Implementing a Long-Term Energy Policy Planning Process for Azerbaijan: A Roadmap

International Energy Agency

Co-funded by the European Union

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Introduction

Long-term energy planning is central to a country's strategic direction. Without it, governments may end up relying on a patchwork of policies and legislation that can be incoherent and ill-suited for the complex challenges countries are increasingly faced with. Good long-term energy planning encompasses domestic and foreign policy, while touching on many key areas of the economy including industry, natural resources and trade. The process involves multiple stakeholders across the government, but also brings in the private sector as well as citizens, as it aims to set out a strategic path towards a clear goal.

At a time when most countries have signed on to the Paris Agreement and are working towards their nationally determined contributions (NDCs), developing an energy strategy with a long-term view is all the more important. Many governments have developed or are in the process of developing energy strategies via long-term energy planning. The energy transition is at the core for many of these countries, but other goals, such as energy security, energy access and trade, must also remain central. Each country will have a combination of priorities that drives its strategic goals and informs the policy planning process.

As the world works to recover from the Covid-19 pandemic and looks towards a net zero future, long-term energy planning is becoming a necessity, rather than a choice. While each country has its own path to energy policy planning that reflects its unique situation, it is clear that countries must take ownership of this process. While some aspects can be externalised or developed in concert with other organisations, energy policy planning and the eventual development of an energy strategy must come from within governments, stemming from a clear assessment of the current context, as well as the country's needs and goals.

Azerbaijan, like many of its peers, is looking to understand how best to meet the opportunities and complexities of the global clean energy transition. The 2014-2015 oil shock prompted the government to consider and draft a slate of new laws and reform packages, and at present efforts are being made to finalise and pass an energy strategy. The price volatility seen in global markets over 2020-2022 is making it even clearer that energy planning using scenario analysis and modelling will help countries successfully respond to new and unexpected challenges in a resilient fashion.

The energy policy planning process and the process of creating an energy strategy are inextricably linked. An energy strategy is an evolving collection of targets and policies that sets out a country's goals for a defined period of time. The overall policy planning process both feeds into an energy strategy and is also based on it. The process of long-term energy planning is one of strengthening a country's ability to take on unexpected challenges and emergencies. This circular process means that a country's energy strategy is constantly evolving.

Energy statistics play a key role in policy making and the process of putting together an energy strategy. However, that role is not always well defined. While this roadmap sets out one approach to the long-term energy planning process, and others are indeed possible, all good energy policy planning involves statisticians and energy statistics, as well as modelling.

A long-term strategy will start from a political or economic goal. In order to reach that goal and to understand the consequences and potential trade-offs, modelling of scenarios or pathways will likely be necessary. However, such modelling can be achieved only if there are comprehensive energy statistics that properly measure and thus quantify the energy system from both the supply and demand perspectives.

Achieving a long-term plan requires strong political thought leadership, but that alone will not be enough. This is why long-term energy planning is a process that needs to be embedded in government policy making, from both structural and procedural levels.

This roadmap details the necessary steps in building that process and exploring relevant policy options that producer economies have pursued, which may be relevant to Azerbaijan. It then discusses data collection and survey design, which are key to establishing the base for energy modelling. The roadmap then looks at energy modelling and its role in policy making.

Successful policy development needs good communication across government, integrating statistics into the policy-making process and investing in data collection where information gaps exist. Those topics are explored as well as the importance of monitoring and evaluation policies and creating meaningful indicators to help understand the impacts of these policies.

Many countries have embarked on long-term energy planning, increasingly so in the lead-up to the 26th Conference of the Parties (COP26), as governments worked to define their net zero timelines and pledges. However, energy planning can take its lead from other priorities. India, while still prioritising pollution and energy access, has put energy security at the heart of its planning. Meanwhile energy producers such as Egypt and the United Arab Emirates (UAE) have examined ways to diversify their energy use and mitigate vulnerabilities, often through the development of renewables, to seek to maximise export volumes and thus the value of their energy resources.

This roadmap aims to help Azerbaijan reconsider the policy planning process as it looks to connect key laws and reforms into a greater energy strategy. It also sets out a path for Azerbaijan to make this process sustainable and iterative, connecting its policymakers with its statisticians, and investing in in-house modelling capacity. Every country must choose its own energy path, based on its specific needs and resources, but having a long-term plan can smooth out that path significantly.

Azerbaijan's energy context

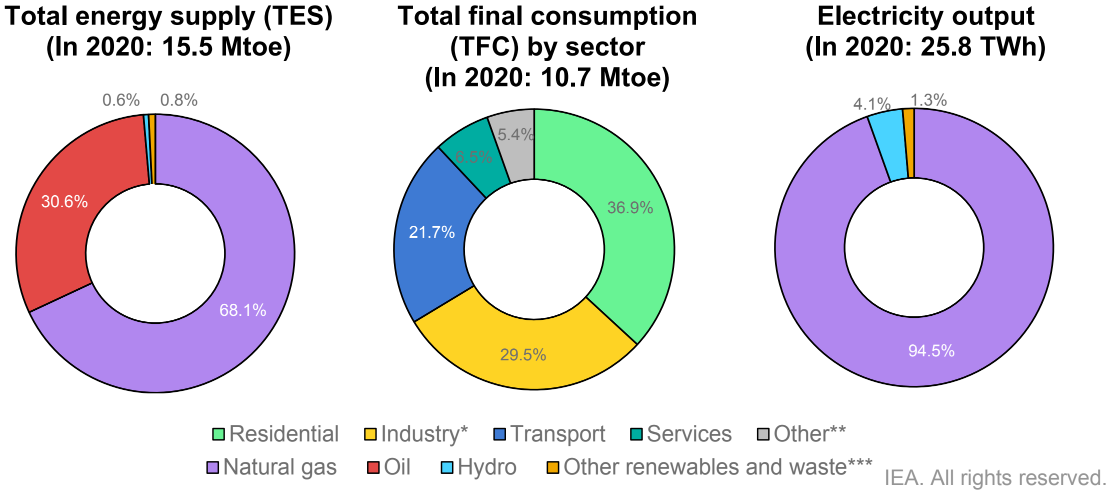
Oil and gas

Azerbaijan's economy is driven by the oil and gas sector, which accounts for some 90% of the country's exports and between 30% and 50% of its GDP, depending on oil prices. Export revenue from oil and increasingly from gas as well has brought Azerbaijan significant wealth and raised the standard of living in the country. The dynamics of the country's oil and gas sector substantially influence economic growth, through both industrial activity and consumer spending linked to employment and salaries.

Overall, Azerbaijan produces around four times the energy it consumes and has one of the highest levels of energy self-sufficiency in the world. In recent years, almost 90% of oil and over 40% of natural gas have been exported.

Azerbaijan's domestic total energy supply (TES) relies on natural gas (68% in 2020) and oil (31% in 2020) (Figure 1). Natural gas is used to generate most of the electricity and heat in the country (over 90% in 2020). Fuel oil was phased out in the early 2000s, but had to be briefly reintroduced following the gas supply squeeze in 2015-2017. Crude oil is refined locally to satisfy most national oil product consumption, and local production is about to expand following a refinery upgrade which is now under way. It is noteworthy that no coal is used in the country.

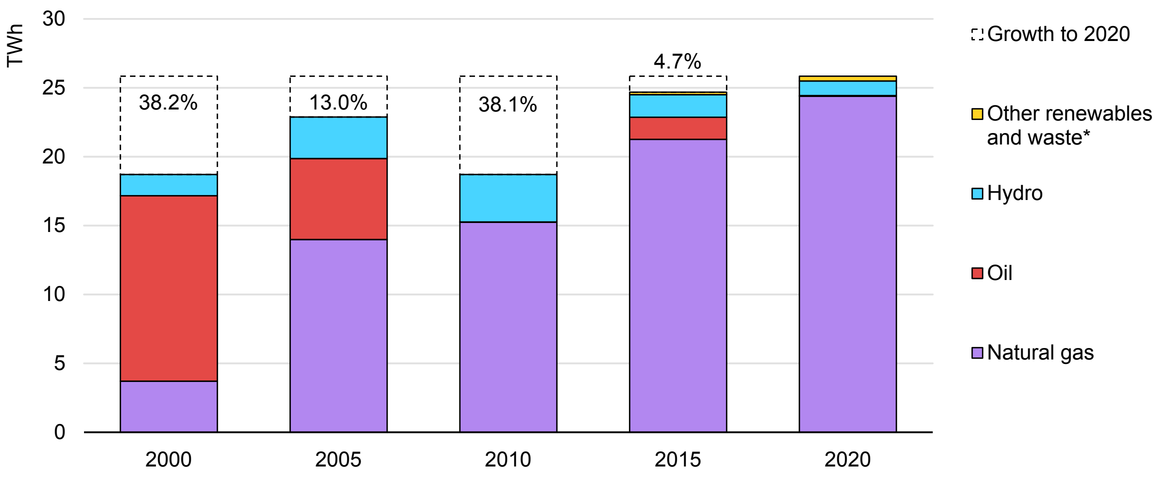
Figure 1 Energy snapshot of Azerbaijan, 2020



* Includes non-energy use.
** Includes agriculture, fishing and unspecified energy consumption.
*** Includes electricity generated with municipal waste, wind and solar PV.
Note: Mtoe = million tonnes of oil equivalent; TFC = total final consumption; TWh = terawatt-hours.
Source: IEA (2022), World Energy Statistics and Balances (database), www.iea.org/data-and-statistics.

Natural gas is the largest source of TES, but a major share of it is transformed into electricity and heat (Figure 2). This explains the relatively equal shares of oil products and gas in TFC, with oil averaging 42% of TFC in 2010-2020 as compared with gas (40%). In the same time period, electricity accounted on average for 16% of the TFC.

