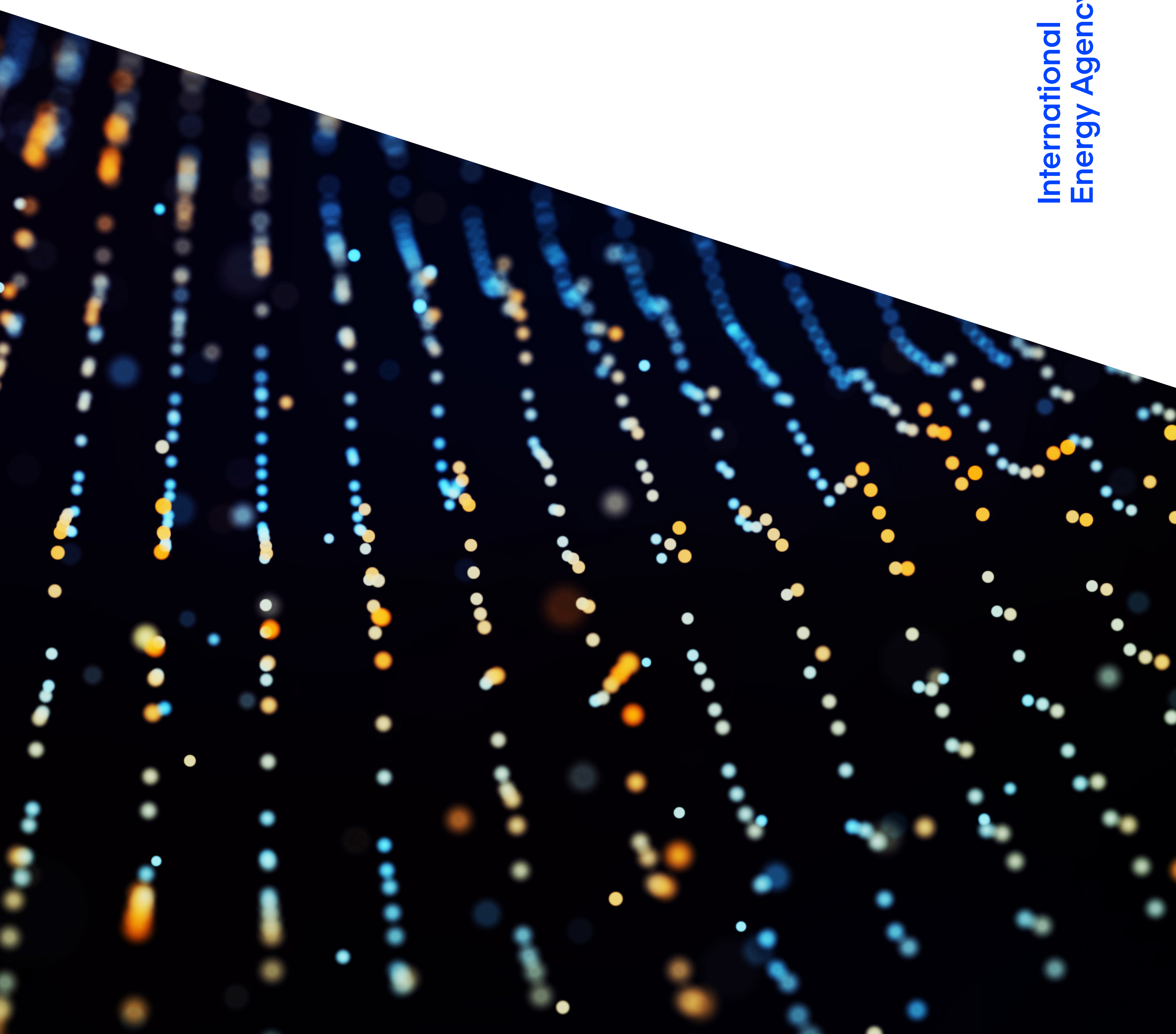
Developing Capacity for Long-Term Energy Policy Planning: A Roadmap

International Energy Agency



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Executive summary

Policymakers face the acute challenge of balancing economic competitiveness with climate change and energy security issues. Finding an equilibrium will require comprehensive and cohesive long-term policies, targets and strategies, elaborated into appropriate short- and medium-term action plans and measures to achieve them. In other words, overall energy policy planning is becoming increasingly complex.

Today's main policy questions relate to what an energy policy should look like to be robust and flexible enough to deal with the uncertainties of the future. Therefore, a scenario-approach relying on energy system models is essential to support decision making because modern energy system analysis provides the best chance of ensuring decisions will not be regretted in the medium to long term. The results of these analyses can help change prejudiced perceptions of energy and climate issues within governments, and steer public discussion.

Developing analytical capacity (i.e. tools and staff skills) is complex and time-consuming. To maintain – and especially expand – a country's capacity for long-term energy planning, adequate resources need to be allocated, particularly to a dedicated modelling team, to ensure continuity. The costs associated with energy system modelling are dwarfed by the economic benefits of robust, well-informed policy decisions. Indeed, the substitute for a modelling framework is simply educated guesswork.

In addition, energy modelling and scenario analysis also require reliable energy statistics as input data to depict the current situation of the energy sector. Thus, the development of energy modelling capabilities should be complemented by improvements in the collection, validation and analysis of national energy statistics.

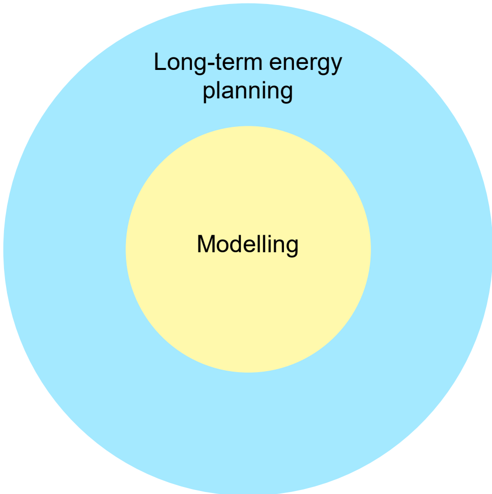
This roadmap builds on IEA analysis of long-term energy policy planning, and further explores the capacity required at the national level for the different work areas. It equally targets countries in the early stages of developing long-term energy plans and those with more established structures seeking to further develop a specific area or sector.

We therefore provide countries with a self-assessment framework to identify key areas for further improvement, as well as a list of available resources that national stakeholders can immediately tap into. It is advisable for countries to expand from a modest base to establish relevant processes and build up their capacity gradually.

What long-term energy policy planning constitutes

In national energy policy debates, the terms 'plan', 'scenario' and 'model' are often heard and sometimes used interchangeably, even though the concepts are notably different. Thus, to strengthen national long-term planning capabilities, it is necessary to distinguish among these areas of work and assess them separately.

Relationship between energy planning and modelling



IEA. CC BY 4.0.

The outer perimeter

Although no single, universal definition for energy policy planning exists, IRENA has captured the essence:

Long-term energy planning is the process whereby national or regional targets, policies and investment strategies are derived from quantitative analysis of energy sector scenarios, often aided by the modelling of energy systems. Such planning is a central component of energy policy-making processes around the world, guiding decisions on when, where and how to invest in the energy sector.

Simply put, sound long-term energy system planning encompasses domestic and external policy while touching on many key areas of the economy, including natural resources, industry, external trade and the environment. With the objective of laying out a strategic pathway to a clear goal, the process involves multiple government and private sector stakeholders. Importantly, citizens – both as individuals and as part of non-governmental organisations – should also be viewed as policy-planning stakeholders.

From literature reviews and discussions with policymakers and both national and international experts, certain recurring themes have allowed us to identify key enablers for long-term energy policy planning (the 'outer perimeter'). The enablers should not be perceived as a cascading sequence of actions, but as parallel elements of the policy planning cycle:

- **Enabler 1:** Political will to adopt and sustain (finance) quantitative analysis as a policy tool
- **Enabler 2:** Analytical capacity in relevant national institutes to formulate scenarios and interpret modelling results
- **Enabler 3:** Adequate, reliable and timely data to support energy modelling and scenario analysis.

The inner core

As scenarios can be used to assess the potential outcomes of alternative actions, their development is an integral part of modern long-term energy policy planning. Energy modelling refers to the technical and analytical exercise of quantifying these scenarios and translating the modelling results into a format that aids decision making. The integration of scenarios and energy models is therefore crucial for effective energy planning.

A wealth of freely accessible literature, technical support and capacity-building activities exists to support the objectives of the inner core. In contrast, less guidance material exists to help countries reach the point at which these resources become relevant. Still, developing a functioning energy policy planning process (the outer perimeter) is a prerequisite to acquire sustainable and relevant energy modelling capacity at the country level.

