) scenarios are required. With regards to long-term energy planning for the clean energy transition, conservative scenario analysis is thought to put too much emphasis on projecting the technologies and issues of today into the future. On the other hand, exploratory analysis is useful for preventing persistent business-as-usual conclusions, raising awareness of opportunities, considering future shocks and challenges, and identifying risk and uncertainty related to the clean energy transition. The campaign observed that exploratory scenarios, such as 100% renewable energy scenarios, have been developed primarily by academics and NGOs.

United Kingdom

In the United Kingdom (UK) the power system operator, National Grid, uses scenarios to inform UK energy policy by identifying a range of credible (conservative) scenarios across gas and electricity on a country-wide basis. The *Future Energy Scenarios* publication, with a horizon of 2050, feeds into investment and pre-investment decisions, provides insight into the industry, identifies future opportunities and is a reference point for other forecasts and a starting point for academic studies (National Grid ESO, 2020a).

Australia

In Australia, the Institute of Sustainable Futures (ISF) at the University of Technology Sydney produced scenarios to explore "100% renewable energy for Australia" (UTS, 2016). The most ambitious scenario in the report results in a renewable electricity system by 2030 and a fully renewable energy system by 2050. This requires all coal power plants to shut by 2030 and electricity use to double by 2050 to replace direct fuel consumption, as well as all new capital investment in the power sector being almost entirely (99%) directed to renewables and cogeneration until 2050. Furthermore, the ISF collaborated with the German Aerospace Centre (DLR) and the University of Sydney to develop the OneEarth Climate Model. The model was used to produce three global energy scenarios for staying below 1.5°C temperature rise by transitioning to 100% renewable energy and implementing natural climate solutions such as carbon sinks in the form of forests. The scenarios contained a comprehensive assessment of energy solutions, as well as an assessment of the metals required for manufacturing, and an employment analysis (Teske, 2019).

Box 6: THE PRIVATE SECTOR'S USE OF LTES

Stakeholders are increasingly requesting information from companies regarding their alignment with clean energy technology, sustainable development and the Paris Agreement targets. LTES can be a suitable tool for incorporating energy- and climate-related issues (mitigation and adaptation) into a company's strategic planning process and for understanding the related uncertainties. A scenario-based forecast analysis can be used to study how an organisation might perform under different possible futures, each of which is described by a scenario.

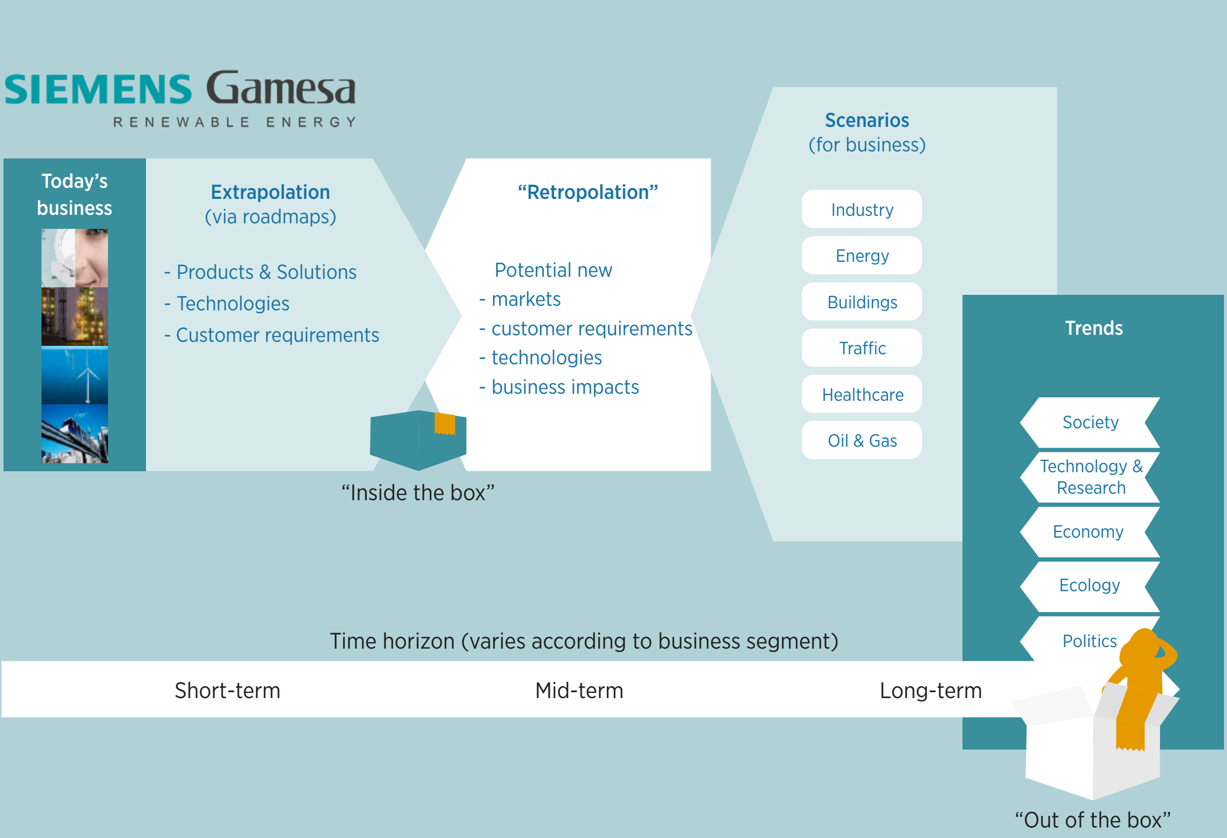
The French Association of Private Companies (AFEP) and its members carried out a study, *Energy and Climate Scenarios: Evaluation and guidance*, to assess the use and development of energy and climate scenarios in companies (AFEP, 2019). The study found that the publicly available climate–energy scenarios that project future changes in energy flows, greenhouse gas emissions and certain socio-economic variables made by multiple stakeholders such as international organisations, NGOs and research centres, are not fit for companies' purposes, especially in terms of input assumptions and modelling tools. Given this limitation, companies should conduct an in-house scenario-based foresight analysis based on storylines that narrate the pathway of the company's business environment in the future

Siemens Gamesa is an exemplar of a private company using scenarios (Siemens Gamesa, 2020). The scenario analysis is described by the company in terms of 'extrapolation' (forecasting) and 'retropolation' (backcasting). Extrapolation uses today's knowledge to understand what the future could look like. Retropolation is a method that starts with the goal, working its way backwards, looking at what needs to be done to achieve this goal. This approach is represented in Figure 25, in which energy scenarios are included to illustrate the impact of trends in Siemens Gamesa´s business model. This scenario analysis essentially allows the company to build a better picture of complexity; but whilst the scenarios can be used to identify the largest uncertainties, disruptive innovations and technologies cannot be predicted.

Once a company has completed an in-house scenario-based forecast analysis, it may disclose its information. The Task Force on Climate-related Financial Disclosures (TCFD) guidelines, for example, provide a framework to develop voluntary, consistent climate-related financial risk disclosures for use by companies in providing information to stakeholders (TCFD, 2017). The TCFD suggests that companies with revenues in excess of 1 billion EUR are expected to conduct a scenario analysis to test the robustness of their business model against potential risks of climate change and demand scenarios to include a range of transition and physical risks relevant to the organisation. For example, the Bank of England uses scenarios to translate the impact of physical and transition risks into financial risks and wider macroeconomic impacts (Bank of England, 2019).

The Network for Greening the Financial System (NGFS) is a group of 65 central banks and supervisors, and 12 observers, committed to sharing best practices, contributing to the development of climate- and environment-related risk management in the financial sector and mobilising mainstream finance to support the transition toward a sustainable economy. The Scenario Explorer (IIASA, 2020) is a web-based user interface hosting the NGFS-developed transition scenarios. The explorer models the scenarios and provides data visualisations of the results.

Figure 25: Siemens Gamesa scenario analysis for a strategic vision of the future's impact on business



Adapted from the Second LTES International Forum (Siemens Gamesa, 2020).

