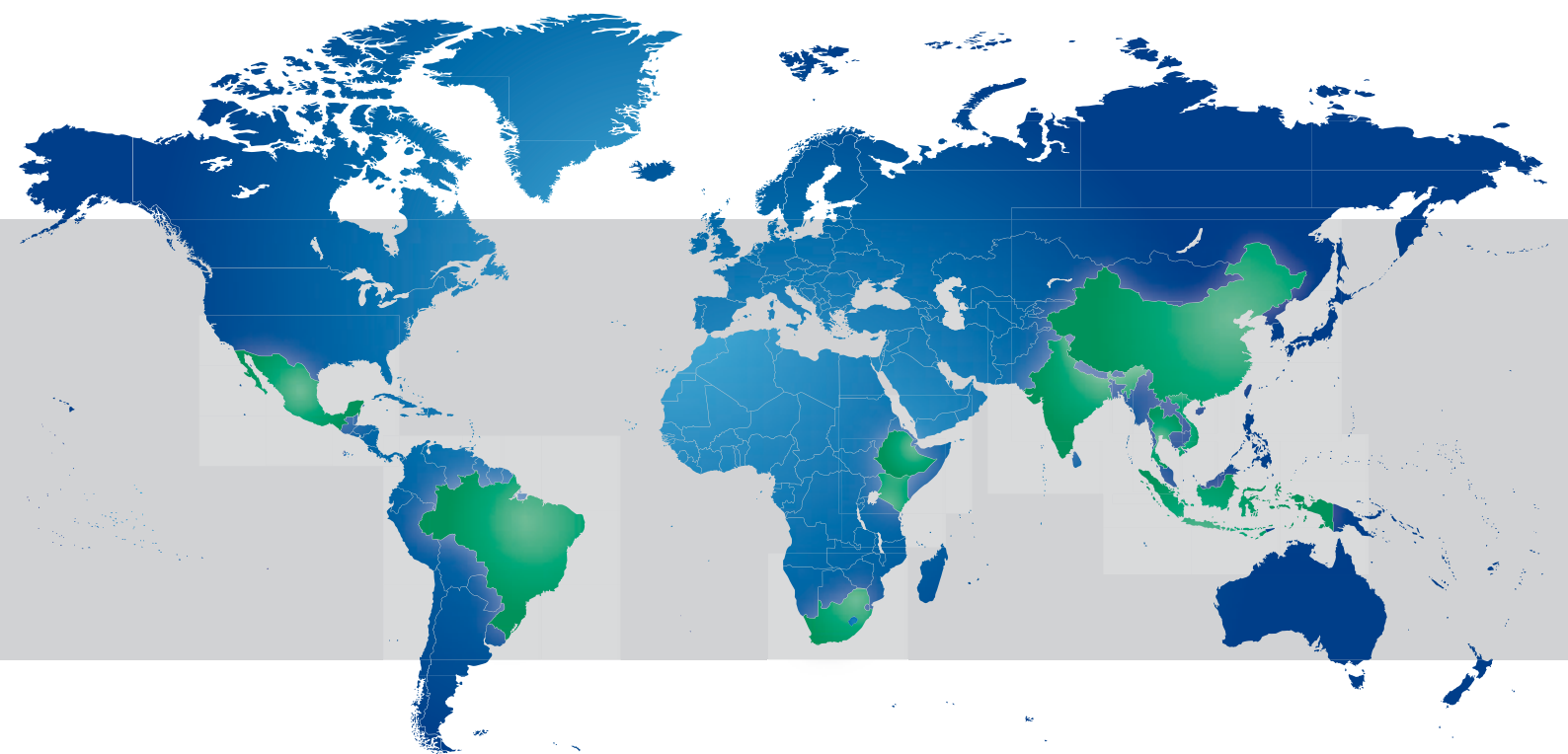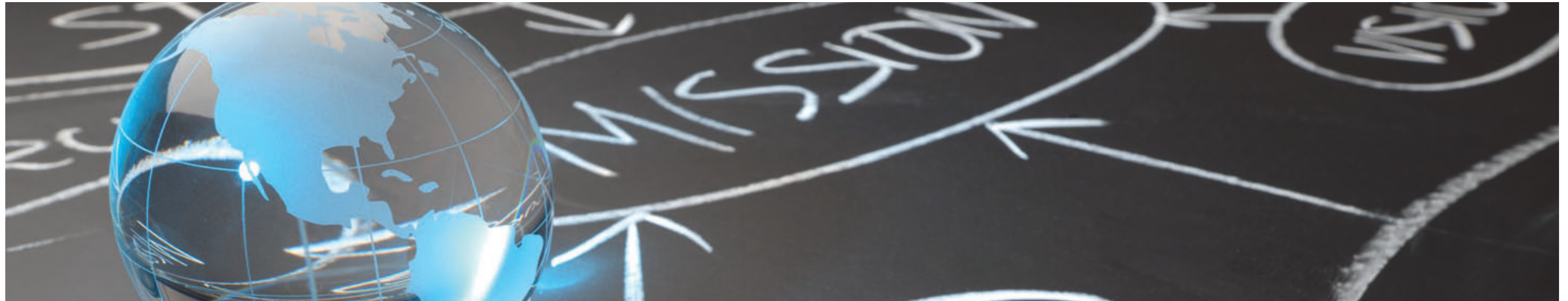# National Greenhouse Gas Emissions Baseline Scenarios

Learning from Experiences in Developing Countries

A report by the Danish Energy Agency, the Organisation for Economic Co-operation and Development and the UNEP Risø Centre, based on contributions from experts in Brazil, China, Ethiopia, India, Indonesia, Kenya, Mexico, South Africa, Thailand and Vietnam

DANISH ENERGY AGENCY

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BETTER POLICIES FOR BETTER LIVES

UNEP RISØ CENTRE
ENERGY, CLIMATE AND SUSTAINABLE DEVELOPMENT

Foreword

Successful policy-making hinges on robust analysis of expected future developments. Planning for climate change policy is no exception: understanding likely future trends in greenhouse-gas emissions is important not only for domestic policy-making but also for informing countries' positions in international negotiations on climate change. To this end, many countries have developed scenarios describing plausible future trends in emissions. Generally, the most important among these scenarios is the baseline or business-as-usual scenario, which aims to characterise future emissions on the assumption that no new climate change policies will be adopted.

Greenhouse gases are emitted as a result of many different types of economic activity. As a result, preparing emissions scenarios involves making decisions and assumptions concerning many different underlying drivers of emissions, ranging from political factors to the type of modelling tools used. Such decisions are often governed by constraints on resources, including skills, information and funding. Naturally, these constraints, and how they affect climate change policy-making, vary from country to country.
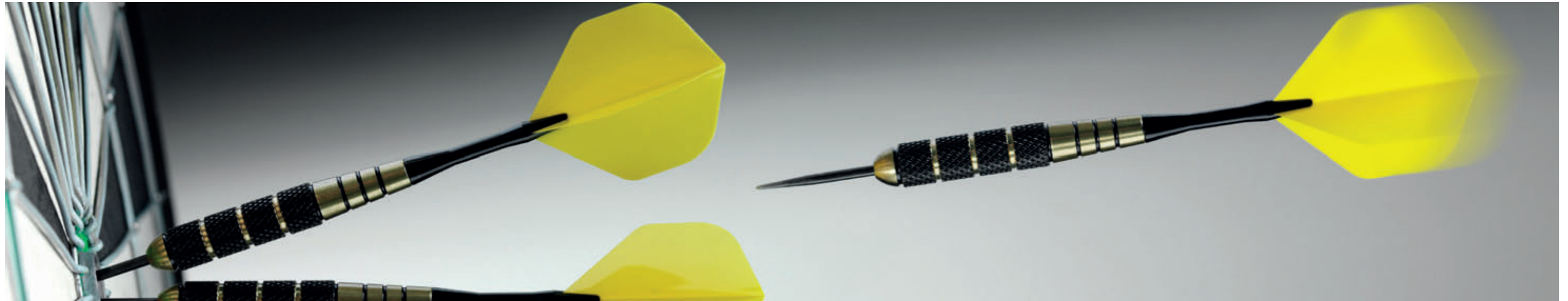
It is not surprising, therefore, that existing approaches to developing national baseline scenarios are highly disparate. Yet this diversity is increasingly at odds with developments in the international negotiations under the United Nations Framework Convention on Climate Change. Since 2011, emissions reduction pledges put forward by Parties are formally recognised under the Convention. Some Parties have pledged quantified emissions reductions and actions for 2020 relative to their baseline scenario. This means that the expected magnitude of the overall global mitigation effort and, hence, the likelihood of achieving the agreed goal of limiting global warming to 2°C, depends in part on the way those baseline scenarios are calculated. Consequently, improving international understanding of those scenarios and achieving a minimum level of comparability is important.

While perhaps desirable from the point of view of the international climate change regime, the establishment of universally-applicable guidelines for developing baseline scenarios is likely to be technically difficult and politically challenging. Given these constraints, this report aims rather to contribute to a better understanding of the issues and challenges involved in drawing up baseline scenarios, by documenting and drawing lessons from the breadth of existing practices in a range of countries. This existing diversity is both a key asset for gradually increasing the robustness of baseline scenarios, but also the reason for a lack of comparability. We hope that this work shows the value of improving transparency in baseline scenarios and we invite governments and other stakeholders to continue to share experiences in this area.

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Acknowledgements

Table of Contents

Key terminology

Base year: An historical year which marks the transition from emissions estimates based on an inventory to modelling-based estimates of emissions volumes. In many countries the base year coincides with the latest year for which emissions inventory data are available. In other instances, there may be a gap of a few years between the latest year for which inventory data are available and the initial year for which projections are made.

Exclusion criteria: A sub-set of assumptions concerning policies or technologies which, while feasible in principle, are ruled out on ideological or economic grounds.

Existing policies: Existing policies are those that have been legally adopted by a certain cut-off date. Some policies that have been implemented before the cut-off date may have had an impact on emissions before that date, while others may only have an impact later on.

Forecast: A projection to which a high likelihood is attached.

Model: A schematic (mathematical, computer-based) description of a system that accounts for its known or inferred properties. The terms 'model' and 'modelling tool' are used interchangeably in this publication.

Projection: Estimates of future values for individual parameters, notably those that are key drivers of emissions in a scenario.

Reference year: Year against which emissions reduction pledges are measured. This could be a past year (for example, 1990 in the case of the European Union's commitment under the Kyoto Protocol) or a future year (as is the case for those non-Annex I countries that have defined their pledge relative to a baseline scenario).

Scenario: A coherent, internally consistent and plausible description of a possible future state of the world given a pre-established set of assumptions. Several scenarios can be adopted to reflect, as well as possible, the range of uncertainty in those assumptions.

- **Baseline scenario**: A scenario that describes future greenhouse-gas emissions levels in the absence of future, additional mitigation efforts and policies. The term is often used interchangeably with business-as-usual scenario and reference scenario.

- **Mitigation scenario**: A scenario that describes future emissions levels taking account of a specified set of future, additional mitigation efforts and policies.