Based on the same analysis as for the outer perimeter, the key enablers for effective energy modelling are:

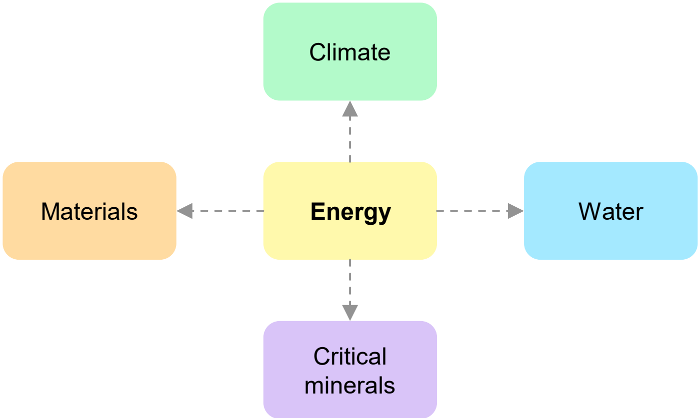
- **Enabler 4:** Relevant set of scenarios to explore strategy options.
- **Enabler 5:** Modelling of the energy system.
- **Enabler 6:** Stakeholder engagement and communication.

The next section discusses these enablers in detail and also includes self-assessment questions to gauge the status of each enabler in the national context. Furthermore, the Resources to Strengthen Enablers section lists resources that can be used to assess the strength of enablers and make them more effective.

Energy policy planning boundaries

To ensure that strategic energy policy planning aligns with the objectives of clean-energy transitions, long-term energy plans must be co-ordinated with the aims of other key areas, such as climate change and water management. Given that roughly 75% of all GHG emissions are energy-related, the domains are strongly connected.

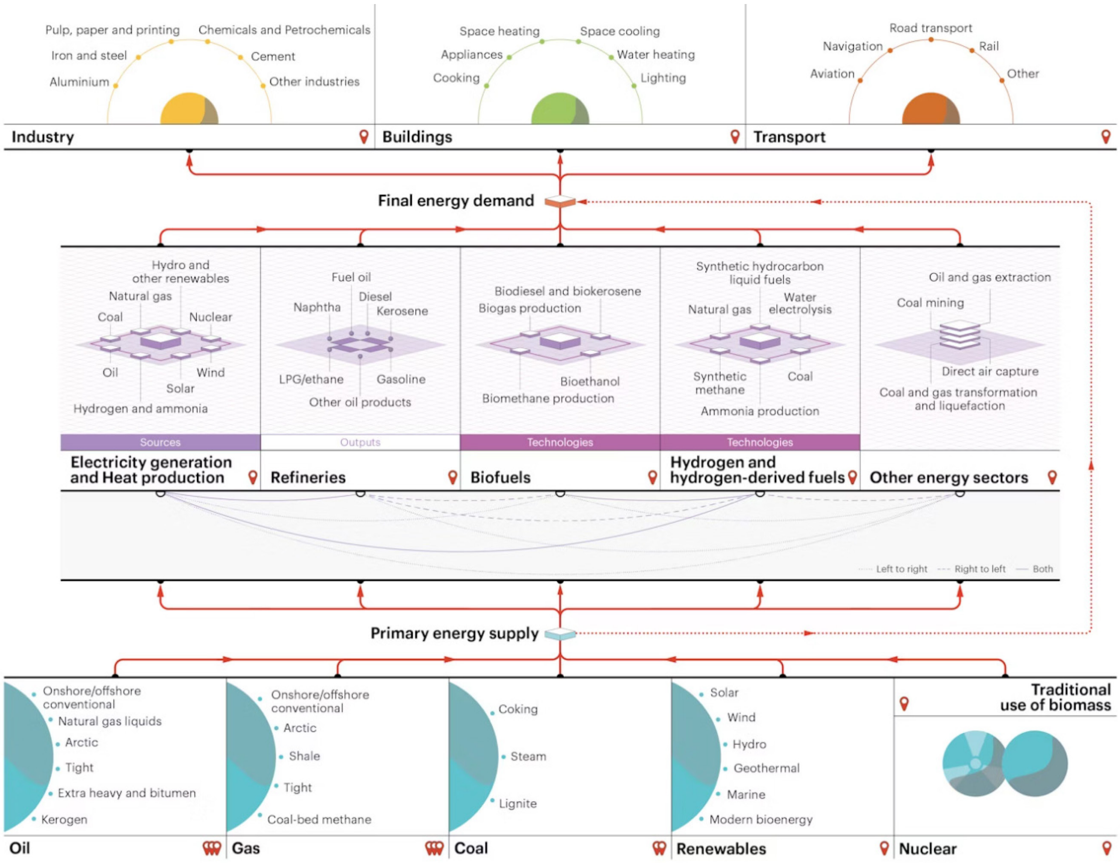
Connections between the energy sector and selected domains



Areas in which the energy system relies heavily on hydro-based electricity generation should take particular care to consider the water-energy nexus – ideally from a regional perspective. While energy policy planners have become better at incorporating critical minerals into clean-energy transition schemes in recent years, still their focus must not be limited to only critical minerals, as a wealth of common materials will also be required for the energy transition. Energy policies also have wider socioeconomic impacts that should be considered (e.g. green jobs, energy access).

Without a strategic approach, governments may develop only isolated policies and legislation (i.e. tools that do not address energy and climate challenges as a whole). Instead, long-term energy planning should cover an energy system in its entirety rather than address its elements individually. This approach allows policymakers to identify the most important substitution options linked to the system overall – an exercise they cannot carry out when single technologies, commodities or sectors are analysed individually.

Defining energy system – IEA's World Energy Model framework

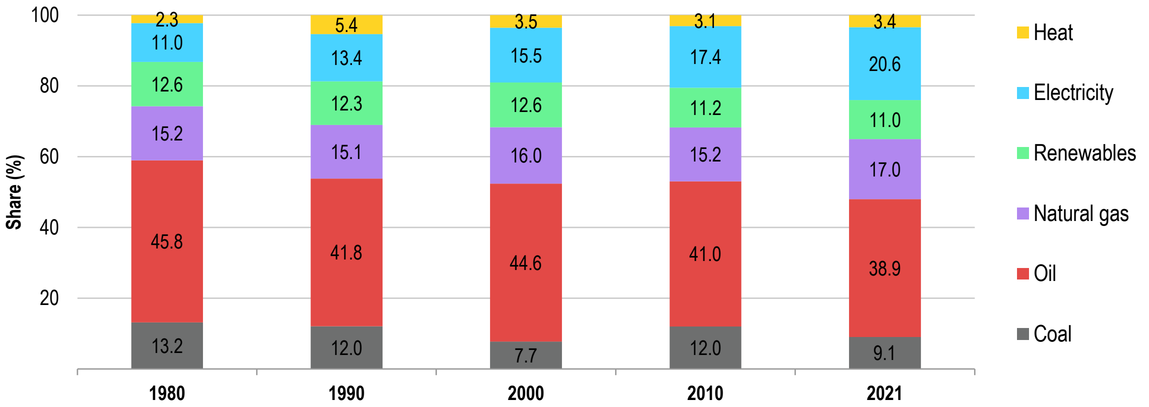


Source: IEA (2023), World Energy Outlook 2023.

For instance, by focusing on the electricity sector only, policymakers may overlook the possibility of unforeseen, fundamental changes in electricity demand due to, for example, transport or heating sector electrification. This is not to say that power system planning should be omitted – quite the opposite: transmission system operators should continue to be responsible for grid development (e.g. through their 10-year plans), but their work should be aligned with overall energy system planning.

A planning approach that encompasses the energy system as a whole, which is the scope of this roadmap, appears obvious when we examine the shares of each energy resource in final energy consumption.

Shares of energy sources in global final energy consumption, 1980-2021



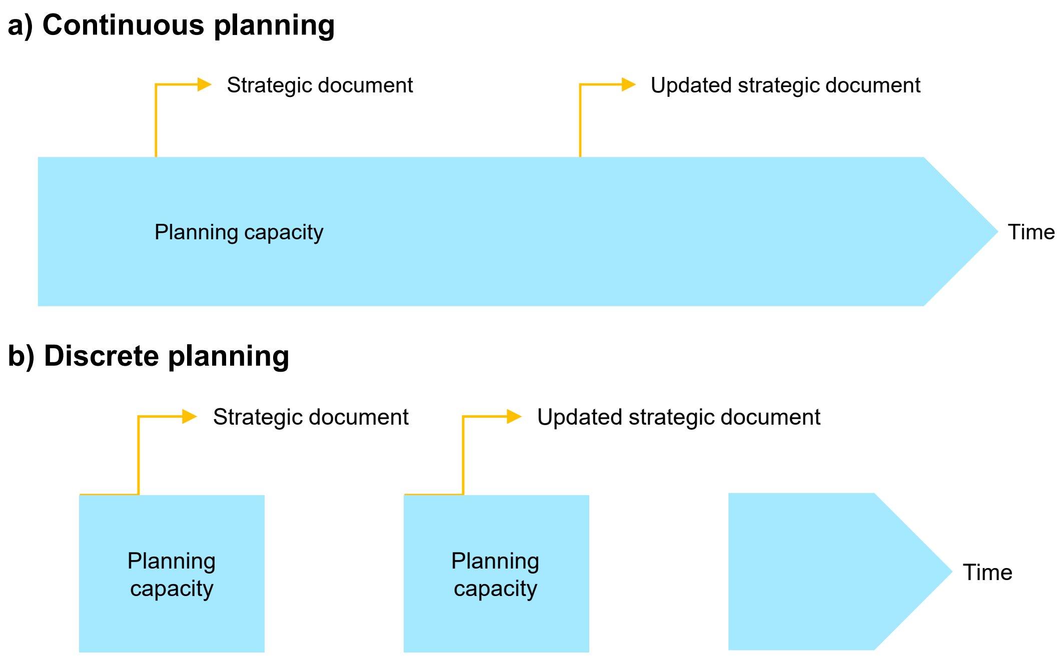
Note: 'Renewables' includes geothermal, solar thermal, biofuel and waste. 'Coal' includes peat.
Source: IEA analysis based on World Energy Statistics and Balances (database accessed 1 May 2024).