Figure 2 Electricity generation in Azerbaijan, 2000-2020

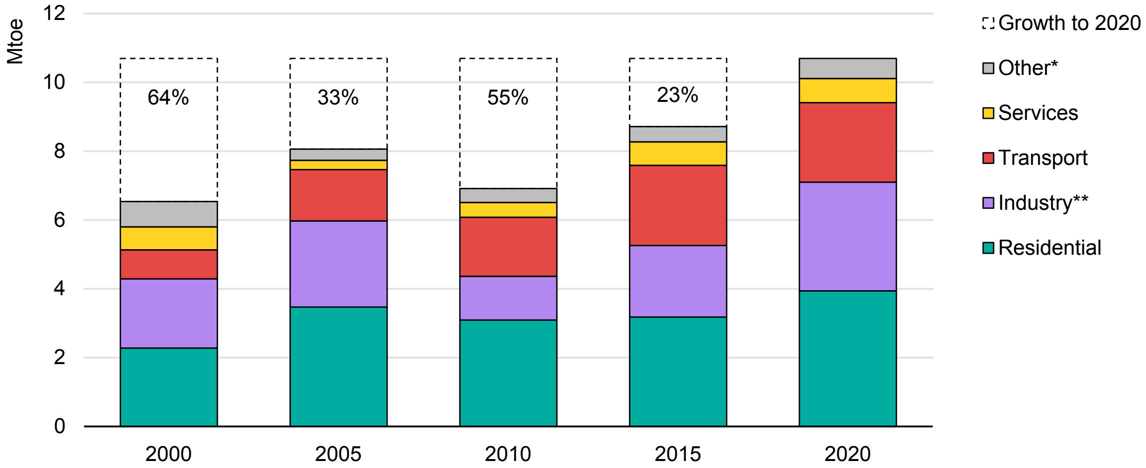


* Includes electricity generated with municipal waste, wind and solar PV.
Source: IEA (2022), World Energy Statistics and Balances (database), www.iea.org/data-and-statistics.

It is noteworthy that while the shares for the three main energy sources have remained essentially constant, the consumption of each has grown by more than 50%. In contrast, the share of district heat in TFC was only 3% in 2020, but its consumption has grown over fivefold since 2010. Oil is the primary energy source in transport and industry. Natural gas is the main energy source in the residential sector, and also increasingly important in the service and industrial sectors. However, the drop in economic activity due to the Covid-19 pandemic led to a 70% year-on-year decline in natural gas consumption in the service sector.

The residential sector is traditionally the largest final energy consumer, and was responsible for 37% of TFC in 2020 (Figure 3). Households consume energy mostly in the form of natural gas; gas made up over 80% of total household consumption in 2020. Industry was responsible for over 30% of TFC, with oil being the main energy source (46% of the sectoral total in 2020). Energy consumption in the transport sector has almost tripled in volume since 2000 and accounted for 22% of TFC in 2020, almost all in the form of oil (around 97% of total transport consumption in 2020). The service and agricultural sectors accounted for around 12% of TFC in 2020, with electricity as the main energy source (48% of the sectoral total).

Figure 3 Total final consumption in Azerbaijan, 2000-2020



* Includes agriculture, fishing and unspecified energy consumption.
** Includes non-energy use.
Source: IEA (2022), World Energy Statistics and Balances (database), www.iea.org/data-and-statistics.

Oil and gas exports continue to dominate Azerbaijan's economy, providing the majority of government revenue. These fossil fuel resources are plentiful, but as major importing countries around the world commit to net zero GHG emissions by 2050, Azerbaijan will need a strategic long-term outlook.

The oil price volatility seen in 2020 and 2021 has reconfirmed the need to encourage private-sector-led and productivity-based development and diversification in Azerbaijan. The recently announced decarbonisation targets in a growing number of oil- and gas-importing countries point to the same conclusion. Economic diversification still has far to go, however, and dependence on the oil and gas industry will persist for years.

Sustainable energy

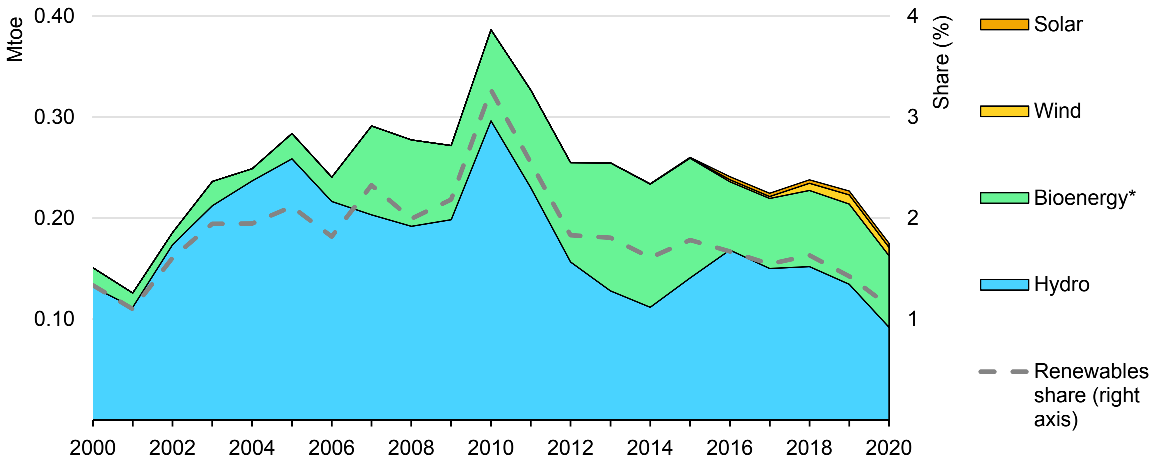
While interest in using renewable energy and energy efficiency has begun to increase only in recent years, the Azerbaijani government recognises that renewable energy in power generation can help diversify energy sources and divert natural gas from power generation for potentially more profitable exports and use in petrochemicals, and also help meet climate policy objectives.

Moreover, Azerbaijan has strong potential for renewable energy development. The country has excellent solar and wind resources and significant prospects for biomass, geothermal and hydropower. Practical deployment has been limited, however, compared with the scale of the country's available resources and long-term ambitions. That focus is changing, however. The government is now drafting legislation to promote renewable energy and is aiming for renewable energy to provide 30% of electricity generating capacity by 2030, roughly twice the current share. Major contracts for building wind and solar power capacity were signed in early 2020, and construction is currently underway.

Renewable energy, together with energy efficiency, also offers the most promising low-carbon solution to meeting Azerbaijan's climate targets. At COP26, Azerbaijan committed to reducing its GHG emissions by 40% by 2050, measured from the 1990 base year set in its NDC under the Paris Agreement, roughly equivalent to a 20% reduction from the current emissions. The government is also working to meet the United Nations' (UN's) 2030 Sustainable Development Goals (SDGs), among which SDG 7 (access to affordable, reliable, sustainable and modern energy resources) is a priority for Azerbaijan.

The share of renewable energy sources (RES) in Azerbaijan's TES has remained stable but low since the 1990s (Figure 4). The share in electricity generation has declined from 18% in 2010 to 5.1% in 2020, mainly due to a reduction in hydropower output. The dominance of hydropower in RES leads to similarities in the patterns of RES in TES and RES in TFC.

Figure 4 Renewables in total energy supply



* Includes solid biofuels and renewable municipal waste.
Source: IEA (2022), World Energy Statistics and Balances (database), www.iea.org/data-and-statistics.

Hydropower accounted for 53% of total renewable energy supply in 2020. The remainder came mainly from renewable municipal waste and bioenergy. With a combined installed capacity of 102 megawatts (MW) in 2020, wind power and solar PV remain small, but the government has indicated strong ambition to develop the sector. Statistics for heat pumps were available for the first time in 2018, showing a total installed capacity of 1.4 MW. Heat pumps, too, are in the early stages of utilisation in the country.

For the past decade, Azerbaijan has been working to put together strategies on renewable energy, and has passed key legislation that will allow for faster deployment of renewables. While draft strategies were put forward in the 2010s, nothing was formally adopted. The 2016 Strategic Road Map for the development of utilities (electricity, heating, water and gas) in the Republic of Azerbaijan included a target to add 420 MW of renewable electricity capacity by 2020, comprising 350 MW of wind, 50 MW of solar and 20 MW of bioenergy.

The European Union has been supporting the Ministry of Energy of Azerbaijan in its work to build a Long-term Energy Strategy from 2021-2050. This Strategy has not yet been adopted, but remains under consideration.

In May 2020, the Cabinet of Ministers approved the Action Plan on Attracting Additional Investments in the Renewable Energy Field. The role for renewable energy in heat supply is small, and no direct role for it in transport was envisaged, with the focus mainly on investment in the power sector.

In early 2021, President Aliyev approved Azerbaijan 2030: National Priorities for Socio-economic Development, which set out the government's development strategy across the economy. This strategy envisions Azerbaijan as a "clean environment and green growth country," and envisions the increased use of renewable energy sources. In May 2021, Parliament approved the Law on the use of renewable energy resources in electricity production. This new law will allow Azerbaijan to take advantage of its renewable energy potential by setting the legal basis to develop renewable energy projects, and introducing competitive bidding processes and support mechanisms for active consumers i.e. prosumers. In addition, draft laws on electricity and gas supplies are currently under review.

In July 2021, Parliament also approved the Law on rational use of energy resources and energy efficiency. Prior to this, the country had no legal framework or targets for energy efficiency. Having the legal framework in place will open the door for Azerbaijan to begin to take rapid action on energy efficiency, via tools such as stringent standards and support for more efficient energy use in all subsectors.