Acronyms

BaU: Business-as-Usual

CCXG: Climate Change Expert Group (a group of government delegates and experts from OECD and other industrialised countries)

CETA: Carbon Emissions Trajectory Assessment (a model)

CGE: Computable General Equilibrium (a type of model)

CO$_2$e: Carbon dioxide equivalent (a unit of measurement)

COMAP: Comprehensive Mitigation Assessment Process (a model)

COP: Conference of the Parties to the United Nations Framework Convention on Climate Change

DEA: Danish Energy Agency

EFOM: Energy Flow Optimisation Model

ERC: Energy Research Centre (University of Cape Town, South Africa)

ERI: Energy Research Institute (China)

GDP: Gross Domestic Product

GHG: Greenhouse Gas

Gt: Gigatonne

GW: Gigawatt

IEA: International Energy Agency

IPAC: Integrated Policy Model for China

IPCC: Intergovernmental Panel on Climate Change

LEAP: Long-range Energy Alternative Planning System (a modelling framework)

LULUCF: Land Use, Land Use Change and Forestry

LUWES: Land Use Planning for loW Emissions development Strategy (a decision support tool)

MAC: Marginal Abatement Cost

MAED: Model for Analysis of Energy Demand

MAPS: Mitigation Action Plans and Scenarios (a multi-country programme)

MARKAL/TIMES: MARKet ALlocation / The Integrated Markal/Efom System (a model in its first – MARKAL – and second – TIMES – generation versions)

MEDEE: Long-term Demand Prospective Model

MESSAGE: Model for Energy Supply Strategy Alternatives and their General Environmental impact

MW: Megawatt

NAMAs: Nationally Appropriate Mitigation Actions

NEMS: National Energy Modelling System (an economic and energy model)

NGO: Non-Governmental Organisation

OECD: Organisation for Economic Co-operation and Development

POLES: Prospective Outlook on Long-term Energy Systems (a model)

PPP: Purchaising Power Parities

REDD: Reduced Emissions from Deforestation and forest Degradation

RESGEN: Regional Energy Scenario Generator Module (a model)

SGM: Second Generation Model

TERI: The Energy and Resources Institute (India)

UFRJ: Federal University of Rio de Janeiro

UN: United Nations

UNEP: United Nations Environment Programme

UNFCCC: United Nations Framework Convention on Climate Change

URC: UNEP Risø Centre

WEM: World Energy Model

Main findings

The following summary highlights the key findings of the main content of Part 1, Chapters 1-5. The authors' reflections on good practice for baseline setting can be found in Chapter 6 and are not summarised here. Throughout the document, mention of national experiences refers only to the ten countries contributing to this publication.

Chapter 1: Introduction

- A national emissions baseline scenario aims to inform decision makers about how greenhouse-gas (GHG) emissions are likely to develop over time under certain given conditions. Even if developed primarily for national policy-planning purposes, baselines can also be important in an international context.

- Within the context of the international climate change negotiations, some developing countries have defined their mitigation actions on the basis of deviations from their baseline scenarios. Five of the ten participating countries – Brazil, Indonesia, Mexico, South Africa and Vietnam – fall into this category. In these countries, the model and assumptions behind the baseline affect the resulting targeted emissions reduction levels, making these baselines particularly important for climate change negotiations.

- For all developed and developing countries (irrespective of the type of pledge), baseline scenarios are valuable for planning purposes, including to support the design of energy and climate change policy and investment decisions.

- There is currently no international guidance on how to develop baseline emissions scenarios and there is no explicit requirement for developing countries to report on emissions baselines.

- The ten countries differ widely in their sources of GHG emissions. For some countries, the energy sector is the most important emissions sector, while for others the land-use sector and/or the agricultural sector dominates the emissions picture.

Chapter 2: Model choice and use

- The choice of modelling tool used to prepare baseline scenarios tends to be driven by a trade-off between performance (in the form of sophistication and anticipated accuracy) and resources available (including human capacities and data availability). Familiarity with the tool, ease-of-use and financial and technical assistance from other, more experienced countries,

all contribute to shaping decisions on model choice. In general, resource constraints often play a dominant role in model selection in the participating countries.

- To model energy sector emissions, most participating countries rely on bottom-up models, which provide a fairly detailed representation of the energy system, albeit at the expense of a more complete representation of macroeconomic trends and feedbacks. Few countries use simple extrapolation top-down models. Hybrid models can combine elements of top-down and bottom-up models to overcome the limitations of both types, but are often complex to build. The onerous requirements of hybrid models, in terms of both data and expertise, seem to make them difficult to apply in most countries; at the moment, only China, India and South Africa, among the ten participating countries, use them.

- In general, most countries use existing models to develop their baseline scenarios. One reason for this is that developing a model from scratch is demanding and resource-intensive, and there is no guarantee that the model will be better than an existing alternative. Some countries tailor existing tools to satisfy their specific needs. Mexico previously used a fully purpose-made model.

- One might expect that countries whose land-use sector emissions account for a large proportion of national emissions would have a stronger interest in investing in building modelling capacity in this area. However, experience suggests that availability of existing tools and processes, as well as resource constraints, are the main determinants of the sophistication of the modelling approach used. One reason for this may be the inherent uncertainty that charcaterises the modelling of emissons from the land-use sector: beyond a certain level of complexity, the incremental effort needed to enhance the output appears to be significant.

- Baseline scenarios are not an end in themselves: they support broader national and often international processes. As a result, the process of setting baseline scenarios is inevitably governed by the institutional arrangements put in place to implement those broader processes. These arrangements may have been designed with other purposes in mind and so may not

be best adapted to the task of preparing a baseline scenario. Increased awareness about the importance of baselines, coupled with stronger political mandates, and increased experience and resources, could help improve governance arrangements and enhance inter-agency cooperation.

Chapter 3: Assumptions and sensitivity analyses

- There is no commonly-agreed definition of baseline scenario. It is defined in this report as "a scenario that describes future greenhouse-gas emissions levels in the absence of future, additional mitigation efforts and policies". In principle this could include either scenarios that eliminate effects of all climate policies or scenarios that model effects of existing climate policies (but in both cases excluding possible future policies). Which policies are considered 'existing' can have a great impact on the resulting emissions baseline scenario.

- Most countries include the estimated effects of some existing policies in their baselines. The selection of which policies to include is not necessarily restricted to climate change policies, because policies implemented on grounds other than climate change mitigation can have an impact on emissions levels. Worth noting is South Africa's choice to develop two baseline scenarios – one with existing policies and a second, no-policy scenario. The government of South Africa adopted the latter as its official baseline (using a range, rather than a single point estimate for each year).

- How to select 'existing policies' and how to model the impacts of any one approach ('no policies' or 'only existing policies') are key questions, in that the choices made greatly influence the results of the analysis. Given the wide range of possible answers to these questions, combined with the lack of commonly-agreed approaches in this area, clarity on the steps taken in the analysis will be crucial to understand the meaning of baseline scenarios.

- Exclusion criteria are a sub-set of assumptions concerning policies or technologies which, while in principle feasible, are ruled out on ideological or economic grounds. Implicitly or explicitly, all countries introduce exclusion criteria in their baselines. For example, cost

minimisation is central to the modelling approach used in India and South Africa. Baseline scenarios seldom depart from established technologies and often introduce cost constraints, which are in themselves exclusion criteria.

- The choice of base year (or start year) for the baseline scenario depends on both technical and political considerations. Agreement on which criteria are to guide the choice of base year could be helpful, recognising that there can be valid reasons for choosing different base years in different countries. Choosing a year in which emissions in the country departed from the trend in previous years can mask the likely evolution of emissions in the future.

- Only one participating country (Mexico) has made legal provisions for regularly revising the baseline scenarios as well as mitigation trajectories. Those provisions specify a time period for revision and update and define circumstances that may trigger a more frequent review.

- Key modelling assumptions regarding socio-economic and other factors driving projections may be politically-determined. Among the most critical assumptions are estimated changes in gross domestic product (GDP), population, energy prices and the sectoral composition of national income. For some countries, these assumptions are based on government targets, notably GDP targets. However, these assumptions may not always correspond to 'the most likely' outcome.

- Most countries use national data sources for key drivers such as GDP, population and energy prices, rather than datasets available internationally (from, for example, the United Nations Population Division, the World Bank, the OECD or the IEA).

- Sensitivity analyses assess the uncertainty of the output of a model with respect to its inputs, thus providing an indication of the robustness of model outputs. Generally, the extent of sensitivity analyses carried out to date has been limited, though baseline developers do recognise the importance of sensitivity analysis. Sensitivity analysis for GDP growth assumptions is critical (especially for some sectors) and deserves special scrutiny. Further, while uncertainty of land-use

sector emissions estimates can be high, sensitivity analyses have not been used to estimate the resulting potential impacts on baseline scenarios.

Chapter 4: Data management

- Data management issues are important for many aspects of baseline-scenario development, as is the completeness of the national emissions inventory. In addition to problems with basic data availability, a key challenge is to reconcile existing data collection frameworks with the IPCC source categories. If data are unavailable, scenarios must rely on assumed growth trends.

- The accuracy of emissions factors used in baseline calculations differs greatly among countries. Given the difficulty of calculating country-specific emissions factors for all sectors, many countries use default IPCC emissions factors. In countries such as Brazil, with long experience of emissions modelling, country-specific emissions factors are used. In other countries, country-specific emissions factors are often developed only for certain high-emissions sectors (as is the case in Vietnam and Thailand, for example). Preparing country-specific emissions factors is a resource-intensive task.

- The inventory included in a country's most recent national communication to the UNFCCC may not contain the latest data available (as countries may update their inventory more regularly than they report to the UNFCCC). In some baseline scenarios, the base year coincides with the latest year for which emissions inventory data are available; in other cases, the base year itself is modelled. In the latter case, countries are in effect estimating emissions levels for that base year. How well this can be done depends on the quality of historical emissions data. Clarity on the approach taken is crucial for understanding the baseline scenario

- Several of the participating countries have established a coordinating committee or working group to organise and allocate the inter-agency work related to national climate change mitigation policies. Besides fulfilling an administrative role, such a framework can help to ensure political support in the different governmental agencies. Without this, the lack of international

guidance on baseline-setting means that it is left to resource-constrained government agencies to decide on the myriad options involved in baseline development, often in the absence of a coherent overview.

- Data management presents a challenge for most participating countries. Chief amongst those challenges is lack of high quality data. Improving data accuracy represents an ongoing concern for most countries; some countries rely on international assistance to improve practices and standards.

Chapter 5: Transparency and inclusiveness in baseline setting

- Although not all countries state transparency and international credibility as specific objectives when setting a baseline, there is broad acknowledgement among the participating countries that these are key concerns. Accordingly, in the process of developing their baseline, countries have made available varying levels of information regarding the assumptions chosen for the preparation of the baseline.

- Countries have had varying experiences with stakeholder consultation in the baseline development process, including the extent to which stakeholders (notably industry, civil society, labour and government) are consulted and at which stage in the process. The stakeholder-consultation process conducted in South Africa during the preparation of its Long Term

Mitigation Scenarios was particularly comprehensive. Mexico is planning an extensive stakeholder consultation.

- International review of national baselines can be a politically sensitive matter. Informal peer reviews can be one way around this difficulty. By increasing transparency, peer review can add to both the robustness and credibility of the baseline. South Africa is the first of the participating countries to have conducted this type of peer review.

- Some participating countries note that there are benefits from comparing and understanding differences across various studies on baselines for the same country, whether they are domestic or international studies. For example, the government of India commissioned five different baseline studies, to benefit from the different approaches each study followed.

- International peer review can be particularly beneficial when it is conducted in an open manner, with participating parties having access to each other's data and models. Besides, analysing a national baseline against an international background can shed new light on key international developments of relevance to that national baseline (for example, it can help understand the sensitivity in demand for fossil fuels due to changes in GDP in different regions).

