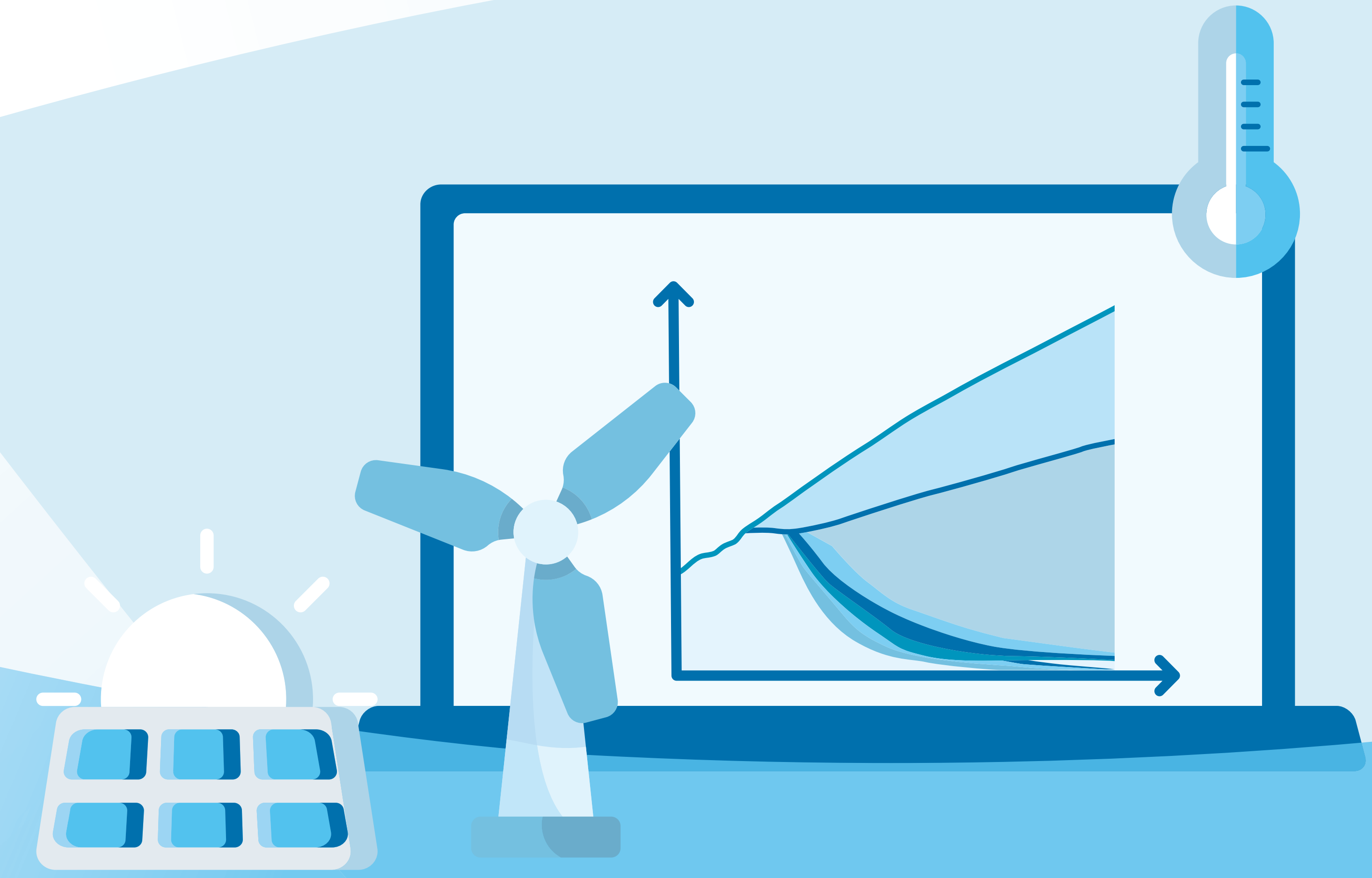
Partnership on Transparency
in the Paris Agreement



Projections of Greenhouse Gas Emissions and Removals:

An Introductory Guide for Practitioners

On behalf of:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

of the Federal Republic of Germany

Imprint

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Dag-Hammarskjöld-Weg 1-5
65760 Eschborn, Germany
T +49 30 33 85 25 15

E carlos.essus@giz.de
I www.transparency-partnership.net

Responsible:
Anna Schreyögg

Authors:
Sina Wartmann, Dominic Sheldon, John Watterson (Ricardo E&E)

Coordinators:
Oscar Zarzo Fuertes, Carlos Essus, Victor Mediavilla, Martha Schloenvoigt (GIZ)

Design/layout:
SCHUMACHER — Brand + Interaction Design, www.schumacher-visuell.de

URL links:
This publication contains links to external websites. Responsibility for the content of the listed external sites always lies with their respective publishers. When the links to these sites were first posted, GIZ checked the third-party content to establish whether it could give rise to civil or criminal liability. However, the constant review of the links to external sites cannot reasonably be expected without concrete indication of a violation of rights. If GIZ itself becomes aware or is notified by a third party that an external site it has provided a link to gives rise to civil or criminal liability, it will remove the link to this site immediately. GIZ expressly dissociates itself from such content. The opinions put forward in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety or the majority opinion of the Parties to the Paris Agreement. This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of Germany (BMU) supports this initiative, based on a decision by the German Bundestag.

Berlin, May 2021.

Table of contents

Annex

About the Partnership on Transparency in the Paris Agreement

In May 2010, Germany, South Africa and South Korea launched the Partnership on Transparency in the Paris Agreement (formerly: International Partnership on Mitigation and MRV) in the context of the Petersberg Climate Dialogue with the aim of promoting ambitious climate action through practical exchange. With the Paris Agreement entering into force in 2016, the path has now been paved for the Partnership to focus on implementing the Agreement and particularly on the Enhanced Transparency Framework. Over 100 countries, more than half of which are developing countries, have taken part in the Partnership's various activities to date. The Partnership has no formal character and is open to new countries. Currently, the secretariat of PATPA is hosted by the GIZ Support Project for the Implementation of the Paris Agreement (SPA).

Find more information on the partnership here:
www.transparency-partnership.net

Executive Summary

Greenhouse gas projections are an estimate of a country's future GHG emissions based on a set of assumptions. They are not, however, a prediction of the future. These assumptions will change over time and projections should be updated when they do.

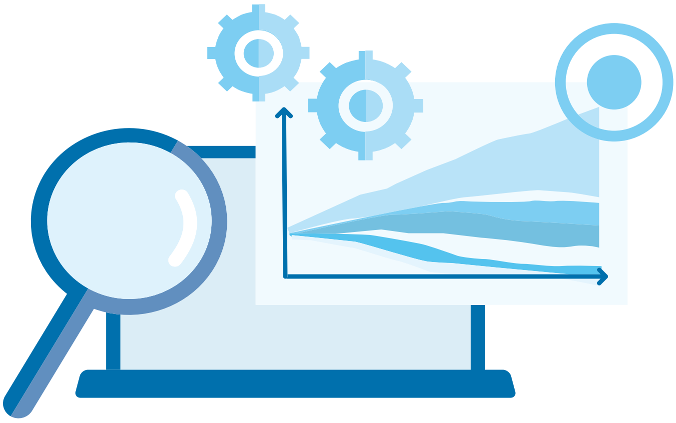
Understanding future GHG emissions can help a country to define a GHG reduction target, see if they are on track to meeting an existing target, estimate the impacts of certain mitigation measures and help plan mitigation measures in the medium and long-term.

Under the Paris Agreement's Enhanced Transparency Framework (ETF) all countries are required to report on GHG emissions projections. However, Parties that need flexibility in light of their capacities are only encouraged to do so and if they decide to report GHG projections, they are provided further flexibility, e.g., with regards to the methodology used and how far they project into the future. Whilst having the option not to report GHG projections can be helpful, countries should, nevertheless, carefully consider developing GHG projections as this information enables many decision-making processes.

There is no one size fits all projections tool, there are a number of options, each used to help answer a different set of questions. In order to select a tool, a country must understand a few things: which questions they are trying to answer, what functions the tool should have, what time horizon they want to understand, what scope the model should consider and whether it should provide the flexibility to grow with the user.

Key factors in developing GHG projections are the future development of activity data and emission factors. Activity drivers can be used to estimate activity levels for future years. The most relevant drivers are typically GDP development and population. When certain data are not available, proxy data can be used in their place.

When developing GHG projections, countries can start simple, making the best of what is available, focussing on those categories that have a large share of the historical emissions in the recent years or that show a strongly increasing trend. Then, as they start developing GHG projections, countries should plan how to enhance their projections over time. Specific needs for improvement and lessons learned should be identified in each compilation cycle.



1 The importance of developing projections of greenhouse gas emissions and removals

Projections of greenhouse gas emissions and removals (GHG projections) are an estimate of a country's future greenhouse gas (GHG) emissions based on a set of assumptions about how activities in that country, that cause those emissions, might change over time. Having an understanding of how its GHG emissions might develop in the future can help a country to:

- Establish a baseline scenario and define a GHG reduction target, e.g., under a Nationally Determined Contribution (NDC),
- Understand if they are on track to meeting an existing GHG reduction target,
- Estimate the impacts of mitigation measures on future GHG emissions.

Understanding potential GHG emissions developments and the impacts of mitigation measures is also helpful for mitigation planning in a specific sector or at a national level both in the medium and long-term e.g., under long-term low-emission development strategies (LT-LEDS). This is vital for countries to be able to track progress in the implementation and achievement of their NDC targets.

It is important to understand that while GHG projections are the best estimate of future GHG trends at a certain point in time, they are not a prediction of the future. Relevant knowledge and assumptions will change over time, and consequently, projections should be updated to incorporate this new knowledge.