Key institutions and stakeholders

The presidential administration, Cabinet of Ministers and Ministry of Energy (MoE) are the main government institutions in the energy sector, while several state-owned monopolies control individual subsectors, including the State Oil Company of Azerbaijan Republic (SOCAR) and its subsidiaries (oil and gas production, oil refining, storage, transmission, distribution and supply), Azerenergy and its subsidiaries (Azerenerji, electricity generation and transmission, heat energy generation and selling), Azerishiq (electricity distribution, supply and small-scale electricity generation) and Azeristiliktejhizat (heat energy generation, transmission, distribution and supply and heated water production, distribution and supply).

Executive power in the Republic of Azerbaijan is held by the president, and the president assembles a Cabinet of Ministers to organise the work of the executive authorities. The Cabinet of Ministers is an executive body accountable directly to the president.

The MoE is the central executive authority responsible for implementing state policy in the energy sector. The MoE has the authority to issue secondary legislation in the energy sector, except for those related to tariff regulation, which is under the authority of the Tariff Council.

The Tariff Council determines the retail and wholesale tariffs for electricity, gas, district heat and refined petroleum products as well as purchase tariffs for renewable electricity. As of April 2022, it has been removed from the central executive body of the Ministry of Economy, and is now operating on a voluntary basis.

In December 2017, the **Azerbaijan Energy Regulatory Agency (AERA)** was established under the MoE, by Presidential Decree No. 1750. AERA is a public legal entity which regulates relations between producers, transmitters, distributors, suppliers and consumers; analyzes enterprise activities; submits proposals on restructuring measures, developes incentives for investment; and organises control over compliance with engineering and communication support systems and service quality requirements in the field of electricity and heat energy, as well as gas supply in the Republic of Azerbaijan. Eventually, after the approval of the draft Law on the regulator in energy and utility services, all functions related to the calculation and approval of energy tariffs will be transferred from the Tariff Council to AERA. The draft law was submitted to the Cabinet of Ministries for inter-ministerial consultations in October 2021. In accordance with the Rules on implementation of supervision on supply of electricity and heat energy, as well as gas, approved by Presidential Decree No. 204, in July 2018, AERA fulfills its regulation and inspection functions in the relevant fields.

In September 2020, the president of Azerbaijan signed a decree establishing the **State Agency for Renewable Energy Sources** under the MoE.

The **Ministry of Ecology and Natural Resources** is a central executive body implementing state policy on environmental protection. The ministry maintains environmental safety, monitors the extraction of natural resources and their conservation in the country, and takes measures to avert damage to natural ecological systems from economic or other activities.

The **Ministry of Emergency Situations** is responsible for emergency response mechanisms in all sectors of the economy. Its mandate includes emergencies arising from natural and human-caused disasters and fire, as well as emergencies involving power systems, utility systems, hydropower facilities, oil and gas production and processing facilities, and main pipelines.

The **State Statistical Committee of the Republic of Azerbaijan** is responsible for official energy statistics and meets regularly with the MoE to discuss data findings and potential additional needs of information.

Why is long-term energy policy planning important?

At present, countries around the world are facing myriad challenges, such as ensuring energy security, recovering from the impacts of the Covid-19 pandemic and the increasing effects of climate change. These challenges often intersect, and can arise unexpectedly. Long-term energy policy planning and the process of creating and maintaining an energy strategy are important tools to help countries face these challenges coherently and successfully. Long-term energy policy planning and target-setting are ongoing processes that evolve, rather than conclude. A priority for governments should be to build these processes in a serious but flexible manner, making sure that the policies are impactful but also adjustable in the face of unexpected developments and crises.

Azerbaijan has been working towards a long-term energy strategy for several years. As the oil and gas sector remains the backbone of the economy, the country has been looking to improve the efficiency with which it uses its energy resources.

Azerbaijan 2030: National Priorities for Socio-economic Development is now the main framework for policy reforms and strategy. However, long-term energy policy planning and target-setting remain important for the country's energy sector development. In the lead-up to COP26 in 2021, an increasing number of countries announced new targets, and many were specifically focused on achieving net zero emissions, including Azerbaijan, which updated its target to a GHG emissions reduction of 40% (UN, 2021).

Across the world, many countries have embarked on policies and targets to increase the share of renewable electricity in their systems for a mix of reasons, including to protect the environment, improve energy security and reduce costs. For those who rely heavily on imports of fossil fuels, increasing the share of renewables in the energy mix can help reduce import dependence. For other countries, increasing the share of renewables may increase the amount of fossil fuels available for export. In the case of Azerbaijan, it may be most useful to look at the policies introduced by other oil- and gas-producing countries.

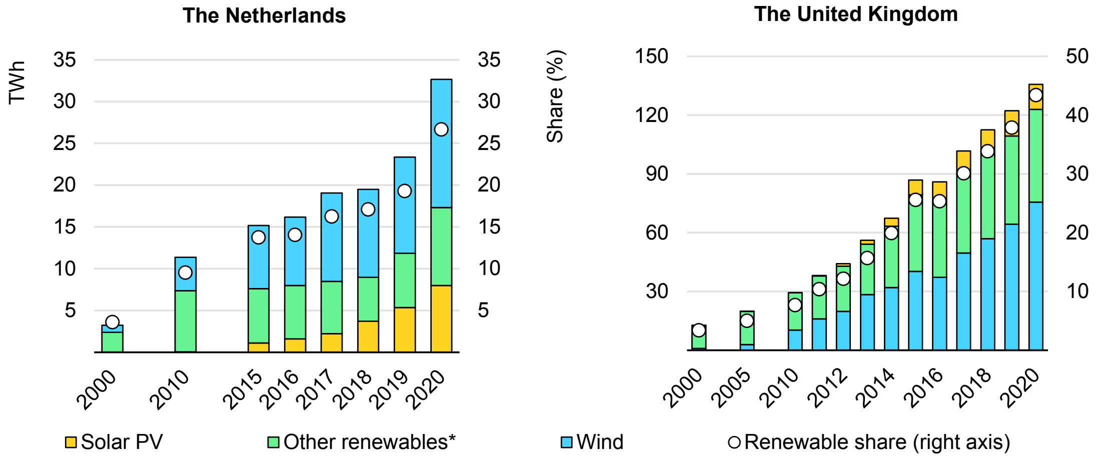
Europe's main gas producers are the Netherlands, Norway and the United Kingdom (UK), and all have policies to support the growth of renewable electricity. As in many countries there are a number of policies involved to meet their set targets. And as targets are met and the policy context shifts, new targets are added and policies are either changed or streamlined.

In the Netherlands, a key policy is the Energy Agreement for Sustainable Growth. This is a negotiated plan between the government and organisations and interest groups to further the energy transition in the country. It includes a target to increase the proportion of energy produced from renewable sources from below 5% at the time of establishing the agreement in 2013 to 14% in 2020 and to 16% in 2023. In addition, the Netherlands has developed a detailed policy framework, the 2019 Climate Agreement, to help achieve its climate targets. This framework, combined with other initiatives, allows the government to implement key legislation, policies and measures to effectively target support for the energy transition across the full spectrum of the Dutch economy (IEA, 2020).

In the UK, the Contract for Difference (CfD) was introduced in October 2014 to replace Renewable Obligations. The CfD scheme is designed to support the deployment of large-scale renewable projects (over 5 MW), while separate policies such as feed-in tariffs support smaller-scale renewables, and is based on the difference between the market price and an agreed "strike price". If the "strike price" is higher than a market price, the CfD counterparty must pay the renewable generator the difference between the "strike price" and the market price and vice versa (Government of the United Kingdom, 2022).

As Figure 5 indicates, renewable electricity generation has grown by around 60% over the past four years in both countries, and with it the share of renewables in total generation.

Figure 5 Evolution of renewable electricity generation in the Netherlands and the United Kingdom



* Includes hydro, solid biofuels, biogases and renewable municipal waste.
Source: IEA (2022), World Energy Statistics and Balances (database), www.iea.org/data-and-statistics.

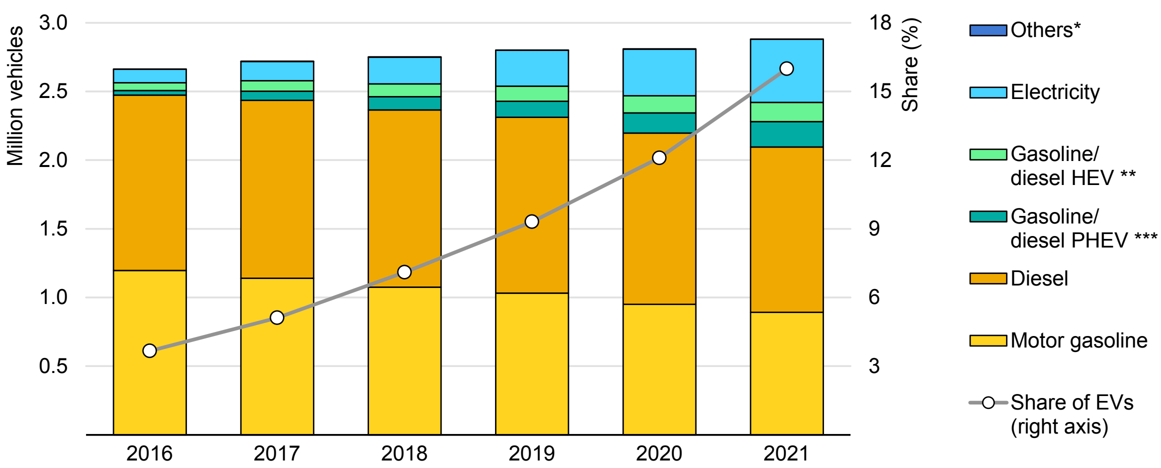
One of the challenges in working out the potential for renewables in a country is how to access information on the best areas or regions in which to deploy different types of renewables. The International Renewable Energy Agency (IRENA) has launched an atlas to assist countries and investors in finding information on these areas (IRENA, 2022).