2.2 Transparent and effective communication

Transparency ensures the quality of scenarios and builds trust. Scenario assumptions and results need to be clearly communicated in the context of the more complex clean energy transitions and innovative communication methods that are now emerging.

Scenarios are often most useful as a communication tool that translates the complexities of the energy system into understandable and internally-consistent messages. The clean energy transition introduces new elements and dynamics into energy systems; through effective scenario communication, policymakers can develop a better understanding of how these elements and dynamics play out and thereby make more informed decisions.

In LTES campaign discussions, communication was flagged as one of the main challenges in terms of the use of scenarios. The abundance of scenarios offering diverse pathways to achieve the clean energy transition often confuses decision-makers. Recognising this issue, an increasing number of research institutions have created web-based platforms that allow comparison of LTES (see Box 7), and some LTES campaign member countries have initiated innovative approaches to improve communication.

Effective communication tools

Communication facilitates the LTES participatory processes and engages important actors whose co-operation is required to achieve the clean energy transition. The insights offered by scenarios must be communicated in simple messages that can be understood by non-experts and people who do not deal with scenarios on a regular basis.

Web-based LTES visualisation platforms and calculators are now an integral part of the scenario development process in LTES campaign member countries and many others. Such tools can aid better understanding among decision-makers of the strengths and weaknesses of different modelling approaches, i.e. which scenario is best suited to answer which question. They also provide access to scenario insights by a broader range of stakeholders and the general population interested in seeing LTES through a more palatable communication medium.

United Kingdom

In the United Kingdom, the Department for Business, Energy and Industrial Strategy (BEIS) is developing the MacKay Carbon Calculator, following the flagship DECC 2050 Calculator (DECC, 2013) – an online tool that calculates the resulting emissions and energy mix based on users' selections of ambition levels for elements of each sector with a time-horizon of 2100. This provides the user with experience in, and creates understanding of, scenario analysis and pathway results. Harvesting these user-defined scenarios provides BEIS with some insight on citizen perspectives. The DECC 2050 Calculator was the inspiration and foundation for many other calculators, including the Global Calculator, which is a model of the world's energy, land and food systems to 2050 (DECC et al., 2020).

Canada

In Canada, the Canada Energy Regulator (CER) developed Exploring Canada's Energy Future, an online interactive tool based on data from the *Energy Futures* report (CER, 2019a, 2019b). The tool allows the user to explore energy production and consumption trends and forecast them into the future. The user can explore by region, sector, electricity, scenario or demand. The tool is part of the Data Visualisation Initiative (DVI), which aims to transform how the CER structures and shares data (CER, 2019c). The objective is to enable evidence-based decision making and remove barriers to understanding Canada's energy and pipeline systems through the use of user-friendly interactive visualsations. All the data is downloadable and shareable, as is the source code for the visualisations.

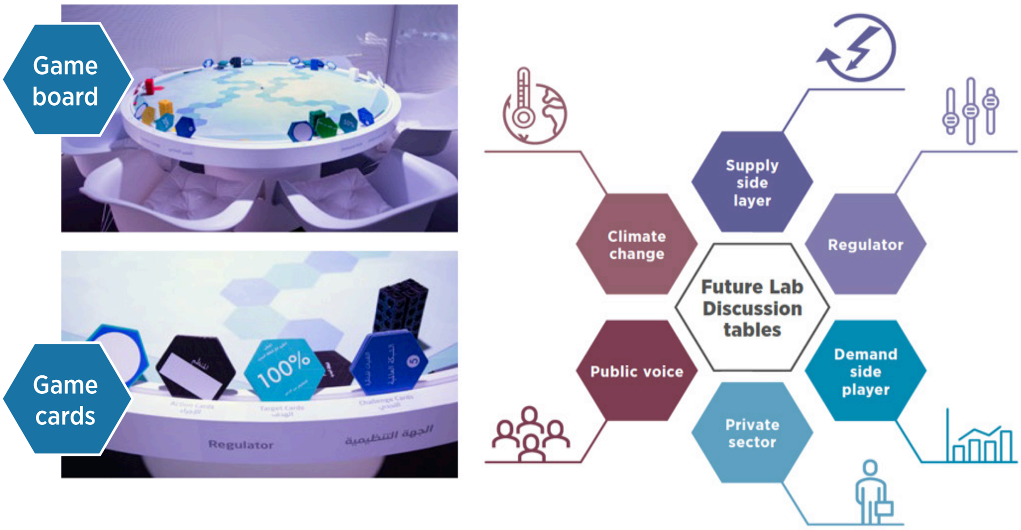
Denmark

In Denmark**,** Denmark Technical University has built an innovative online communication tool for scenario analysis. The purpose of the tool is to open debate and increase understanding around energy planning. The user selects a scenario and the tool generates a visualisation of the results, the tool can also visualise a comparison of scenario results. The scenarios provide a unique opportunity for in-depth understanding and interaction with political strategies in relation to energy and climate policy. For example, previously, scenarios were based on political party manifestoes, the updated scenario visualisation tool is now based on the Climate Partnerships, through which the Danish government works closely with the business community that plays a central role in the clean energy transition (DTU, 2020).

United Arab Emirates

In the United Arab Emirates, the Ministry of Energy and Industry designed the *Future Lab* game, as part of its Energy Strategy 2050 (Ministry of Energy and Infrastructure, United Arab Emirates, 2017). The purpose of the game was to provide a means for high-ranking officials to learn about the complexities of future scenarios in a comprehensible way (see Figure 26). The outcome offered the possibility to stress test the opportunities and systemic consequences of each future with decision makers. The game provided the players with experiential insight into future scenarios – such as 'smelling the air of the future' if scenarios continued burning fossil fuels (Ministry of Energy and Infrastructure, United Arab Emirates, 2019).

Figure 26: A game to improve scenario transparency: The FutureLab communication exercise used by policy makers in the United Arab Emirates



Source: (Ministry of Energy and Infrastructure, United Arab Emirates, 2019).

Saudi Arabia

In Saudi Arabia, KAPSARC have developed a user-friendly platform for the transport analysis framework, which provides users with insight into scenarios. The scenario results are determined by infrastructure, technology and efficiency, and pricing measures that are intertwined with energy policy (KAPSARC, 2020).

Chile

In Chile, the Ministry of Energy has developed a Tableau-based platform to visualise national scenarios that includes energy demand, generation capacity, GHG emissions and an investment map (Ministerio de Energía de Chile, 2019b). This platform, alongside the annual update report, provides a valuable means of communicating Chile's long-term energy plans.

Transparent and publicly available information

Transparency is required in terms of input data, methodology and assumptions. This allows scenarios to be thoroughly scrutinised and decision makers to trace which assumptions drive specific results