1.1 Reporting requirements for GHG emissions projections

Under the Paris Agreement's Enhanced Transparency Framework (ETF)[1], which is operationalised by its modalities, procedures and guidelines (MPGs)[2], all countries are required to report on GHG emissions projections as part of their Biennial Transparency Reports (BTR). The MPGs detail how this should be done (more information on the reporting requirements for GHG emissions projections can be found in Annex 1). Parties are to submit their first BTRs at the latest by 31st December 2024. Whilst the MPGs state that *all* parties are required to report GHG projections, they also state that developing country Parties that need flexibility in light of their capacities are only *encouraged* to report those GHG projections. If developing countries do report on them, they can make use of less stringent requirements with regards to the numbers of years to be projected into the future and the scope and the level of detail of the methodology used (see Annex 1 for more detail). However, Parties may want to consider whether and in which way they opt to use the flexibility, as developing GHG projections has many benefits, including informing policy development sufficiently early to allow for policies to be revised and possibly amended.

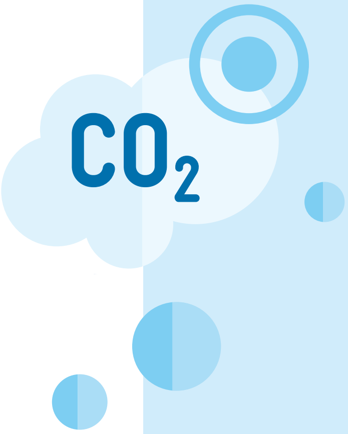
This is the first time that reporting projections has become a requirement for *all* parties under the United Nations Framework Convention on

---

[1] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[2] https://unfccc.int/sites/default/files/resource/cp24_auv_transparency.pdf

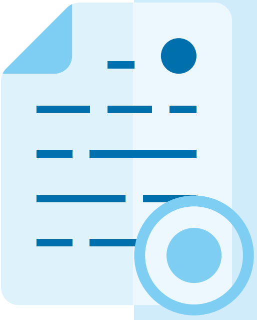
Climate Change (UNFCCC). Developed countries are already requested to report GHG projections as part of their National Communications (NC) and Biennial Reports (BR). Reporting projections had not been a requirement for developing countries, neither in the National Communications nor in the Biennial Update Reports (BUR). Collective country experience is thus limited.



1.2 Aim and structure of this paper

This paper aims to provide a short practical introduction about developing GHG projections, targeted at policymakers and other climate practitioners from developing countries with limited experience in this field. The paper provides an overview of key steps for preparing GHG projections, and highlights existing guidance as well as good practices / lessons learned in doing so. Section 2, immediately below, presents the basic approach to developing GHG projections, including an overview on tools for GHG projections; Section 3 describes how to approach quality control and quality assurance of GHG projections including understanding uncertainty; finally, Section 4 addresses how countries starting out with GHG projections can do so in a simple fashion and enhance their approaches, including tools used, over time.

The annexes contain an overview of the reporting requirements under the ETF related to GHG projections, an overview of key activity drivers to use as input data in GHG projections, and finally a summary of common considerations that can limit the choice when selecting a GHG projections modelling tool.



2 Basic approach to developing GHG projections

Put very simply, GHG projections are developed by considering today's GHG emissions – which are based on activity data and emission factors – and estimating how these might develop in the future. As opposed to historical data, where activity data is available from statistics and measurements, such data is not available for the future. Emission factors in the future could be the same or similar to those in the past – but technological improvements could mean these factors might be different. This means that several assumptions must be made about how activity data and emission factors might develop in the future. Figure 2-1 below shows a basic approach to estimating future GHG emissions using an activity driver. In a first step, GHG emissions for the reference year are calculated by using activity data and an emission factor for the reference year (e.g., the year for which the latest GHG inventory data is available). To calculate future emissions, the emissions for the reference year are then multiplied by an activity driver expressing activity data growth in the future to estimate GHG emissions for a specific year in the future.

What is an activity driver?

An activity driver is a factor that affects how activity data (e.g., electricity demand) will develop in the future.

Figure 2-2 on the next page shows a detailed view of the key steps in developing GHG projections. The basis is the calculation of historical emissions for a reference year, then applying an activity driver to understand how these emissions change over time in order to obtain the total projected emissions for future years. Each step is described in the following subchapters.

Figure 2-1 Basic approach to calculating projections (source: authors)

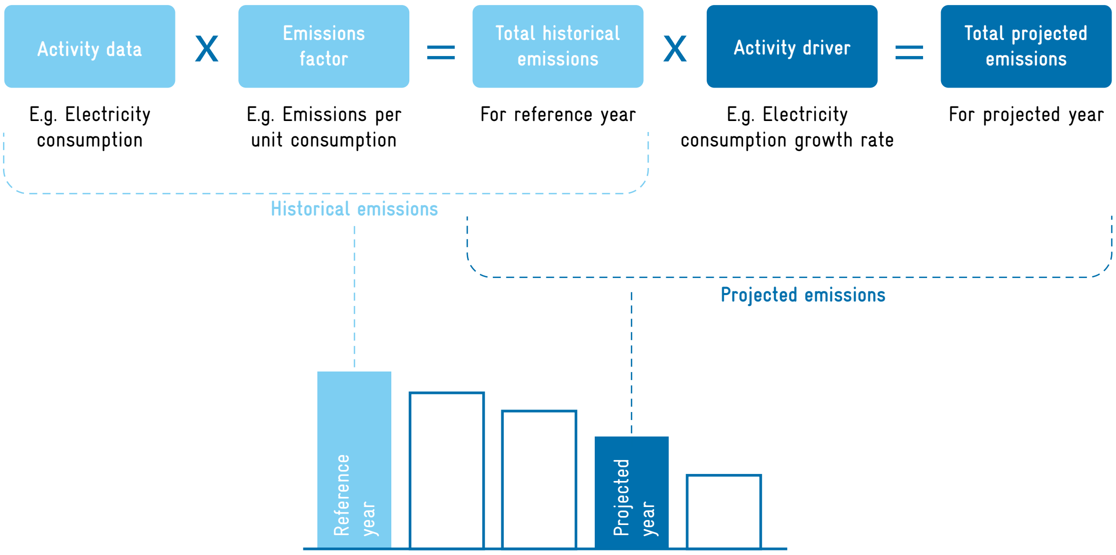
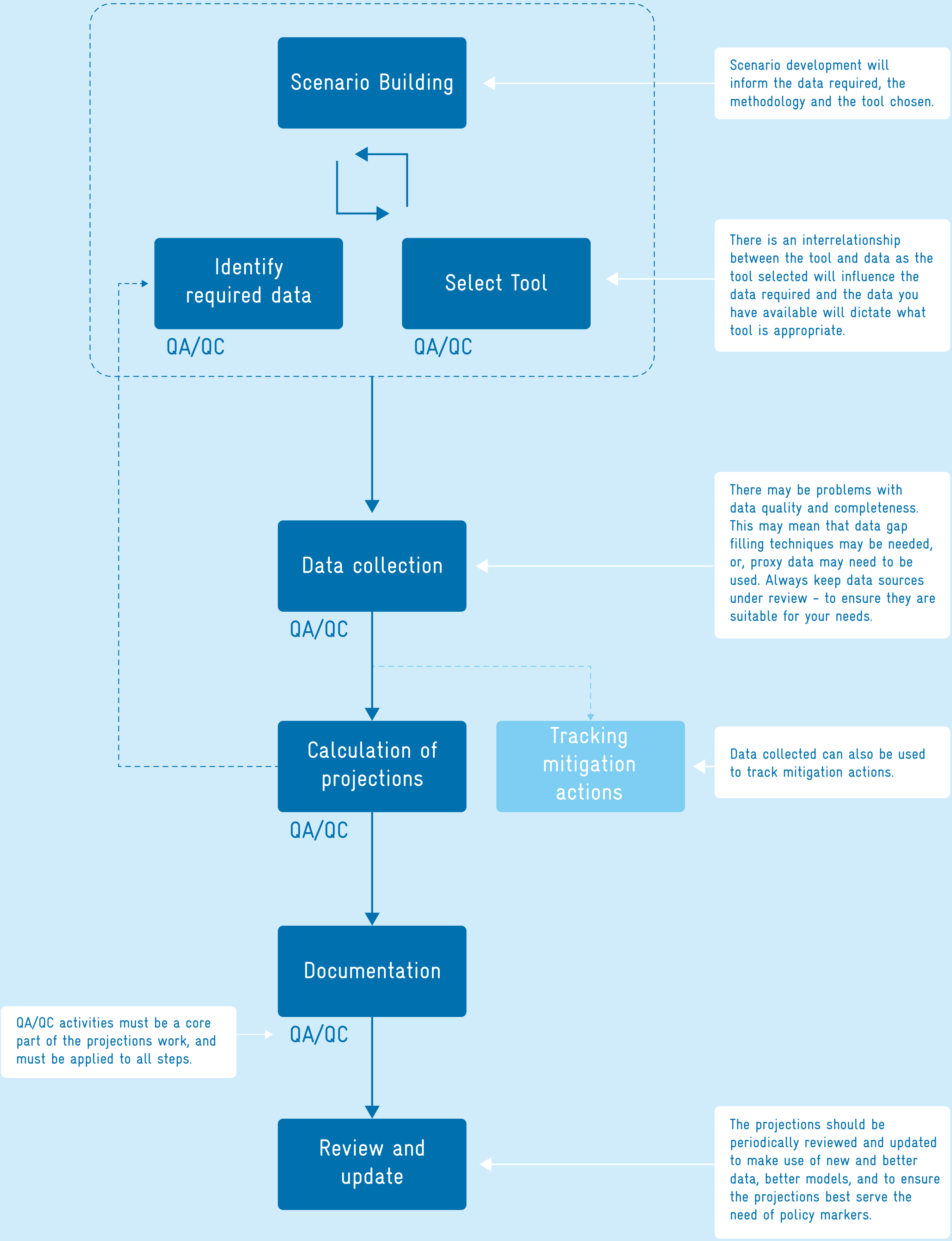


Figure 2-2 Key steps to developing GHG projections[3] (source: authors)



Scenario development will inform the data required, the methodology and the tool chosen.

There is an interrelationship between the tool and data as the tool selected will influence the data required and the data you have available will dictate what tool is appropriate.

There may be problems with data quality and completeness. This may mean that data gap filling techniques may be needed, or, proxy data may need to be used. Always keep data sources under review – to ensure they are suitable for your needs.

Data collected can also be used to track mitigation actions.