Norway, one of Europe's main oil and gas producers, has ambitious 2050 climate and energy targets. It is an energy-rich country, but its abundant and affordable hydropower has enabled a high degree of electrification (IEA, 2017). Yet Norway still needs to focus on how to further reduce emissions in key sectors in order to meet 2050 goals. At the same time, the country's support for renewable energy through its policy planning process led it to become a global leader in increasing the penetration of electric vehicles (EVs) in its overall fleet (Norsk elbilforening, 2022). It has instituted a range of measures, including:

- no purchase/import taxes (1990-present)
- exemption from 25% value added tax on purchase (2001-present)
- no annual road tax (1996-present)
- no charges on toll roads or ferries (1997-2017)
- free municipal parking (1999-2017)
- access to bus lanes (2005-present)
- 50% reduced company car tax (2000-2018)

As a result, Norway has seen very strong growth in EVs in its overall fleet, with nearly 350 000 EVs in 2020, an almost fourfold increase over five years (Figure 6).

Figure 6 Private car fleet in Norway by type of fuel, 2016-2021



* Includes compressed natural gas (CNG), hydrogen, liquefied petroleum gas (LPG) and unspecified fuels; not visible at this scale.
** Non-chargeable hybrid electric vehicles (HEVs).
*** Chargeable, i.e. plug-in hybrid electric vehicles (PHEVs).
Source: Statistics Norway (2022), Registered Vehicles, www.ssb.no/en/statbank/table/11823.

It is not just oil- and gas-producing countries from Europe that have policies or targets to support renewables. Particularly in the wake of COP26 and the general global push to a net zero future, producer economies around the world are taking the prospect of the energy transition seriously. This is reflected in government policies and new targets, as well as investment deals with companies.

In late 2021, the UAE announced a commitment to a net zero target by 2050. The country's 2050 energy strategy includes a total energy mix involving 50% clean energy sources (renewables and nuclear and 50% hydrocarbon-based sources, mainly natural gas). The UAE has worked with external consultants and international organisations to build an integrated energy model that has allowed the government to put forward policies that will help it achieve these targets. This modelling is now fully in-house and serves to inform government policy at the federal level.

In addition, Algeria has established a 27% renewable energy target by 2030, and has committed to building 15 000 MW of renewable generation capacity by 2035 (IEF, 2021). Iraq has signed USD 27 billion worth of deals with TotalEnergies, including work on addressing gas flaring, as well as a 1 gigawatt solar power plant (Reuters, 2021).

Meanwhile, Egypt has prioritised investment in renewable energy, as a way to ensure long-term energy security. The country has set ambitious targets, including 20% of electricity generation from renewable sources by 2022 and 42% by 2035. Egpypt is now on track to surpass its 2022 target, thanks to strong government support, and an active push to attract international financing while committing to regulatory reforms.

Key elements of energy policy planning

Collaboration with statistics agencies

Energy is central to nearly all aspects of everyday life and business activity. Therefore, developing a long-term energy plan is most successfully achieved in a collaborative way that involves all government ministries, as well as outreach to the public and businesses. Producers of energy statistics are a key element in this process.

There are two key aspects of this collaboration: first, statisticians will provide the essential information needed to understand the current energy situation. These data need to be used effectively in the policy planning process and in the ensuing modelling work. Thus, it is vital that the statisticians are effectively integrated in policy planning and later in the policy monitoring processes that are ultimately established.

However, there also needs to be collaboration within the statistics community. In general, government statistics are organised in two ways: centralised or decentralised. For centralised information, the National Statistics Institute (NSI) is responsible for collecting and disseminating information to users, including ministries. Decentralised statistics will see ministries collecting and compiling data themselves, although ideally in co-ordination with the NSI. There are pros and cons to both approaches. A more centralised approach allows for greater resilience and the sharing of knowledge across a wider statistics workforce. A decentralised approach brings policy colleagues closer to the data, but it can also mean that statisticians in ministries may be less aware of wider statistics developments or less able to maximise the benefits of wider statistical surveys.

A large statistical institute will still need a strong push to communicate across all topic areas, and will still need to reach out to the respective topic policy makers to ensure the statistics accurately reflect the situation in the country. Where a system is less centralised, statisticians will need to communicate and co-operate across ministries to achieve a cost-effective approach to working, sharing ideas and informing colleagues of policy changes.

Fundamentally, structure is less important than achieving good co-operation among statisticians, and effectively working together and enhancing links with policy colleagues (something that should be pushed from both sides). An advisory group involving all the relevant stakeholders has proven to be an effective channel for the countries to co-ordinate activities around energy statistics.

A further beneficial condition for ensuring comprehensive energy statistics is the degree to which they are produced independently. There are several ways of achieving this, either via a Statistics Act or via codes that govern the way statistics are produced and disseminated. To whom the NSI reports in a government structure can also be important, especially in a centralised approach. In general, the closer the NSI is to the heart of government, such as a president or prime minister, the more likely it is that statistics are developed to meet the needs of a whole country across all topics – especially if independently governed.

Policy making

At its core, policy planning is a cycle:

- identify the initial need for a policy
- begin the design process
- implement the policy
- monitor and evaluate how well the policy is working
- redesign if necessary.

However, in the real world, policy planning and implementation are rarely as straightforward. Different stages of this process may need to be repeated or revised, depending on the actual outcomes of the policy.

Deciding what policies are actually needed is often a complex process. Initially there should be an overall strategy emanating from observed needs and providing a view on the main goals a country needs or wants to achieve. These goals are likely to come from the top of government, and may often be quite high-level, such as improving energy security, boosting the economy or achieving environmental targets.

The next step is to understand what these high-level goals mean in practical terms. Enhancing security could mean many things, including embarking on a programme of energy efficiency (to reduce demand), diversification of electricity supply, changing the way fuels are used in homes and business, and enhancing energy interconnections, among many others.

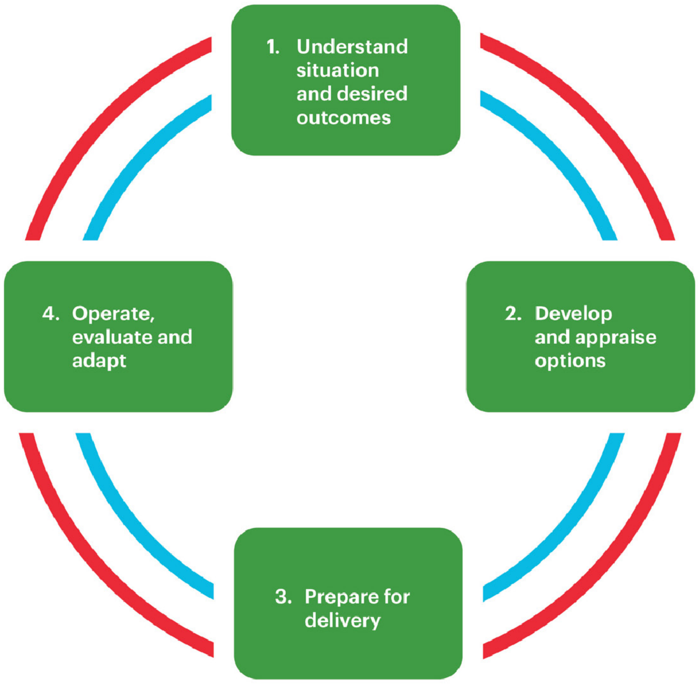
At this point, strategic goals need to be transformed into actual policies. The government must assess the current situation, the reasons for lack of action or change, possible solutions, and what policy or intervention can make an impact to achieve those goals. Only then can work begin on actual policy design, and one of the key inputs of policy design is energy modelling, which in turn relies on high-quality energy statistics.

In order to be able to properly assess and evaluate these strategic goals and move into the policy-making process, the government must call on a variety of skill sets and expertise. Policy making needs input from all analytical professions (statisticians, economists, operational and social researchers), engineers, technical energy specialists and policy advisers.

The role of statistics and statisticians in the policy cycle

One essential part of statisticians' responsibilities is to measure and assess what happens as a result of the policy, via a monitoring process. However, statisticians and statistics should be involved across the entire process for if they play only this one role, then the policy design will be less comprehensive with less optimal outcomes.

Figure 7 The policy delivery cycle

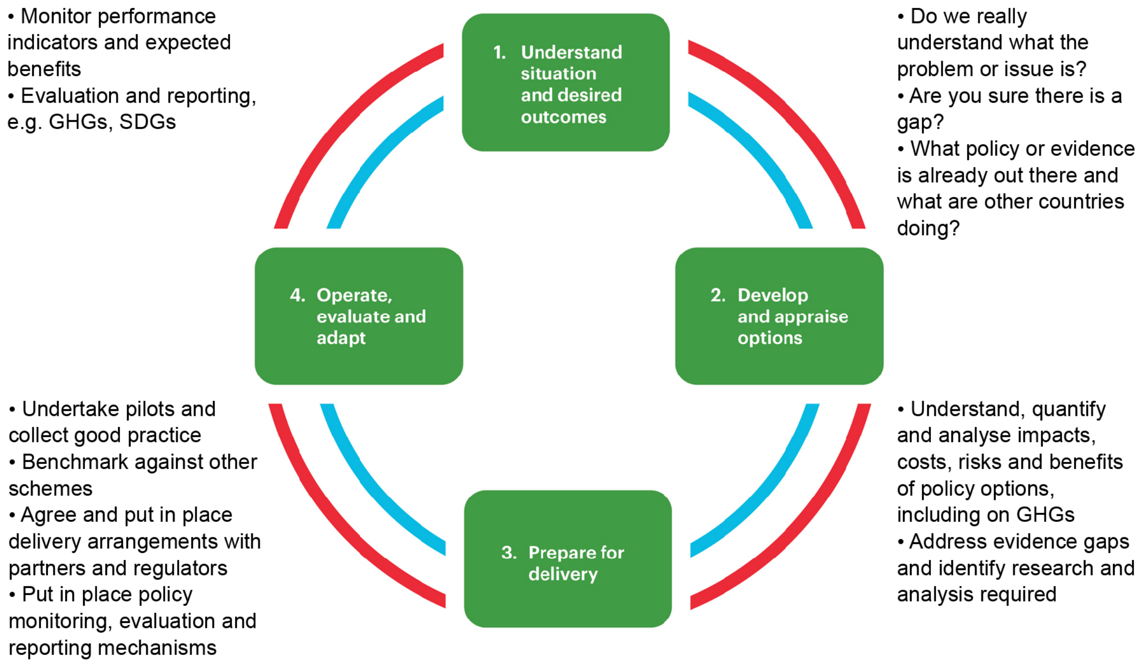


The policy delivery cycle, as shown in Figure 7, has a role for statistics and statisticians in all stages. Starting from the initial understanding of the situation, statistics are vital to show what is actually happening, and to explain why there may be unknowns, via missing data. This will help policy makers understand how the impact of a policy could be measured. In this first stage, as well as in the second stage when policy makers develop and appraise options, it is helpful and often necessary to review what other countries have done. Energy data are also a boon here, as they allow both statisticians and policy makers to understand the impact of similar policies.