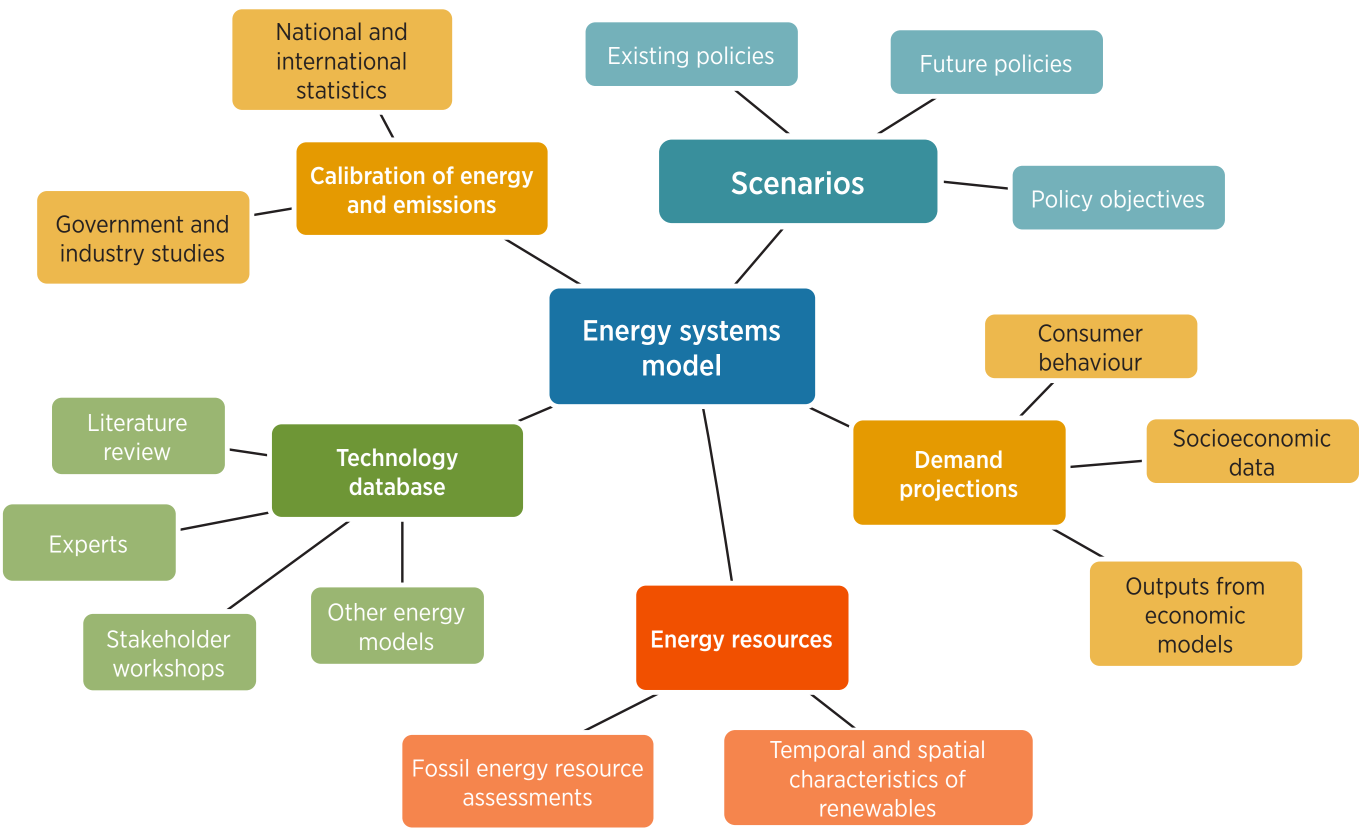
The LTES campaign saw calls from scenario for clarification of key input data and parameters into models and scenario outputs (see Figure 27). Both government officials and representatives from civil society – namely from NGOs and the open source modelling community – asked for more transparency and accessibility to the abundant input data that models require, and to avoid 'black box' approaches (Open Energy Modelling

Initiative, n.d.; RGI, 2018). Technology cost data was identified as especially important, given that most scenario developers use renewable technology cost projections for 2030 and 2040 that are already in place now (IRENA, 2020d), so results are very conservative – indeed, there is a call to take account for the speed of data change in scenarios.

In the campaign discussions, several stakeholders suggested that it is sometimes useful to engage a broader group of models and modelling teams to gain a broader range of outcomes. Comparing outcomes allows users to identify what drives the scenarios and the meaning of variations in results. Such a network of modellers and models acts as a form of quality control through peer review, which stimulates improvements. See Box 7 for an example of using scenario comparison for creating transparency and mapping uncertainty.

Transparency and availability of LTES assumptions and data is crucial in order to engage a broader range of stakeholders and open the process to criticism from consulting participants. Government officials should use scenarios to promote transparency and predictability in their plans, so that the private sector can adapt and prepare for the transition.

Figure 27: Data analysis and inputs required for modelling LTES



Adapted from the Second IRENA LTES international Forum (IEA, 2020).

Italy

In Italy, the Energy Services Manager (GSE) is responsible for curating national LTES that advise the National Energy Strategy (MISE and MATTM, 2017) – which was replaced by the Integrated National Energy and Climate Plan (INECP). It is also committed to the statistical production and analyses that are required for understanding how the energy system works, and subsequently the pathway to a clean energy transition. The GSE is therefore part of a broad collaboration of private and public bodies constituting the National Statistical System (SISTAN).[7] SISTAN provides the country and international organs with official statistics through annual publications (SISTAN, 2019). This creates transparency and data legitimacy, and creates a platform for wider and more reliable research surrounding LTES.

Denmark

In Denmark the Danish Energy Agency (DEA) publishes the Energy Cost and Technology catalogues (DEA, 2020c), which provide year-on-year updates on costs and the efficiency of technologies to be used for analysis of energy systems and as a reference point for scenario building. The catalogue is continuously updated as technologies evolve, if data changes significantly or if errors are found. Its purpose is to establish a uniform, commonly accepted and up-to-date basis for long-term energy planning both nationally and internationally. This public sharing of information, methodology and caveats provides complete transparency. The catalogues are key for the DEA to produce the Danish Energy Outlook (DEA, 2020a).

United States

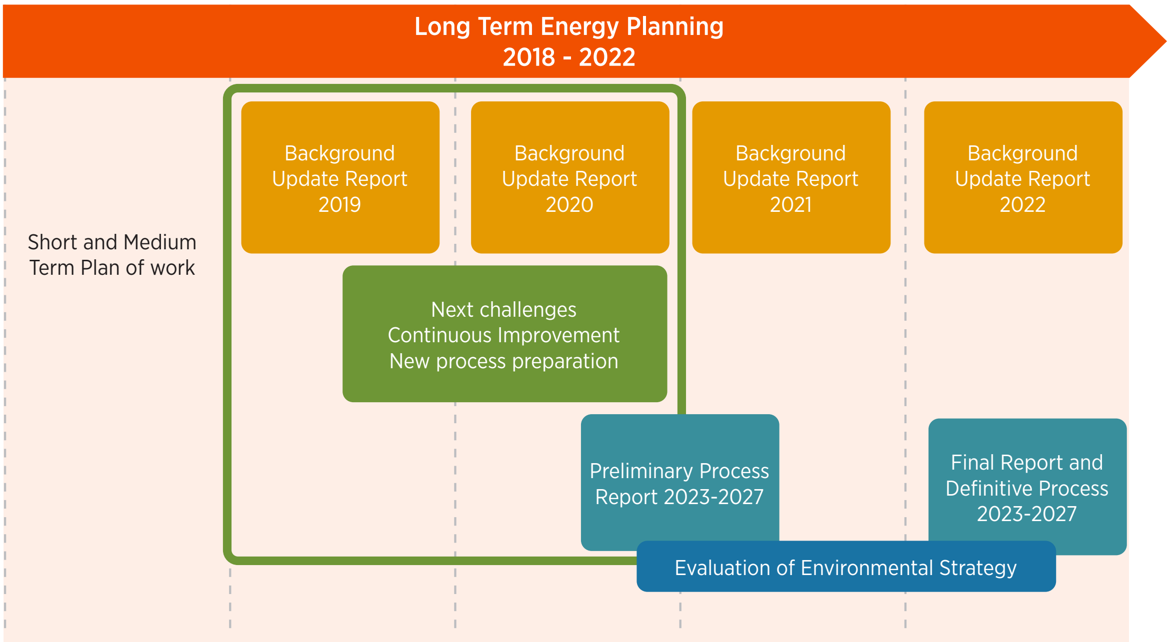
In a similar fashion, in the United States, the National Renewable Energy Laboratory (NREL) publishes the Annual Technology Baseline (ATB) report, which includes detailed current and projected cost and performance data for renewable and conventional technologies to support and inform the power sector (NREL, 2020b).

Chile

In Chile the Ministry of Energy, has a 5-year Long-term Energy Planning process (PELP), (Ministerio de Energía de Chile, 2018c), the timeline for this process is depicted in Figure 28. The PELP process is publicly available and accessible online; this includes all the information about how committees are formed, as well as methods, assumptions and deadlines (Ministerio de Energía de Chile, 2020). This level of accessibility ensures transparency of national LTES, in terms of their development and even their uncertainties. Also available are annual background update reports on assumptions, cost trends and technology developments of the PELP process, generated to meet the evolving nature and ever changing landscape of the clean energy transition (Ministerio de Energía de Chile, 2019c).