QA/QC activities must be a core part of the projections work, and must be applied to all steps.

The projections should be periodically reviewed and updated to make use of new and better data, better models, and to ensure the projections best serve the need of policy markers.

---

[3] If the projections do not sufficiently help plan GHG emission reductions, or do not help track mitigation actions well in practice, new and/or different data might be needed.

2.1 Scenarios as basis for developing and defining GHG projections

Assessing potential developments of GHG emissions in the future requires an understanding of "what the future might be like", e.g., with regards to economic, social and technological developments. We call this a "scenario". A scenario could be defined as the "big picture" of how we envisage the future in the long term. In developing their NDCs, many countries have developed several scenarios. These include the "Business as Usual" (BAU) scenario, which is commonly assumed to be a scenario where no additional climate policy to that which currently exists is undertaken. Then, there might be several mitigation scenarios, e.g.,, moderately ambitious scenarios, considering slightly enhancing the existing climate change action, as well as highly ambitious scenarios, depicting bold and highly transformational climate policies.

Under the current MRV framework[4] [5] [6], developing countries must report (*shall* requirement):

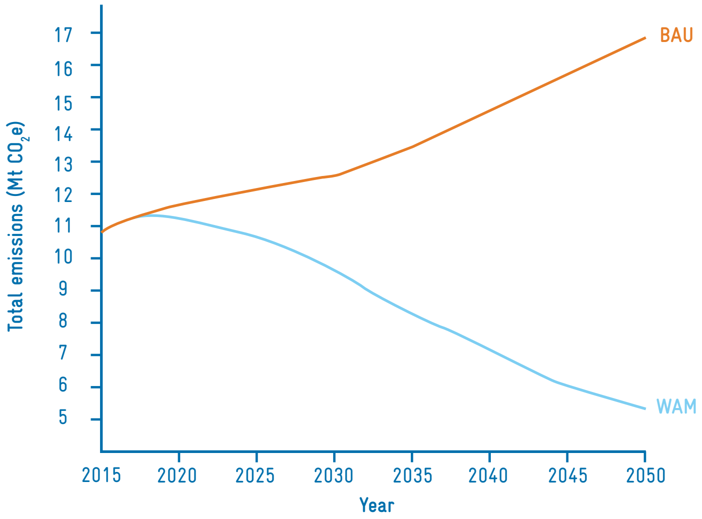
- One scenario which depicts GHG trends based on the overall impacts of currently implemented and adopted mitigation measures – the "with existing measures (WEM)" scenario.

They *may* also report two additional scenarios:

- One scenario which depicts GHG trends in the case that no measures are implemented (and have not been in the past) – the "without measures (WOM)" scenario.
- One scenario in the case that all planned mitigation policies are implemented alongside measures already implemented – the "with additional measures (WAM)" scenario.

Figure 2-3 presents projections reported by a developing country, Costa Rica, in its second Biennial Update Report (2019). The figure illustrates two scenarios: a BAU scenario which reflects emissions under a scenario *with existing*

Figure 2-3 Projections of total GHGs in Costa Rica's second Biennial Update Report[7]



What is a scenario?

According to the Intergovernmental Panel on Climate Change (IPCC): "A scenario is 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" (IPCC Data Distribution Centre Glossary).

---

[4] https://unfccc.int/sites/default/files/resource/IBA-2019.pdf, adapted
[5] https://unfccc.int/preparation-of-ncs-and-brs#eq-1
[6] https://unfccc.int/non-annex-I-NCs
[7] https://unfccc.int/BURs

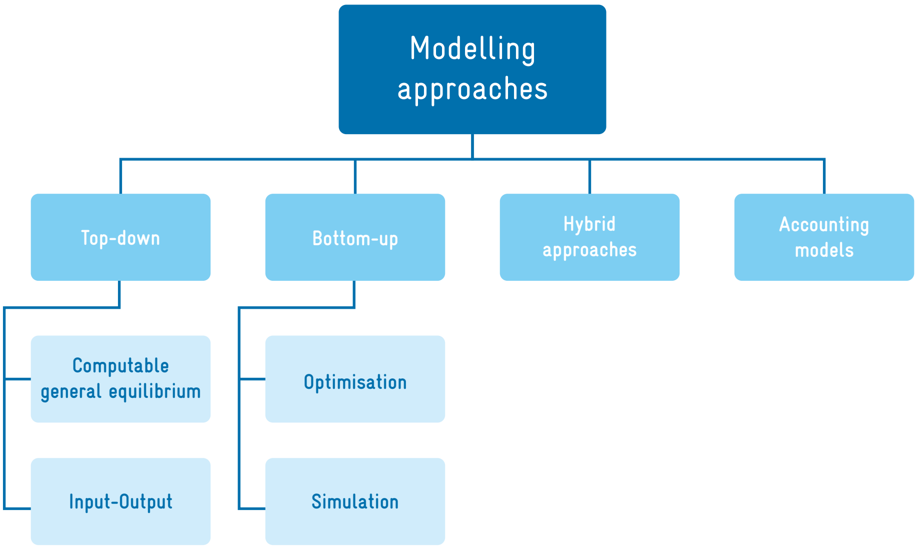
measures, or "WEM", and a scenario *with additional measures*, or "WAM". The figure shows that under the BAU scenario, total GHG emissions were forecast to increase rapidly from 2020 onwards to 2050. The WAM scenario shows that GHG emissions could be reduced over the time series from 2020 to 2050 and suggests that very large reductions might be possible by 2050. This would represent the achievement of a high level of mitigation ambition. In reality, the likely outcome might not be such a large reduction in future GHG emissions because of imperfect mitigation implementation and the pressures of economic growth to support development – but – the WAM scenario gives "a sense of the possible".

2.2 Choosing a projections' modelling tool

Preparing GHG projections can be complex as it can require a technical understanding of a wide set of variables. No standardised methodologies or tools exist to allow GHG projections to be calculated. However, there are several modelling tools available which can help with this task. Different tools help answering different questions or "perspectives" in preparing GHG projections. This chapter presents an overview of modelling approaches and selected tools, and helps countries understand how to choose the tool most appropriate for them, depending on their aims as well as existing capacities.

Figure 2-4 presents a categorisation of modelling approaches which can be used to prepare GHG projections.[8]

Figure 2-4 Categorisation of modelling tools



---

[8] This categorisation is taken from a GIZ paper with the title "Methodological approach towards the assessment of simulation models suited for the economic evaluation of mitigation measures to facilitate NDC implementation" https://www.transparency-partnership.net/system/files/document/simmodel-methodological-approach-%28web%29_20180214.pdf. More detail on each of the categories and example tools for each category are provided in the paper.

Top-down and bottom-up models examine the linkages between the economy and specific GHG emitting sectors, such as the energy system. Top-down models evaluate the system from aggregate economic variables (e.g.,, energy demand and supply), whereas bottom-up models consider technological options or project-specific climate change mitigation policies. We could also say that "top down" models use aggregated data, while "bottom up" use disaggregated data. Hybrid models use a combination of top down and bottom up approaches. Accounting models include descriptions of key performance characteristics of systems (e.g.,, an energy system), allowing users to explore the implications of resource, environment and social cost decisions. They are often less complex than models falling under the other three categories and can thus be an easier starting point for compiling GHG projections, if no previous experience exists.

With all models, GHG emissions are still projected using the basic approach of activity data multiplied by an emission factor. Activity data will often be estimated as part of the modelling approach, e.g.,, a model might calculate energy demand in the economy as a whole or in specific sectors under certain conditions. Emission factors will often be entered into the model, e.g., as emission factors for specific fuels or emission factors for process emissions when a specific production technology (e.g.,, related to cement or steel production) is used.

These modelling categories and selected models falling under them are presented in more detail in the following sections.

2.2.1 Top-down models

There are two main types of top-down models:

Input/Output (I/O) models:

Input-output analysis ("I-O") is a form of macroeconomic analysis based on the interdependencies between economic sectors or industries, e.g.,, where outputs from one industry are bought and used as input by another. This allows assessing, how changes in output in one industry will affect other industries. Such models are used when the sectoral consequences of mitigation or adaptation actions are of particular interest[9]. As with CGE models (described below), the model calculations will provide relevant activity data for GHG estimations. I/O models are in most cases not suited to model factor substitution (e.g., replacing labour by capital), behavioural aspects or technological change. I/O-models are suited for considering developments within the next 5–15 years. I/O models are complex and require a comprehensive dataset and extensive expertise.

EXAMPLES

IOTA
https://www.sei.org/projects-and-tools/tools/iota/

REMI
https://www.remi.com/models/

---

[9] https://www.transparency-partnership.net/documents-tools/methodological-approach-towards-assessment-simulation-models

Computable General Equilibrium (CGE) models: A CGE model is a large-scale numerical model that simulates the core economic interactions in the economy. It uses data on the structure of the economy along with a set of equations based on economic theory to estimate the effects of fiscal policies on the economy[10]. The basic principle of general equilibrium theory is that within the economy, an efficient allocation of goods and services is achieved through a set of decisions that balance supply and demand and coordinate production[11]. The output from the model will be activity data relevant for estimating GHG emissions, e.g., energy demand or industrial production. CGE models examine the economy in different states of equilibrium and, thus, are not able to provide insight into the adjustment process (e.g., to indicate a technology path from one state of equilibrium to the other), as might be needed to plan towards an NDC target.