It is always important to start with a defined benchmark, or the base data year from which change can be measured. These data may already be collected in energy statistics, but it may be necessary to produce a new data series. That work needs to start very early in the policy cycle, and to be complete by the time policy makers are in stage three, preparing for delivery. During this phase statisticians should be finalising the means of collecting the data to monitor the policy. This is likely to involve discussions with policy advisers as well as implementing agents, in order to have the correct data recorded that will make up the key administrative information captured as part of the policy. Should a policy be piloted, then statisticians should be involved in assessing the results of the pilot. Finally, as the policy is launched, then statisticians should continue to play a key role, ensuring the effective monitoring of the policy so that its impact can be properly understood.

The policy delivery cycle – where the use of statistics can really make an impact

Figure 8 The policy delivery cycle benchmarks



Data needs for key energy policy areas

Each country has its own energy policy priorities. However, as countries grapple with the effects of global warming, many are working to transition their energy systems towards increased sustainability. As a result, tracking energy transitions has become a priority for many governments as they work to both set and meet targets. When tracking clean energy transitions, several policy areas can be identified:

- Sustainable Development Goals (SDG 7)
- energy efficiency policies
- sectoral policies (industry, transport, buildings, power sector – clean power)
- renewable energy policies
- security of electricity supply
- fuel switching in the electricity mix
- strong links between energy and climate policies
    - energy is most often the main contributor for the GHG emissions
    - many NDCs are related to energy.

The policy areas above use both single indicators (e.g. SDGs) and large datasets (e.g. energy balance, GHG inventory) to support government analysis and the resulting policy choices. The data allow policy makers to define the status quo and track the progress of selected policy measures. The majority of the necessary energy information is derived from the same basic energy data collection, therefore any investment in data directly benefits the policies as well.

The data needs can be narrowed down to three categories:

Data on energy supply

- production, trade and stocks of energy
- energy infrastructure (e.g. production capacities).

Data on energy demand

- energy transformation (e.g. electricity and heat, oil refining)
- consumption by sector (industry, transport, residential, services, agriculture, etc.)
- should also cover non-commercial energy consumption (e.g. fuelwood)
- end-use energy consumption (e.g. residential space heating, light road transport consumption).

Economic activity data (essential for energy efficiency)

- output of economic sectors (both in physical and monetary terms)
- characteristics of e.g. the building and transport stock in a country.

It is evident that there are overlaps in policy areas. To avoid optimising the energy system only on a "local" level, a holistic view of the energy system and all the potential pathways is necessary. Given the complexity of a modern system, it is not feasible to conduct such analysis manually. Modelling allows policy makers, analysts and statisticians to use data for scenario analysis to assess the impact of different alternatives. This will in turn be used to inform and drive policies and targets.

Modelling, however, should not just be seen as a mechanical input-output exercise. Several steps are necessary both before and after the actual modelling work in order to mimimize uncertainty and maximise the usefulness of the results:

- Energy data production – must be adequate to support the data-heavy models.
- Energy data validation and analysis – allows users to assess uncertainties in the model inputs.
- Scenario formulation – translates the research question into targets. It is also essential to properly assess economic drivers and take into account the potential impact of energy efficiency.
- Validating assumptions and compiling model inputs – while some assumptions are always necessary, understanding their impact to the results is important.
- Running the model itself – requires skilled capacity that can only be developed over time for the activity to be sustainable.
- Interpreting the results – assessing the results requires information from all the previous steps.
- Formulating policies based on the results.

Models

Energy modelling remains an important part of the policy development process. There are virtually as many energy models out there as there are policy questions to understand. The choice of which model to use is driven by the needs of users and depends on the questions to be answered. Often a single model is not enough to address all relevant aspects of a question or scenario.

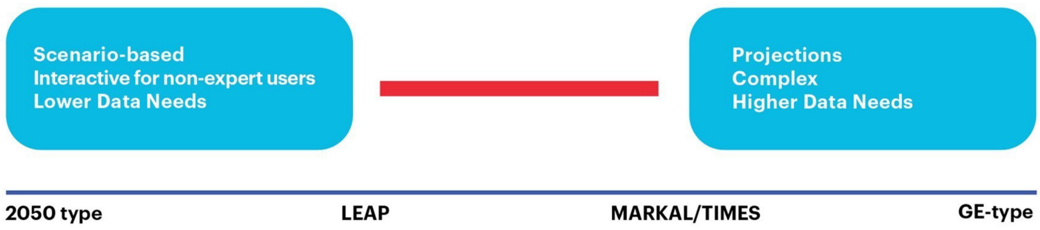
Models can be used to provide projections and explore scenarios. They can answer questions such as what will happen in 2050 with today's existing policies. They can also explore normative scenarios such as how to reach a single (or a set of) policy target(s), or explorative scenarios such as understanding the impact of specific policy measures or strategies on the energy sector. Often these are compared against a baseline or business-as-usual scenario. Some models can be very complex and only usable by trained users, but some are designed to be used by a wider population, in order to open up debate in government, media, academia and the investor community. These models do often require a lot of work outside of the model itself. Energy models can be top-down or bottom-up. They can aim to model everything in the energy system (including its climate impact) and find cost-based solutions or they can be used to explore more speculative scenarios.

In some cases, models can be used to estimate missing data on a more granular level than provided in energy balances, or check the plausibility or consistency of data from different sources. In general, though, direct collection of such data is preferable.

As a generalisation, models in wide use can be thought of as being one of four types: general equilibrium (GE) type models; MARKAL/TIMES; LEAP and 2050-type calculators. Figure 9 highlights some of the differences between these models based on three factors.

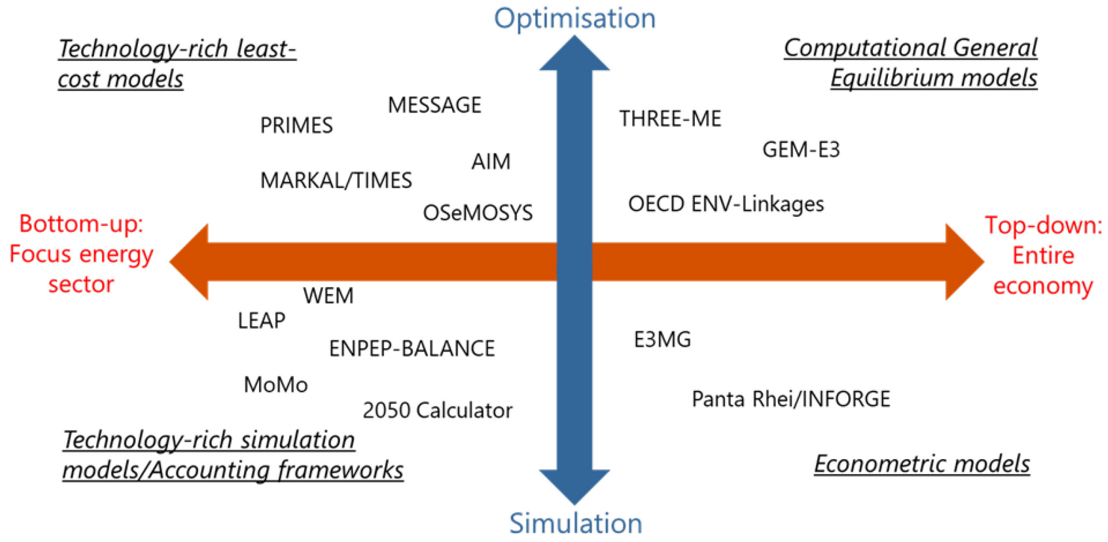
For a more detailed description of model types, please see Annex 1.

Figure 9 Energy model types and differences



Models can also be distinguished along the dimensions of simulation versus optimisation and energy sector versus economy-wide models, designed around the questions that different fundamental modelling approaches can address (Figure 10).

Figure 10 Energy models and uses



Note: For a detailed description of these models, please see Annex 1.

GE type models cover the entire economy, while energy system models such as LEAP and TIMES cover only the energy sector (for that reason, the latter are also referred to as "partial equilibrium models"). While the energy sector is not represented in a technologically detailed fashion as in energy system models, GE models help to analyse the interactions of the energy sector with the rest of the economy, e.g. the impact of energy policies on GDP, employment or trade balances.

Some models are used widely around the world, for example LEAP and calculator type models, given that these are available for free in developing countries. However, the software costs alone do not reflect the full costs of energy modelling – the most expensive aspect is the staff needed to do the modelling. Staff fluctuation, particularly in government ministries, has often hampered the development of long-term in-house modelling capacity in developing countries.