Although electricity use is trending upwards – with a strong global push for further electrification – electricity makes up only just over 20% of total final energy consumption globally. Therefore, focusing exclusively on long-term planning for the power sector may lead to sub-optimal results for the energy system as a whole.

Energy policy planning capacity

Visible outcomes of energy planning include various strategic documents, roadmaps and action plans (e.g. national energy efficiency action plans (NEEAPs) and national energy and climate plans [NECPs]). While these important milestones set the stage for governments to plan their near-term (e.g. five-year) actions, countries should also continue to develop their underlying policy planning capacity.

Developing energy policy planning capacity



In the first illustration, the process is a trunk from which different strategies are delivered. As the process – including the co-operation network and energy modelling capacity – is always in place, planning capacity accumulates over time, increasing the quality (i.e. usefulness) of subsequent deliverables.

The second graphic represents the preparation of strategic documents on an ad-hoc basis with whatever policy planning capacity is available at that moment, be it sufficient or not. In practice, external parties are often involved (e.g. international consultancies), but the lack of an ongoing, permanently established process implies there will likely not be much more capacity available when the deliverable (e.g. an energy strategy) must be updated. Tapping into any resources developed by a consultancy in a previous round is often difficult due to lack of knowledge transfer ('black box' effect). Thus, the country probably will not have the planning capacity necessary to modify or expand upon previously delivered materials (e.g. modelling tools) when updates are required.

While governments lacking the minimum capacity needed to develop and model energy scenarios may initially outsource these activities, knowledge-transfer activities for developing and using scenario modelling tools should follow (i.e., strengthening the inner core). Furthermore, experts involved in the process of delivering strategic documents should maintain and expand both their individual and institutional capacities. The consensus among energy planners is that building up policy planning capacity is a long-term process, so efforts must be made to retain existing capabilities while continuously developing new ones.

Evidently, any future-defining strategy must eventually be updated. Long-term energy policy planning and the process of creating and maintaining an energy strategy are important tools to help countries face challenges coherently and successfully. Rather than having a definite end date, these tasks should be ongoing and must evolve according to circumstances.

A priority for governments should therefore be to design these processes in a permanent but flexible manner, ensuring that policies are impactful but also adaptable to unexpected developments and crises. As targets are met and the policy context shifts, new targets can be added and policies either changed or streamlined.

Key institutions and stakeholders

To achieve the best results, several stakeholders should be involved in the long-term energy planning process, particularly during the scenario development phase.

National research institutions and energy modelling groups fill the important role of using modelling tools and providing scientific insights and guidance based on their knowledge of the field and the models in use. Moreover, modelling group representatives have the expertise to quantify the effects of selected policy measures.

Experts from ministries and other government agencies can have diverse roles, as they represent multiple ministries and other organisations. Functions can include overall co-ordination, management and external communications, but they can also represent their corresponding sector during scenario building.

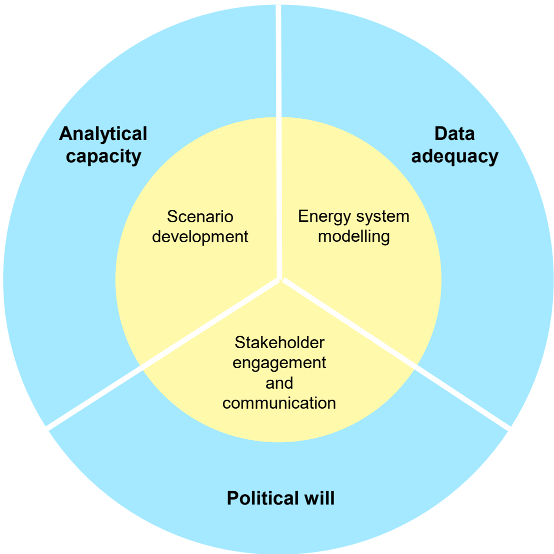
Political actors involved in the energy and/or climate policy domain can include members of parliament and their policy advisors. While not directly involved in scenario building nor part of the official working groups, they should be contacted regularly by public officials to ensure political acceptance of the proposed measures. In certain cases, politicians may also provide specific goals for inclusion in the scenarios, but caution should be used when deciding whether to incorporate and subsequently shape the scenario-building process following such guidance (see '2050 calculators').

National statistical information providers, particularly a national statistical office and/or the entity responsible for official national energy statistics, should be considered integral to the planning process. Modern policy planning, including scenario development and modelling, is a data-heavy exercise. If the existing data production system is inadequate, the lead time for new data production may be as long as one year. It is therefore crucial to involve the relevant experts in this domain as early as possible.

Assessing enablers

This section describes the key enablers required for successful long-term energy policy planning. Each section contains a self-assessment guiding the user to identify the priority areas for further development. The lists of questions are nowhere near exhaustive, but high number of either 'YES' or 'NO' answers provide indications of the status quo.

Key enablers for effective long-term energy planning



Enabler 1: Political will

Developing scenario-building capabilities is a long-term undertaking that requires commitment and constant training. National ownership and capacity building are key principles for developing a robust strategic energy planning process. The Energy Technology Systems Analysis Program (ETSAP) is one of the IEA's longest-running Technology Collaboration Programmes. In its experience, dedicated institutes and universities can offer the commitment necessary to develop modelling capabilities. but in all cases a clear mandate and continuous support from the government are necessary.

Governments also play a vital role in ensuring that external support for energy planning aims to maximise the long-term benefits for the country. While criteria for donors have been developed, it is up to policymakers to ensure the principles are respected.

To avoid optimising the energy system at only the sectoral level, policymakers need to obtain a holistic overview of the entire system and all potential pathways. However, given the complexity of modern systems, it is not feasible to conduct such analysis manually. Energy system modelling thus allows policymakers, analysts and statisticians to use scenario analysis data to assess the impacts of various alternatives, which can in turn be used to inform and elaborate policies and targets.

Once a country acknowledges the need to improve its long-term energy planning process and capacities, the first question should NOT be which tool to use. Instead, the foremost order of business should be to appoint a dedicated entity to co-ordinate the policy planning process and take stock of existing national energy modelling capacities.

Initial resource allocation should also take the skill development of individual experts into account. Furthermore, it should be recognised at the highest political level that developing scenario-building capacity is a long-term task requiring commitment and constant training.

Many of the differences between 'continuous' and 'discrete' planning are linked to the funding of activities. In practice, a co-ordinator of long-term energy planning activities, as well as energy modelling experts, should be sustainably funded (i.e. staff salaries and IT infrastructure costs should mainly be covered by the core state budget, instead of through international grants or project funding).

Self-assessment – Enabler 1

Enabler 1 – Political will	Yes	Partially	No
Does your country have a dedicated long-term energy strategy?	☐	☐	☐
Is an assigned entity responsible for the energy planning process (including strategy drafting)?	☐	☐	☐
Is quantitative analysis ('energy modelling') adopted as the standard tool for planning?	☐	☐	☐
Is current funding for energy planning activities sufficient?	☐	☐	☐
Is current funding for energy planning activities sustainable?	☐	☐	☐
Does the government actively engage with the public on energy policy issues?	☐	☐	☐
Count of 'YES' answers		**/**	**6**

Enabler 2: Analytical capacity

In this context, analytical capacity refers to the ability of policymakers and other officials to develop, understand and use scenario insights to inform policy and investment decisions. Developers and users of the scenarios are rarely the same people, therefore these capacities can be developed independently. For a country only establishing a scenario-based energy policy planning process, focus should be on the 'user base', i.e. strengthening their understanding of the research questions, scenario development, as well as the overall policy planning process elements.

At the highest levels of national and international energy policy-making, countries' ambitions and obligations can both be reduced to single-figure targets (e.g. 'The share of renewable electricity will be 50% by 2030.'). Announcing such targets is easy, but for it to hold any credibility it must become official national policy, which requires a great deal of analysis – particularly to create the scenarios to be researched during policy development.

The capacity to conduct this type of analysis often resides either within the government (internal capacity) or another institute (external capacity). The latter can be further divided into public (national) or private (either national or international). The International Renewable Energy Agency (IRENA) has summarised the pros and cons of both alternatives.