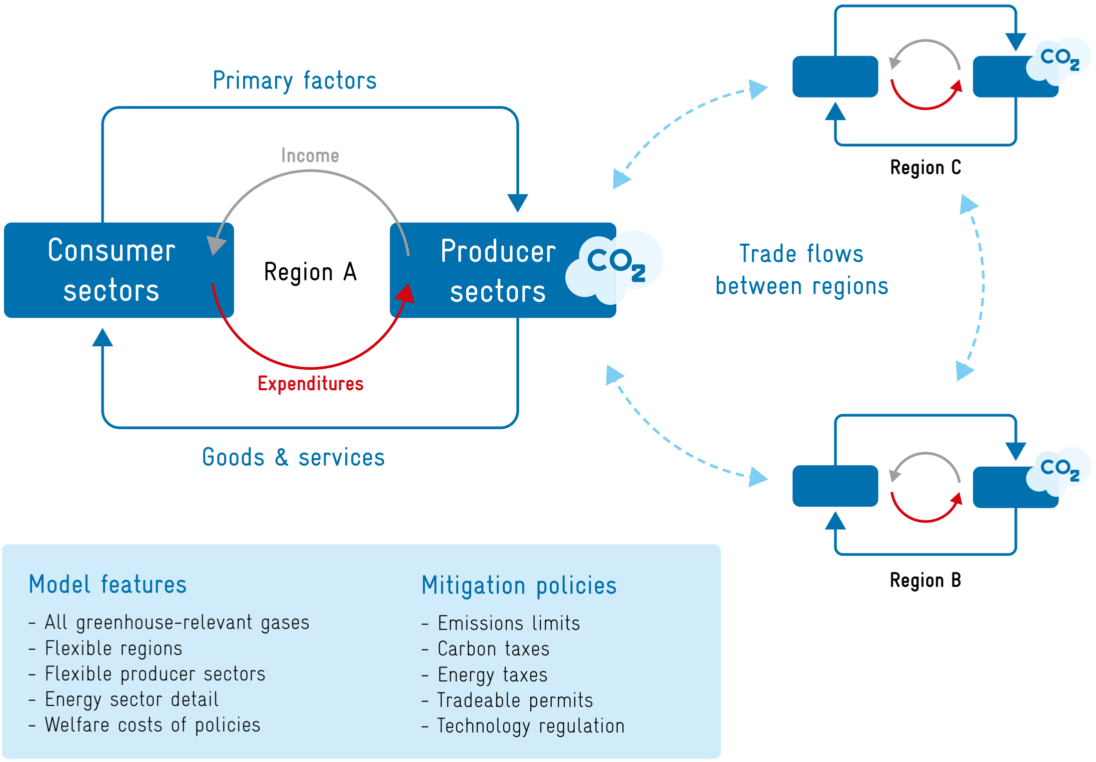
CGE models are complex and time-consuming to use, requiring a comprehensive dataset and economic expertise as well as experience with the specific model used.

EXAMPLES

EPPA Model

https://globalchange.mit.edu/research/research-tools/human-system-model

Figure 2-5 MIT Economic Projection and Policy Analysis (EPPA) Model[12]



Model features
- All greenhouse-relevant gases
- Flexible regions
- Flexible producer sectors
- Energy sector detail
- Welfare costs of policies

Mitigation policies
- Emissions limits
- Carbon taxes
- Energy taxes
- Tradeable permits
- Technology regulation

---

[10] https://web.stanford.edu/~jdlevin/Econ%20202/General%20Equilibrium.pdf

[11] https://globalchange.mit.edu/research/research-tools/human-system-model, adapted

[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/263652/CGE_model_doc_131204_new.pdf

2.2.2 Bottom-up models

There are two main types of bottom-up models:

Optimisation (or optimal solution approach):

Optimisation models provide a preferred, “optimal” option or set of options based on achieving a certain goal or set of goals, “for example, the least cost, highest emissions reductions or the greatest number of jobs”[13]. An optimisation model can be described as a prescriptive model, seeking “to generate the plan that best satisfy the selected decision criteria”.[14] An example could be the aim of minimising the total costs of a defined energy system, including all end-use sectors, over a 40 to 50-year horizon. Optimisation models will require a very detailed description of the current system, involving a significant amount of data in this regard.

Figure 2-6 displays an illustration of key approaches under the TIMES model.

EXAMPLES

MARKAL/TIMES

https://iea-etsap.org/index.php/etsap-tools/model-generators/times

Analytical simulation (or alternatives assessment approach):

These models aim to simulate and envisage the behaviour of a system under a given set of conditions[15], i.e. they will describe what will happen in terms of certain selected key parameters (e.g., energy consumption) if a specified plan is adopted[16]. They can also be considered as “scenario models,” built to demonstrate different options and allow the user to compare between them. Simulation models include, among other, a detailed representation of energy demand and supply technologies, including end-use, conversion, and production technologies and therefore require some technical expertise in order to set the model up correctly. However, simulation models are significantly less complex than I/O models, for example. They are best suited for short to medium-term assessments.

EXAMPLES

POLES

https://www.enerdata.net/solutions/poles-model.html

---

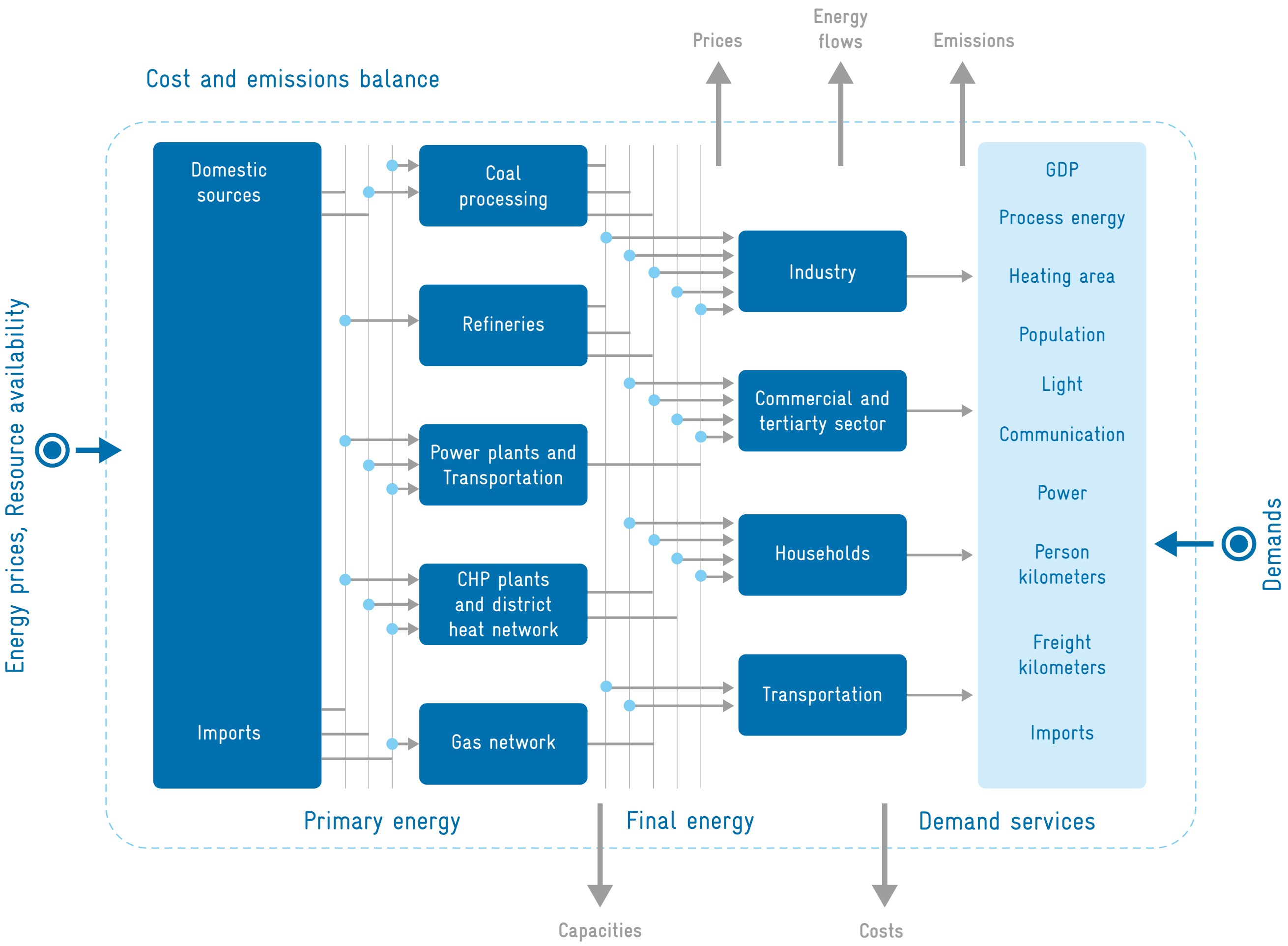
[13] https://www.africaportal.org/publications/guidelines-for-the-selection-of-long-range-energy-systems-modelling-platforms-to-support-maps-processes/

[14] https://www.mdpi.com/1996-1073/10/7/840/htm#:~:text=These%20decision%20variables%20are%20typically,for%20the%20optimal%20system%20design

[15] Ibid.

[16] Ibid.

Figure 2-6 Illustration of key approaches in the TIMES model[17]



2.2.3 Hybrid model or hybrid modelling approach

The category of "hybrid models" does not refer to a set of specific tools or models. The approach involves combining both top down and bottom up models, something that can be particularly useful when exploring possible pathways to deep decarbonisation or the setting of long-term targets. The combination of top down and bottom-up models helps modelling highly uncertain futures[18] as each model has its own strengths and limitations, and the combination allows viewing things from different perspectives.

EXAMPLES

CGE economic model and TIMES energy model.

TIMES provides electricity generation shares, investment required and costs of electricity production as output (among other) and these are used as inputs into the CGE economic model. The CGE model then calculates GDP and sectoral growth as well as household income growth which can feed back into TIMES to refine the assessment.

---

[17] https://iea-etsap.org/index.php/etsap-tools/model-generators/times, adapted

[18] https://d1v9sz08rbysvx.cloudfront.net/ee/media/assets/simmodel-methodological-approach-(web)_20180214.pdf

2.2.4 Accounting models

Accounting models are often less complex and require less comprehensive data than the other modelling alternatives. They offer an easier starting point for countries with limited modelling experience. A wide range of tools is available from options requiring no previous experience, using default data and pre-included mitigation actions, to tools which can be used in a simplified manner in the beginning and grow with the user to become more sophisticated over time, as the user's experience grows.