What is key to remember is that no one model type is better than another. Finding the right model is driven by the needs of the country. And since not all models can do all things, combinations of models can be very beneficial. For example, a country may want to use a 2050-type calculator to have a wider debate about possible policy choices, but then may need to make use of a MARKAL/TIMES model to properly understand the costs of the chosen route. An approach like this may well be a good route for Azerbaijan.

Data needs for models

As a general rule, the more data that are available the better the model. However, the accuracy of the data and an understanding of their uncertainty may be even more important. A model cannot improve the quality of poor data, so a well-designed model being fed with poor or incomplete data will not produce useful results. Data for models, a large amount of which will be drawn from official energy statistics, also have uncertainty. When using less precise data in a model, it is sensible to do sensitivity analysis, using ranges for the variable you are modelling.

At the heart of all energy models will be comprehensive supply and demand energy data. In general, supply-side data are taken from an energy balance and the supporting commodity balances. Thus, a prerequisite for a model is a good energy balance, built in accordance with the International Recommendations for Energy Statistics, as endorsed by the UN Statistical Committee (UN, 2018).

An energy balance provides only extremely high-level data on the demand and use of energy, and as demand drives supply, all models need comprehensive demand data covering all four main sector groups (transport, industry, household and commercial), but in quite a detailed way. This will nearly always mean that some form of consumption survey will be needed for the household, industrial and commercial sectors. For transport, a large amount of data might be available from administrative sources, but the real challenge is often accessing private-sector data. In this case it can be useful to work with the expenditure survey (that is likely to be run in a country) to see if questions can be added there. However, the ideal is to run a household transport survey.

In most cases it is very valuable to have current as well as historical data, in order to help establish trends. In addition, it is very important to choose the right year as a base year. Ideally it should be the most recent year for which data are widely available.

It is highly unlikely that all of the data needed will be available in-country, so they will probably need to be supplemented by available data from international sources, or by utilising data from neighbouring countries with similar energy infrastructures. Finally, it is inevitable that some estimates will need to be made.

Nearly all models have options attached to them, and as such they can usually be run in a simplified or more advanced way, for example adding costs, GHG emissions, air quality, etc.

Concrete steps for Azerbaijan

Setting a timeline

Estimating the timeline for Azerbaijan to develop a long-term energy strategy is complex, as there still remains some uncertainty on the availability of demand-side data. This is a multi-year process for all countries, and really depends on where the government is starting from. If certain key elements are in place, such as survey data, this process can take significantly less time. However, planning is key, and governments can begin to develop strategic goals at the same time as they commence the statistical survey process.

Designing a survey: Steps and timing

As has been noted above, the availability of quality energy statistics is fundamental to policy planning and building energy models. The use of existing data should be maximised, including administrative data, which may be overlooked. Often, however additional data – specifically on end uses of energy – will need to be collected using statistical surveys. In the case of Azerbaijan, the results of the household energy consumption survey from 2018 should be very useful in aiding policymakers who want to make targets for the residential sector. However, reconducting the survey at regular intervals (every five years ideally) is necessary to provide a reliable baseline. As a result, it is important to make sure that the time necessary to run those surveys is added to the overall long-term policy planning timeline. An outline of the steps is provided below. The timing is based on household surveys, but this could also apply to business surveys.

It is difficult to predict exactly how much time will be needed to run a survey, but it is likely to take roughly six months, or nine if a pilot survey is added (this is a recommended step in order to validate whether the survey design has been successful).

Table 1 Designing a survey

Step	Design Phase
Design questions • What data are required • Complexity of the data to be collected • Where they can be sourced • Whom to survey – what data they may hold • Costs of running the surveys and budget (needed/available)	

Step	Design Phase
• Legal requirements for acquiring the data or voluntary survey	
Questionnaire and methodology • Number of questions • Length of the questionnaire • Complexity of the data to be collected • Timing of the data collection • Can existing survey be used as a basis, including those used by other countries **Census or survey (which sampling method)?** **Piloting** • Pilot testing and revising the questionnaire based on feedback • Using expert in the field of the topic • Using experienced questionnaire designers • Testing data entry and validation **Finalising the questionnaire**	**Data collection** • likely to have to take place over a complete calendar year to assess the seasonal variation of different energy uses • the sampling design must take this into account, perhaps designed on a quarterly cycle so the sample is representative of the whole country throughout the year

Data quality – How to deal with
• low response rate
• partial responses
• misclassifications
• missing data
• duplication
 	
Validation/Comparability of the data with other surveys
 	
Data protection: Confidentiality and sensitivity of the data provided
 	
Validating data, possible elements to be used are:
• What entries are expected – i.e. electricity or input fuel
• Defined minimum/maximum quantities by fuel
• Defined range of overall energy consumption depending on household characteristics
• Default values for energy end uses
    • Depending on number of persons (cooking, water heating)
    • Depending on floor space (space heating and cooling)
 	
Approach to grossing up survey results
	Processing results
	• typically this will take 3-6 months

Plans for dissemination	**Dissemination** • typically this should take 1-3 months

A single survey can be useful, but limited in its impact. Instead, policy makers and statisticians should plan for and put resources towards a series of surveys, ideally every two to three years. This way changes in energy use can be properly monitored. It will always be better to have two small surveys in separate years than one large one-off survey.

Timing to build a 2050 calculator

As discussed, using a 2050-type calculator is just one approach to looking at and building scenarios, but considering its use from a time perspective helps to better understand and assess the whole timeline for developing a long-term plan.

Building a calculator ready for launch generally takes around a year, but that will depend on the availability of data. Work can also begin while data are being collected, as these can be added later. Usually six months is needed for the design and discussion on sectors and levels, as well as the building of the Excel sheets. The rest of the time is spent on planning and communication. Best practice is to launch the calculator as soon as possible in beta mode in order to allow testing and feedback on the calculator. Typically, a first version of the calculator does not include costs, given that data on costs can often be restricted or very hard to access, but costs are often built into later versions. Countries should aim to have a minimum viable model that can be adapted in later versions to suit specific needs and answer more complex questions.

Monitoring and evaluation

As discussed, a key role for statisticians in the policy-making process is to effectively monitor the outcome of the policy. This is essential, as monitoring and evaluation should be seen as key features of the policy-making process. Monitoring and evaluation are linked, but they are fundamentally still separate processes.

Monitoring provides headline data on policy performance, working to answer the question, “what happens as a result of the policy?” Meanwhile, evaluation provides an understanding of what is happening or has happened, why it happened, and what can be done about it. Thus, the evaluation stage covers impact, economic and process elements.

Monitoring and evaluation are not stages that happen only at the end of the policy, but need to happen continuously throughout the policy-making and implementation process.

Before the launch

Key questions:

- **How will the policy work?**
- **Will it be worth it?**
- **What baseline data are needed to monitor impact?**

Planning is key:

- Convene policy makers and analysts (statisticians, economists, social researchers) to work together from the beginning.
- Review the evidence, understand whether there is a policy gap or insufficient data.
- Map the policy, understand how it is intended to work and set out the benefits.
- Design and prioritise evaluation projects within the budget envelope.
- Budget adequate resources for the design and implementation of the policy.

Determine what the policy will ideally deliver:

- Assess what has worked in similar contexts and examine global best practices.
- Assess cost-effectiveness: whether it is cost-effective:
  - Will the costs of the policy be less than the savings incurred over the life of the policy? (How long will savings last)?
  - Gather evidence for savings and benefits from other policies, expert opinions and other countries.
  - Is the required saving achievable?
- Lay out how the policy will be implemented.
- Divide responsibilities; how likely is it that target stakeholders will act on the policy?
- Assess whether the policy administrators can implement it.

Map the benefits of the policy:

- Ensure clarity regarding outputs and outcomes.
- Identify areas of risk and uncertainties.
- Map the benefits to determine:
  - What to measure (outcomes, outputs).
  - What assumptions need to be tested.
  - Where priorities and difficulties/challenges lie (e.g. risk, uncertainty).

Identify the initial necessary work on data and statistics in relation to the policy:

- What data are needed for monitoring and how they can be collected.
- How to produce a baseline (that change is measured against).
- How to pilot the policy and/or undertake pre-launch research.

During delivery

Key questions:

- **Is it working? For whom?**
- **Why/how?**
- **Unforeseen events**

After a successful pre-planning stage, it will be time to launch the policy. However, in reality the time for pre-planning may be limited by the political desire to launch a policy by a certain date. During this phase of the policy cycle the focus on monitoring and evaluation must switch to what is actually happening.

- Produce reliable evidence – what is working, in what context, for whom, and how? What is not?
- Understand if the anticipated benefits and outcomes are happening.
- Produce evidence-based recommendations to increase chance of policy success.

In order to be effective, this stage has to use very timely data. Most likely this would include administrative records from the delivery agents, who are often part of government operating the policy. Survey data will not be sufficiently timely to be able to understand what is happening at the present time.

However, if the policy intervention is a choice by the government to promote something that is not yet happening, it is likely to require some form of financial support. Therefore, these records should exist (for accounting or audit purposes). Ideally statisticians and policy makers will have used the planning stages to discuss accessing these records for statistical reports, as well as designing what information will be recorded. It is very difficult to change the recording system once the policy is up and running.

Evidence gathered as the policy is running is vital to ensure that the overall policy will be a success. Good information can allow for changes in policies, such as potentially raising or lowering incentives depending on if take-up is lower or higher than planned.