7 See: www.sistan.it

Figure 28: Chile's Long-term Energy Planning process including annual updating of LTES background assumptions



Adapted from the 3rd Regional Forum of Energy Planners for Latin America (Ministerio de Energía de Chile, 2018c).

Global

In the Middle East and North Africa (MENA), the Regional Center for Renewable Energy and Energy Efficiency (RCREEE) has developed a renewable energy artificial intelligence database for the region – its Pan-Arab Regional Renewable Energy Investment Platform, TAQAWAY (www.taqaway.net), populated with daily data from energy systems across the Arab region. This information product allows RECREE to review instances of market failure and/or commonality for regional co-ordination. This enables cross-boundary solutions to be identified for advancing the clean energy transition by guiding regional co-ordination in energy planning and regional LTES (LAS and RCREEE, 2016).

The World Energy Council has supplemented its scenarios with the launch of a strategic early warning system – called the Energy Futures Radar (World Energy Council, 2020a) which is aligned with its Covid-19 post-crisis scenarios (World Energy Council, 2020b). The radar detects and decodes signals of change emerging from around the world to see through the current fog of uncertainty and support a more informed strategic conversation on post-pandemic action plans. The radar and crisis scenarios are tools that help leaders to design and stress test recovery plans and post-pandemic strategies. Ultimately, as the world emerges from crisis, the radar will enable a deeper thinking on implications for long-term scenarios and the energy transition. Since its launch in June 2020, the radar has shown that many countries are turning the Covid-19 crisis into an opportunity for transformational change. These and other insights will be considered in the revision of the World Energy Council long term scenarios.

As these examples illustrate, many countries and institutions are improving the use of LTES by clarifying the purpose of the scenarios they build and communicating scenario information to a wide audience. Expectations for what answers scenarios are able to provide can be managed by establishing, from the outset of the development process, the precise purpose and type of analysis to be undertaken (forecasting, backcasting, ambition-raising or exploring). Given that the clean energy transition is a multi-stakeholder process, scenarios need to provide a trustworthy outlook for the evolution of the energy system. Trust in LTES can only be attained through transparency in the assumptions, data and models used to arrive at different views of the future. Examples make extensive use of online platforms not only to display LTES results, but to showcase the complexity of the processes and also gather immediate feedback from observers.

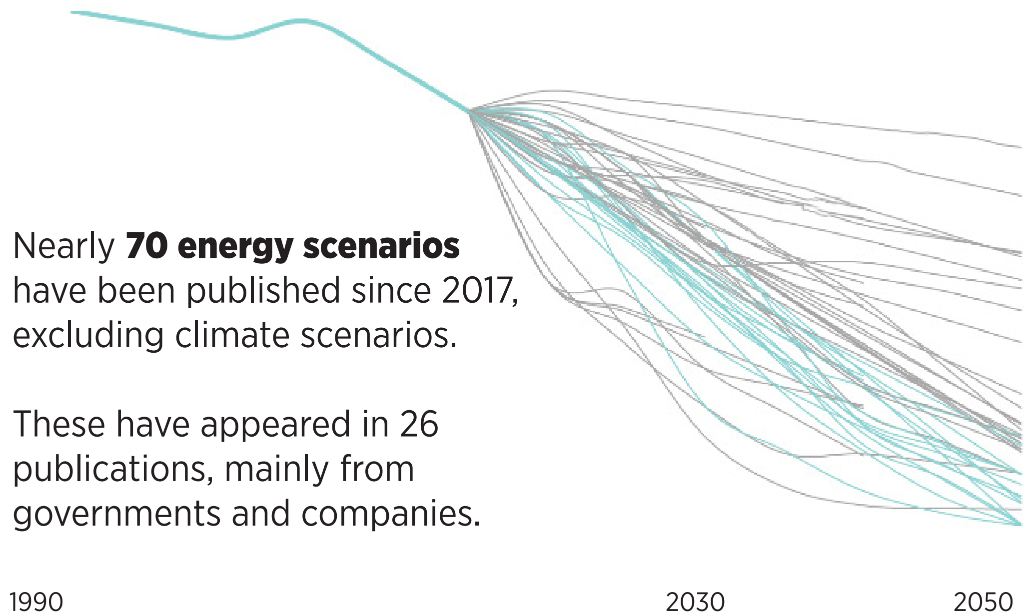
Box 7: IMPROVING TRANSPARENCY AND MAPPING UNCERTAINTY THROUGH LTES COMPARISONS

The LTES campaign has revealed that the use of multiple scenarios from multiple sources has its benefits, as it allows the assessment of a broad range of results and accounts for the inherent biases of scenario developers and modellers. Exercises, in which different scenarios address a common question – for example, how to reach net-zero emissions by mid-century – can improve the communication between modellers and decisionmakers.

However, the multiplicity of views is most useful when they are systematically compared in an effort to benchmark the assumptions and results of scenarios to provide increased reliability of scenario outputs and greater robustness of insights for policymakers planning the energy transition. Scenarios are built for different purposes, have different time horizons and scopes in terms of their sectoral and technological granularity and boundaries, and geographical reach and aggregation, which makes comparison a challenge. Nonetheless, there are good experiences arising from a number of institutions of comparing LTES for the clean energy transition (Ansari et al., 2019; PBL, 2019c; RFF, 2020; RMI, 2019; World Energy Council, 2019).

The European Commission Joint Research Centre (JRC) routinely carries out scenario comparisons. The latest study analysed 20 low carbon energy scenarios published since 2017, mostly from government or private organisations (European Commission JRC, 2020). The study compares a number of indicators that characterise transition scenarios, seeking to point out similarities and differences by 2030 and 2050. This analysis exposes the main differences between scenarios in terms of: divergence in energy efficiency, renewable energy share and the use of biomass, nuclear and hydrogen identified by 2030; and further differences in final energy reductions, renewable energy, amounts of power, renewables replacing oil in transport and technology deployment by 2050. By comparing the similarities between the scenarios, it was found that to achieve deep decarbonisation, fossil fuel use must be reduced by more than 75 percent, 75–100 percent of electricity must be derived from renewable sources (with at least 60 percent coming from VRE), and more than 65 percent of vehicles must be zero-emission vehicles, all by 2050. Figure 29 displays the emission trajectories of these scenarios and the uncertainty range relating to energy- and process-related CO_2 reductions for the EU.

Figure 29: European emission trajectories, past and projected



Emission trajectories based on energy-related and process CO_2 scenarios highlighted in blue have been reviewed by JRC.

Adapted from the 2nd IRENA LTES International Forum (European Commission JRC, 2020
Note: scenarios in blue have been reviewed by the JRC

03

IDENTIFYING CAPACITY BUILDING APPROACHES

3.1 Building the right type of scenario capacity in government

The capacity to use scenarios can be created through the use of modelling tools within government institutions. If modelling is outsourced, governments must still ensure they have the capacity to understand the results.

From the government's perspective, LTES use capacity – the ability of policymakers and other officials to understand and make use of scenario insights to inform policy and investment – is naturally developed in-house, where policymakers are. However, LTES building capacity (including modelling) can be either insourced or outsourced. Figure 30 presents a schematic of the allocation of scenario-building capacity from the government's perspective.

Some governments build in-house modelling capacities to elaborate on the technical aspects of scenarios. Governments that opt to build and maintain modelling capacity in-house do so directly in energy ministries, energy agencies or other government-dependant institutions. Independent energy agencies or technical institutions can be a middle-of-the-road option for allocating scenario-building capacity and boosting in-house capacity. Governments can also choose to outsource all or part of their scenario development work to one or several research/technical institutions or consultancies. IRENA has taken stock of the modelling tools used for energy planning activities (IRENA, 2017a) and how they are applied in different countries around the world, namely in Latin America and the Middle East (IRENA, 2020e, 2017b).