Internal vs external national analytical capacity

Aspect	Internal	Outsourced
Government involvement	Ensures closer and quicker interactions with policymakers	Can result in intermittent and shorter interactions with policymakers
Scenario diversity	Tends to produce a limited number of scenarios, often reflecting more conservative viewpoints	Tends to cover a broader range of scenarios, reflecting the client's (=government) views and agenda
Quality of results	Depends on the government's technical capacity and its access to tools and information	Allows for the procurement of different commercial tools tailored to purpose
Response rate	Responses to pressing government policy demands can be quicker, depending on the team's capacity	Producing scenarios may take longer, but the timing of their execution can be more flexible to accommodate government needs
Transparency	Close interactions with an in-house modelling team ensures full transparency of inputs and outputs	Tends to be a black box, and proprietary licence may prevent full access to the tools
Cost	Can be more affordable, but significant effort is required to build modelling capacity	Hiring commercial consultancy firms tends to be expensive
Keys for success	• Establish quality assurance (e.g. engage with academics) • Dedicate a team or agency to modelling and scenario building	• Establish absorptive capacity within the government to understand modelling results and transfer knowledge of the process

Aspect	Internal	Outsourced
	• Set up an institutional process for regular scenario updates	• Ensure full disclosure of scenario data and modelling methodology • Secure adequate access to high-quality research institutions

ETSAP has surveyed [where energy analysis capacity resides](#) within its community member countries. The vast majority (90%) of respondents indicated either a national technical institute or a university, with only one of the 20 countries surveyed indicating that a government department possesses this capacity.

Locations of analytical capacity

In-house	National	Commercial
• **Energy ministry** • **Other government institution**	• **Independent energy agency** • **Technical institution** • **Academia**	• **Consultancies**

Source: IEA analysis based on International Renewable Energy Agency (2020), [Scenarios for the Energy Transition](#), as modified by the IEA.

Indeed, experience has shown that a hybrid approach in which technical capacity exists in a national technical institution that collaborates closely with the government tends to yield good results. In this setup, the capacity is protected from potential political turmoil and constant short-term assignments. There is also consensus among energy planners that, even with dedicated staff, it takes several years to develop a national energy model from scratch.

Self-assessment – Enabler 2

Enabler 2 – Analytical capacity	Yes	Partially	No
Is national analytical capacity adequate to formulate scenarios?	☐	☐	☐
Is national analytical capacity adequate to interpret results of the quantitative analysis (energy modelling)?	☐	☐	☐
Are commercial stakeholders involved in the energy planning process?	☐	☐	☐
Is staff stability at a reasonable level (average staff turnover 3+ years)?	☐	☐	☐
Do national experts regularly participate in training sessions and workshops?	☐	☐	☐
Are there active projects to improve national analytical capacity?	☐	☐	☐

Enabler 2 – Analytical capacity	Yes	Partially	No
Do national academic institutions offer courses/ educational programmes on energy system studies?	☐	☐	☐
Count of 'YES' answers		**/**	**7**

Enabler 3: Data adequacy

Possessing the right data for quantitative analysis is crucial for its relevance. Countries are therefore encouraged to systematically collect energy statistics, adhering to international methodologies and standards, particularly the International Recommendations for Energy Statistics (IRES). When data gaps are detected, working with key data providers to narrow those omissions is recommended. Implementing a Long-Term Energy Policy Planning Process for Azerbaijan discusses how to develop new surveys to increase energy data coverage. Rarely all data needed for the energy system analysis is readily available. Therefore, improving data at the national level should be seen as a continuous process paralleling energy planning.

To this end, the IEA recently developed guidelines to improve national energy demand data and energy efficiency indicators, as well as a framework for statistical capacity to produce national energy data (forthcoming). As we therefore do not offer detailed advice on improving the quality of energy statistics here, users applying this roadmap in a national context are advised to consult the data-related documents if they encounter important data gaps.

However, it is worth highlighting one of the key points of these publications: the need to collaborate with key data providers. The entity responsible for producing national energy statistics (e.g. a national statistical office) should be involved in policy planning as both a data provider and the authority tracking (quantifying) the impact of the policies through the established indicators.

Compiling an energy balance according to international recommendations is a good starting point for elaborating an energy system model, with the minimum viable dataset items being:

Energy supply data:

- energy production
- energy imports and exports
- energy stocks.

Energy demand data:

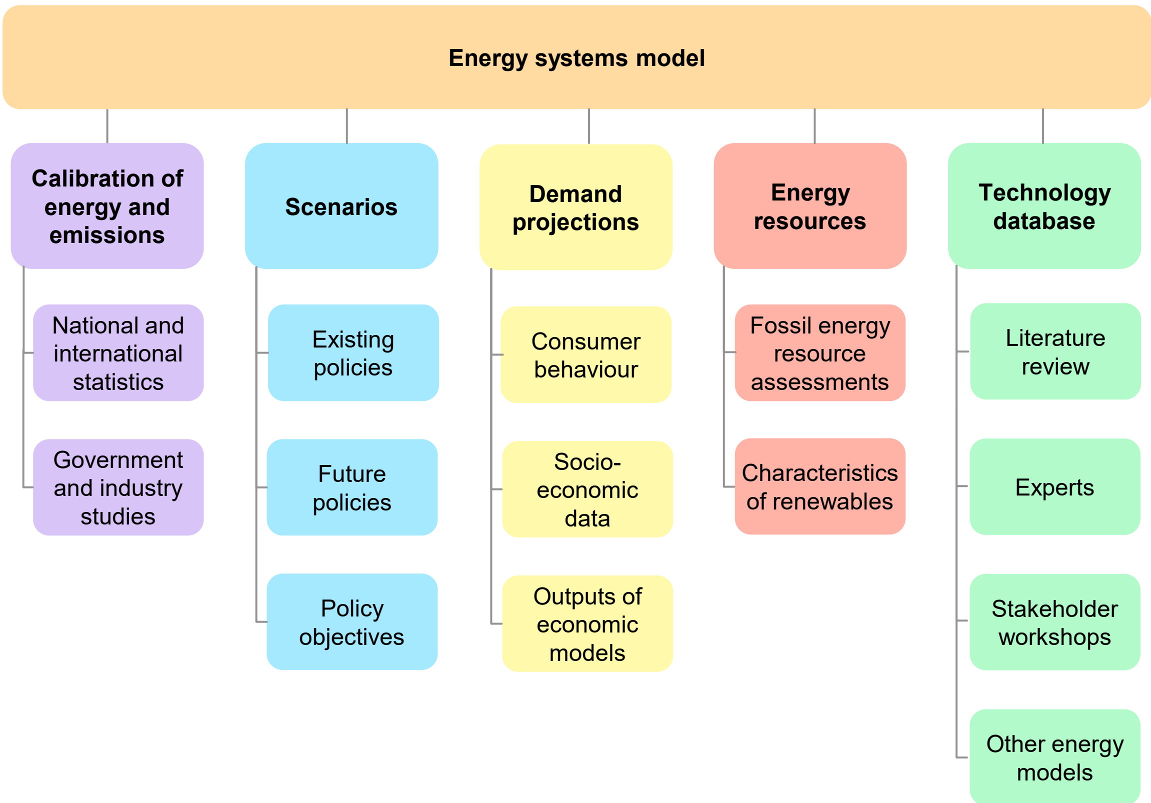
- energy transformation (e.g. electricity and heat, oil refining)

- consumption by economic sector (industry, transport, residential, services, agriculture, etc.)
- non-commercial energy consumption (e.g. fuelwood).

However, country circumstances must always be considered as certain energy flows may be unique to the country context and thus not included in the generic energy statistics guidelines. Also, data requirements are not limited to basic energy information, as a range of other inputs – sometimes interconnected adding to the complexity – may also be necessary:

- macroeconomic drivers (population, GDP)
- economic activity data (e.g. steel production) and end-use intensities
- historical stock (e.g. electrical capacity), cost and performance (e.g. process efficiencies) of technologies
- policies and regulations (quantified for the models)
- socio-economic drivers
- price data (fuel prices, end-user prices, CO_2 price).

Required data research and analysis for an energy system model



Source: IEA (2020), Aspects of a robust LTES development process, as modified by the IEA.

Energy data have three key uses in the energy policy planning process:

Calibrating the used-energy model. Model assumptions are validated to ensure that similar results are produced as for the year for which the latest data are available. Without this step, the model would be disconnected from reality. Therefore, calibration to the initial period is one of the key tasks when setting up any model. The more disaggregated data are on the demand side, the more accurate the modelling results can be.

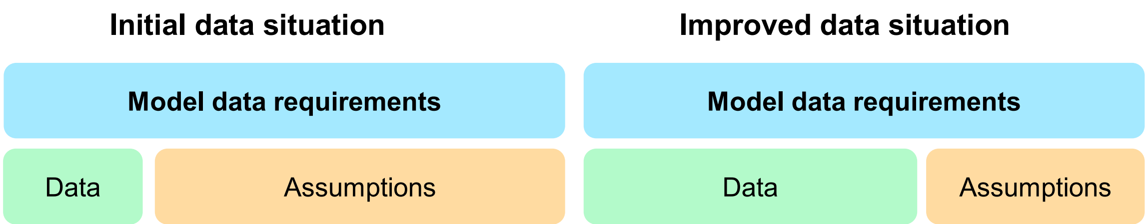
Users of bottom-up energy models should interact with the energy data providers in case notable discrepancies are observed to understand whether they are caused by limitations in energy data collection or the model itself. Ideally, energy data collection and modelling support each other's activities.