Chapter 1: Introduction

This report reviews national approaches to preparing baseline scenarios of greenhouse-gas (GHG) emissions. It does so by describing and comparing in non-technical language existing practices and choices made by ten developing countries – Brazil, China, Ethiopia, India, Indonesia, Kenya, Mexico, South Africa, Thailand and Vietnam. The review focuses on a number of key elements, including model choices, transparency considerations, choices about underlying assumptions and challenges associated with data management. The aim is to improve overall understanding of baseline scenarios and facilitate their use for policy-making in developing countries more broadly.[1]

The findings are based on the results of a collaborative project involving a number of activities undertaken by the Danish Energy Agency, the Organisation for Economic Co-operation and Development (OECD) and the UNEP Risø Centre (URC), including a series of workshops on the subject (Box 1). The ten contributing countries account for approximately 40% of current global GHG emissions[2] – a share that is expected to increase in the future. The breakdown of emissions by sector varies widely among these countries (Figure 1). In some countries, the energy sector is the leading source of emissions; for others, the land-use sector and/or agricultural sector dominate emissions.

The report underscores some common technical and financial capacity gaps faced by developing countries when preparing baseline scenarios. It does not endeavour to propose guidelines for preparing baseline scenarios. Rather, it is hoped that the report will inform any future attempts at preparing such kind of guidelines.

1. This report does not cover project or sector-level baselines (for example, for a project to recover methane from landfills, or to increase the use of renewable energy for electricity generation), which are common to offset-based carbon markets.
2. Based on total GHG emissions in 2010 as estimated in the IEA's World Energy Outlook 2012.

Figure 1: Emissions and sinks in participating countries
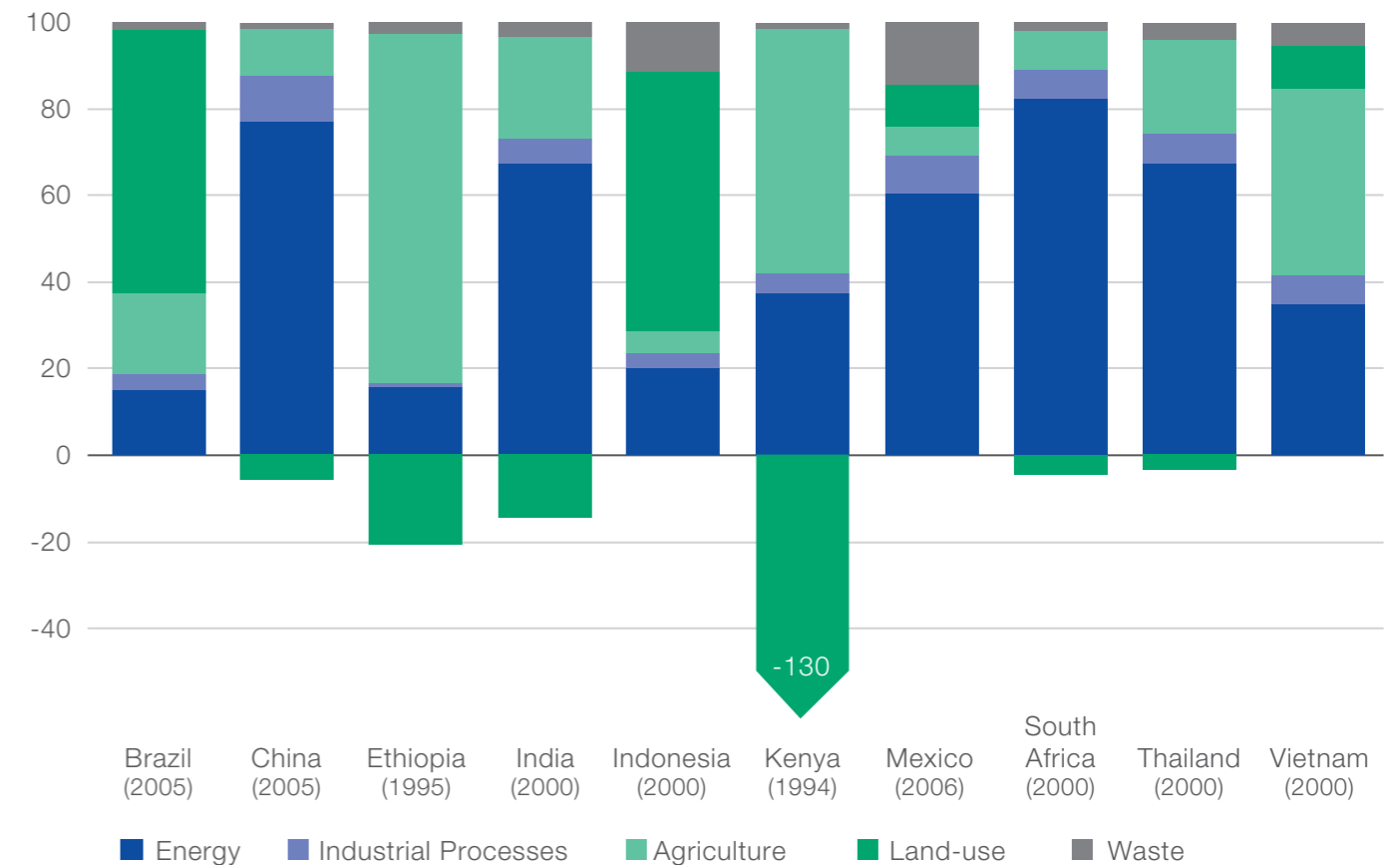
Note: This figure is indexed to highlight the different emissions compositions in the ten countries. The indexation is done by setting the sum of emissions (excluding sinks) to 100. The differences in absolute size in emissions across the countries are not visible here.
Source: National Communications to the UNFCCC.

Box 1
Origins of this report

In 2011, the DEA invited five developing countries – Ethiopia, Kenya, Mexico, South Africa and Vietnam – to share information on how they had prepared their national GHG emissions baseline scenarios. At the same time, the OECD was working on the development of baseline scenarios under the aegis of the Climate Change Expert Group (CCXG).

It was decided to bring these two activities together by organising a series of workshops in 2011 and 2012. The

UNEP Risø Centre joined the collaborative project at this point, to provide additional technical expertise. As the workshops progressed, experts from five other countries – Brazil, China, India, Indonesia and Vietnam – joined the project, bringing the final list of participating countries to ten. The countries shared existing practices and challenges they have faced in establishing their baseline scenarios. More background information about the collaboration can be found in the appendix.

The report does not address practices in developed countries. However, some of the participating countries suggested that future work on best practices in preparing national baseline scenarios should take into account experience in developed countries as well.

Role of baseline scenarios

We define baseline scenario as a scenario that describes future GHG emissions levels in the absence of future, additional mitigation efforts and policies.[3] Baseline scenarios are used routinely to support domestic policy planning as well as to inform national positions in international climate-change negotiations. In recent years national baselines have grown in importance in the context of the United Nations Framework Convention on Climate Change (UNFCCC), as some developing countries have defined their mitigation pledges in terms of reductions from their respective baselines. As a result, the strength of overall efforts to reach the internationally-agreed mitigation target of limiting global warming to 2°C is indirectly linked to the reliability of national baseline scenarios.[4]

Against this background, there is growing interest in both understanding and improving approaches to calculating baseline scenarios. There is little guidance available to aid this process, particularly for developing countries. Guidelines exist for the preparation of National Communications by parties to the UNFCCC, as well as for compiling the forthcoming biennial update reports (Box 2). However, no specific guidelines or protocols are available to assist countries in preparing their national baseline scenarios.

Box 2
UNFCCC guidelines relevant for reporting by non-Annex I parties

Guidelines for national communications
(Decision 17/CP.8)

- Protocols for the compilation of national GHG inventories, including inventory year, tier methods, default emissions factors, activity data, key category analysis and sectoral approaches, gases and global warming potentials.

- Protocols for describing programmes containing measures to mitigate climate change.

Guidelines for biennial update reports
(Decision 2/CP.17)

- Protocols for the compilation of the national GHG inventory report.

- Protocols for describing mitigation actions, including quantitative goals; methodologies and assumptions; objectives of the actions; progress of implementation; information on international market mechanisms; monitoring, reporting and verification arrangements; financial, technology and capacity-building needs; and support received.

In addition, the sixth compilation and synthesis of national communications from non-Annex I parties to the UNFCCC (FCCC/SBI/2005/18/Add.3) includes information about expected GHG abatement, mitigation opportunities, examples of measures implemented or planned by developing countries and indications of the financial resources required to implement identified measures or projects.

Source: presentation by Dominique Revet (UNFCCC Secretariat) at a side event held in Bonn on 15th May 2012.

Relevant existing literature

Preparing baseline emissions scenarios invariably involves the use of energy and emissions modelling techniques. For many years, researchers, governments and international organisations have been working to develop and improve these techniques. This report does not aim to provide a comprehensive overview of the subject, so a full academic literature review is not included. Few reports have focused specifically on national baseline scenario development. Some relevant works include:

- *In-depth reviews on national communications*, by the UNFCCC secretariat.[5]

- *Greenhouse gas emission projections and estimates of the effects of measures: moving towards good practice*. A 1998 OECD information paper aimed to identify good practices in the preparation of greenhouse-gas emissions projections in Annex I countries.[6]

- *Projecting Emissions Baselines for National Climate Policy: Options for Guidance to Improve Transparency*, by C. Clapp and A. Prag. A 2012 OECD/IEA information paper providing options and elements for guidance and potential future guidelines in baseline development (published under the CCXG).[7]

- *Developing Baselines for Climate Policy Analysis*, by E. A. Stanton and F. Ackerman. A 2011 UNEP document prepared as a part of an initiative aimed to support long-term planning for climate change, which included guidance on baseline scenario development.[8]

Related initiatives

Complementing the work leading to this report, two other international initiatives may be of interest to countries seeking to improve how they go about preparing their baseline scenario:

- **The Mitigation Action Plans and Scenarios (MAPS) programme**. This programme aims to share best practices on low-carbon transition planning and scenario development, including preparing baseline scenarios. It is a collaborative effort involving developing countries, led by the University of Cape Town's Energy Research Centre in partnership with SouthSouthNorth, a network organisation. The programme is active in five Latin American countries: Argentina, Brazil, Chile, Colombia and Peru.[9]

- **The Mitigation Accounting Initiative**. Launched by the World Resources Institute in 2012, this multi-stakeholder initiative seeks to develop voluntary guidelines to increase the consistency and transparency with which a wide array of stakeholders, including governments, account for GHG reductions arising from specific mitigation actions and goals. These guidelines include recommendations for developing baseline scenarios.[10]

While both initiatives are dealing with baseline scenarios, it is not their exclusive focus. Furthermore, a number of other initiatives are also relevant to baseline scenario development, including the following: the Low Emissions Development Strategies Global Partnership (LEDS GP), the Green Growth Best Practices (GGBP) Initiative, and the World Bank's Partnership for Market Readiness (PMR).

Structure of the report

The report is organised in two parts. Part 1 comprises this introduction, four analytical chapters and a final section including reflections by the authors of Part 1. The analytical chapters cover model choices and uses (chapter 2), assumptions used in the modelling process and sensitivity analyses (chapter 3), data management (chapter 4) and transparency and inclusiveness (chapter 5). Chapter 6 gives the authors' views on three key issues related to developing baseline scenarios: good practice, transparency and uncertainty. Part 2 comprises individual country experiences as provided by the experts from each participating country.