LTES Campaign discussions identified several key factors that broadly determined the success of the approach used to source modelling capacity; these are summarised in Figure 31.

Figure 30: Allocation of scenario building capacityfrom the government's perspective

In-sourcing
LTES capacity allocated solely within ministries or energy agencies

50/50

Out-sourcing
LTES capacity out-sourced to research/ technical institutions or consultations

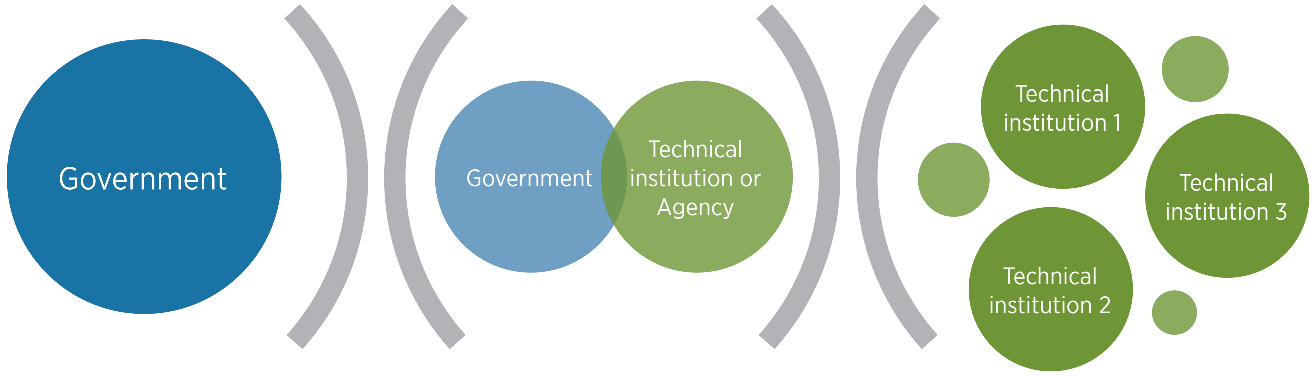


Figure 31: Advantages and challenges of insourcing and outsourcing LTES development capacity

INSOURCING: LTES capacity within ministries or energy agencies		**OUTSOURCING:** LTES capacity out-sourced to research/ technical institutions or consultancies
Ensures closer and faster interaction with policymakers.	**GOVERNMENT INVOLVEMENT**	Can result in intermittent and shorter interactionswith policymakers.
Tends to have a limited number of scenarios, often reflecting more conservative viewpoints.	**SCENARIO DIVERSITY**	Tends to cover a broader range of scenarios, reflecting the client's views and agenda.
Depends on government technical capacity and access to tools and information.	**QUALITY OF RESULTS**	Allows procurement from different high-end commercial tools tailored for purpose.
Quick response to pressing government policy needs, subject to the capacity of the team.	**RESPONSE RATE**	May take time to procure scenarios but offers a range of execution timings as specified by government needs.
Ensures full transparency of inputs and outputs through closer interaction with an in-house modelling team.	**TRANSPARENCY**	Tends to be black-box, and proprietary licences may potentially limit full access to the tools.
Can be cheaper but requires significant efforts to build modelling capacity.	**COST**	Tends to be expensive to hire commercial consultancy firms.
• **Quality assurance (e.g. engaging with academia).** • **Team or agency dedicated to modelling and scenario building.** • **Setting an institutional process for regular updates of LTES.**	**KEYS FOR SUCCESS**	• **Absorptive capacity within a government to understand the modelling results.** • **Full disclosure of scenario data and modelling methodology.** • **Access to enough high-quality research institutions.**

Insourcing scenario development capacity

Having a team or agency dedicated to modelling and scenario building is crucial for successful insourcing. Setting an institutional process for regular updates of LTES and engaging with external stakeholders to establish quality assurance, both support the continuity and growth of internal capabilities.

The experiences of campaign participants provide examples of countries with government officials in ministries or agencies dedicated solely to the task of energy modelling.; hence, they have used models and understand the complexities of building scenarios. Institutionalising energy modelling capabilities in-house requires effective presentation of the tools and their benefits for an institutionalised LTES process – otherwise support for in-house modelling capacity might be undermined. While insourcing modelling and scenario capacity should ensure that scenario developers have closer interaction with governmental energy planners, it most often results in conservative scenarios that are heavily biased toward government agendas.

Scenario development entails more than just modelling; building and maintaining these capacities in one organisation is a challenge that requires time and continuous training, due to the evolving modelling sphere. National ownership and capacity building are key principles for developing a robust strategic energy planning process. Governments who do not have the minimum capacities to insource may outsource as a first step, followed by knowledge transfer activities in the development and use of scenario modelling tools. Partnerships with academic institutions and the international community for knowledge exchange should be pursued to improve the quality and technical robustness of scenarios (see Box 8). Those who are beginning to build up an in-house team should start small – for example with an accounts-based calculator instead of a complex energy system optimisation model; see Box 9 for a discussion on proprietary and non-proprietary tools.

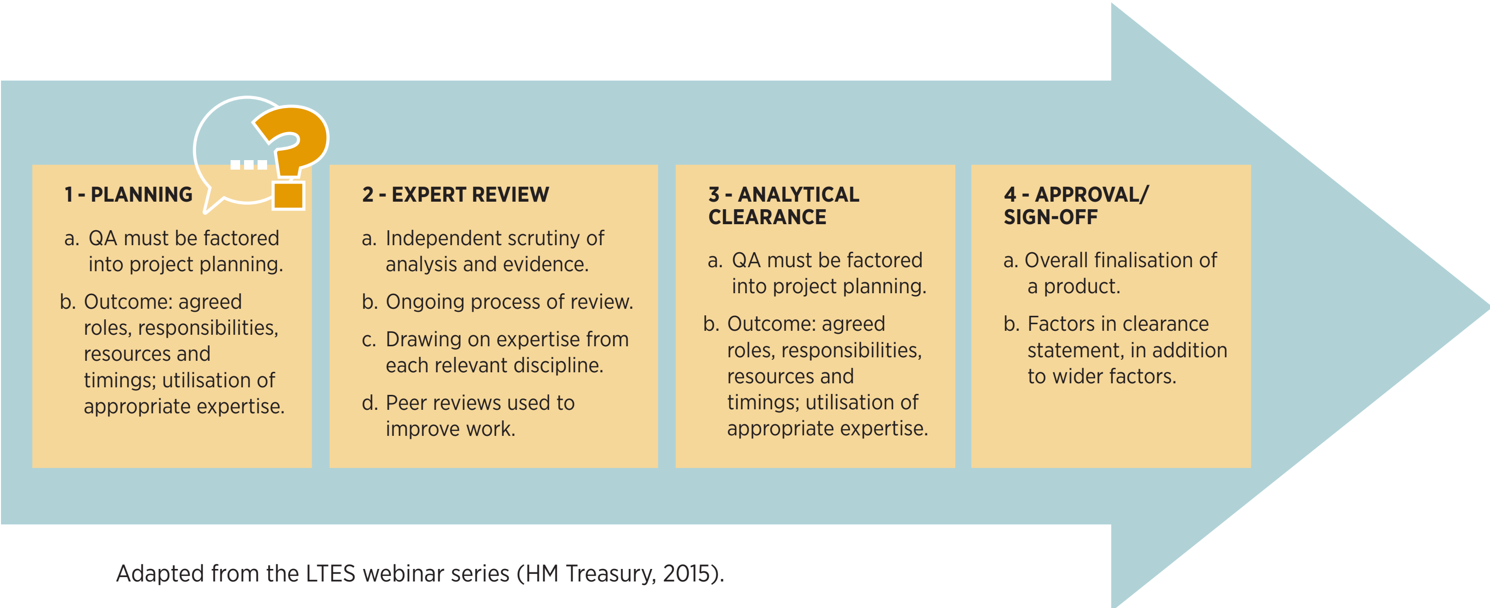
Mexico

In Mexico, the Secretariat of Energy (SENER) considers LTES as a planning tool that can provide trustworthy information on the current situation and future development of the energy system. SENER produces a yearly series of LTES for specific components of the energy system, namely; renewable energy, liquefied natural gas, natural gas, crude oil and oil products and the power sector (SENER, 2018) – the most recent series for the period 2018 to 2032. In 2014, SENER launched its first National Energy Strategy (ENE), (SENER, 2014). The Mexican energy planning team has benefitted from partnerships and training with external institutions to build and improve LTES capacity. The Danish Energy Agency has provided training on the BALMOREL capacity expansion model to Mexican experts in SENER and assisted in the set-up for model operation and scenario development (DEA, 2019b). IRENA has partnered with SENER to produce a roadmap to 2030, generating targets for Mexico's renewable energy mix (IRENA and SENER, 2015).