Scenario drafting. Without accurate information on the current energy landscape, it is not possible to quantify current key performance indicators (KPIs). In other words, there are no benchmarks against which to set future targets (e.g. the share of renewables in final energy consumption).

Tracking progress. Part of developing long-term energy policies is to define a set of KPIs that can be used to monitor the impact of those policies. [Implementing a Long-Term Energy Policy Planning Process for Azerbaijan] (pp. 33-34) discusses this subject in detail.

It is important to acknowledge that no model or tool can improve the quality of input data. Even a well-designed model fed poor or incomplete information will not produce useful results. Conversely, uncertainty of the modelling results can be reduced if the input data is of high quality (in terms of accuracy, coverage, etc.).

Impact of improved data availability



With improved data availability, certain assumptions, non-country-specific or low-quality data can be replaced with primary data to reduce the uncertainty of model outputs. To quantify the overall uncertainty of a model's results – primarily a function of the input information – energy system analyses are exposed to sensitivity tests. Through this testing, it is possible to identify which input values have the greatest impact on the results and what the overall confidence interval of the results is.

Nevertheless, limited data availability should not dissuade one from undertaking long-term energy planning. While improving the data situation will take time, it must begin somewhere. It is best to start from modest ambitions, develop an efficient methodology, identify key data gaps and establish a co-ordination framework – and then gradually develop and improve work in these areas.

Self-assessment – Enabler 3

Enabler 3 – Adequate data availability	Yes	Partially	No
Is a dedicated entity responsible for developing national energy statistics?	☐	☐	☐
Is it involved in the energy planning process?	☐	☐	☐
Do national energy statistics adhere to international recommendations?	☐	☐	☐
Is final energy demand data available by economic sector?	☐	☐	☐
Is available energy data relevant for energy planning needs?	☐	☐	☐
Does the energy modelling team interact with the entity responsible for national energy statistics?	☐	☐	☐
Are there ongoing projects to improve national statistical data collection capacity?	☐	☐	☐
Are national energy statistics publicly available?	☐	☐	☐
Count of 'YES' answers		**/**	**8**

Enabler 4: Scenario development

Investment decisions cannot be tested in the real world, as they involve large capital requirements. In addition, certain choices may have irreversible impacts e.g. on the energy system or environment. Scenarios have therefore become the de facto approach to depict possible outcomes of development alternatives when evaluating climate and energy policy measures. It is useful to distinguish between the scenario development process (including actors involved and models used) and the use of scenarios as a tool in policy planning.

The Intergovernmental Panel on Climate Change (IPCC) defines a scenario as a 'coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold.' It also recommends creating a set of scenarios to reflect the range of uncertainty in projections.

Based on its stocktaking exercise, IRENA has formulated a series of key recommendations for policymakers to maximise the benefits of the scenario approach:

Strengthen scenario development by

- Establishing a strong governance structure through a participatory scenario development process and co-ordination among all stakeholders.
- Expanding the boundaries of scenarios to include social impacts of the energy transition and innovation in the energy sector.

Improve scenario use by

- Clarifying the purpose of scenario building internally.
- Communicating the results transparently and effectively (see also Enabler 6).

Particularly because of the general global push for net zero emissions, countries must prepare scenarios that not only take national priorities into account, but also international commitments, such as nationally determined contributions (NDCs) to reduce GHG emissions. These must be considered in government policies as well as in investment deals with companies.

Scenarios can be divided into three main categories depending on their approach. It is worth noting that the mechanics of energy system modelling are the same regardless of the selected scenario type.

- **Exploratory (possible) scenario:**
  - addresses the question, "What could happen?"
  - example research query: "We have pledged to develop 500 MW of renewable electricity capacity by 2040. How could this impact the energy system?"
  - example scenario: IEA Stated Policies Scenario (STEPS)

- **Normative (target-oriented):**
  - addresses the question, "How can a specific target be reached?"
  - example research query: "We have pledged to become a net-zero emitter by 2050. How can this be achieved at lowest cost?"
  - example scenario: IEA Net Zero Emissions by 2050 Scenario (NZE)

- **Predictive (probable) scenarios:**
  - addresses the question, "What will happen on the condition of some specified events?"

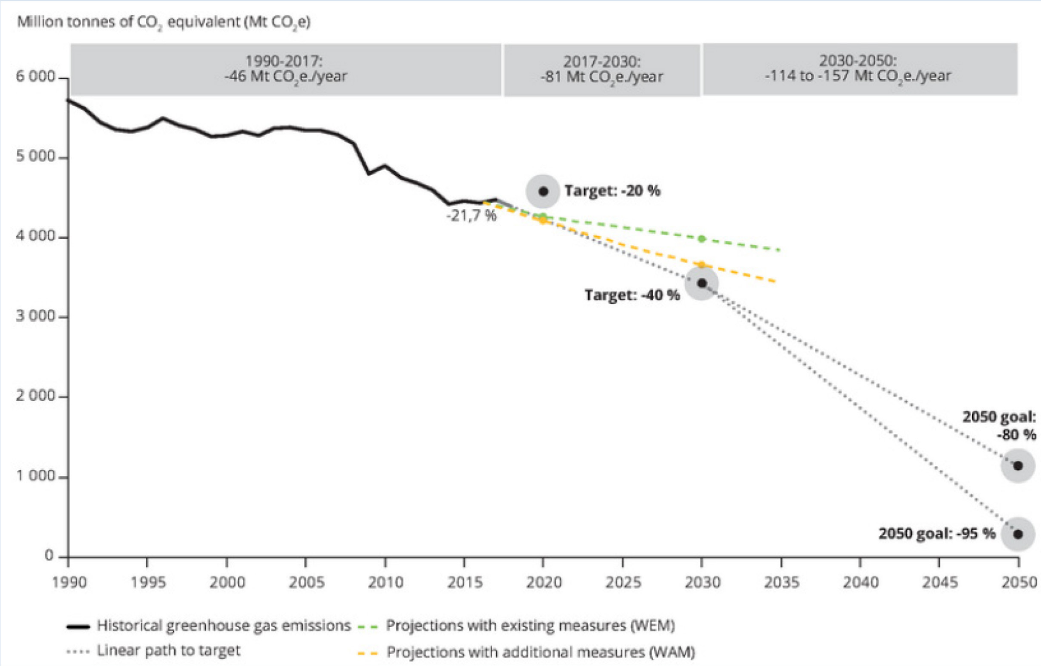
Often, the scenarios developed include both a reference case (often colloquially called business-as-usual) assuming that current trends and policies remain in effect unchanged, and an ambitious (even idealistic) case that demonstrates at what cost such goals would be met. The other scenarios then set between these two extremes. Most importantly, developing scenarios for a country's energy future should ideally be done in consultation with a range of experts (i.e. in climate, the environment and economics). Furthermore, scenario development entails more than just modelling: building and maintaining an organisation's capacities is a challenge that requires time and continuous training to adapt to the evolving modelling environment.

EU member state scenario development for national energy and climate plans (NECPs)

According to EU legislation, member states are required to report their air pollutant emissions projections under the following scenarios:

- **With existing measures (WEM) –** WEM-projections encompass the effects, in GHG emissions, of policies and measures adopted and implemented based on current national and European legislation. Every EU member state must report projected emissions to the EU. Countries also report their policies and measures (PaMs) alongside the projected emissions. Currently, WEM forms the reference case (in the past, also 'without measures'-scenarios were developed but they are now discontinued.
- **With additional measures (WAM) –** WAM-projections encompass the effects, in GHG emission reductions, of policies and measures adopted and implemented, as well as policies and measures that are planned (e.g. measures under discussion having a realistic chance of being adopted and implemented after the date of submission of the national plan). In other words, these projections provide a more optimistic projection, assuming that additional laws with higher ambition will come into effect.

Relationship between the existing measures and additional measures scenarios, and effects of policies and measures



Source: European Environment Agency (2019), Greenhouse gas emission trend projections and target.