3. See the Key Terminology section at the front of this report for more detail on this and related terms.
4. A similar case could be made for so-called nationally appropriate mitigation actions (NAMAs). This is because NAMAs are often prioritised by means of the same tools used for preparing baseline and mitigation scenarios. Given that, in some instances, bilateral or multi-lateral funding sources are sought to finance NAMAs, clarity on approaches to scenario development could facilitate funding agreements.
5. Available at: http://unfccc.int/national_reports/items/1408.php
6. Available at: http://search.oecd.org/officialdocuments/displaydocumentpdf/?doclanguage=en&cote=env/epoc(98)10
7. Available at: http://www.oecd.org/env/cc/CCXG%20(2012)3%20National%20Baselines.pdf
8. Available at: http://www.mca4climate.info
9. See http://www.mapsprogramme.org/
10. See http://www.ghgprotocol.org/mitigation-accounting/
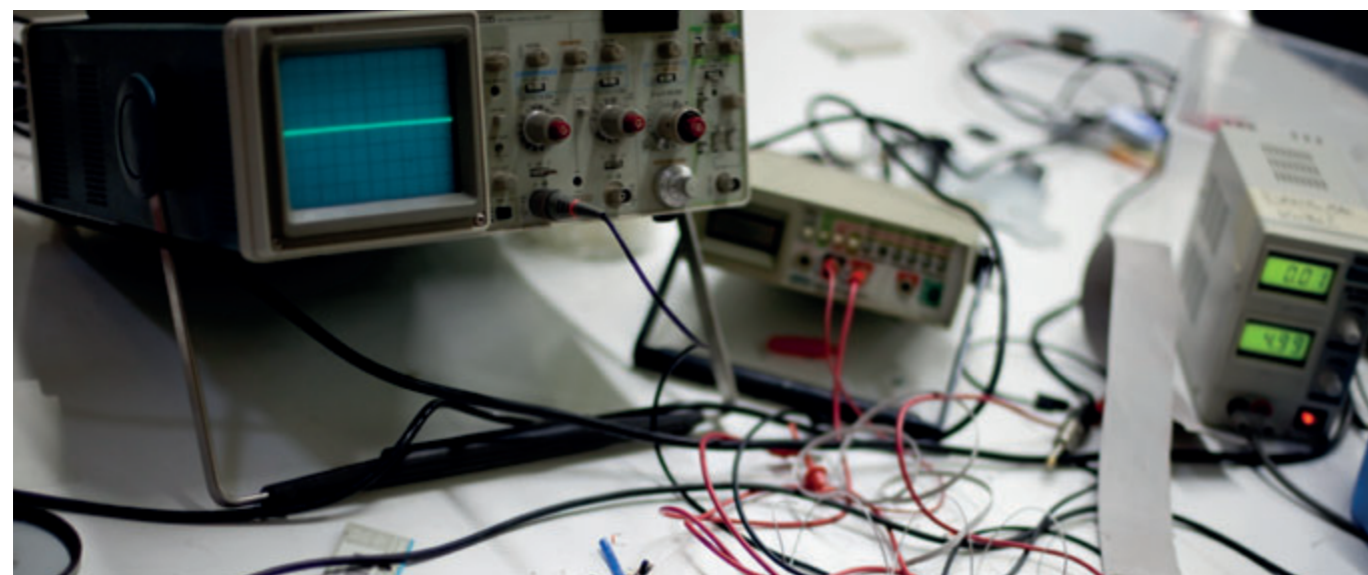
Chapter 2: Model choice and use

In practice, national baseline and mitigation scenarios are almost exclusively quantitative: they generally rely on model-derived projections of sectoral activity and sinks, underpinned by assumptions about GDP, population and energy prices, among others. The models used and the assumptions made to prepare those projections have a strong influence on the resulting scenarios. The main sectors for GHG emissions in most baseline scenarios are: energy, agriculture, land-use, industrial processes and waste. The energy sector and the land-use sector account for the bulk of GHG emissions in many developing countries. Emissions in the energy sector come mostly from electricity generation, space heating, industry and transportation. Land-use sector emissions and sinks include those resulting from changes to the use of land (for example, agricultural land converted to urban use); planting, cutting down or management of forests; and emissions from the soil.

Types and use of models

Models used to generate projections of GHG emissions are typically categorised as top-down or bottom-up; the former approach focuses on economic inter-linkages, while the latter involves more detailed treatment of specific technologies (Table 1). Hybrid models, such as the International Energy Agency's World Energy Model (WEM), attempt to bridge the differences between top-down and bottom-up approaches.

In its simplest form, a top-down scenario of energy-related GHG emissions relies on projections of both future economic output and overall emissions intensity (defined as GHG emissions per unit of GDP). The product of these two series of values over a future time period provides an anticipated baseline for energy-related emissions (the model used to generate such a scenario is referred to as a simple extrapolation model in Table 1).[11] More complex top-down models, such as computable general equilibrium (CGE) models, can simulate interactions among economic sectors, taking into account their overall effects on key macroeconomic variables such as consumption, investment and GDP.

Table 1: Overview of model types

	Bottom-up		Top-down		Hybrid
	Accounting	**Optimisation**	**Simple extrapolation**	**Computable general equilibrium**	
Strengths	Ease-of-use and potentially small data needs	Technological detail and least-cost projections	Ease-of-use and potentially small data needs	Feed-back effects on macroeconomic variables	Technological detail and consistency with economic projections
Weaknesses	Linkages with broader macroeconomic developments missing		Lack of technological detail		Can be very resource-intensive
Examples[12]	LEAP[13], MEDEE and MAED	MARKAL/ TIMES, POLES, RESGEN and EFOM	Spreadsheet models	ENV-Linkages (OECD), SGM and CETA	WEM (IEA), NEMS, MARKAL-MACRO and IPAC

Bottom-up models use highly disaggregated data on specific technologies, such as for energy supply, including estimated costs. This approach makes it possible to produce fairly detailed projections of energy use by type and sector, based on assumptions about underlying drivers such as demographic changes and variations in consumer income. However, including this level of detail usually means there is a less thorough characterisation of the interactions among economic sectors, which are only represented indirectly through exogenous energy prices, discount rates and technology learning rates. Bottom-up models can be sub-divided into accounting models (such as LEAP) and optimisation models (such as MARKAL/ TIMES). The former allows users to systematically analyse an assumed structural or policy-related development in each sector, whereas the latter incorporates some form of optimising behaviour for economic agents. Up to now, most national GHG emissions scenarios have relied on some form of bottom-up model, especially in the case of energy-related emissions.

" By using a CGE-type model in IPAC, national level fiscal policies including carbon tax, energy pricing, subsidies and emissions caps can be analysed. Similarly, IPAC's bottom-up technology model can analyse energy efficiency polices… This capability is quite similar to that of other modelling teams in China.
China (ERI)

Hybrid models attempt to combine the advantages of top-down and bottom-up modelling by linking the two types of approaches. The main challenge lies in the complexity of making two models (fundamentally different in their constructions) run in a consistent manner, which can require a lot of resources (especially in terms of data needs) and expertise.

11. This is a simplified version of the Kaya identity which states that the total GHG emissions is the product of four inputs: population, GDP per capita, energy consumption per GDP and GHG emissions per unit of energy consumed.

12. Some of these models are proprietary and may not be available for wider use (e.g. WEM); others have been designed specifically to be adapted and used by third parties (e.g. LEAP).
13. A recent addition to the LEAP model allows for simplified optimisation.

Country Experiences

Practices in the ten participating countries span the full spectrum of modelling approaches, ranging from simple extrapolation to advanced engineering models (Table 2).

Most countries rely on bottom-up models (LEAP, MARKAL/TIMES, MESSAGE/MEAD or purpose-developed models). The appeal of those models lies in their ability to provide a reasonably detailed representation of the energy system (which in most countries is the principal source of emissions), while keeping resource needs down to a reasonable level.

In China, ERI's IPAC model is a type of hybrid model, essentially combining three different models: an emissions model, a technology model and a CGE model. This design allows the interactions of the energy sector with broader macro-economic developments to be taken into account. Several other hybrid models have also been used in China.

Ethiopia relies on a combination of simplified top-down and simplified bottom-up modelling. The top-down model generates projections of broad emission trends, while the bottom-up model is used to produce additional detail at the sectoral level.

The requirements of hybrid models, in terms of both data and expertise, seem to make them unsuitable for most participating countries at present. Conversely, simple top-down models provide a solution for countries with few resources. Bottom-up models are clearly the tool of choice for most countries participating in this study.

In practice, the choice of model tends to reflect a trade-off between model performance and the expected use of model outputs on the one hand, and resource and data availability on the other. Performance is often a function of both the level of sophistication of the model and its suitability to national conditions. Resource constraints take the form of limits on funding and the technical capacity within the government departments tasked with preparing baseline and mitigation scenarios.

Resource constraints have been highlighted as a key factor influencing the choice of model in many of the participating countries. In Indonesia, this is made more challenging by a relatively decentralised government structure, where sub-optimally equipped provincial entities play a significant role in baseline development. In such settings, LEAP – a widely-used software tool for energy policy analysis and climate change mitigation assessment developed at the Stockholm Environment Institute – is often the preferred solution. China, Brazil and South Africa have used more sophisticated bottom-up and hybrid models, reflecting their longer experience of modelling and their greater in-country capacity compared to many other developing countries.

Few estimates exist of the full financial costs incurred in the preparation of a given baseline scenario, mainly because of the difficulty in coming up with a reliable estimate. One reason for this is that modelling tools and skills are developed and applied gradually, making it hard to allocate costs to the preparation of a single baseline scenario.

Nonetheless, the costs can clearly be high relative to national income in some developing countries. For this reason, several developed countries have provided technical and financial support for the preparation of baseline scenarios in developing countries. In addition to easing the financial burden of preparing the scenarios, this support has also influenced the choice of model, by allowing countries to opt for more sophisticated models and, in some instances, because donors may have indirectly favoured a particular modelling approach (as mentioned specifically by Vietnam).

> The business-as-usual emissions level for all sectors was developed using the bottom-up LEAP because of its flexible data structure, past experience, transparency and accessibility.
> *Thailand*

> The costs of developing the baseline [is a challenge because it is] fairly expensive to conduct coordination process and intensive capacity building for all the local government officers.
> *Indonesia*

> It took two Senior Researchers, together with several other ERC staff members, all new to MARKAL, a period of more than a year to complete the model…
> *South Africa (ERC)*

" The COMAP model is appropriate to the national circumstances of Vietnam and depends on the interest of donors. Vietnam also has experience with this model, from the Initial National Communication of Vietnam to the UNFCCC. *Vietnam*

Existing versus purpose-made models

Most developing countries use an existing model to build their energy-sector emissions scenarios, but some – most commonly those with especially large or complex economic and energy systems – develop models customised to their own particular national circumstances. Some other countries adapt an existing model to their specific context or combine it with some additional customised modelling. The choice of which model to use depends on each country's institutional capacity, as well as its particular needs for, and expectations from, the resulting emissions scenarios.

Several countries have indicated that the choice of model is influenced by each model's ease of use and by the familiarity that governments have with any given type of model. Once a first baseline scenario has been prepared with a particular model, there is often interest in also using that model for subsequent updates, rather than developing the capacity from scratch to adopt new modelling tools. This familiarity also helps to give others in government and in the private sector confidence in the modelling results.

Land-use sector emissions modelling

The importance of land-use sector emissions varies significantly from one country to another. While it is a key source of emissions in Brazil and Indonesia, for example, the sector makes a very small contribution to overall emissions levels in the other participating countries. Modelling approaches range from relatively complex sector-specific models to simple add-ons to energy-sector models. These models typically include agriculture, though a separate model is used for agriculture in Indonesia.

While land-use sector emissions may also be projected using a top-down model, bottom-up approaches are the norm in countries where emissions from these sectors are small or where their economic output is modest. This is because the expected change in national output over time may not be a good indicator of the rate of change of land-use sector emissions, especially in countries where agriculture and forestry represent only a small share of economic activity. Established models for projecting land-use sector emissions and sinks do exist – including some add-ons to energy sector models – but are less well-established than energy and emissions models.

Country Experiences

Indonesia, Thailand and Vietnam all rely on LEAP for developing their emissions scenarios. Reasons for this include ease of use and manageable data requirements. India (TERI) and South Africa (ERC) both use MARKAL/TIMES. A convenient user interface and the model's optimisation routines are unanimously cited as the main reasons for this choice.