United Kingdom

The United Kingdom has in-house scenario capacity in the Department of Business, Energy and Industrial Strategy (BEIS). To ensure successful in-sourcing, Her Majesty's (HM) Treasury produced *The Analytical Quality Assurance (AQuA) Book* (HM Treasury, 2015) as a good practice guide for those conducting model analysis for government. The Department of Business, Energy and Industrial Strategy (BEIS) refined these guidelines to produce *Quality Assurance: Guidance for Models* (BEIS, 2018), the purpose of which is to provide a standard that modelers must meet in order to produce dependable scenario analysis. Both these standards help build trust between modelers and users, and therefore are an important aspect of improving governmental LTES capacity. Figure 32 illustrates the process of quality assured analysis, as recommended.

Figure 32: The United Kingdom´s quality assurance framework for modelling in government



Adapted from the LTES webinar series (HM Treasury, 2015).

United Arab Emirates

In the UAE, an integrated energy strategy team in the Ministry of Energy and Industry models scenarios and prevents the emergence of any 'black boxes' regarding scenario results, thereby aiding transparency and the applicability to policy. The *UAE Energy Strategy 2050* was developed using a scenario modelling tool that was initially outsourced to consultants; however the in-house energy strategy team is now in the process of absorbing the requisite capabilities to use the tool and develop scenarios in-house, thus eventually being able to satisfy the government's future scenario requirements internally (UAE Ministry of Energy and Infrastructure, 2019). The Ministry is also securing the involvement of other stakeholders in scenario building and stress testing.

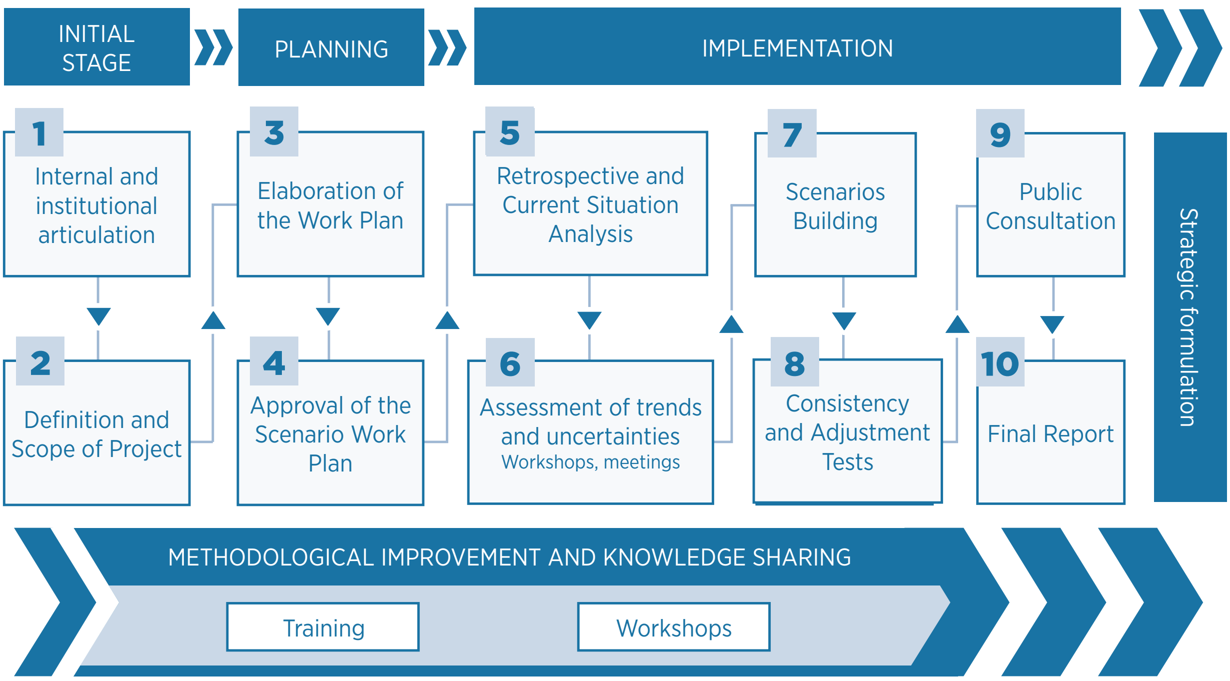
Italy

In Italy, the scenarios for the Integrated Energy and Climate Strategy for 2030 (INECP)(MISE et al., 2019) have been processed through different models and by different public companies, under the operative co-ordination of the Italian Manager of Energy Services (GSE). The company, Research on the Energy System (RSE), used the "TIMES-Italia" model (developed by the Italian National Agency for New Technologies, Energy and Sustainable Economic Development [ENEA]), while the Italian Higher Institute for Environmental Protection and Research (ISPRA) used its own model. Having two comparable models makes it possible to achieve more reliable and accurate process outcomes, and more dimensions for analysis. The impact analysis of the electricity sector was performed by RSE, while GHG emission scenarios have been developed by ISPRA by considering the output of the TIMES-Italia model and additional analysis for non-energy GHG emissions. Simultaneously, GSE and ENEA worked on the INECP macroeconomic and employment impacts.

Brazil

In Brazil the scenarios built by the Energy Research Office (EPE) are used by the Ministry of Mines and Energy (MME) to formulate the National Energy Plan (MME and EPE, 2007) and the Ten-Year Energy Expansion Plan (PDE), (MME and EPE, 2020). According to the EPE, the LTES campaign has brought important insights for the scenario building process of the National Energy Plan (PNE 2050). Figure 33 presents some of the actions developed in the preparation of the Plan that are well-aligned with various best practices and recommendations described in this report.

Figure 33: Stages for developing LTES in Brazil for the National Energy Plan 2050



The Netherlands

In the Netherlands, the Netherlands Environmental Assessment Agency (PBL) is the national institute for strategic policy analysis for the environment. Therefore, PBL is the government agency that maintains in-house scenario development capacity which results in national outlooks, analyses and evaluations in order to guide policymakers to take action to achieve the clean energy transition (PBL, 2019a). PBL also has the capacity to use models for global scenarios and has co-developed models including IMAGE[8], which incorporates energy supply and demand in its framework to decipher how environmental problems develop over time (PBL, 2014). The agency is autonomous and provides safeguarded independent insight, therefore benefitting from the resulting legitimacy.

Finland

In Finland, the VTT Technical Research Center of Finland Ltd (VTT) is a state-owned limited liability company committed to open access and transparency. VTT performs independent scenario development and modelling resulting in reports that provide insight to advise government on energy planning policy – for example, to Finland´s Climate Roadmap 2050 (The Ministry of Employment and Economy of Finland, 2014). VTT is owned by the government, providing easy accessibility, communication and coordination between policymakers and the technical institution whilst also benefitting from innovative methods and expert input.

Box 8: INTERNATIONAL CO-OPERATION TO IMPROVE MODELLING AND SCENARIO DEVELOPMENT PRACTICES

The LTES campaign has showcased several examples of co-operation between governments and technical institutions on the international stage to develop energy scenarios and build capacity in governments to use and understand scenarios. International co-operation has also proven to provide an efficient and collaborative platform for the exchange of best practices and experiences.