Key takeaways have emerged from lessons and interviews related to the Finnish scenario development process:

Lessons learned from the Finnish scenario development process

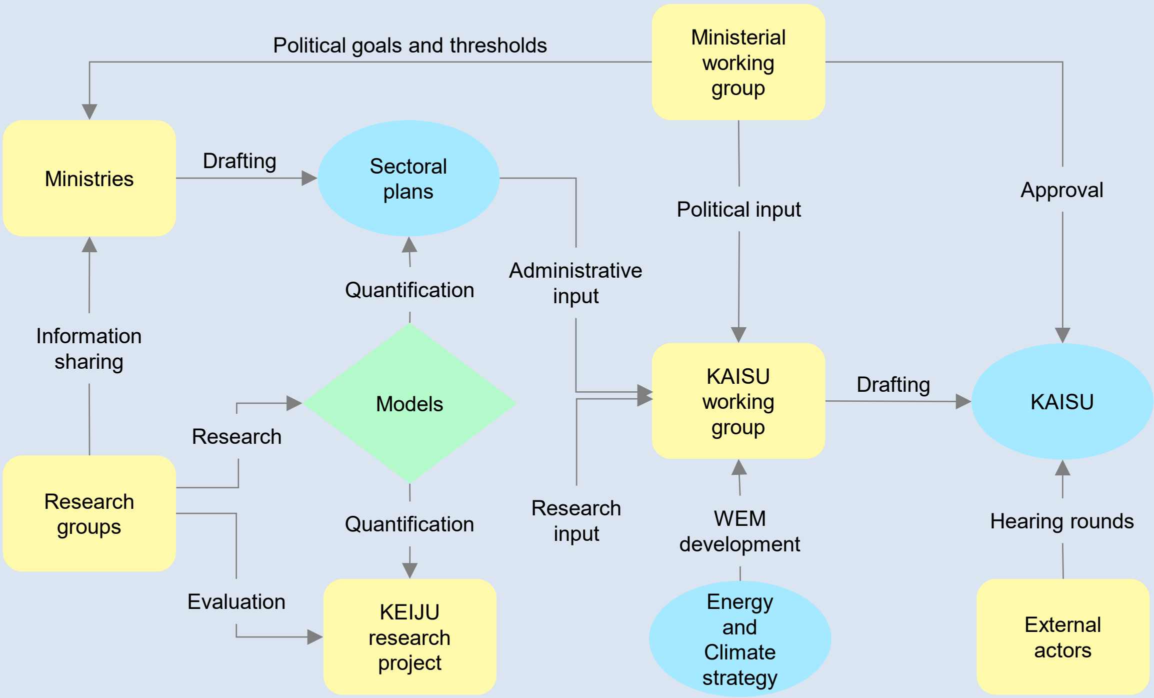
Scenario development	Improve co-ordination of different processes during scenario building Provide transparent documentation of models and sectoral plans Ensure sufficient resources and time allocation Expand group of experts involved
Scenario components	Provide transparent assessments of sensitivities and uncertainties Enhance the use of qualitative assessments Employ a wider range of scenarios
Use of scenarios	Improve communication of scenarios to a wider audience Clarify the role of scenarios to policymakers Regularly update scenarios

Scenario planning process – The Finnish experience

In 2017, Finland prepared its Medium-Term Plan for Climate Change to 2030 (the KAISU), and scenario building was an integral component of its development. The scenarios were formulated by compiling sectoral estimations of possible emission reduction measures, and the impacts and cost-effectiveness of these actions were then evaluated to form a cohesive set of additional policy measures.

However, it has been difficult to uncover the rationale for some of the internal choices made during the process. Subsequent research suggests that transparency should involve not only providing access to the data and models used, but also documentation on the structural assumptions made during scenario development. The researchers also retroactively developed a schematic of the planning process:

Flowchart of the scenario planning process



Source: Aro, K., Aakkula, J., Lauttamäki, V., Varho, V., Martens, P., & Rikkonen, P. (2022). The use of scenarios in climate policy planning: an assessment of actors' experiences and lessons learned in Finland. Climate Policy, 23(2), 199–211, as modified by the IEA.

Increased transparency would be particularly useful for parties not directly involved in the modelling exercises, such as policymakers and stakeholders. Hence, to make national scenario development work better and improve understanding of the process, it is important to evaluate how the administration, policymakers and scenario developers interact, which background assumptions guide the process and scenario models, and how scenarios influence policy decisions.

Self-assessment – Enabler 4

Enabler 4 – Scenario development	Yes	Partially	No
Is the scenario approach used in national energy planning?	☐	☐	☐
Are scenarios developed mainly by national stakeholders?	☐	☐	☐
Does scenario development involve all key stakeholders?	☐	☐	☐
Are details of the scenario development process (e.g. assumptions) documented?	☐	☐	☐
Are the chosen scenarios diverse enough to capture a representative range of potential futures?	☐	☐	☐
Count of 'YES' answers		**/**	**5**

Enabler 5: Energy system modelling

"All models are wrong, but some are useful." [1]

Rather than suggesting that energy modelling should not be done, this famous quote often attributed to George Box implies that no model can completely and accurately mimic reality. This underlines the importance of rigorous preparation of scenarios and their underlying data inputs.

Energy sector models are analytical tools used to analyse the performance and dynamics of energy systems over time. The primary purpose of energy modelling is to provide evidence for policymakers on the impacts of different policy options to national energy security, economic development and environmental aspects. As many energy system models are effective illustrators of technology-rich, least-cost energy system pathways, they have been used extensively (initially in the 1970s and 1980s) to explore least-cost options to reinforce energy security and, more recently (particularly since 2000), to transition to a low-carbon future.

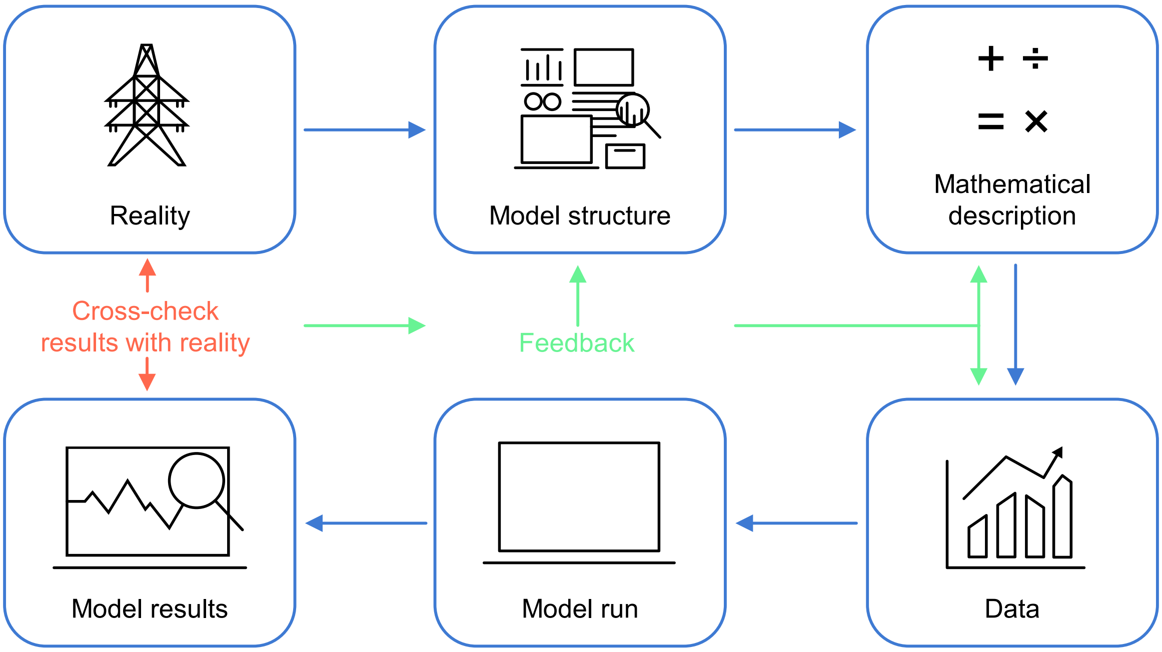
For conducting quantitative analyses, energy systems are presented in organised model structures involving inputs/data, equations and outputs. This enables analysts to compare different system configurations without the cost of building them. Ideally, the results will make it easier to design an energy system, but will also account for local/national resources, energy demand, policies and other constraints.

Building an energy system model requires several key components: a model generator; a solver; interfaces for handling data and results; and a detailed database. Energy system models also require key external inputs such as energy supply and demand data, as well as policy objectives (scenarios). While this may

[1] Box, G. E. P., Draper, N. R. (1987), Empirical Model-Building and Response Surfaces, p. 424.

sound complicated, good results can already be achieved with relatively simple spreadsheet tools. Thus, a country just initiating development of a national energy system model may begin its journey with this approach. Once the policy planning processes have been established, it may become relevant to develop more complex capacity and models.

Components of a generic energy system model



Source: IEA (2020), Aspects of a robust LTES development process, as modified by the IEA.

In other words, a model translates a real-world energy system into a set of mathematical equations. These equations then rely on input data (see Enabler 3) to begin the computations, but also use it to formulate objectives to be reached at the end of the modelling exercise.

While energy modelling should not be considered an ultimate policy objective or a means to formulate absolute policy decisions, it is a useful tool for informing discussions and drafting legislation. Furthermore, given the complexity and global nature of today's energy systems, it is also the only option for managing countless system variables.

Nevertheless, energy modelling should not be seen as an isolated mechanical data input-output activity. The several steps it encompasses both before and after the actual computational modelling exercise aim to minimise uncertainty and maximise the usefulness of the results.

Steps of the energy modelling process

Energy data production	• must be adequate to support the data-heavy models
Energy data validation	• allows users to assess uncertainties in the inputs
Scenario formulation	• translates the research question into targets
Validation of assumptions	• involves compiling model inputs • reveals impacts on results
Running the model	• requires skilled capacity that can only be developed over time
Interpretation of results	• requires information from all the previous steps

Source: IEA (2022), Implementing a Long-Term Energy Policy Planning Process for Azerbaijan: A Roadmap, as modified by the IEA.

The first steps of the modelling process show that having high-quality initial data is crucial. When information is not available, assumptions and estimates must be made, but quantifying certain real-life phenomena (e.g. socio-economic behaviour) is extremely complex, if not impossible. Furthermore, the technical constraints, efficiencies and costs of new technologies, as well as the timing of their commercial introduction, are highly speculative.