In Brazil, MESSAGE/MEAD was chosen largely because key stakeholders, not least the technical agencies charged to support the baseline development process, were already familiar with it. This helped to reduce start-up costs and ensured broad support for the results.

In Mexico, both the original baseline scenario in 2009 (using a top-down approach) and the revised baseline in

2010 (using a bottom-up approach) were prepared using purpose-made models.

Ethiopia's approach – a combination of top-down and bottom-up modelling – was driven by the time and capacity constraints under which the baseline development process took place. A more sophisticated approach is envisaged for the future. Kenya also suffered from capacity constraints and opted for a similar simplified approach.

China has used several different models over the years (see Country Experiences above) to take account of the interactions of the energy sector with broader macroeconomic developments. ERI's IPAC modelling team and several universities in the country use this approach.

Country experiences

Brazil relies on extrapolations of past deforestation trends. More detailed information from existing satellite observation programmes are being used for planning purposes, but not for preparing the country's baseline scenario.

Mexico has integrated land-use-change data into a larger purpose-made bottom-up model. Conversely, Ethiopia and Kenya use simple top-down extrapolation methods, which rely on land-use-change data. Given the varying quality of these data and the complexity of land-based emissions modelling, the robustness of those extrapolation methods is similarly variable.

Indonesia, South Africa and Vietnam rely on more sophisticated approaches. Indonesia has used the Land

use planning for Low Emission Development Strategy (LUWES) decision-support framework to develop a national forestry plan. The plan includes future land uses, which forms the main set of assumptions for the baseline scenario. Building on existing work, South Africa has developed a spreadsheet-based optimisation model for afforestation (costs included forest establishment, tending, protection, harvesting, transport, overheads and the opportunity cost of land and water). Vietnam has been using a pre-existing model (the Comprehensive Mitigation Analysis Process, or COMAP, model), which had been used for the preparation of the country's first national communication to the UNFCCC.

The models used by several of the participating countries are characterised by a degree of customisation, but only one country (Mexico) used a fully purpose-made model. However, this is about to change, as a new update of the Mexican baseline scenario is currently being finalised using LEAP. It would appear, therefore, that in most countries, for fairly homogeneous sectors such as power

generation and also energy-intensive industries such as cement or iron and steel, generic models provide a more convenient solution than purpose-made models. Conversely, modelling of emissions from more diverse and/or uncommon sectors often relies on custom-made models, because few, if any, generic off-the-shelf models are available for those sectors.

One might expect that countries whose land-use sector emissions account for a large proportion of national emissions would have a stronger interest in investing in building modelling capacity in this area. However, experience suggests that existing tools and processes, as well as resource constraints, are the main determinants

of the sophistication of the modelling approach used. One reason for this may be the inherent uncertainty that charcaterises the modelling of emissons from forestry and land-use-change: beyond a certain level of complexity, the incremental effort needed to enhance the output appears to be significant.

Institutional arrangements and capacity constraints

Institutional arrangements and the technical expertise and resources available also influence the choice of method and approach to preparing a baseline scenario. The way in which government agencies and, in some cases, academic or other non-governmental entities share responsibility for the task, including the types of co-operation mechanism to facilitate the exchange of information, data, and decision-making, differs greatly from country to country. International co-operation also varies. The existence of a specific political mandate or other formal goals for baseline scenarios, which may call for the construction of several baselines based on different assumptions, can also influence the choice of method.

Irrespective of the chosen modelling tools, the institutional needs for producing baseline and mitigation scenarios are large: it generally takes several years for a government agency to develop all the required tools and build all the necessary capacities to be able to produce such scenarios with a certain level of sophistication. As capacities expand, the range of modelling tools may also grow; this may improve the robustness of the resulting scenarios, but adds complexity to the process (in particular as regards the land-use sector) and puts added strain on already limited budgets and capacities.

Country experiences

The preparation of baseline scenarios is always embedded in broader climate change planning efforts. A variety of institutional arrangements are used to oversee these efforts, ranging from formal inter-ministerial committees to more ad-hoc structures.

In Ethiopia the process of developing the baseline is part of the Climate Resilient Green Economy Strategy, a high-profile initiative implemented by the national environmental and development authorities. In South Africa, the baseline has been developed in support of the country's Long Term Mitigation Scenarios process, carried out by a research team overseen by the Ministry of Environment.

In Brazil and Thailand, the development of the baseline scenario supports national reporting to the UNFCCC, whereas in Mexico it informed the national climate change plan. In all three countries, an inter-ministerial committee was tasked to guide the work. This approach helped secure support from the ministries concerned and facilitated the exchange of data between government departments.

In Vietnam, the environmental authorities prepare the national baseline scenario, coordinating inputs from several agencies. No formal institutional structure exists, which has hampered coordination.

Baseline scenarios are not an end in themselves: they support broader national and international processes. As a result, the process of setting baseline scenarios is inevitably governed by the institutional arrangements put in place to implement those broader processes. These arrangements may have been designed with other purposes in mind and so may not be best adapted to the task of preparing a baseline scenario. Increased awareness about the importance of baselines, coupled with stronger political mandates, and increased experience and resources, could help improve governance arrangements and enhance inter-agency cooperation within governments in this regard.

Table 2: Overview of the sectors included in baseline scenarios and the models used

	Energy	LULUCF	Agriculture	Industrial Processes	Waste
Brazil (UFRJ)	Bottom-up (MESSAGE/ MAED)	Simple extrapolation of historical annual deforestation			
China (ERI)	Hybrid model (IPAC)				
Ethiopia	Top-down (simple extrapolation using spreadsheets) and bottom-up (MAC curves)				
India (TERI)	Bottom-up (MARKAL/TIMES) and CGE models			Included in energy modelling	
Indonesia	Bottom-up (LEAP) for both provincial and national level	LUWES/Abacus – spatial planning approach	Included in LULUCF modelling	Included in energy modelling	Simple linear projection model
Kenya	Bottom-up (intensity extrapolation)				
Mexico	Bottom-up (in-house). Planned future work: bottom-up (LEAP)				
South Africa (ERC)	Bottom-up (MARKAL/TIMES) and CGE-model	Spreadsheet model	Spreadsheet model	Spreadsheet model	Spreadsheet model
Thailand	Bottom-up (LEAP)				
Vietnam	Bottom-up (LEAP)	COMAP	Based on IPCC guidelines		

Note: The colours indicate whether sectors are included or not in the baseline scenario (where information was made available). Green=included, dark grey=not included and light grey=information not provided.
Source: Country contributions (see Part 2).

Chapter 3: Assumptions and sensitivity analyses

Baseline scenarios attempt to characterise plausible future developments in emissions of greenhouse gases given a certain level of policy action (or lack thereof). Because the range of plausible developments is potentially very large, establishing and clearly defining the guiding principles used to narrow that range is indispensable. How the baseline scenario is defined, its purpose, the extent to which existing policies are included in the baseline and any provisions for revising the baseline are of critical importance.

The resulting scenarios are usually highly dependent on the choices and assumptions made regarding these underlying principles. Scenarios can also be influenced strongly by the base year chosen, the drivers selected (typically, economic growth and population), the methods used to forecast likely trends in those drivers and the assumptions made regarding technology learning and development.

Definition and purpose

The definition of baseline scenario used in this report is "a scenario that describes future GHG emissions levels in the absence of future, additional mitigation efforts and policies". This definition leaves significant latitude for deciding how to construct the baseline and what the baseline may be used for. Precise definitions facilitate the work of the scenario developers by helping them determine the best methodological approach and boundaries of the analysis, and help users interpret the scenarios by clarifying, for example, the sectors and technologies covered.

Economy-wide baseline scenarios are typically developed to inform the process of determining national emissions reduction efforts (as articulated, most often, in a country's national climate change plan), as input to national communications and, in some cases, mitigation pledges, to the UNFCCC. Governments and the private sector may also develop sector-specific baselines, to underpin planning efforts and support the design of specific policies (such as voluntary agreements and cap-and-trade schemes) within individual or multiple sectors, ranging from electricity generation to the iron and steel or the cement industries. In practice, the extent to which sector-specific and economy-wide baselines are consistent with one another can vary substantially.

Country experiences

Only China provides an explicit definition of baseline emissions scenario. However, this definition (the definition provided in the country contribution) does not correspond fully with that in China's latest National Communication to the UNFCCC.

South Africa's approach to baseline scenarios highlights the importance of clear definitions and a clear statement of the criteria used to choose which policies are to be included in that scenario: it distinguishes between a no policy scenario (Growth Without Constraints - GWC) and one that takes into account implemented policies (Current Development Plans - CDP). In fact, the official baseline scenario (from October 2011) is defined as a range of possible deviations of the GWC scenario, rather than a single pathway. This was a political decision, taken after the scenarios had been prepared under the Long Term Mitigation Scenarios process.

The Indian government commissioned the development of five different baseline scenarios, which it used to plan its climate-change mitigation policies. The five baseline scenarios were found to vary significantly. The Indian government has not adopted an official baseline.

In Brazil, the main political driver for the definition of the baseline was the international climate regime and, in particular, the preparation of a national negotiating position in the run-up to the 2009 Conference of the Parties to the UNFCCC (COP-15). Subsequently, Brazil formalised its baseline scenario by incorporating it into domestic law, helping to underpin domestic mitigation actions.

Clearly, baseline scenarios serve different purposes. In some cases, they are used for multiple objectives (notably to inform both domestic planning efforts and national positions in international negotiations). In other cases, different baselines are developed for each purpose, to better accommodate the specific requirements of each application. Either way, explicit definitions, in line with the purpose of the baseline and how it is to be used, can help in identifying key assumptions and generally support the overall process of developing baseline and mitigation scenarios.

In the case of baseline scenarios used for international purposes, the international dimension requires that certain political considerations are carefully weighted. These include issues such as whether or not to (i) take

> … the choice of a particular baseline, if targets were indeed set from these, could result in significantly different levels of emissions reduction requirements.
> *India (TERI)*

into account existing or planned policies, (ii) define the baseline as a range of possible scenarios, or (iii) select one particular baseline over others, given the range of plausible non-policy assumptions. As a result, the precise definition of the baseline scenario may evolve according to the purpose for which it is used.

Existing versus additional policies

The classification of policies as existing or additional (new) is a key element of baseline-scenario development. While the specific purpose of the baseline may be established in national law or in official documents, the precise definition – including the distinction between existing policies and additional policies – may not be.

Which policies are treated as existing typically depends on two main considerations: when the policy was made into law (this also includes policies for which the impact on GHG emissions is expected to occur only in the future) and whether the policy is expected to have a significant impact on GHG emissions. Whether or not the policies

considered are specifically motivated by climate change mitigation efforts should not matter: if a policy or measure has an impact on emissions, it should be included in the baseline scenario regardless of whether it is labelled a climate-change policy or not. There is invariably a large subjective and sometimes politically-driven element involved in choosing which policies to include. Furthermore, it is not always an easy task to isolate and model the potential effects of a particular policy. This means that the decisions taken on how to treat particular policies in the baseline scenario can have a potentially large effect on the resulting projections.

Exclusion criteria

Exclusion criteria are a sub-set of assumptions about policies or technologies that, while in principle feasible, are ruled out on ideological or economic grounds. These criteria are of particular importance for building mitigation scenarios (that is, scenarios aimed at exploring the potential impacts on emissions of policies that are not yet established). This is because such criteria typically limit the scope of the technological and political options being contemplated, by ruling out, for example, nuclear energy or some form of energy taxation that may be politically sensitive. Nonetheless, exclusion criteria can also play a role in baseline scenarios, albeit to a lesser extent than they do in mitigation scenarios (see below).