Denmark

The Danish Energy Agency (DEA) has collaborated closely with several countries to enhance capacity and co-develop energy models and scenarios. The DEA co-operated with the Secretary of Energy in Mexico to develop capacity and instill the knowledge needed for modelling and scenario development, with a focus on climate change mitigation, renewable energy and energy efficiency (DEA, 2019b). This co-operation led to the development of a Balmorel model for Mexico (for the optimisation of electricity supply, system and grid) and ambitious scenarios that were included in the country's *Renewable Energy Outlook* documents in 2016, 2017 and 2018 (SENER, 2018). This co-operation also included the training of Secretariat of Energy experts in the use of modelling tools. The DEA has also partnered with Indonesia to build capacity to develop and use the Balmorel model alongside the existing model employed at the National Energy Council (NEC), (DEA, 2019b). The model developed encompasses 35 interconnected regions in Indonesia and helped produce scenarios that were included in the NEC's *Indonesia Energy Outlook* documents (Ministry of Energy and Mineral Resources, 2020).

Intergovernmental agencies also facilitate international co-operation to improve modelling and scenario development practices. IRENA provides capacity building support to countries for developing or updating national energy masterplans through its Masterplan Development Support Programme (IRENA, 2020f; 2018c).

8 Balmorel is a bottom-up partial equilibrium energy system optimisation model with a special focus on electricity and district heating sectors (Wiese et al., 2018).

For example, IRENA provided energy planning support to the Kingdom of Eswatini, including training on the SPLAT model (IRENA's in-house least-cost power capacity expansion model), data management and scenario development. Based on this training, the national experts formed a national working team and applied energy planning tools – for both energy demand and supply – for preparation of a national energy masterplan. The draft masterplan was presented and discussed at a national stakeholder workshop in 2017. The Energy Masterplan 2034 was approved by cabinet and formally launched in 2018 (Kingdom of Eswatini, 2018).

The Energy Technology Systems Analysis Programme (ETSAP), one of the IEA's Technology Collaboration Programmes, has been fostering international co-operation on energy modelling for over 40 years (IEA-ETSAP, 2019a). Its main objectives include: developing and maintaining the MARKAL and TIMES modelling tools; assisting policy decisions to model future energy pathways; conducting biannual workshops and training worldwide; and conducting collaborative research and analyses.

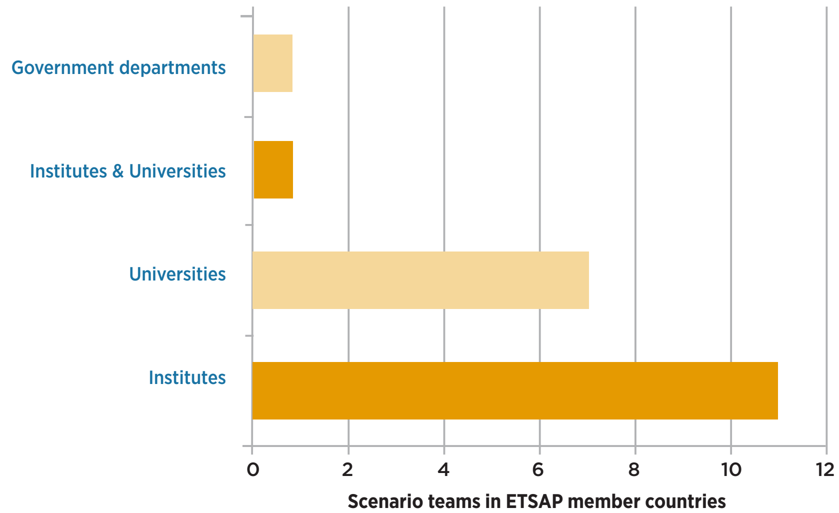
The programme directly influenced Portugal's National Action Plan on Climate Change in 2014, the UK's Climate Change Act in 2008 and the Republic of Ireland's Climate Action and Low Carbon Development Act in 2015 (IEA-ETSAP, 2019a). ETSAP's community consists of 20 contracting countries and modelling tool users from 63 countries, Figure 34 shows where energy modelling capacity resides in the ETSAP community.

Intra-agency initiatives can also allow several institutions to jointly provide support for energy planners worldwide.

The Roundtable Initiative on Strategic Energy Planning works with 17 major development partners and technical institutions, including IRENA, to improve the support they provide for energy planning in developing countries (EEG, 2019). They present five principles to improve the effectiveness of supporting emerging economies in strategic energy planning:

- National ownership through empowered stakeholders; ensuring the planning process is country-led.
- Coherence of energy planning processes within the broader spectrum of economic, social and environmental goals.
- Supporting capacity building and co-ordination of development partners in governments.
- Promotion of technically- and economically-robust decision-making tools fit for the clean energy transition.
- Promotion of transparent planning inputs as well as access to outputs for key stakeholders.

Figure 34: ETSAP's community allocation of energy modelling and scenario capacity



Source: (IEA-ETSAP, 2019b).

Outsourcing scenario development capacity

Successful outsourcing of LTES requires absorptive capacity within government to understand the modelling results. Outsourcing allows access to high-end scenario building techniques; however full disclosure of scenario data and modelling methodologies is needed to aid understanding and use of scenario results in government.

While outsourcing has the benefit of having specialists develop the scenarios, it can also undermine capacity development within the government and create a lock-in/dependency on a small number of consultancy firms that will look to comply with the wishes of the contractor. The quality of consultancies from technical institutions providing the service will be determined by the budget allocated, which are usually scope-bounded according to the terms of the contract.

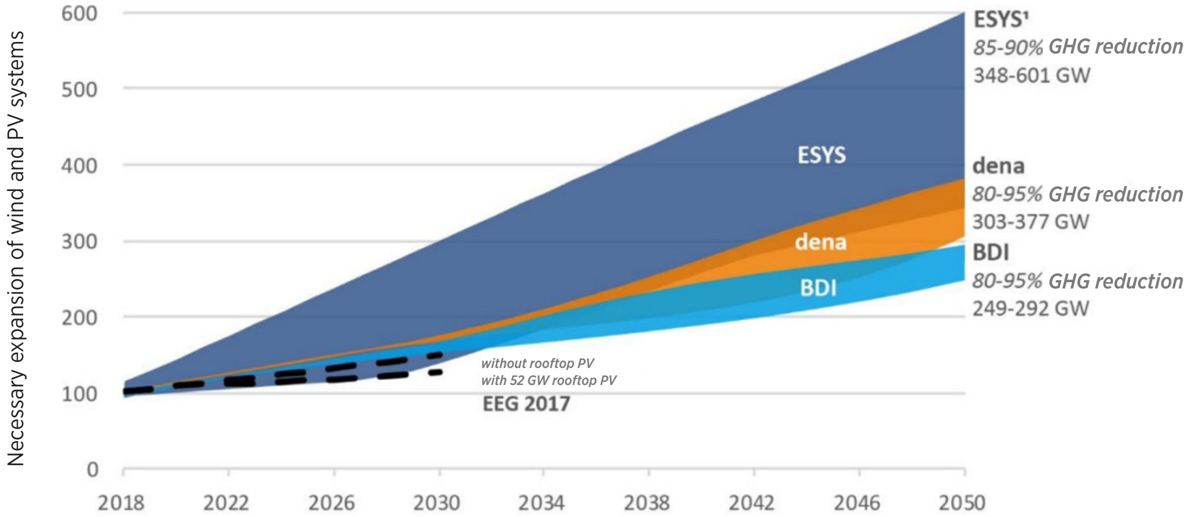
Out-sourcing of scenario capability requires strong in-house (government) capacity to understand scenarios and models and know what to look for when contracting; therefore, training users of scenarios (policymakers) is necessary. Dissemination of knowledge on the use of scenarios begins from an education-based understanding of scenarios and evolves towards understanding within decision makers.