The uncertainty that these approximations inevitably introduce into the model outputs must be understood and potentially quantified through multiple scenarios or sensitivity analyses. Through these examinations, it is possible to gauge a model's usefulness for describing the potential future, given a set of boundary conditions and/or ultimate targets. Indeed, models should demonstrate robust steps that need to be taken in the immediate future while ensuring that the chosen path will not be regretted later.

Picking the tools

Compiling an exhaustive review of all available modelling tools is not feasible given the sheer number of options. Before discussing individual tools, it is essential to understand that common to each one is the need to have experts operating, maintaining and updating them. Countries at the initial stages of establishing an in-house energy planning team should start small, for example with a simple spreadsheet tool instead of a complex energy system optimisation model.

The IEA publication Implementing a Long-Term Energy Policy Planning Process for Azerbaijan reviews some commonly used tools and touches upon grouping the tools from a technical point of view (optimisation vs simulation, bottom-up vs top-down). From the perspective of capacity building, it is important to distinguish between commercial (proprietary) and open-source (non-proprietary) tools.

Commercial tools come at a cost for users, but often offer a wider support base, are updated regularly and provide professional training courses. In many cases, developing countries and academic institutions may purchase the licence at a discounted rate. Nevertheless, annual licence costs are often a barrier to the adoption of modern modelling tools.

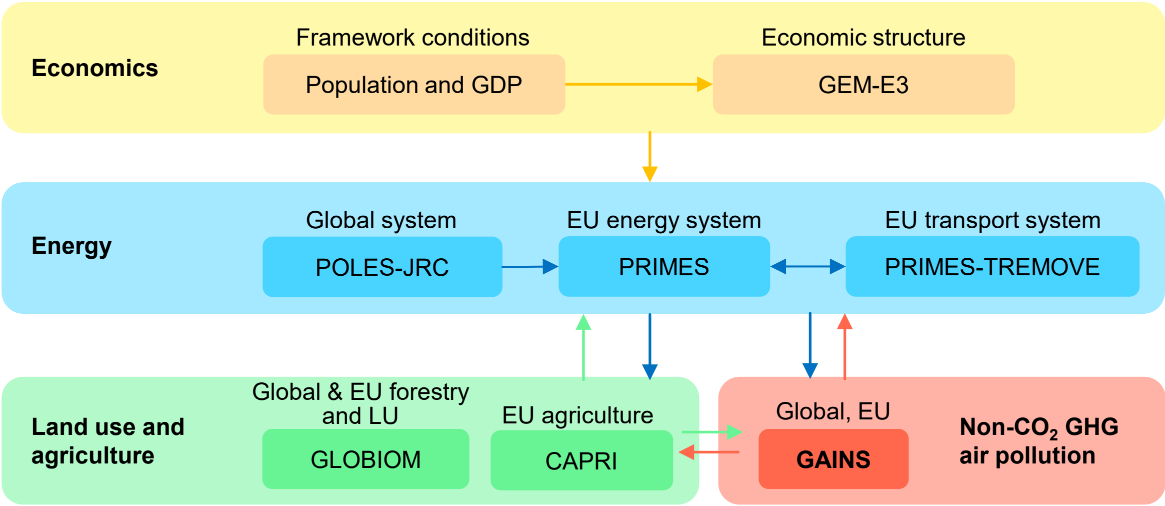
To address the cost issue, more and more tools are being made available for free. Generally, these tools rely on user-community maintenance and peer support, including through capacity-building events.

A country's choice of model should be based on its distinct national needs. While models have been tailored to specific situations in the past, this solution depends solely on a country's internal capacity and thus poses a higher risk of corporate memory loss than more widely used applications. Tools (often more than just one) should be chosen based on several considerations:

- Is the tool able to provide insights into the main research questions?
- What are the tool's primary limitations?
- Is the tool widely in use, i.e. is there a support community?
- What are the running costs of the tool (e.g. for licences)?
- Does domestic capacity exist or must it be developed?
- How difficult is it to develop relevant IT skills?

Regardless of the tool, according to ETSAP a key success factor is to have a committed team working almost full-time on the modelling activity during the initial phase when capacity is being developed. Such a team becomes all the more important once the activity expands to cover several parallel models specialising in different aspects of the economy.

Modelling framework of the EU Reference Scenario 2020



Note: LU = land use.
Source : IEA analysis based on European Commission (2020), EU Reference Scenario 2020, as modified by the IEA.

Self-assessment – Enabler 5

Enabler 5 – Energy system modelling	Yes	Partially	No
Is a permanent team dedicated to energy modelling?	☐	☐	☐
Does the team interact with national energy data providers?	☐	☐	☐
Does the national energy modelling community have direct connection to the energy policymakers?	☐	☐	☐
Is the team resilient to staff turnover?	☐	☐	☐
Does the national energy modelling community interact with the teams of other countries or international modelling communities to develop capacity?	☐	☐	☐
Count of 'YES' answers		**/**	**5**

Enabler 6: Stakeholder engagement and communication

A general criticism of energy system models is that their structural complexity and numerous input parameters and variables render them a 'black box' for non-modellers who lack specialised programming knowledge. It should also be emphasised that the results of the modelling must be interpreted and refined by experts to become useful inputs for policy-making. Thus, such capacity should also be developed (see Enabler 2).

Multiple scenario analyses consistent with different policies produce wide uncertainty ranges in the results, whereas policymakers often prefer to see a discrete number of outcomes instead of a range. While academic literature embraces uncertainty, the public perceives a wide range of outcomes as an indication that scenarios do not offer much more than evidence that almost anything is possible.

Since a model's accuracy – and thus its usefulness – inevitably depends upon the number of details and input fed into it, it is necessary to find other means of sharing results than asking non-experts to explore the model or the raw results themselves. Once a modelling exercise has yielded robust outputs, it is important that policymakers communicate this information in a concise and transparent manner.

For full transparency, the final deliverable (e.g. a report or presentation) should be accompanied by relevant documentation to allow interested parties to examine the underlying assumptions and data sources used for the modelling exercise.

Furthermore, it is in the best interests of the modelling team to properly document their work so that the model (and the results) can withstand both national and international scrutiny. Ideally, the scenario development phase should already be clearly documented and publicly available.

The UK Energy Research Centre defines three levels of model transparency:

1) **Open-description models** – provide a concise methodological summary, and outline documentation and links to outputs and applications.

2) **Open-access models** – give a user group access and shared responsibility for model development, plus offer full documentation and data sets.

3) **Open-source models** – are fully transparent and accessible, available for any user to download and use.

However, experience shows that energy modellers – whether in academic, government or consulting environments – often struggle to make their models open and accessible to key stakeholders. Ensuring a model's transparency is time-consuming, unglamorous, rarely prioritised by funders, and undervalued in terms of a modeller's career progression. Nevertheless, transparency is crucial to ensure that the implications and limitations of a model's insights can be fully understood.

A medium-term aim is to make all policy-orientated energy modelling more transparent (at least level 1 – open description), while all publicly funded energy modelling should reach a higher transparency threshold (at least level 2 – open access). Modellers can update their entries as efforts are made to increase the transparency of their models.

Because countries can find it difficult to build on their energy plans, especially when planning activities are supported by external assistance (e.g. donor-funded consultancies), the U4RIA standards were developed to regulate the documentation of data and data sources, methodologies applied, and assumptions used in energy system planning studies and projects.

Aspects of the U4RIA-standards

U4RIA aspect	Key points
Community management (= Ubuntu)	• Modellers should have clear plans and commitments to engage with national energy stakeholders to transfer knowledge, capacity and ownership of data, tools and models. • National stakeholder involvement should go beyond requesting data and their interpretation. • Plans for capacity building should be incorporated into all strategic energy planning support activities, according to the possibilities of the project.
Retrievability	• Data should be easily retrievable, with good metadata, clear archiving and formats that allow for interoperability. • Poor retrievability and inability to test and audit outputs can easily erode confidence in the modelling exercise.
Repeatability	• When results are recorded and disseminated, modellers should specify the model version and machine specifications used. • Any changes in model version and minimum technical requirements should be clearly specified in new version releases and be made publicly available.
Recon-structability	• Modellers should ensure that data used for energy planning analysis (including metadata, assumptions, methodology, and outputs/results) can, as much as possible, be subsequently reconstructed.
Reproducibility	• Applying best practices in data management and storage is important to achieve a sustainable energy planning ecosystem.
Interoperability	• Modellers should produce a guide or manual on best practices to facilitate the interoperability of datasets and models, including defining interchangeable policies with open standards, and interoperable and vendor-neutral software.
Auditability	• Following all these principles should ensure that the data and deliverables produced during energy modelling activities can be successfully audited.

2050 calculators – Improving understanding on energy policy pathways

As national policy planning is also a mechanism for advocacy groups to promote their solutions to the public, scenarios can be viewed as forums in which alternative low-carbon solutions compete for recognition and publicity. As politicians, stakeholders and citizens all have different opinions on possible, probable and preferred future circumstances, the line between processes for creating and using scenarios may become blurred.

Ideally, the role of modellers is to create the best conditions (large quantitative outcomes/findings) to make the decision-making process easier and more transparent (data based). In this sense, it may still be good to interpret and test specific objectives – even if biased - with the exact purpose to unveil the contradictions and complexity they introduce to the energy system.