EXAMPLES

LEAP can be developed within 3–6 months and is flexible to different levels of detail and data availability, i.e. it can grow with the user. Where information on electricity generation capacities, fuels to be used to generate this electricity (where applicable), costs and demand is available, LEAP allows the calculation of which capacities to use to meet this demand. The tool is suited for long-term modelling and includes a database of technologies (e.g., impacts, costs) which can be used where national-level information is not available.
https://leap.sei.org/

GACMO can be used to evaluate the costs and benefits of a wide range of mitigation options to calculate the GHG emissions reduction and the average mitigation cost expressed in US$ per ton of CO_2-equivalent. It can combine the options in the form of a marginal abatement cost curve (MACC, see Figure 2-7 for a general example of a MACC), showing the average cost of reducing GHG emissions for different alternatives. The software includes 100 mitigation actions based on clean development mechanism methodologies, which can be used directly with default data, included to estimate costs. A first estimate of future emissions can be made easily and with limited data and expertise, by capturing information on current electricity and fuel consumption and projecting them into the future using growth factors. The tool is more suited for simplified assessments in the short term.
https://unepdtu.org/publications/the-greenhouse-gas-abatement-cost-model-gacmo/

PROSPECTS+ allows calculating projections using sectoral indicators, e.g., emission intensity of electricity production. Mitigation measures are included in the form of modified sector indicators. PROSPECTS+ offers a simplified sectoral approach for the residential, transport, cement, iron and steel sectors, which again allows starting with less data and expertise and moving to the full sectoral approaches over time, as data and expertise grow.
https://newclimate.org/2018/11/30/prospects-plus-tool/

EX-ACT was developed by the Food and Agriculture Organization of the United Nations (FAO) and focuses on the agriculture, forestry and land use sector. The tool allows estimating GHG emissions as well as carbon sequestrations in the sector. It has been designed to assess the impacts of projects, but can be scaled up to programme level activities or be used for policy analysis. The tool includes default data and allows comparing the situation with and without a project. The tool is more suited to assessments for the short term.
http://www.fao.org/tc/exact/ex-act-home/en/

Figure 2-7 Example Marginal Abatement Revenue (MAR) Curve for Country X in 2030 in GACMO[19]

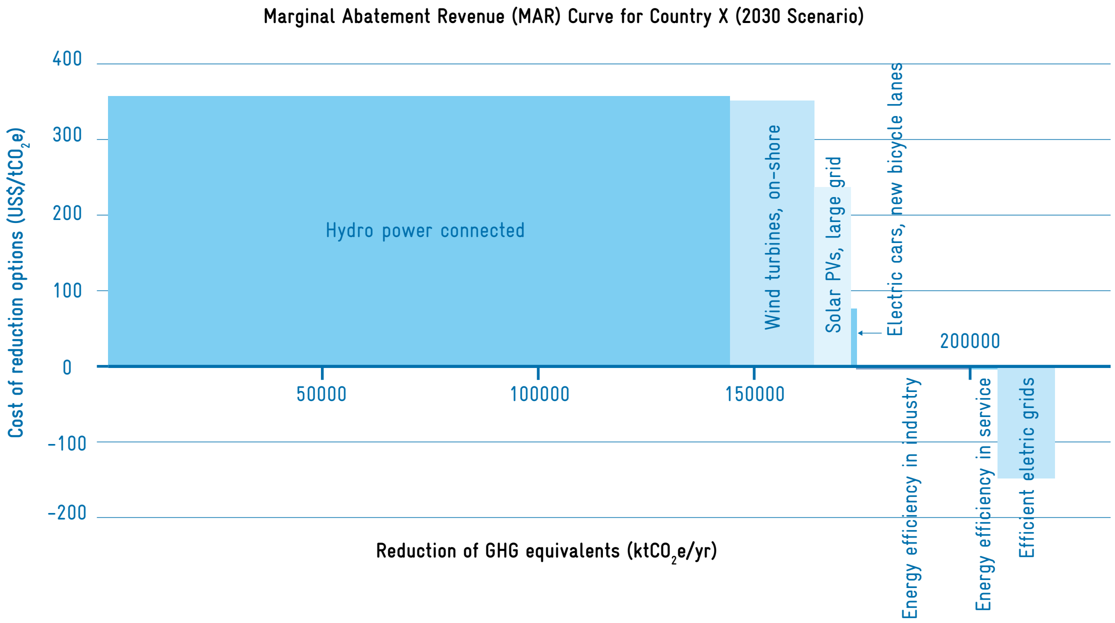
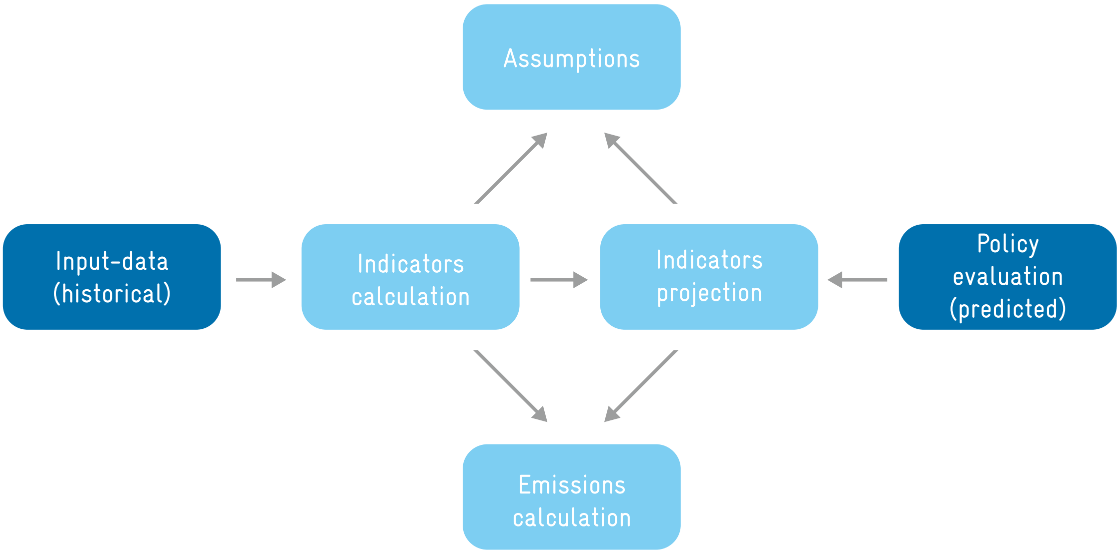


Figure 2-8 Basic GHG emission estimation approach in the PROSPECTS+ tool[20]



---

[19] https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/Impact%20of%20the%20financial%20crisis%20on%20carbon%20economics%20Version%2021/Impact%20of%20the%20financial%20crisis%20on%20carbon%20economics%20Version%2021.pdf

[20] https://newclimate.org/wp-content/uploads/2020/02/PROSPECTS_Methodology.pdf

2.2.5 Which projections tool to choose?[21]

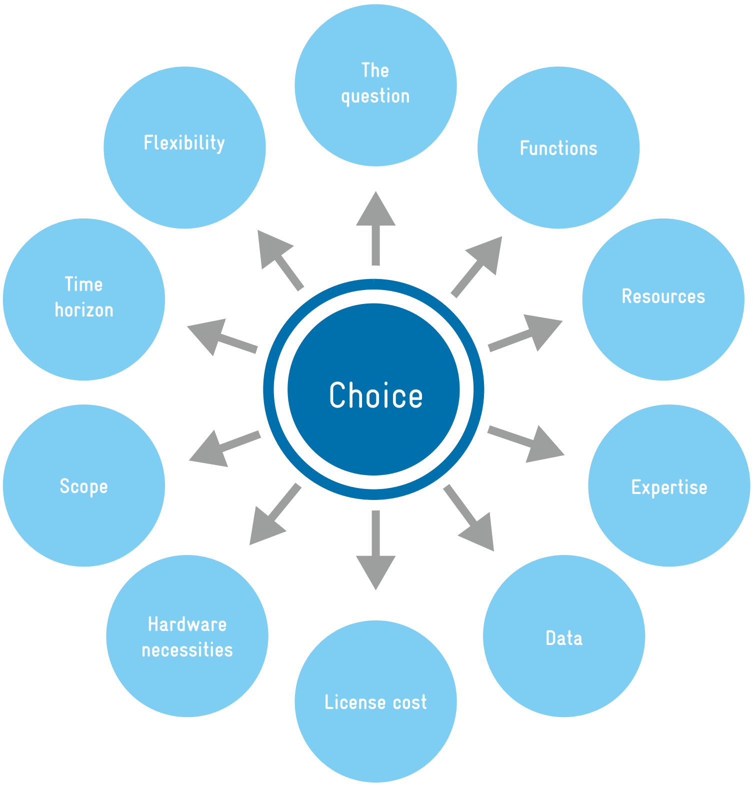
There is no “best model”. The choice of model needs to consider a wide range of factors (see Figure 2-9) concerning what the users aim to achieve by using the model, but also certain conditions and constraints they are facing.

Each model is built to help the modeller answer a certain question or set of questions. The most relevant issues to consider are, what the question you are trying to answer is (e.g., how will GHG emissions develop if a certain set of mitigation actions are implemented?), what functions the tool should have (e.g., generating MACC curves), what time horizon you are looking into (e.g., 2 or 50 years?), what scope it should consider (e.g., the whole economy vs the energy sector) and whether it should provide the flexibility to grow with the user. Table 1 on the next page shows a number of typical questions together with suggestions of a modelling approach for each of them.

There are also a number of constraints to consider. These relate for example to the the data necessary for a specific model, the staff resources, as well as the expertise needed to set-up and run the model and interpret its results. Licence costs for software and hardware requirements (which can be relevant e.g., for top-down, bottom-up and hybrid models) also need to be contemplated. More information on how to consider these factors is provided in Annex 2.

Figure 2-9 provides an overview of the factors to be considered when selecting a model.