After delivery

Key questions:

- **Did it work?**
- **How and why did it work?**
- **Was it worth it?**
- **Who gained?**
- **Were objectives met?**

The after-delivery stage does not necessarily focus only on when the policy has concluded, although it may. It may also just refer to a planned review of the policy, and having such reviews can be very useful as part of the overall policy cycle. The key questions being considered at the review or final stage are what has happened and why. For example:

- What has been achieved and at what cost?
- How efficient was implementation and delivery?
- How do costs and benefits compare with other policies targeting the same outcomes?
- Who paid the costs and who benefited? (and other distributional impacts)

To properly understand the impact of a policy requires a counterfactual i.e. "what would have happened if you hadn't implemented the policy?" Of course, in reality this is very difficult, and while the best way to measure it is by having a control group who did not benefit from the policy to compare against, this is very hard to establish. The United Kingdom's work on its National Energy Efficiency Data-Framework does provide an example.

However, in reality when effective evaluations are done, they are normally carried out against a modelled counterfactual – i.e. what situation was considered likely without the policy – which was most likely done as part of the planning for the policy. In these instances, it is worth looking at the initial model as there may have been changes in the wider national or global economy that were not assumed (for example a large rise or fall in the price of oil) and so modelling again with these changes taken into account will be useful.

Monitoring an evaluation may seem like a large burden, given the desire to move ahead and get a policy up and running. However, it is essential in order to ensure that the planning process for the policy is properly thought through, that changes to the policy can be made if needed and that good evidence can be produced to show what impact the policy had.

Key performance indicators

A sensible part of developing a long-term energy strategy is to agree on some key performance indicators (KPIs) that can be used to track the overall development of the energy situation. These will likely be different from the specific goals of individual policies that are covered by monitoring, as KPIs will need to look at all the elements of energy supply and demand, but often at a headline level.

It can be challenging to choose which KPIs to use, but as a guide, key indicators should reflect:

- Overall policy needs and strategy (however, KPIs can differ internationally to nationally and nationally to regionally).
- Consistent data of known quality.
- A baseline to measure change.
- A time series to be most effective, so it is vital to plan data collection on a regular basis.
- International definitions for consistency.

There are many examples of indicator sets globally and a good place to start is the IEA Scoreboard, which was developed in 2009. However, it is worth noting that these indicators were developed before the significant growth in non-hydro renewable sources used for electricity generation and the general expansion of energy end-use data. This just emphasizes that any major changes in the national energy landscape may very well require developing new KPIs to correctly track progress.

In designing a set of indicators, thought needs to be applied to the choice of data for both the numerator (top) and denominator (bottom) and to ensure they provide a sensible and meaningful assessment. Following are a few examples.

Historically, a leading indicator of energy system diversity has been the share of each fuel as part of TES. While still a useful indicator, it is not the most reflective measure of the share of renewables, for example, due to the established international accounting rules of energy (as set out in the International Recommendations for Energy Statistics). Instead, for renewables it is likely to be more useful to look at their share in electricity generation, and here actual generation will be far more useful than share of capacity given the different capacity (or load) factors.

Another question is whether to use TES or TFC as a denominator. There can be good arguments made for choosing either, but it is important to understand why these numbers might change and what impact that might have on an indicator using them. One example is to think of a country which imports electricity from a neighbouring country, which is produced by hydropower, but has fossil fuel generation backup for years when hydro generation is low and thus its imports are limited. If everything else is the same, TES will be higher in years when electricity has to be generated in the country, but TFC will be unchanged, as the demand for energy is independent of how it is produced. So often using TFC and focusing on energy demand in the country will provide more informative and stable indicators.

A final example is to look at energy efficiency. Often, in the absence of anything else, this is measured via an economy-level intensity index e.g. GDP/energy consumption. However, this is only at best a proxy, as the value of this indicator will change for a number of reasons, including as a result of changes in the scope of industries in a country. A country growing its service sector but seeing declines in its manufacturing sector is very likely to see its energy intensity indicator fall, even if there has been no effective improvement in energy efficiency, as the service sector on average uses less energy per unit of GDP produced.

Therefore for energy efficiency it is more representative to link sectoral energy consumption with the activity that energy is used for, so a generic sectoral indicator (intensity) will look like:

$$Generic\ energy\ efficiency\ indicator = \frac{sectoral\ energy\ consumption}{corresponding\ activity}$$

Table 2 Examples of activities for main sectors

Sector	Activity
Overall	GDP Population
Residential	Population Number of dwellings Floor area Number of appliances
Service (ideally by category)	Value added Number of employees Floor area
Transport	Passenger-kilometre Tonne-kilometre
Industry (by subsector)	Value added Physical production Process-level production

More information on energy efficiency indicators can be found in the IEA's energy efficiency indicator manual, which provides guidance on how to collect the data needed for indicators and includes a compilation of over 170 existing practices from across the world (IEA, 2014).

A timeline for Azerbaijan's energy policy-making process

Table 3 Timeline through 2030

ACTIVITIES	2022-2024	2024-2026	2026-2028	2028-2030
DATA COLLECTION				
Assessment of data gaps	●			
Plan and secure budget for surveys	●			
Institute pilot surveys	●			
Explore new, innovative data sources to input into policy-making process	●	●		
Finalise and conduct surveys		●		
Use survey data to communicate findings to users		●	●	
Expand surveys as needed			●	●
Track progress of KPIs	●	●	●	●
POLICY MAKING				
Work with statisticians to assess data needs and availability	●	●	●	●
Put in place policy monitoring, evaluation and reporting mechanisms	●			
Assess and understand desired goals and targets; build scenarios	●			
Build scenarios as model inputs	●	●		
Use modelling outputs to determine policies		●	●	
Monitor and evaluate outcomes of policies; adjust scenarios and rerun model as necessary			●	●
MODELLING				
Choose the right model, based on needs and targets	●	●		
Input model with desired scenarios	●	●		
Run model and discuss outputs with key stakeholders		●	●	
CAPACITY BUILDING AND CO-OPERATION				
Capacity building (trainings, etc.) for policy makers and statisticians	●	●	●	●
Ongoing interaction between statisticians and policy makers to ensure right data are available and they are used correctly	●	●	●	●

Conclusion

This report set out a path for a country to develop a long-term energy strategy to help understand and plan in order to meet the energy priorities. Should Azerbaijan choose to develop a long-term approach to energy, then following this broad outline is likely to be advantageous. Many other countries have embarked on long-term planning, knowing that to create change a form of government action is needed. This needs to be understood by people and businesses, so that they in turn can take the actions required.

Across the world, countries are developing longer-term strategies to accelerate clean energy transitions, to ensure energy security and -- for some -- to maximise the potential of their natural assets. Should Azerbaijan wish to do the same, then ensuring it has comprehensive energy statistics covering the entirety of its energy supply and use will be a vital step. However, those data need to be made available to all and that may require stronger co-operation across government ministries.

Expanding energy statistics, especially on the demand side, will allow Azerbaijan, like other countries, to embark on energy modelling to better understand how best to achieve its long-term aims.

Ultimately the choice to follow this pathway, as outlined here, is a choice for Azerbaijan. The country has natural assets, both fossil and renewable, that are available to be harnessed and used effectively to support broader goals of energy security, transition and prosperity. A long-term, strategic approach to doing so will ultimately prove beneficial.

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Annex: Different types of models and their uses

2050-type calculators

A 2050-type calculator is an interactive tool that helps improve understanding of choices around the energy system in order to achieve long-term goals such as meeting carbon reduction targets or energy security. It does this by splitting up the energy system into a number of sectors (or elements) covering the whole range of supply and demand. Then for each sector a number of levels (usually four) are developed to show the range of change from a level one (broadly no effort) to a level four (maximum potential), which can encompass both behavioural and technology changes. The user can then select their preferences for levels across each of the sectors and see the results, which can then be compared against long-term policy goals and thus increase the understanding of the types of choices that need to be taken.

Process

The key to the calculator is to define the sectors and the levels of ambition. The sectors need to be set up in a way that covers the whole of the energy system but in a way that allows for clear options to be developed for the levels alongside considerations on the availability of data that can be used for the model. Too few sectors will lead to very high-level choices that will not be informative; too many sectors will most likely mean there are insufficient data to build the model. Generally around 40 sectors seem to be about right, and the sectors used in the United Kingdom and the south-east Europe models differ a lot in aggregation.

Once the sectors are defined then work can start on the levels, which are simply different views on where the sector could be in 2050. They need to represent genuine different choices and perhaps can best be thought of as level one = no effort, nothing done; level two = achievable change; level three = deliverable change (more effort than achievable); level four = maximum possible change.

There will of course be different views on what these levels mean in a country, and as such it is essential that they are designed in as open as possible way with all involved e.g. other ministries, business, non-governmental organisations, academia all being able to contribute to their definition (and indeed the definition of the sectors). All views are needed: an advocate for a technology might be able to provide a great description of level four, but a sceptic may well have a good case for what level two could be. Early engagement with partners is essential to get their support for the process and additionally to open discussions on data they may have which can be used in the model. In many countries workshops have been held as part of the discussion with experts.

For some sectors there may not be sufficient scope to have all four levels, but if that is occurring too often it would be sensible to have a rethink of the sectors – perhaps they could be more disaggregated. One alternative used by Switzerland was to have a sliding scale of choices rather than distinct levels.

Once the sectors and levels are agreed upon (and they can and possibly will be refined later or in a second version), work can start on the model itself starting with the sheets for each sector.

A good starting point to develop a calculator will be to base it on one that already exists. Building the model will need someone with advanced Excel knowledge, but only in the standard formula and logic of Excel. The United Kingdom is very open about all methodology, and links are provided below under guidance.

Work on the calculator started in the Department of Energy and Climate Change in 2006, which developed the tool in an open way to allow other countries to use it and adapt for their own needs. As such calculators have been built in a range of countries and regions including Australia, the People's Republic of China, India, Ireland and Switzerland and for regions such as south-east Europe.