Germany

In Germany the Ministry of Economy and Energy (BMWi) has strong in-house capacity to understand and develop scenarios (BMU, 2007). However, scenario development is outsourced to several institutions to gain a broader scope and make use of the abundance of first-class energy research institutions available in the country. The German Science Academies – with their Energy Systems of the Future (ESYS) initiative – the Association for German Industries (BDI) and the German Energy Agency (dena) have independently examined the feasibility of the German energy transition in three scenario studies (BDI, 2018; dena, 2020; Leopoldina et al., 2020). Following the culmination of their analyses, these institutions produced a study to compare and map the uncertainty of results for whole energy system emissions reductions of between 80 and 95 percent by 2050 (Leopoldina et al., 2019). This comparison concluded that energy transition is feasible – but only if the federal government acts decisively and consistently. Figure 35 shows a scenario comparison of total cumulative installed capacity of solar PV and wind for the three studies.

Figure 35: German scenarios for PV and wind generation by 2050 – a comparison of views from three independent institutions

Necessary expansion of wind and PV systems in Germany



*The GHG reduction in the ESYS study refers only to the energy system, including Scenario 85_aktiv

As these examples illustrate, developing scenario-building capacity is a long-term issue that requires commitment and constant training. Insourcing scenario development capacities will require a specific team dedicated entirely to LTES modelling. Some experiences show that modelling capacity to develop scenarios can be housed in technical energy agencies, while capacity to use and understand scenarios can be built in policy-making institutions, such as ministries. Outsourcing of scenario capacity can be seen as an intermediate step towards insourcing LTES scenario capacity in emerging and developing countries. However, it can also represent complementary activity to insourcing, when it is used to compare and benchmark a broad range of scenarios. It can also be an opportunity to make use of more advanced modelling tools and establish co-operation with academia and research centres.

Box 9: PROPRIETARY AND NON-PROPRIETARY LTES MODELLING TOOLS

Proprietary tools are those that are created for a profit and so have a cost for users, they usually offer wider user support bases and are constantly updated to meet the needs of their clients. Consultancy firms are typically the owners of such tools. However, developing countries may not have the local resources to pay for annual licences that can be expensive and inefficient if the tool is not fully used. There are, however, some proprietary tools that are accessible for developing countries and for academic institutions (e.g. LEAP).

Non-proprietary tools simply imply that the tools are free, making them easier to access (e.g. EnergyPlan, SAM, NEMS, MESSAGE). While non-proprietary tools can be an alternative to paid models, they do not always enjoy the same level of user support – such as structured training courses – that paid options do. The argument for non-proprietary models is that they are accessible to countries that otherwise cannot afford such tools and so have more far-reaching impacts.

Among the non-proprietary tools are a number of opensource tools (such as OSeMOSYS or GCAM). Users can access the source code of these tools and make alterations to how they operate; they can even contribute to further tool development. However, the quality and version control of open-source tools remain challenging and serve to limit the widespread use of these options, in particular for governments.

For many countries that do not have modelling capacity, building an energy system model from scratch is challenging. Especially if advanced paid software is required and access is limited to up-to-date data banks for technology and infrastructure costs, fossil fuel reserves, etc. However, there are efforts to make scenario modelling resources freely and easily available for developers, such as the Energy Modelling Platform for Europe. Also, taking existing models and recalibrating them for national contexts requires less effort; this is possible with the TIMES starter model, the national and regional models available online for the OSeMOSYS model, and the IRENA System Planning Test (SPLAT) Models for Africa.

For a comprehensive list of energy and power sector modelling tools and their characteristics, please refer to IRENA's report, *Planning for the renewable future: Long-term modelling and tools to expand variable renewable power in emerging economies* (IRENA, 2017a).

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APPENDIX

LTES campaign and network activities 2018–2020

Details of, and materials from, the below events can be found on IRENA's website.[9]

Date	Event	Topic	Place
September 2020	CEM 11	A pre-event on: "Raising global climate ambition in uncertain times with long-term energy scenarios"	Virtual
September 2020	Joint IRENA–JRC Expert Workshop on "Benchmarking long-term scenario comparison studies for the clean energy transition".	A workshop to map the motivation, focus and methods of such studies; provide a platform to discuss a systematic and formalised approach to scenario comparison; and identify how scenario comparison insights can be used in policymaking.	Virtual
March 2020	Second International Forum on Long-Term Energy Scenarios for the Clean Energy Transition	Experience and good practices in the use and development of LTES to support planning for the clean energy transition.	Virtual
January 2020	IRENA Assembly	Side event on "International dialogue on energy planning: Global best practices form the Long-Term Energy Scenarios; Network and Roundtable Discussion on Strategic Energy Planning".	United Arab Emirates
October 2019	III Regional Forum of Energy Planners for Latin America	A session on "Global practices in the use and development of long-term energy scenarios for the clean energy transition" showcased insights from the campaign.	Peru
September 2019	24th World Energy Council Congress	The "Role of scenarios and planning" in the context of energy transformation and regional integration of power systems.	United Arab Emirates

9 IRENA, "Events – LTES Network and LTES Campaign", www.irena.org/energytransition/Energy-Transition-Scenarios-Network/ETS-Net-Events/.

August 2019	Latin America & Caribbean Climate Week	A side event on "The relevance of long-term energy scenarios to climate policy making and NDC target setting in Latin America & the Caribbean".	Brazil
July 2019	Workshop to exchange experience on energy systems modelling for planning	A presentation on the "First-year findings of the CEM LTES campaign" and a discussion session with government energy system modellers.	Croatia
June 2019	World New Energy Vehicle Congress	A session on "Integration issues of EVs and their role in long-term energy scenarios".	China
June 2019	Seventeenth Meeting of the IRENA Council	A thematic session on "Planning the Clean Energy Transition: How long-term energy scenarios can support decision-makers".	United Arab Emirates
May 2019	10th Clean Energy Ministerial	A session on "Planning the clean energy transition: How long-term energy scenarios can support decision-makers".	Canada
April 2019	Long-term Energy Scenarios (LTES) Campaign: 2019 International Forum	The first forum that gathered members and partners of the campaign.	Germany
March 2019	Forum on Scenarios for Climate and Societal Futures	A session on "Renewable-based Electrification: How can we improve scenarios for the Clean Energy Transition?"	USA
February 2019	Long-term scenarios for the clean energy transition in Latin America workshop	A workshop on "how Latin American countries use, develop and build capacity for long-term energy scenarios".	Brazil
February 2019	Bundling expertise, shaping politics – energy change now! Essence of the three basic studies on the feasibility of the energy transition until 2050 in Germany	A discussion session on "Lessons learnt on the use and development of scenarios for the clean energy transition in Germany"	Germany
January 2019	World Future Energy Summit	A session on "Planning energy positive solutions".	United Arab Emirates

November 2018	Global Science, Technology & Innovation Conference (G-STIC)	A session on "Practical examples and the impact of the application of long-term energy scenarios, and their better use/development".	Belgium
November 2018 – March 2019	A series of webinars on Long-term Energy Scenarios	A webinar series looking at "How to best use scenarios for decision making, improve scenarios for the clean energy transition and identify approaches to build capacity in governments".	Virtual
November 2018	The Energy Technology Systems Analysis Program (ETSAP) workshop	An ETSAP–IRENA–CEM collaboration: "Innovation in long-term energy scenarios".	Germany
October 2018	The third international forum on energy transition at Suzhou city	A workshop: "China Power System Modelling Workshop: Enabling transformation".	China
September 2018	IRENA Innovation Week 2018	Side event on "Innovations and the future energy system: What's missing in today's long-term scenarios?"	Germany
July 2018	Exchange of experience with the modelling of energy systems for planning purposes	Sessions on "Solutions to analytical challenges and improving analysis in member states"; and "Relevance of energy systems analysis for policy in the member states".	Croatia
July 2018	The 37th edition of international energy workshop	A side event on "Renewable energy and the future of long-term energy scenarios: Emerging practices and channels for policy impact".	Sweden
June 2018	Fifth RGI future scenario exchange workshop	A session on "Modelling the clean energy transition: Clean Energy Ministerial campaign on LTES".	Belgium

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