Figure 2-9 Factors to consider when selecting a model



---

[21] This paper aims to provide a first overview on how to choose a model but cannot provide comprehensive guidance. For this purpose, please consider the paper “Methodological approach towards the assessment of simulation models suited for the economic evaluation of mitigation measures to facilitate NDC implementation” https://www.transparency-partnership.net/system/files/document/simmodel-methodological-approach-%28web%29_20180214.pdf

Table 1 Questions modellers might aim to answer and suggestions for suitable modelling approaches

QUESTION	SUGGESTION
What are the impacts of the mitigation actions planned and how much will they cost?	All of the model types described can be used to assess the impacts of mitigation actions, and nearly all of them include costs.[22] From this, assessments of the mitigation potential of the sector can be made.
What impact will these mitigation actions have on economic development e.g., job creation?	Top-down macro-economic models are best placed to "provide insights into economic impacts and job creation, taking account of interactions within the system.[22]
What is the most cost-effective route to achieve our target?	Optimisation models (e.g., TIMES) are built to output an "optimal" pathway based on the criteria selected by the modeller, for example the most cost-effective pathway to an emission reduction target.
What will our future emissions be?	An accounting model could be a good starting point for gathering the data needed to forecast future energy supply, demand and emissions, and to model the likely impact of economic growth, renewable energy and energy efficiency measures on future GHG emissions.[22]
How will emissions evolve in a certain sector?	A bottom up simulation model or a sectoral accounting model (e.g., EX-ACT for the AFOLU sector) can be a useful starting point for exploring how emissions in a specific sector might evolve.
How do we model a long-term target?	Hybrid modelling tools are most appropriate for this scenario, combining different approaches for different time horizons to help manage uncertainty.
We need a very quick assessment of the potential impact of mitigation actions but do not have much expertise or data	Simple accounting tools offering default data like GACMO seem most appropriate in this case.
We have limited data and expertise now and we would like to continue using the same model over time	Accounting tools like LEAP or PROSPECTS+ seem most suited.

---

[22] https://d1v9sz08rbysvx.cloudfront.net/ee/media/assets/simmodel-methodological-approach-(web)_20180214.pdf

2.3 Collecting and/or generating activity data and emission factors

Once scenarios have been built, the data required to calculate the GHG emissions' projections, i.e. the activity data and emission factors, need to be collected or generated.

What is a proxy?

The EU GHG Projection Guidance[24] defines proxies as a measurable unit which can be used to construct a unit which is not directly measurable – for instance population size can be used as a proxy for electricity consumption.

2.3.1 Activity data

As indicated previously, we can use activity drivers[23] to estimate activity levels (e.g., electricity demand, transport demand, cement production) for future years. What is most important to understand is that what we refer to as activity drivers, which reflect how activities lead to anthropogenic GHG emissions, might change over time.

The most relevant drivers at the national level are typically GDP development and population. Further drivers can be related to costs (e.g., the costs of key fuels like coal, oil and gas), and to the emission intensity of key technologies (e.g., in power generation, cement, steel or glass production). Development of demand is also a key driver (e.g., related to power consumption in households or transport demand). When certain data are not available, proxy data can be used in their place.

When generating projections, it is important to ensure that there is close correlation between the driver and the activity data. Taking energy use in a specific industrial sector as an example, it might be the case that there are estimates of the amounts of future consumption of fuels for that industrial sector. Should no estimates be available, a country could use GDP as a proxy, and use this as a driver to predict future energy use. This assumes that there is a close coupling of GDP and industrial activity – which is normally true. It would be better to use GDP for a given industrial sector, if that is available, because this would improve accuracy. Table 3, in the Annex 3, provides a list of examples of key sectoral activity drivers.

At the national level, statistical offices typically prepare projections of drivers like GDP and population. Often, projections will also exist for future power and primary energy demand as well as for fuel prices. Where energy-related drivers are not available from the statistical offices, Ministries of Energy might have produced such projections. Energy-related projections might also be available from the International Energy Agency (IEA)[25]. Projections of different drivers might have been developed for different purposes using different assumptions. For example, projections of energy prices can be related, among other, to expectations of how the demand is going to develop and, for certain fuels, to the development of, and costs for, specific extraction technologies. It is therefore important to understand these assumptions and ensure that, where drivers are related to each other (e.g., prices for different types of fuels), they are at least basically aligned and not contradicting (e.g., based on completely different estimations of total energy demand).

---

[23] There is no standardised terminology to describe the data used to help predict future levels of activity based on the current levels of activity. They are sometimes referred to as indicators or parameters, however, the clearest terminology used to avoid confusion is "activity drivers".

[24] European Commission. 2012. GHG Projection Guidelines. Part A: General Guidance. CLIMA.A.3./SER/2010/0004.

[25] See www.iea.org

2.3.2 Emission factors

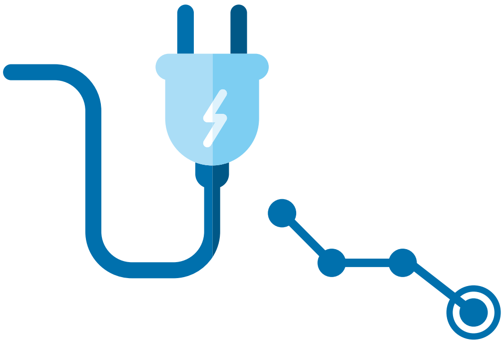
Emission factors suitable for generating GHG projections could be the same as those used in historical inventories. For example, the carbon contents of liquid petroleum gas (LPG) and gasoline in the future are likely to be similar to their values now. This is because the technologies that use these fuels are unlikely to change substantially in the future. But where technological changes, such as in some industry sectors (e.g., reduced process related emissions from iron and steel production due to process changes), or changes in agricultural practice (e.g., reduced methane emissions from livestock due to changes in feeding practices), emission factors for these sources may see considerable change in the future. It is important to select appropriate emission factors for GHG projections. Using expert judgement is entirely acceptable as long as the reasons for the choices made are documented.

2.3.3 Integrating mitigation measures into the projections.

There are several approaches for integrating the impacts of relevant mitigation measures (e.g., policies, programmes or projects) into the projections. Among other, this can be done by considering their impacts on:

- activity data, e.g., reduced power consumption in households due to energy efficiency measures;
- emission factors, e.g., where policies promote certain technologies or require certain emission standards (e.g., maximum CO_2-levels / km driven for cars). For long-standing policies and measures, the effects of such measures can be included in the calculation of aggregate emissions factors;
- the total GHG emissions / removals of a specific category. This can be the case where a specific reduction target has been set, e.g., under a cap-and-trade system, in which the total emissions of a category or a group of categories are limited to a maximum amount by a specific year. This amount can then be used as assumed GHG emission levels for those categories for that specific year.

The Organisation for Economic Co-operation and Development (OECD) paper "Greenhouse Gas Emission Projections and Estimates of the Effects of Measures: Moving Towards Good Practice"[26] presents an overview of how typical mitigation measures in various sectors reduce GHG emissions and how they can best be projected. To facilitate understanding of the projection approaches listed in the paper, it is suggested to first consider Section 2.2 of this document on projection tools, as the OECD paper makes reference to various types of models.



---

[26] OECD. 1998. Greenhouse Gas Emission Projections and Estimates of the Effects of Measures: Moving Towards Good Practice. OECD Information Paper. ENV/EPOC(98)10, http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/EPOC(98)10&docLanguage=En

3 Quality assurance and quality control (QA/QC)

Just as with national GHG inventories, specific activities are required to ensure the quality of GHG projections. Any considerations with regards to quality have to start with a definition of what is considered as “quality”. There is no commonly agreed definition of quality for GHG projections at present. The IPCC has laid down principles for historical GHG inventories to define quality and these can be equally used for GHG projections. The relevant principles are:

- **Transparency:** There is sufficient and clear documentation such that individuals or groups other than the compilers can understand how the projections were compiled;

- **Accuracy:** The projections contain neither over- nor under-estimates so far as can be judged, and with uncertainties reduced as far as practicable;

- **Completeness:** Projections are reported for all relevant categories of sources, sinks and gases;

- **Consistency:** Estimates for different years, gases and categories are made in such a way that differences in the results between years and categories reflect real differences in emissions. This means that to the extent possible, the same data sources and methodologies are used for all years for which projections are produced.

Quality control (QC) for projections can be defined as a set of activities carried out by the compilation team as part of the preparation of projections. Quality assurance (QA), in contrast, relates to activities carried out by staff external to the compilation team.

QA/QC is relevant for each step of compiling projections, from the planning over data collection, calculation, to documentation and archiving (see next chapter). While projections might draw on different types of data, many QA/QC activities applicable to GHG inventories are applicable for GHG projections as well, both with regards to general as well as sectoral QA/QC activities. Consult the QA/QC volume of the IPCC 2006 Guidelines for National GHG Inventories[27] for more information and additionally the QA/QC volume of the 2019 Refinement of the 2006 Guidelines.[28]

3.1 Uncertainty in projections

Projecting future emissions is an inherently uncertain task as projections are a combination of two main components:

- An estimation of the emissions that are occurring at the start of your projection period: a base year inventory;

- How you expect the activity that causes those emissions to change in the future: Changes in activity data and emissions factors over the projection period[29].

Neither of these components can be estimated perfectly and that is uncertainty – the fact that the precise value of a variable is not known.

---

[27] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf

[28] https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/1_Volume1/19R_V1_Ch06_QA_QC.pdf

[29] https://unfccc.int/files/national_reports/biennial_reports_and_iar/submitted_biennial_reports/application/pdf/methodologies_for_u_s__greenhouse_gas_emissions_projections.pdf

However, it is possible to estimate that a value likely falls within a range of a certain size. The size of this range and the likelihood that the value falls within it determine how uncertain a variable is.

An important point to consider is that all projection calculations will have uncertainty, no matter how sophisticated. The aim of assessing uncertainty in projections is not to determine whether the projections are "good" or not, but to help prioritise future efforts to reduce that uncertainty.

Understanding uncertainties of projections is also important for another reason. A better understanding of the uncertainty of projections means a better understanding of the sensitivity of those projections to different policy scenarios as well as different economic scenarios and different assumptions on technological developments[30]. This will support better policy decision-making.