Country experiences

As stated above, South Africa has developed two separate scenarios – one in which no climate policies are included (GWC scenario), and a second scenario including already implemented policies (CDP scenario). Thailand's baseline scenario does not include any climate policies, because the extent to which existing policies have been implemented was considered too uncertain.

All other countries opt for including existing policies in the baseline in some form. However, it is not always clear exactly which policies have been included.

China notes that its baseline scenario reflects existing policies and measures, including current efforts to increase efficiency and control emissions. Vietnam notes that its baseline for the land-use sector is consistent with its Forestry Development Strategy (2006-2020), which includes some existing mitigation policies.

Indonesia screens all relevant policies, whether they are explicitly climate, agriculture or rural development policies, one by one to determine whether they should be taken into account in the baseline scenario. The current baseline includes policies that are likely to have a significant effect on emissions.

Mexico and Brazil, among other countries, do not include existing policies explicitly in their baselines, but take into account current trends relating to technological development in key sectors. These trends indirectly take account of existing policies.

In Kenya, the baseline scenario (called a reference case) deviates somewhat from the developments anticipated in the country's power generation strategy (the 'Updated Least Cost Power Development Plan 2011'). This is because the baseline scenario is based on existing policies and regulations, and assumes no growth in international aid and related international investments.

Country experiences

All participating countries introduce exclusion criteria in their baselines in some form. For example, cost minimisation (which can be seen as an exclusion criterion since it restricts the choice of technologies available) is central to the MARKAL/TIMES modelling approach used in India and South Africa, while the LUWES model used in Indonesia is based on a stakeholder-engagement process that screens, prioritises and sometimes excludes options against development goals.

In contrast to economic and methodological factors, exclusion criteria often manifest themselves in the form of practicability considerations. For example, Ethiopia and Kenya include key sources of emissions only, to make the best use of limited resources. Brazil assumes that, owing to the difficulty of expanding hydropower capacities, the increase in electricity demand in the country is assumed to be met by natural gas (only hydropower projects already under construction are included in the baseline scenario).

Which approach to follow (e.g. 'no policies' or 'only existing policies'), how to select 'existing policies' and how to model the expected impacts of either option are all key questions, in that the choices made and the methodologies applied greatly influence the results of the analysis. Given the wide range of possible answers to these questions, and lacking commonly agreed approaches in this area, clarity on the steps taken in the analysis will be crucial to understand the meaning of baseline scenarios.

> The energy baseline includes an assumption of autonomous energy efficiency improvements based on historical trends. Some policy-driven energy efficiency measures are also included in the baseline.
> *Brazil (UFRJ)*

Explicitly or implicitly, most baseline scenarios include some kind of exclusion criteria, not least because baselines seldom depart substantially from established technologies and often introduce cost constraints, and because the choice of model does have an impact on the number of technologies considered. Just like for decisions about which policies to include in the baseline, a clear description of the different types of exclusion criteria is needed to understand the meaning and implications of the baseline.

Base year

The choice of base year to be used as the starting point for the baseline and mitigation scenarios depends on both technical and political considerations. Technically, choosing a recent year ought to lead to more reliable projections in principle, but it may be necessary to opt for an earlier base year for which more national-level data are available. These data are used to both characterise emissions on that reference year and underpin the projections of future emissions. Clearly, if the data in the base year are inaccurate, the projections will be unreliable.

Politically, it is useful to select a base year which coincides with the reference points introduced in international climate-change negotiations. Choosing a year in which emissions in the country were particularly high (due to an economic upturn, for example) might result in higher emissions in future years in the baseline scenario, though sophisticated model techniques ought to be able to compensate for this. However, this approach can have the effect of making less onerous any emissions reduction commitments defined as relative reductions against the baseline, which would effectively lessen the overall global mitigation effort. Which consideration prevails in the choice of base year varies from country to country.

Revisions

Revisions to baseline scenarios may be necessary as a result of changes in key parameters or assumptions following a change in circumstances. The frequency of such revisions can be laid down by law. However, it is usually determined by political factors, typically related to the needs arising from a number of planning exercises, such as updates of national climate change mitigation strategies or the growing number of sector-specific planning efforts. Similarly, a new government may make a political decision to update the baseline as a stand-alone effort in its own right. In some cases, baseline revisions may be motivated by technical advances, such as the availability of new data or improvements in modelling capabilities.

Country experiences

Given that non-Annex I countries are not required by the UNFCCC to prepare regular inventories of GHG emissions, more recent data than those included in the latest formal inventory submitted to the UNFCCC as part of a national communication may be available in those countries at any given time. As a result, only in some countries do the most recent emissions data used for the preparation of the baseline scenario coincide with the data included in the country's latest inventory. Often, baseline scenarios use more up-to-date data, even though full inventories may not have been completed (see also Table 4 in chapter 4).

Brazil, Mexico and Vietnam all choose base years that coincide with the most recent year they have reported in their respective inventories of greenhouse gas emissions. South Africa uses slightly more up-to-date data for its base year, compared to its national inventories (2003 data for the start year in the baseline, versus 2000 data for the most recent year in its inventory). The gap is even bigger in Thailand, which uses 2008 data for the start year in its baseline (compared to 2000 data for the most recent year in its inventory).

Country experiences

Only one participating country – Mexico – has made legal provision for revising the baseline scenarios as well as mitigation scenarios on a regular basis. In addition those provisions define the circumstances that may trigger a more frequent review.

Mexico and South Africa are currently updating their respective baseline scenarios. In both countries, decisions about when to update the baseline are driven mainly by the need to support national policy-making, the availability of newer datasets and improved modelling techniques.

Brazil has not announced any plans to update the baseline that was fixed in the climate change law of 2010. The government has indicated that projected emissions from the land-use sector, which are incorporated in the climate change law, will not be revised in the next update.

In Indonesia, the preparation of the baseline scenario is seen as a dynamic process and mechanisms are being established to regularly update it (at least every 5 years in line with the country's mid-term development plans). At the time of writing, the baseline scenario was still being developed.

Aligning the timeframes for the preparation of GHG emissions inventories and baseline scenarios may be desirable to ensure consistency and to streamline procedures. However, this is seldom an easy task, as these are relatively independent processes within a country. A similar argument could be made at the international level: while an internationally agreed common base year could

potentially increase comparability across national baseline scenarios, the often ad hoc nature of the process of developing a baseline scenario can make this difficult. Nevertheless, agreement on which criteria to use to guide the choice of base year could be helpful, irrespective of data availability considerations.

Whether and when to revise national baseline scenarios is currently left to the discretion of individual governments. Inevitably, the decision hinges upon both political and technical considerations. This is because baselines serve different purposes, which may be politically driven; incorporating technical advances and data updates through revisions in the baseline can help to achieve those purposes.

Revisions can be partial or complete, depending on resources available and political factors. A revision can include a change of start year – for example, to use a more recent base year as data becomes available. It is also possible to revise baseline scenarios for certain purposes, whilst still making use of previous versions for other purposes. For example, if a country has made a mitigation pledge for 2020 relative to a particular baseline scenario, it may choose to continue referring to the original baseline, whilst carrying out updates to inform domestic policy planning.

Key drivers

Key modelling assumptions about socio-economic and other factors in baseline scenarios may be politically determined or may reflect international practice (that is, they rely on data used and/or methodologies endorsed by international organisations). Among the most critical assumptions are changes in GDP (or other measures of national income), the sectoral composition of GDP, population and energy prices. Each assumption needs to be explained and justified. The utility of the resulting scenarios may be enhanced by a clear articulation of the likely effects on baseline emissions of the particular choices made, possibly by means of sensitivity analyses (see below).

Explaining the methods employed to determine future values in key drivers can help users understand the limitations of the resulting projections. In most cases, assumptions about GDP are based on projections from time-series models or econometric forecasting methods; projections of population growth rely on completely different methods (mostly period or cohort observations, to quantify future fertility rates). Equally diverse methods are used to come up with assumptions about developments in other key parameters, from energy prices to the structure of the economy. The diversity of methods used and the uncertainty associated with any kind of projection, irrespective of the approach utilised to arrive at it, underscore the need for transparency.

Country experiences

Brazil, China, Ethiopia, India, Mexico and South Africa all highlight GDP as the most important driver of emissions, often citing demographic developments as the second most important driver. Some countries, notably Vietnam and South Africa, differentiate growth rates between key sectors (for example, the service sector). In India and South Africa, energy prices are seen as the next most important driver. Additional drivers cited among the participating countries include currency exchange rates (South Africa), urbanisation (Brazil and China) and household income levels (India).

Unsurprisingly, given their importance to GHG emissions, GDP assumptions tend to receive most attention in baseline and mitigation scenarios. India and South Africa use sectoral breakdowns, in an attempt to improve the characterisation of structural changes in the economy over time. While some countries make use of adjusted, purpose-made forecasts of GDP, for example Ethiopia and Kenya, several rely simply on governmental economic growth targets.

With the exception of Ethiopia, all countries in the table below use domestic forecasts of GDP and all, without exception, use domestic forecasts of population growth. Brazil and South Africa use domestic forecasts of fossil fuel prices (for oil imports and domestic coal, respectively), whereas India indicates that its fuel-price projections are 'generally aligned' with the International Energy Agency's Reference Scenario in its annual World Energy Outlook.

Table 3: Key Driver Sources

Country	GDP	Population	Fossil fuel prices
Brazil (UFRJ)	National	National	Expert judgment
China (ERI)	National	National	-
Ethiopia	International	National	-
India (TERI)	National	National	International (IEA)
Mexico	National	National	-
South Africa (ERC)	National	National	National
Thailand	National	National	-

Source: Country contributions (see Part 2)
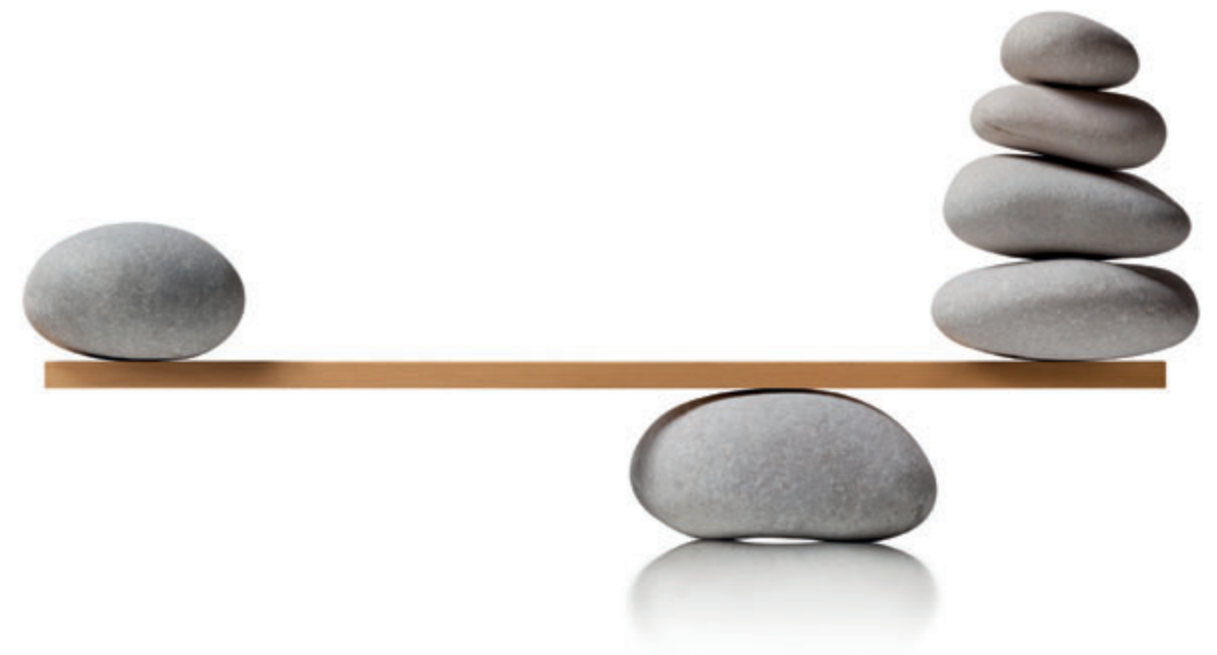
GDP is typically the single most important determinant of GHG-emissions trends in baseline scenarios, at least in the medium term. Simply stated, an increase (or decrease) in projected GDP results in a corresponding increase (or decrease) in emissions. For this reason, reliable purpose-made forecasts of GDP are of critical importance to the results of the scenario. Where possible, the uncertainty surrounding GDP forecasts ought to be quantified. Scenario developers need to strike a balance between using appropriate economic forecasting techniques and ensuring a consistent approach among governmental entities.