The Business, Energy and Industrial Strategy International 2050 Calculator programme supported ten countries to create their own calculators in its first phase. Although many of these countries have had access to much more complex energy and emissions models, the calculator has shown that it can play a unique role by bringing together different parts of government and giving instant, easy-to-understand results. Four of these (Colombia, India, Nigeria and Viet Nam) used their calculator models in the formulation of their NDC targets for the Paris Agreement.

- In Colombia, the calculator was used to display the results of more complicated modelling on different sectors to promote discussion between government departments during the NDC development process, and ministries have also used the tool to define how they will reduce each sector's emissions by 20%. Regional versions were also created, so that regional governments could use them in planning their decarbonisation.
- The Indian calculator, called India Energy Security Scenarios 2047 (IESS), was the first model to be created in-house in the Government of India. The model has been personalised for the country, with more of a focus on energy security than other calculators. In 2017, the IESS was used in the development of the draft National Energy Policy.

- Vietnam also used the calculator for inputs to its Power Development Plan, and is keen to continue to use it in its NDC implementation process.
- Calculators have been used in outreach to bring discussions about energy and climate to more audiences. The South African government created a version aimed at schoolchildren, designed to work on low-bandwidth internet. Funding from the UK Department for Business, Energy and Industrial Strategy supported teacher training to promote its use.

LEAP

LEAP (Long-Range Energy Alternatives Planning System) is a widely used software tool for energy policy analysis and climate change mitigation assessment developed at the Stockholm Environment Institute and now adopted by thousands of organisations in more than 190 countries worldwide (LEAP, 2022). Its users include government agencies, academics, non-governmental organisations, consulting companies and energy utilities.

LEAP is often used for countries undertaking integrated resource planning, especially in the developing world, and many countries have also chosen to use LEAP as part of their commitment to report to the UN Framework Convention on Climate Change (UNFCCC). At least 32 countries used LEAP to create energy and emissions scenarios that were the basis for their Intended Nationally Determined Contributions on Climate Change.

LEAP is an integrated, scenario-based modelling tool that can be used to track energy consumption, production and resource extraction in all sectors of an economy. It can be used to account for both energy sector and non-energy sector GHG emissions sources and sinks. In addition to tracking GHGs, LEAP can also be used to analyse emissions of local and regional air pollutants and short-lived climate pollutants, making it well-suited to studies of the climate co-benefits of local air pollution reduction.

It is not a model of a particular energy system; rather, it provides a given structure of the energy sectors (thus making it quite appealing for new users), with options to adapt them to the specific situation that can be used to create models of different energy systems, where each requires its own unique data structures. LEAP supports a wide range of different modelling methodologies: on the demand side these range from bottom-up, end-use accounting techniques to top-down macroeconomic modelling.

MARKAL/TIMES

TIMES (The Integrated MARKAL-EFOM System), which is an energy model developed by the IEA Energy Technology Systems Analysis Program (ETSAP) Technology Collaboration Programme, is the successor of the MARKAL model (the word MARKAL was generated by concatenating two words (MARKet and Allocation) (ETSAP, 2005). The basic components in a TIMES model are specific types of energy or emissions control technology, including future ones. Each is represented quantitatively by a set of performance and cost characteristics. Both the supply and demand sides are integrated, so that one side responds automatically to changes in the other.

TIMES is a very flexible modelling framework to represent energy systems in a technology-rich manner, on a local, national, regional or global scale. TIMES typically uses cost optimisation to identify cost-effective strategies in the energy sector, but also allows the use of alternative optimisation targets or the combination of different targets.

TIMES is typically used in the context of long-term questions in the energy sector, such as air pollution, energy security, climate change and economy-wide implications of energy policies. In addition to the long-term time horizon, a dispatch variant of TIMES also allows analysis of the operation of the electricity system at an hourly time scale, e.g. flexibility needs for the integration of variable renewable energy sources. Further other variants or extensions of TIMES are available, such as the linkage to climate model or to a computable general equilibrium (CGE) model. TIMES can be also used beyond the energy system, e.g. the energy-water nexus has been analysed with TIMES.

Some uses of MARKAL/TIMES:

- to identify least-cost energy systems
- to identify cost-effective responses to restrictions on emissions
- to perform prospective analysis of long-term energy balances under different scenarios
- to evaluate new technologies and priorities for research and development
- to evaluate the effects of regulations, taxes and subsidies
- to project inventories of GHG emissions
- to estimate the value of regional co-operation.

As of 2015 the MARKAL and TIMES model generators were in use in 177 institutions spread over 70 countries including Kazakhstan, Moldova and Ukraine, and in a study for the Caspian region.

Studies using UK MARKAL underpinned the Energy White Papers in 2003 and 2007, the Climate Change Bill 2008, the first report of the Committee on Climate Change (CCC) and the CCC and Department of Energy and Climate Change fourth carbon budget reports.

General equilibrium models

These types of models tend to be very bespoke, i.e. individually built to meet specific needs, although all rely on the same economic theory that drives them. Econometric input-output models are a second category of economic models, beside CGE models. One example is E3ME from Cambridge Econometrics in the United Kingdom. Examples of this type of models is given below.

GEM-E3

GEM-E3 (General Equilibrium Model for Economy-Energy-Environment 1) is an applied general equilibrium model that covers the interactions between the economy, the energy system and the environment (European Commission, 2013). The GEM-E3 model simultaneously computes the equilibrium in the goods and services markets, as well as in production factors (labour and capital). It is especially designed to evaluate energy, climate and environmental policies. GEM-E3 can evaluate consistently the distributional and macroeconomic effects of policies for the various economic sectors and agents across countries.

The GEM-E3 model is flexible in its regional and sectoral aggregation. Typically, it represents individually the 28 European Union (EU) member states as well as the OECD and the G20 countries. It models 21 sectors of the economy, with an additional sub-categorisation over 10 types for the power sector.

The GEM-E3 contributed to the EU 2030 Climate and Energy Framework and the European Union's preparation of the international climate negotiations at COP21 in Paris in December 2015. In 2013, it was used to analyse the macroeconomic impacts of the European Clean Air Package and has been used for energy issues such as the trade and price evolution of oil and other energy sources, energy efficiency and deployment of renewables.

Multiple models

Many models used are actually a combination of various sub-models. One example of this is the set of models used in the United Kingdom to produce their estimates of UK energy demand and supply, CO_2, and other GHG emissions.

The model is made up of three separate models, which are then combined to produce the overall estimates.

Energy Demand Model (EDM)

This Excel model contains a set of equations that project energy demand and emissions by sector as named entities or variables. The EDM has over 2 500 of these variables representing all sectors of the UK economy.

Dynamic Dispatch Model (DDM)

The DDM simulates the operation of the electricity generation market and the investment decisions of market participants in response to a given demand profile, power sector policies and other market conditions.

Average Prices and Bills Model

The Average Prices and Bills Model estimates the average impact of energy and climate change policies on energy prices and bills for households and businesses, along with the price impacts of network costs and supplier costs.

Likewise models can be used in collaboration; for example, the IEA World Energy Model has been linked in the past to a CGE model (OECD ENV Linkages model) and the International Institute for Applied Systems Analysis GAINS model (for Greenhouse Gas and Air Pollution Interactions and Synergies) for air pollution (IEA, 2021b).

Data needs for models

Simplified 2050 calculator, with no cost estimation

<u>General demographic data</u>

Population, number of households, average household size, commercial sector floor space

<u>Economic data (at two-digit or ideally three-digit ISIC)</u>

Value added of industrial sectors, value added of commercial/services sectors, employment in industrial sectors, employment in commercial sectors

<u>Energy supply data</u>

Essentially the energy balance plus information on capacities (by type) for electricity and heat generation

<u>Household energy data (by fuel)</u>

Energy used for space heating, cooling, water heating, lighting and cooking, and used for appliances (ideally by type)

Industry energy data (by fuel)

Energy use by sector, GHG emissions by sector

Commercial energy data (by fuel)

Energy used for space heating, cooling, water heating, lighting and cooking, and used for appliances (ideally by type)

Transport data (by mode, including private and public, by fuel and vehicle type)

Domestic aviation, national navigations (shipping), freight transport, passenger transport

LEAP

The data needs for LEAP in its basic form are fairly similar to those needed for a 2050 calculator, but with a few additional requirements. First, projections of most of the data series are needed. This is not the case for 2050 when the levels and so projection are set by the user, with growth either linear or stepwise. Additionally LEAP needs prices and cost data, more data on the characteristics of fuels (calorific values, etc.) and far more detailed information on the electricity sector including, where possible, load curves and dispatch data.

MARKAL-TIMES models

These models need a lot of data on energy technologies to run (e.g. energy efficiency, lifetime, GHG emissions, investment and operation costs) but it depends on the level of detail of the model. In principle the main difference between LEAP and TIMES is that TIMES additionally requires cost data for fuels, technologies etc., since TIMES is based on cost optimisation, while LEAP is on a simulation approach (though some cost aspects have been added over time).

GEM

Like MARKAL type models, these models need a lot of data, though perhaps less energy-specific data than LEAP or TIMES as they work by effectively running multiple transactions across the economy. As such they need full supply demand and price data at very detailed level, all with past and projected data. Outside energy data, these models require very comprehensive economic (and some social) data.

Quality assurance and models

Whichever model is chosen it is essential to think about its quality assurance. As noted above, models can’t improve data quality, but a poorly designed and built one can result in answers that are incorrect and could be misleading.

The key outcomes from any quality assurance exercise are that the deliverable should be:

- Fit for purpose, with purpose defined as part of the scoping process.
- Reliable and accurate, as far as this is possible.
- Transparent and accountable. The deliverable should be fully approved, have an audit trail and be reproducible.

There is a great deal written on this, but a useful guide can be found at www.gov.uk/government/publications/quality-assurance-guidance-for-models.

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