To address this issue but still encourage discussion, the United Kingdom developed the 2050 Calculator Programme to explore all options available, rather than continuing to rely solely on existing models that simply determine an optimum pathway. Over 17 000 people have submitted pathway possibilities through the online calculator, providing insight into public opinion on the energy transition.

Furthermore, many other countries have also developed similar calculators and made them publicly available, so they have become a useful tool in the public debate on what the future energy system should look like.

Implementing a Long-Term Energy Policy Planning Process for Azerbaijan includes a more detailed description of the development process of these tools.

Self-assessment – Enabler 6

Enabler 6 – Communicating the results	Yes	Partially	No
Are modelling results (including data, assumptions, etc.) publicly available?	☐	☐	☐
Have the results been condensed into a communiqué that can be easily understood by non-modellers?	☐	☐	☐
Does the planning process adhere to U4RIA standards?	☐	☐	☐
Were the lessons learned related to communication from previous planning cycles documented?	☐	☐	☐
Can the lessons learned be applied to future long-term energy planning communications?	☐	☐	☐
Count of 'YES' answers		**/**	**5**

Available tools and material to strengthen enablers

It is not possible to estimate the amount of time needed to strengthen enablers, as it will depend on a country's ambition to improve its policy planning process and the level at which it begins. However, regardless of aspirations, it will inevitably be an ongoing multi-year commitment.

Enablers with the lowest scores should be made national priorities. In this section, each enabler is coupled with resources to support capacity development. However, new support material is continuously released and therefore, the resources listed in this section are not exhaustive. As establishing strong enablers is a key prerequisite to reinforce national energy planning capacities, it is natural that commitment at the national level will be required, also to benefit from the latest support resources.

Available tools and material

Enabler: Political will	Score:
Raise awareness on the importance of sustainable energy planning	
Every policymaker in the energy and climate domain should be familiar with the findings of the IPCC's latest synthesis report, Climate Change 2023. The summary for policymakers distils the information into key messages, providing for a relatively short read. The already-documented negative effects of climate change should motivate individual energy experts in every government to further develop their national energy policies.	
Increase the impact of development partner support	
Policymakers should study, then advocate for development partners to adhere to, the Key Principles for Improving the Support to Strategic Energy Planning in Developing and Emerging Economies. These principles were developed through a roundtable consultation process, drawing on the experience of a range of organisations involved in implementing and supporting energy planning (e.g. the World Bank Group, the UN Development Programme [UNDP], the US Agency for International Development [USAID], the IEA and IRENA). **The five key principles are:** • **National ownership** • **Coherence and inclusivity** • **Capacity** • **Robustness** • **Transparency and accessibility**	

Enabler: Analytical capacity	**Score:**
Enrol individual experts in training courses and events to strengthen their analytical capacity	
The UN outreach training course Designed for policymakers and development practitioners, this course offers a practical guide on how tools can best inform policy debates and decisions. It does not provide quantitative modelling skills, a task better accomplished by in-depth capacity development assistance or specialised academic courses **Free open-source online courses** • Modelling, Policy and Political Economy • Infrastructure and Climate Resilience **International Atomic Energy Agency (IAEA) capacity-building activities** IAEA capacity-building programmes are available for all member countries (most countries of the world), irrespective of nuclear energy production. Support ranges from e-training sessions to workshops and bilateral expert missions. E-training through the IAEA Planning and Economic Studies Section (PESS) offers three components: • Information resources – to make it easier to find reliable modelling information • Energy system modelling support – to enhance modelling capacity • Expert tele-support – to make it possible to engage with IAEA energy modelling experts.	

Enabler: Data adequacy	**Score:**
Align national energy statistics collection with international methodology	
UN International Recommendations for Energy Statistics (IRES) The IRES provides data compilers with a complete set of recommendations for all aspects of the statistical production process, from basic concepts, definitions and classifications to data sources, data compilation strategies, energy balances, data quality and statistics dissemination.	
Strengthen national energy data collection capabilities	
Demand-Side Data and Energy Efficiency Indicators: A Guide to Designing a National Roadmap This 2023 IEA roadmap provides tools to assess a country’s current capacity to produce energy demand data and energy efficiency indicators, as well as guidelines on how to minimise obstacles. **Guide to Designing a National Energy Statistics Roadmap (forthcoming)** This 2024 IEA roadmap provides tools to assess a country’s current capacity to produce national energy statistics as well as guidelines on how to mitigate problematic issues.	

Improve understanding of the energy data

IEA energy statistics webinars
IEA webinars cover a range of topics – from the fundamentals of energy statistics to fuel-specific issues, the compilation of overall energy balances, and energy price and emissions estimates. Webinars are available in English, Chinese, French, Spanish and Russian.

IEA online energy efficiency courses
Courses aim to increase the knowledge and skills of policy makers and data experts to identify energy efficiency needs and opportunities, develop and implement appropriate energy efficiency policies and measure their impact.

UN e-learning course on energy statistics
This course aims to improve understanding of the international (UN) methodology for compiling energy statistics and balances to support long-term energy planning and modelling.

IAEA course: Creating and Assessing an Energy Balance with EBS (Energy Balance Studio)
This course helps users create and assess an energy balance with the IAEA's EBS tool.

Tap into open-source datasets to support energy modelling

- The World Bank's Open Data and Analytics platform provides access to energy-related datasets and data analytics.
- Developed by the World Resources Institute, the Resource Watch platform provides free energy-related datasets.
- The Global Atlas for Renewable Energy is an online platform developed by the International Renewable Energy Agency (IRENA) to give policymakers and investors access to renewable energy resource maps for locations across the world.

Enabler: Scenario development	**Score:**

Study the best country practices before designing a national approach

Scenarios for the Energy Transition: Global Experience and Best Practices
This 2020 IRENA report lists dozens of country practices, with emphasis on the participatory process and national co-ordination.

The Use of Scenarios in Climate Policy Planning: An Assessment of Actors' Experiences and Lessons Learned in Finland
In this 2023 study, K. Aro et al. use Finland's experience to provide several generic recommendations on how to further benefit from the scenario approach, as well as a recommendation for documenting assumptions made during scenario development.

Enabler: Modelling the energy system	Score:

Enable national experts to participate in training sessions on modelling

Free open-source courses developed by the UN and international organisations together with the Climate Compatible Growth programme:

- OnSSET/The Global Electrification Platform
- Energy and Flexibility Modelling: OSeMOSYS & FlexTool
- Financial Analysis of Power Sector Projects Using the FinPlan Model
- Introduction to CLEWs (integrated modelling of Climate, Land, Energy and Water systems) for sustainable development policy
- Agent-based energy systems modelling: MUSE
- Energy Demand Projections with MAED (Model for Analysis of Energy Demand)
- Geospatial clean cooking access modelling using OnStove
- Geospatial Data Management for Energy Access Modelling and Planning
- The Electricity Transition Playbook
- Off-Grid Energy Systems Modelling with MicroGridsPy

Free IAEA tools
The IAEA offers member states a wide range of modelling tools for energy system planning and nuclear energy system assessments.

Join relevant community platforms

The European Climate and Energy Modelling Forum (ECEMF)
This project aims to establish a European forum for energy and climate researchers and policymakers to achieve climate neutrality, and to also improve collaboration beyond Europe.

The Energy Modelling Platform for Africa (EMP-A)
This annual event aims to transmit skills for developing models and using tools for energy planning in African countries.

The Energy Modelling Platform for Latin America and the Caribbean (EMP-LAC)
IEA-ETSAP Technology Collaboration Programme for TIMES/MARKAL modelling
LEAP (Low-Emissions Analysis Platform)
Developed at the Stockholm Environment Institute, LEAP is a widely used software tool for energy policy analysis and climate change mitigation assessment.

The Community Platforms repository
The Roundtable Initiative on Strategic Energy Planning maintains a repository of active community platforms.

Enabler: Stakeholders engagement and communication	Score:
Ensure the energy planning process adheres to the best transparency practices	
U4RIA: Ubuntu, Retrievability, Repeatability, Reconstructability, Reproducibility, Interoperability and Auditability The Roundtable Initiative on Strategic Energy Planning has developed guidelines to increase the transparency of the energy planning (modelling) process. It has also designed a Terms of Reference (ToR) template to make it easier to embed reliable data use, modelling transparency and good management practices into the activities to be commissioned.	

Conclusion

With growth in the number of variables making long-term energy planning increasingly complex, scenario development and energy modelling are more crucial than ever. However, developing the requisite analytical capacities is complicated and time-consuming.

We therefore encourage countries to take ownership of and dedicate resources to these processes as early as possible. It is better to begin modestly and expand gradually than wait for the perfect opportunity to undertake a complete overhaul of the policy planning system. Support is available in the form of methodological guidance, training materials and modelling tools.

Adoption of a modern energy planning process based on quantitative analysis empowers the country to anticipate potential challenges, to develop proactive energy policies to address them and to achieve their policy goals. While it is natural for every country to be at a different stage of energy planning, all governments should be demonstrating the political will to either establish a modern energy policy planning process or strengthen its current one and the related capacities.

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