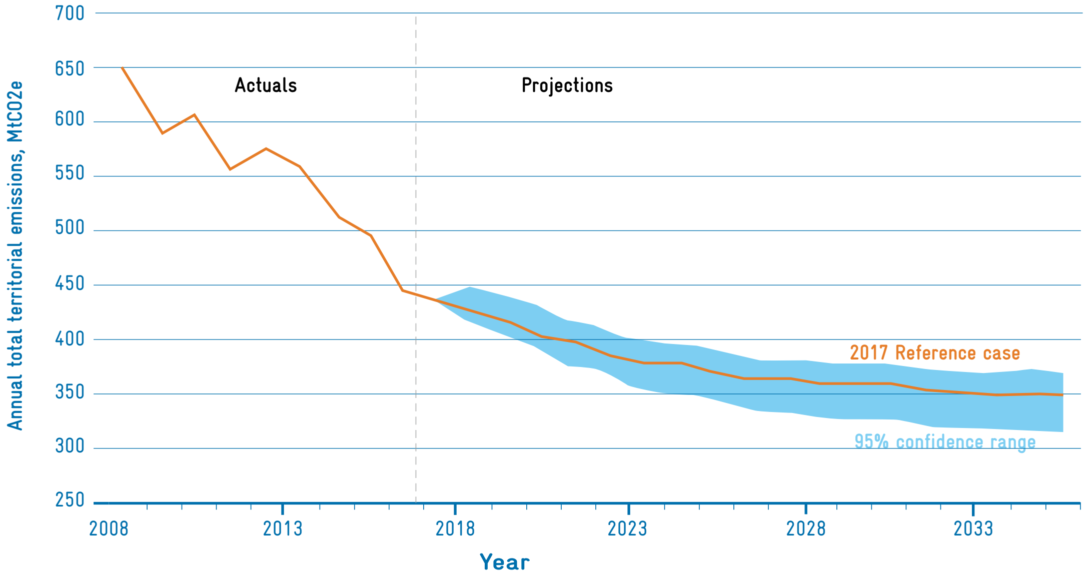
Figure 3-1 shows the uncertainty range calculated for the UK's projected emissions in their sixth National Communication.

For more information on uncertainty calculations, see:

2006 IPCC Guidelines for National Greenhouse Gas Inventories: Chapter 3 – Uncertainties https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_3_Ch3_Uncertainties.pdf

2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories: Chapter 6 – Quantifying Uncertainties in Practice https://www.ipcc-nggip.iges.or.jp/public/gp/english/6_Uncertainty.pdf

Figure 3-1 Uncertainty reported in the UK's Sixth National Communication for projected emission values[31]



---

[30] https://ec.europa.eu/clima/sites/clima/files/strategies/progress/monitoring/docs/ghg_projection_guidelines_a_en.pdf

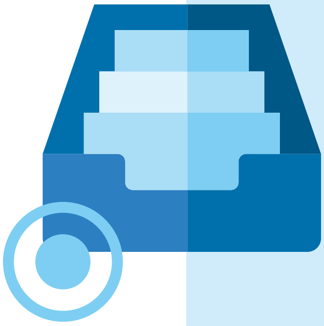
[31] https://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/uk_6nc_and_br1_2013_final_web-access%5B1%5D.pdf, adapted

3.2 Documenting and archiving the GHG projections

No matter how simplified or complex the approaches you use for your projections, or which tools you use, you will need to make a relevant number of assumptions, use data from many different sources, etc. It is important and good practice to document all data, communications, assumptions, calculations and results of the compilation of GHG projections, as well as to archive them in a safe and centrally accessible location. This will enable future compilation teams to build on this information, avoiding starting from scratch and enabling consistency with previous projections to the extent desired.

For this purpose, it is advisable to develop a short checklist of all information that needs to be documented (some documentation might already occur in the form of a GHG projection report), e.g., methodologies, assumptions, data sources, etc., and to allocate responsibilities of who should document what and when. Documenting information throughout the compilation cycle is less convenient for the team, but, ensures a more detailed documentation as information is still fresh on their minds.

Similarly, consider developing a checklist of all information to be archived. In addition to the information to be documented, this could include sheets with original data as received from data providers, communication with data providers, calculation sheets, etc. Agree on a common naming approach and clear folder structure for the archive to ensure information can be easily found in the future.



4 Refining your projection approach over time

When starting to develop GHG projections, limited resources combined with limited experience and time can make it challenging to prepare the projections at a high level of detail. In this case, countries should make the best of what is available, focussing on those categories which are most relevant to national GHG emissions or sinks of carbon. Categories can be considered relevant where they have a large share of the historical emissions in the recent years or because there is a strongly increasing trend. For a start, emissions of such categories could be projected at a moderate level of detail, while the remaining categories are projected using simplified approaches. Section 2.2 on tools for the development of GHG projections indicates which tools are more suited under which conditions – e.g., level of experience and data availability.

It is fully acceptable to start developing projections using simple approaches. As you start developing GHG projections, create an improvement plan, detailing how you plan to enhance your projections over time. These enhancements will include adding categories of GHG emission sources or sinks, gases, increasing accuracy, etc. Ideally, the plan should be developed at least for the next 2-3 compilation cycles of the GHG projections, allowing long-term planning. Additionally, you should identify specific needs for improvement and lessons learned in each compilation cycle. Document these and prioritise them when your current GHG projections have been finalised. They can then be integrated into the long-term improvement plan, guiding the improvement of the GHG projections both at the strategic and at the operational level. Think about the connections between the improvement plan for the projections and the improvement plan for the GHG inventory. Consider if methodological improvements to both the historical inventory and the projections could be synchronised. Make sure the improvement plan is appropriately archived, so it is available for future compilation cycles.

Starting simple and enhancing GHG projections over time can also relate to the models used. Section 2.2 provides information on tools more suited for countries with limited experience and/or data and on tools providing some flexibility to be used in a simpler or a more complex fashion, depending on the experience and data available. The improvement planning could include using a flexible model in a more sophisticated manner or moving from a simpler modelling tool to a more complex one. Such improvements, particularly moving to more complex models, can require considerable time, budget and human resources and thus need careful long-term planning.

Annex 1: Reporting on projections of GHG emissions and removals in the BTR

The modalities, procedures and guidelines (MPGs) under the Enhanced Transparency Framework set out reporting requirements with regards to projections of GHG emissions and removals.

Generally, all Parties must submit projections on GHG emissions and removals. Where developing countries need flexibility in light of their capacity, they are only encouraged to provide projections. This means that, while a developing country makes use of this flexibility option, the submission of GHG projections is voluntary or, if it does report them, the country is able to use less detailed methodologies – in practice this means that less comprehensive reporting requirements apply. Countries wanting to make use of flexibility options must report on the underlying capacity constrains as well as improvement planning on how to overcome these capacity constraints over time.

Specific reporting requirements for projections include:

- **Scenarios:** Parties reporting projections have to report a “with measures” scenario and can also provide a “with additional measures” and a “without measures” scenario.
- **Starting and ending years:** The projections have to start with the most recent year covered in the national GHG inventory report and extend at least 15 years beyond the next year ending in zero or five (as an example, a projection submitted in 2024 should extend until 2040 (=2025+15). A flexibility option exists: if claimed, projections have to extend at least until the end point of the NDC instead.
- **Scope by sector and gas:** Projections have to be provided for the national total, by sector, by gas and with and without LULUCF. A common metric consistent with the Party’s national GHG inventory report has to be used (e.g., Gg CO_2-eq). Where Parties need flexibility in light of their capacities, they can report a less detailed coverage.
- **Methodologies and sensitivity analysis:** Parties have to provide information on the methodology used to develop the projections, e.g., on models, changes since the last BTR, approach and results of the sensitivity analysis (this means testing how much projection results vary when key parameters are varied).

Projections must also be provided for key indicators that are being used to determine progress towards the NDC; this is a new requirement. The MPGs do not specify what key indicators should be, countries are to select the appropriate indicators. Such indicators will largely depend on the specific NDC targets set by a country. It is important to note that the MPGs mandate that projections will not be used for the specific purpose of quantitative progress tracking towards the NDC unless the Party has identified a reported projection as its baseline.

BTR reporting tables for GHG projections remain to be agreed, the MPGs mandate this to happen at COP26 at the latest. The existing Common Tabular Format (CTF) reporting tables for projections (see Table 2 below), used as part of developed countries’ biennial reporting, are likely to be considered as a starting point. These tables present historic emissions and projections in kt CO_2-eq by sector as well as by gas, including and excluding LULUCF. The CTF foresees a table each for a “with measures”, “without measures” and “with additional measures” format. While the CTF tables only present projections for 2020 and 2030, a reporting table for GHG projections as part of BTR reporting would need to allow adding further years. In line with MPG requirements (without flexibility), projections submitted in 2024 would need to cover the period 2024–2040.

Table 2 CTF Information on updated greenhouse gas projections under a "with measures" scenario.

	GHG EMISSIONS AND REMOVALS (kt CO_2eq)							GHG EMISSION PROJECTIONS (kt CO_2eq)	
	Base year	1990	1995	2000	2005	2010	20XX-3	2020	2030
Sector									
Energy									
Transport									
Industry/industrial processes									
Agriculture									
Forestry/LULUCF									
Waste management/waste									
Other (specify)									
Gas									
CO_2 emissions including net CO_2 from LULUCF									
CO_2 emissions excluding net CO_2 from LULUCF									
CH_4 emissions including CH_4 from LULUCF									
CH_4 emissions excluding CH_4 from LULUCF									
N_2O emissions including N_2O from LULUCF									
N_2O emissions excluding N_2O from LULUCF									
HFC's									
PFC's									
SF_6									
Other (specify, e.g., NF_3)									
Total with LULUCF									
Total without LULUCF									

Annex 2: Tool selection limitations

There are several points to consider when planning projections modelling and determining which software to use:

SIMPLICITY

The more detailed a model/
set of models[32] becomes:

- More data is needed.
- Development, maintenance, running and analysis of the model/s becomes more expensive.
- Harder to integrate the models and maintain a level of consistency between them.

DESIRED FUNCTIONS

As we have explored already, different model types have different intended uses. Some have very niche use cases. Understanding exactly what output you are looking for is the first key question.

RESOURCES AND EXPERTISE

Depending on the modelling approach, the software chosen and the degree of complexity, the resource intensity of projections compilation can vary greatly. There can be a desire to use the most sophisticated modelling approach available, but care should be taken to select an approach that best uses the local knowledge, expertise and skills available. This local knowledge will be invaluable in helping to understand the uncertainty surrounding the inputs and therefore working to reduce it. See Section 3.1 for more on uncertainty.