Forecasts of GDP (for use in baseline scenarios) and national economic growth targets (for use in national planning) serve different purposes and, because of this, are not necessarily interchangeable. Growth targets are, by definition, aspirational, providing a framework around which development plans can be drawn up; in some cases, they might be overly ambitious. By contrast, forecasts of GDP used as inputs to climate change models are intended to provide an indication of what is most likely to happen. While the two would not be expected to be wildly different, growth targets are no substitute for purpose-made forecasts of GDP.[15]

" GDP growth is the most critical GHG emissions driver. Governments must be optimistic about this and the Brazilian government is no exception to the rule... This is the main source of discrepancy with other independent studies.
Brazil (UFRJ)

" This particular GDP growth was chosen as it signified a conservative approach in baseline construction.
Mexico

" As a conservative midpoint between the governmental assumption of 11% annual GDP growth, and estimates by the IMF and The Economist of just above 8%, the business-as-usual emissions projections assume 8% annual GDP growth.
Ethiopia

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15. Ideally, forecasts should be developed using probabilistic techniques, to account for the large uncertainty associated with any forecasting exercise, notably with respect to GDP and energy prices.

Technology development and learning

Technology learning effects – the extent to which technologies get cheaper over time – is normally a key input to energy models. Assumptions about technology costs have a large impact on model outputs, particularly when cost-driven exclusion criteria apply.

Technology learning is characterised through the assumed rate at which the cost of a given technology per unit installed falls for each doubling of global cumulative capacity (expressed as a share of the initial cost).[16] To adapt a generic learning rate to certain local circumstances, a number of key estimates have to be obtained (not least, maximum capacity expected). In practice,

scenario developers are faced with a mix of estimates of generic and national rates and, for some technologies, no learning rates at all. In some cases, technology learning may not be taken into account at all in baseline scenarios, for example where the outlook for a technology is very uncertain. The way in which technology learning is dealt with can vary markedly, which raises question marks about the comparability of results across scenarios and countries. Even within countries, comparability issues may arise when it is (only) included in mitigation scenarios. The extent to which technology changes can be included depends on the choice of model.

Country experiences

In Brazil, "autonomous energy efficiency improvements" are included in the baseline scenario, as well as a limited degree of technology displacement in the fuel mix (a shift from hydropower to natural gas in power generation).

In Mexico, the baseline reflects technological development "in line with current trends".

In China, technology learning and cost curves are both key elements in the IPAC model.

In South Africa, a lot of work has been done to apply technology learning rates in emissions models, but a decision was taken not to apply these, since rates were not available for some technologies.

Technology learning rates are difficult to calculate. They require reliable data and sound analysis, as well as the credibility that comes from endorsement by all relevant parties, notably end-users and investors. Scenario developers are faced with difficult decisions concerning whether to use generic or country-specific rates, which technologies they should be calculated for and whether or not they should be incorporated into the baseline scenario. Such decisions are usually left to the discretion of the technical teams involved in scenario development.

Calculating country-specific learning rates in developing countries, in order to reflect national circumstances, is complicated by both the limited capacities of government agencies and the inherent difficulties in adapting global rates. A simple, pragmatic approach involves simply extrapolating past trends, because this may be perceived as being just as reliable as deploying a technology learning rate. In general, the further into the future scenarios reach, and the newer the technologies are, the greater the uncertainty in either approach.

Sensitivity analyses

Sensitivity analyses assess the extent to which the output of a model varies according to its inputs, thus providing an estimate of the robustness of model outputs.[17] In practice, sensitivity analysis involves testing a range of values for key parameters that are particularly uncertain and subject to judgment, to quantify the effects that changes in these inputs have on modelling results: changes that fall within expected ranges suggest that modelling results may be robust. Income and energy prices are among the most uncertain variables.

Sensitivity analyses are used both for the purposes of model calibration and to obtain different versions of baseline and mitigation scenarios, or a range of baselines. They are typically presented individually for each factor tested (that is, as separate results for each variation in the value of the factor). Most often sensitivity analyses are run for one factor at a time (that is, one key driver in the model). However, unless the model under analysis is linear, this approach is likely to be sub-optimal.[18]

Country experiences

Few of the participating countries run sensitivity analyses. When they do, GDP is the main (often the only) parameter considered. The other main parameters that are tested in some cases are fuel prices and emissions inventories.

South Africa has assessed the sensitivity of emissions to future structural changes in the economy, involving faster than expected growth in sectors such as services, transport and manufacturing. Mexico has tested the effect of an increase in the annual growth rate for GDP (5%, corresponding to approximately one standard deviation above the default growth assumption) in a 'high growth' scenario, finding different effects on emissions across different sectors. Vietnam took a similar approach, testing 'low', 'medium' and 'high' growth scenarios (and finally choosing to select the 'medium' growth scenario).

No country conducted sensitivity analyses on population. Mexico concluded that existing population forecasts were reliable and therefore focused their sensitivity analyses on GDP.

Brazil and Kenya have found that emissions are very sensitive to changes in the land-use sector (Brazil has conducted a number of statistical analyses to characterise the level of confidence in the emissions inventory). Brazil further notes that, for political reasons, no formal sensitivity analyses were conducted.

South Africa has run sensitivity analyses for the prices of a number of fuels, and found significant sensitivity to coal prices only. This is in part due to the extensive use of coal to produce transport fuels as well as to generate electricity.

From a purely technical point of view, conducting sensitivity analyses presents few challenges. More difficult is deciding which parameters ought to be analysed and what kind of values correspond to 'plausible' future ranges for those parameters. This may be one reason for the limited use of sensitivity analyses in practice. Another reason could be that, as suggested above, baseline scenarios play a political as much as a technical role, in the sense that the choice of assumptions can result in scenario outcomes that are consistent with politically predetermined

views. If that were the case, the interest of conducting sensitivity analyses would, obviously, be reduced.

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16. It is well-established that the costs of producing a new technology tend to fall over time because manufacturers streamline design and production processes as they move from demonstration units or pilot plants to mass production, and because of the economies of scale associated with those larger production runs.

17. Sensitivity analysis is one way to characterise the much broader concept of uncertainty.
18. Variance-based measures and screening tools can be used to estimate 'total order' sensitivity indices. Sensitivity indices are, in effect, measures of the extent to which an individual model input can drive uncertainty in model output, taking into account interactions amongst multiple model inputs.

Comparing baselines

It can be useful to compare baseline scenarios developed for the same country by different teams using different methods. This can help to identify the extent to which the results depend on the choice of modelling tool and pinpoint the key sources of uncertainty for future emissions. The latter can be studied further by using tailored tools to characterise uncertainty in the scenarios, such as expert consultation, Monte Carlo simulations, 'model ensemble' analyses or sensitivity analyses.

Comparing national scenarios is seldom straightforward and differences in the way they are defined are likely to limit the usefulness of the exercise. Nonetheless, it is often helpful to cross-check the value of key model input parameters (notably income and energy prices). Similarly, it can be instructive to review output values for which there is noticeable disagreement between the scenarios compared – to analyse whether the discrepancies are due to differences in scope, model structures or other factors, with a view to improving the accuracy and credibility of the scenarios.

Country experiences

More than one baseline scenario has been prepared in Brazil, China, India, Mexico and South Africa. In some instances, the scenarios have been commissioned by the government and in others by non-governmental organisation, such as research institutes.

Official government-commissioned scenarios typically represent up-dates of previous efforts, sometimes involving a different model. This has been the case in Mexico and South Africa. India's approach, on the other hand, was different in that the government's explicit goal was to compare different scenarios produced simultaneously at the request of the same government agency. India has no official baseline scenario, so the comparison was used

to inform domestic climate change mitigation plans and, above all, the national position in international climate-change negotiations.

It is sometimes difficult to determine what an 'official' baseline is and which role updates play. In Brazil, a baseline scenario was formally adopted in the national climate change law in 2010, and so can be considered official. The process of preparing the scenario benefited from the findings of complementary work carried out by other bodies, mostly national universities. In China, a baseline scenario was included with other scenarios (all prepared by ERI), in China's second National Communication to the UNFCCC.

The appeal of preparing a variety of baselines lies in the possibility of comparing the resulting scenarios, to confirm the robustness of trends on which there is coincidence across different methodologies and to identify areas in which uncertainty may be high, as evidenced by the discrepancies in the results coming from the different

scenarios. In addition to the possibility of comparing across purely technical matters such as data and models, comparisons are equally if not more useful as regards the use of different assumptions and the impacts those may have on the resulting scenarios.

Chapter 4: Data management

Irrespective of the models used and the assumptions made, preparing baseline and mitigation scenarios inevitably calls for large amounts of data on GHG emissions and a range of socio-economic variables. A minimum level of disaggregation is required to come up with a credible scenario, typically by year, sector, region and gas. While basic data do exist for most countries, it is difficult to collect all the information one could potentially use to prepare such scenarios. Further, the incremental cost of data collection tends to grow rapidly, while the incremental benefit declines. Because of this, and since the data used for building scenarios are not collected specifically to serve that purpose, government agencies typically find that their efforts are constrained by the availability of data and its quality.

Emissions inventories

Most national statistical offices keep reasonably complete and reliable datasets of economic activity. By contrast, information on end-user energy use remains incomplete

and unreliable, particularly in developing countries. Increased deployment on end-user surveys would help improve the quality and coverage of the data, but they are typically very expensive.

Data on historical emissions are even poorer in many cases. Historical emissions data come from national GHG inventories, which are prepared using detailed guidelines produced by the IPCC.[19] Preparing a complete inventory is a resource-intensive task which requires both data on activity in each economic sector and the corresponding emissions factors. As a result, the quality and completeness of emissions inventories varies, sometimes

> ❝ [National GHG emissions inventories] are prepared by a network of more than 50 institutions with expertise in each relevant field, ensuring the generally good quality of the data.
> *Brazil (UFRJ)*

significantly, from country to country. While some developing countries, such as Mexico, have very detailed inventories covering a large number of sectors and gases, others are lagging behind. Nonetheless, the national inventories of many developing countries improved significantly between their first and second National Communications to the UNFCCC. Some countries, such as Brazil, used the revised 2006 IPCC guidelines in their second communication.

Country experiences

Brazil reports that, while the country's inventory is generally of good quality, estimating emissions from the land-use sector remains difficult because of the challenges involved in obtaining data on biomass densities of deforested areas. No formal domestic verification process has been adopted to validate the national GHG emissions inventory.

Thailand highlights the large financial cost of preparing credible emissions inventories. Vietnam cites the difficulty of systematically using IPCC source categories.