DATA AVAILABILITY (INCLUDING SCOPE: SECTORAL, TECHNOLOGICAL, AND TIME HORIZON)

Directly related to the resource and expertise available is the data available. As mentioned before, greater detail does not necessarily improve the quality of projections if the data becomes more uncertain. The level of disaggregation, model type and approach pursued should be guided by the specificity and the type of the data that is available.

COST

There are two primary cost components:

1. Cost of the modelling software
    - Careful consideration should be paid to whether it requires a license fee, one-off payment or is free to use.
    - Hardware requirements should also be considered, additional hardware might be required or cloud storage which come with additional costs.
2. Cost of the work itself

Data sourcing should be mapped so there is a thorough understanding of likely timescales and costs.

---

[32] https://www.africaportal.org/publications/guidelines-for-the-selection-of-long-range-energy-systems-modelling-platforms-to-support-maps-processes/

Annex 3: Key activity drivers for a simplified approach to projections calculations

An overview of activity drivers used for the modelling of GHG projections is provided in Table 3 below. The cross-cutting drivers have been taken from the key parameters used for the European Union's GHG projections and the sectoral drivers have been taken from the New Climate Institute's PROSPECTS+ tool guidance document.

The PROSPECTS+ tool guidance document offers users two approaches to GHG projections modelling, a simplified and non-simplified approach. The activity drivers suggested for the simplified approach are presented here. A more simplified approach does not necessarily mean a less accurate outcome, as when activity drivers become more complex the uncertainty increases as well. The importance of uncertainty is explained in more depth in Section 3.1.

The activity drivers presented here are divided by sector (see further explanation below). Additionally, for each activity driver, further information is provided:

- **Activity driver input:** The formatting of the information presented in this column is as such where the first part of the datapoint is the main activity driver input, i.e. the name of the datapoint itself. The second part, in parentheses and grey font, highlights the input needed to understand how this datapoint changes over time.
- **Data source:** This column contains examples of relevant institutions in-country that could provide this datapoint for the generation of projections.

Alternative proxy data source: This column offers examples of international organisations and organisations with international datasets that could provide proxy datasets that could be used as inputs for projections. These organisations are examples of relevant organisations, not recommendations. These datasets are likely to be less accurate. However, so long as that uncertainty is well understood, they can help to ensure the projection methodology is complete.

The table organises the activity drivers by sectors of the economy. The Intergovernmental Panel on Climate Change (IPCC) also categorises sources of emissions into sectors of the economy (energy, IPPU, AFOLU, waste), and these categories are the international standard for the reporting of those emissions. For the activity drivers of projections, an equivalent standard does not exist. Aligning the categories of the activity drivers with the IPCC sectors must be carefully considered to ensure transparent and accurate reporting.

The IPCC's is a production-based accounting methodology, whereas the activity drivers of projections calculations can be both production (supply-side) and consumption (demand-side). For example, "buildings" is a key category to consider when developing emissions projections. It refers to the consumption of energy in order to heat, cool and power both commercial and residential buildings. However, as the IPCC is production-based, not consumption-based, this activity is not neatly-captured in one sub-sector. To illustrate, the generation of electricity is captured under category "1A1a main activity electricity and heat production", while the consumption of fuel directly within buildings is captured under the category of "1A4 other sectors" in two sub-categories: "1A4a commercial/institutional" and "1A4b residential". To help with the alignment of activity drivers' sectors and IPCC sectors, the relevant IPCC categories have been provided for each sector of activity driver.

Table 3 Key activity drivers for a simplified approach to projections calculations

KEY DRIVERS[33] [34] ACTIVITY DRIVER INPUT (input for change over time)	DATA SOURCE	ALTERNATIVE PROXY DATA SOURCE
CROSS-CUTTING		
Gross Domestic Product (GDP)	Treasury, Statistics Bureau	World Bank, Organisation for Economic Cooperation and Development (OECD)
Gross Value Added (GVA)	Treasury, Statistics Bureau	
Population	Statistics Bureau	
International (wholesale) fuel import prices (coal, gas, oil)	Ministry of Energy, national energy company, Statistics Bureau	
Exchange rates	Treasury, Statistics Bureau	
Carbon price	Ministry of Environment, Ministry of Energy, treasury, Statistics Bureau	
ENERGY IPCC categories: 1A1 Energy Industries, 1B Fugitive emissions from fuels		
Emissions intensity by fuel type (change over time)	Ministry of Energy, national energy company, Statistics Bureau	International Energy Agency (IEA)
Electricity generation by fuel type (fuel mix over time)		
Electricity needed for energy industries own use (share of total electricity generation over time)		
Losses (Transmission & Distribution) (share of losses of total electricity generation over time)		
Imports (share of total electricity generation over time)		
Exports (share of total electricity generation over time)		
Heat generation by fuel type (fuel mix over time)		
Heat needed for energy industries own use (share of total heat generation over time)		
Losses (Transmission & Distribution) (share of total heat generation over time)		

---

[33] European Topic Centre on Climate Change Mitigation and Energy. 2019. Analysis of Member States' 2019 GHG projections. Submitted under Article 14 of the EU Monitoring Mechanism Regulation (EU) No 525/2013. Eionet Report – ETC/CME 2019/6

[34] https://newclimate.org/2018/11/30/prospects-plus-tool/

KEY DRIVERS		
ACTIVITY DRIVER INPUT (input for change over time)	DATA SOURCE	ALTERNATIVE PROXY DATA SOURCE
TRANSPORT IPCC categories: 1A3 Transport		
Number of passenger-kilometres (all modes)	Ministry of Transport, Statistics Bureau	International Council on Clean Transportation (ICCT), International Civil Aviation Organisation (ICAO), International Maritime Organisation (IMO)
Freight transport tonnes-kilometres (all modes)		
Fuel consumption (energy demand by fuel type) by mode		
Overall transport sector: total direct energy demand (total growth rate)		
Overall transport: Fuel mix direct energy use		
Overall transport: Total electricity demand		
BUILDINGS IPCC categories: 1A1a Main Activity Electricity and Heat Production, 1A4a Commercial/Institutional and 1A4b Residential		
Number of households	Local government, Statistics Bureau	International Energy Agency (IEA)
Household size		
Total floor space		
Total direct energy demand (Total direct energy per capita intensity growth rate)		
Fuel mix direct energy use (share over time)		
Total electricity demand (Total electricity per capita intensity growth rate)		
INDUSTRY (CEMENT PRODUCTION) IPCC categories: 1A2 Manufacturing Industries and Construction, 2A1 Cement Production		
Cement production (growth rate)	Ministry of Commerce, Statistics Bureau, industry associations	United States Geological Survey (USGS), Cement Sustainability Initiative, International Energy Agency (IEA), United Nations Framework Convention on Climate Change (UNFCCC)
Electricity intensity of cement production (growth rate)		
Direct energy intensity of clinker production (growth rate)		
Direct energy fuel mix (share over time)		
Process emissions		
Emissions captured with CCS (% captured over time)		

KEY DRIVERS		
ACTIVITY DRIVER INPUT (input for change over time)	DATA SOURCE	ALTERNATIVE PROXY DATA SOURCE
INDUSTRY (STEEL PRODUCTION) IPCC categories: 1A2 Manufacturing Industries and Construction, 2C1 Iron and Steel Production		
Steel production (growth rate)	Ministry of Commerce, Statistics Bureau, industry associations	World Steel Association, International Energy Agency (IEA)
Direct energy fuel mix (% share over time)		
Direct energy emissions intensity of coke (growth rate)		
Electricity intensity of total steel production		
Emissions captured with Carbon Capture and Storage (% captured over time)		
INDUSTRY (OIL AND GAS) IPCC categories: 1A1, Energy Industries, 1A2 Manufacturing Industries and Construction, 1B Fugitive emissions from fuels		
Total production of oil and gas (growth rate)	Ministry of Commerce, Statistics Bureau, industry associations	International Energy Agency (IEA), European Commission Joint Research Centre (JRC), Netherlands Environmental Assessment Agency (PBL), National Oceanic and Atmospheric Administration (NOAA)
Fugitive emissions (growth rate)		
Amount of gas flared (flaring ratio)		
AGRICULTURE, FORESTRY AND LAND USE IPCC categories: 1A4c Agriculture/Forestry/Fishing/ Fish Farms, 3A1 Enteric Fermentation, 3A2 Manure Management, 3B Land, 3C Aggregate sources and non-CO_2 emission sources on land		
Direct energy use in agriculture (and forestry)	Ministry of Agriculture, Ministry of Environment, Statistics Bureau	Food and Agriculture Organisation of the United Nations (FAO)
Electricity use in agriculture (and forestry) (electrification rate)		
Direct energy fuel mix (% share over time)		
Total gross value added (GVA) of agriculture (growth rate)		
Livestock: Dairy cattle, non-dairy cattle, sheep, pig, poultry		
Nitrogen input from application of synthetic fertilisers		
Nitrogen input from application of manure		
Nitrogen fixed by N-fixing crops		
Nitrogen in crop residues returned to soils		
Area of cultivated organic soils		

KEY DRIVERS ACTIVITY DRIVER INPUT (input for change over time)	DATA SOURCE	ALTERNATIVE PROXY DATA SOURCE
WASTE IPCC categories: 4A Solid Waste Disposal, 4B Biological Treatment of Solid Waste, 4D Wastewater Treatment and Discharge		
Municipal solid waste (MSW) generation (growth rate)	Local government, Statistics Bureau, waste operators	Organisation for Economic Cooperation and Development (OECD) and Food and Agriculture Organisation of the United Nations (FAO)
Municipal solid waste (MSW) going to landfills (change over time)		
Share of CH4 recovery in total CH4 generation from landfills (change over time)		
Amount of wastewater generated (growth rate)		
Wastewater treatment rate (change over time)		

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

Friedrich-Ebert-Allee 36 + 40
53113 Bonn, Germany
T +49 228 44 60-0
F +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1 - 5
65760 Eschborn, Germany
T +49 61 96 79-0
F +49 61 96 79-11 15

E info@giz.de
I www.giz.de