In general, it would seem natural from a theoretical point of view to use the latest emissions inventory year as the base year (whether the inventory is reported to

Table 4: Newest inventory year and base year

Country	Base year for known baseline scenarios	Newest published UNFCCC inventory year
Brazil (UFRJ)	2005	2005
China (ERI)	–	2005
Ethiopia	2010	1995
India (TERI)	–	2000
Indonesia	2010	2000
Kenya	–	1994
Mexico	2006	2006
South Africa (ERC)	2003	2000
Thailand	2008	2000
Vietnam	2000	2000

Source: Country contributions (see Part 2) and national communications.

the UNFCCC or not). When this is not the case and a subsequent year is used, the base year itself becomes an estimation. For comparison Table 4 shows both base year and inventory year for seven of the ten contributing countries.

Emissions inventories are prepared with a view to both serve national reporting requirements and for submission to the UNFCCC (using the standard source categories established in the IPCC guidelines). However, because sectoral monitoring programmes and data-collection processes are most often developed for different purposes (and in some cases even precede greenhouse gas emissions reporting), definitions seldom match fully and adjustments in the allocation of emissions to source categories need to be made, sometimes using crude assumptions. This can pose problems for developing

> ❝ Data categories required by the IPCC Guideline differ from the ones in the National Statistics Yearbooks.
> *Vietnam*

baselines, which require emissions inventories. Possible updated (non-voluntary) reporting requirements by the UNFCCC might justify an effort to re-define monitoring programmes and data collection processes, thus easing those constraints.

19. IPCC (2006) Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas. Inventories Programme, H. S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe. (eds). This updates an earlier version from 1996.

Socio-economic data and emissions factors

Full reliance on historical data is rare and baseline scenarios are most often based on projections of economic activity. At their simplest, projections of economic activity and energy use are translated into emissions volumes through a coefficient or emissions factor. Economic activity-based projections are more likely to be consistent with broader planning efforts (in that they could in principle share the same assumptions about economic development), although this is not necessarily always the case.

IPCC guidelines include a database of generic emissions factors, which Parties to the UNFCCC can use for compiling their national GHG inventories when they lack country-specific emissions factors. It is the most complete database of its kind and, as a result, government agencies lacking country-specific emissions factors use it systematically for compiling inventories and for developing baseline scenarios. However, these generic factors are often less accurate than country-specific emissions factors would be, especially for emissions from GHGs other than carbon dioxide. Because of this, countries are encouraged to develop their own specific emissions factors for major sources of emissions. Doing this properly requires significant data, skills and finance, which are not necessarily available in developing countries.

There is no quick fix to the problem of poor or unavailable socio-economic and emissions-related data. Nonetheless, some datasets are more important than others – the most important being those that relate to the key drivers of emissions. Arguably, efforts should initially be directed to improving those datasets.

Countries seeking to improve the treatment of socio-economic factors in their national baseline scenarios could consider one of two approaches: to increase the level of disaggregation by including additional sectors and sub-sectors, or to enhance the quality of the data for the sub-set of sectors that account for most emissions. In practice, however, elements of both approaches are often improved gradually, as they are not mutually exclusive. In addition, preparing projections of GHG emissions (and improving the underlying datasets and modelling tools) is not necessarily always the responsibility of the government agency tasked with preparing a country's baseline, which means that those projections and improvements effectively become an exogenous input to the baseline development process.

Reliable activity data are of limited use if no country-specific emissions factors are available to calculate emissions volumes. It is worth noting here that the IPCC suggests that emissions factors should be customised for all activities representing a major source of emissions.[20] This is all the more important for emissions from GHGs other than carbon dioxide.

Irrespective of whether they concern historical data or projections, socio-economic datasets used to develop baseline scenarios usually come from national statistical offices or from international agencies – or both, in some cases. Using national datasets facilitates comparability with other domestic forecasts, whereas reliance on international datasets makes comparisons between countries easier (provided, of course, that all countries being compared used the same data sources). Thus, documenting the sources of data used (whether national or international) becomes indispensable to facilitate interpretation of results and comparability of scenarios. Similarly, using Purchasing Power Parities (PPP) instead of economic figures expressed in market exchange rates can facilitate comparisons.

> Uncertainty would be greatly reduced by applying consistent, spatially explicit observations of land-use and land-use change, using remote sensing and geographic information systems.
> *Kenya*

> … certain country-specific emissions factors were also developed and used for the inventory, such as the CH_4 emissions factor for rice paddies…
> *Vietnam*

Country experiences

Data availability is a problem common to most of the participating countries. Vietnam, for example, lists a range of parameters for which there is not enough information, noting that data collection processes are slow and not undertaken on a continuous basis.

Some countries choose indirect methods to make up for incomplete datasets and/or sub-optimal monitoring systems: Ethiopia uses expert judgment to generate credible proxies for missing data, while Kenya relies on end-use surveys from India to estimate fuel consumption by selected sectors for which national data are not available.

Similarly, most countries report problems with regards to the consistency of datasets collected by different agencies and/or for different purposes. After highlighting the problems associated with the plethora of data sources, measurement standards and storage formats, Thailand suggests that some form of guidance is needed to increase the quality and comparability of the data.

Brazil points to areas requiring future work. These include harmonising energy balances and economic sector taxonomies (to facilitate the development of input-output tables of the economy, including details of all relevant energy sectors and products), and calculating more precise income and price elasticities for energy products.

To a greater or lesser extent, all countries use at least some country-specific emissions factors. Brazil mostly uses customised emissions factors. Conversely, Thailand and Vietnam rely almost exclusively on IPCC emissions factors (except for certain high emitting sectors specific to local conditions, such as emissions of methane from rice paddies). However, they note that further development of country-specific emissions factors is difficult, due to resource and capacity constraints.

20. The IPCC Guidelines provide useful guidance on 'Key Category Analysis' (e.g. Chapter 4, Volume 1 of the 2006 IPCC Guidelines).

Institutional arrangements and capacity constraints

The complexity of baseline modelling, including data, information and assumptions covering a range of different sectors and ministries, means that complete GHG modelling requires cooperation among many disparate government agencies. This can be difficult to achieve, especially if the overall government mandate to prepare the baseline scenario is not very clear or strong, which can mean agencies whose primary concern is not environment issues may be less willing to commit resources and share data. The need for data from different ministries and sources can exacerbate issues of capacity constraints.

Country experiences

Institutional arrangements for data management vary from well-established processes, such as in Brazil and Mexico, to more ad-hoc structures, for example, in Kenya and Ethiopia. Indonesia, Thailand and Vietnam are at different stages in their efforts to streamline data management arrangements. Indonesia has launched an initiative to build the capacities of local authorities to complement the data-collection work undertaken by the central government (Bappenas). In Vietnam, most of the capacity-building efforts that are being made are contingent upon support from donor countries.

Brazil notes that transport is an area in which improved institutional arrangements could significantly increase the quality of the data used in emissions scenarios. For example, strengthening the capacities of transport agencies could result in better cost data, while new surveys of performance of end-use equipment would increase the reliability of useful energy balances, which currently use data from out-of-date surveys.

The extent to which government agencies tasked to prepare national baselines have the capabilities and resources required to obtain and develop all the necessary information varies markedly from country to country. Challenges faced include inadequate institutional set-ups and unclear political mandates, technical difficulties (for example, in harmonising data from different sources) and financial constraints. The lack of international guidelines on data management means that it is left to the discretion of resource-constrained government agencies to decide on the myriad processes involved in data management,

> International guidelines and standards may be required, to assist countries in setting baseline emissions levels.
> *Thailand*

often in the absence of an overview of what options for improving those processes might exist. In light of this, calls for guidance on data management seem to be warranted.

Box 3 Institutional arrangements for broader climate change planning efforts

Several countries have established a coordinating committee or working group to organise and allocate the inter-agency work related to national climate-change mitigation policies. Besides fulfilling an administrative role, such a framework can also help ensure political support across the different governmental agencies.

Brazil has established a climate-change committee, made up of representatives of all concerned ministries. The committee's executive group meets regularly to coordinate efforts to implement the Brazilian Climate Change Plan, under the coordination of the Ministry of Environment.

In Thailand, a National Climate Change Committee chaired by the prime minister was established in 2006. The committee consists of two sub-committees on technical and negotiation matters, made up of representatives of relevant governmental institutions.

The National Development Planning Agency in Indonesia, Bappenas, coordinates the work on developing a baseline by consulting the relevant governmental and educational institutions. In 2012, Bappenas created a climate change working group to support, monitor and evaluate the implementation of the national and local mitigation action plans.

Vietnam has yet to establish a focal agency responsible for inventory's data collection, analysis, verification and update. Such an arrangement would help improve data collection.

Chapter 5: Transparency and inclusiveness in developing baseline scenario

Transparency in developing national emissions scenarios, including the baseline, is important to facilitate the interpretation of the results and to improve their credibility and acceptance, both domestically and internationally. In this context, transparency means openness regarding both the processes, model choices and data used to develop the scenarios, vis-à-vis both domestic stakeholders and international observers. Acknowledging this, countries are increasingly including transparency considerations in their plans for developing and updating baseline scenarios.

Including stakeholders in the modelling process at an early stage is one way to increase transparency. This can pose certain challenges for modellers, in as much as it effectively represents an additional task within what typically are constrained schedules and strained budgets. At a minimum, stakeholder consultation involves an effort of documenting approaches and processes, as many stakeholder groups are not necessarily familiar with them (and may have difficulty understanding them even when documentation is provided).

In practice, transparency may be compromised by the very nature of baseline development, in that it may be hard to reconcile a request for input from stakeholders with the reality that some decisions are politically driven

and thus not subject to substantial modification, irrespective of the input received from stakeholders. This can lead to tension on the part of both the governmental body responsible for the baseline and stakeholders, such as industry and consumer groups, when stakeholders have a strong commercial or other interest in the outcome of the process. Nonetheless, efforts to elicit input from stakeholders, whether they are conducted under the banner of transparency or as a part of standard data collection and verification processes, are generally valuable for modellers and can help to contribute to the robustness and credibility of the baseline.

> ❝ To improve transparency, a detailed report explaining the emissions scenario is crucial
> *China (ERI)*

Although not all countries state transparency and international (and national) credibility as specific objectives when setting a baseline, there is broad acknowledgement that these are important concerns. In the process of developing their baseline scenarios, an increasing number of countries have made available information about the assumptions made and methods used, albeit to varying degrees.

Stakeholder involvement

Many different types of potential stakeholders may be involved in the construction of baselines, including government agencies (other than the agency leading the work), academia, industry, civil society and non-governmental organisations. In addition to contributing to discussions on data and assumptions, stakeholders may participate by gathering and offering data, or by offering feedback on model choices or emissions scenarios. The degree to which stakeholders are involved varies from country to

country, as do the mechanisms used to engage public interest and the level of understanding among stakeholders of the purpose of the baseline. It should be noted that in some cases stakeholders have a particular motivation to influence baseline projections. For example, an industry group in an emissions-intensive sector may see the baseline as a potential contributor to more stringent emissions regulation in the future.

Country experiences

For the development of its Long Term Mitigation Scenarios, the government of South Africa set up two parallel stakeholder consultation processes at the technical and political levels. The technical consultation was used to guide the work of the four research teams, which focused on energy modelling, non-energy emissions, macroeconomics and climate-change impacts. The political consultation was carried out at the end of the modelling process and involved representatives from government, civil society, labour unions and business.

In Mexico, the 2009 Special Programme on Climate Change underwent a public consultation, which did not include the baseline scenario underpinning most of the programme's goals. When the baseline scenario was finalised the private sector voiced concerns about the conservative approach in the baseline and offered alternative values for key variables (which would have resulted in much higher projected emissions). Because of this, the government is keen to ensure broad stakeholder involvement in the forthcoming process to update the baseline

scenario – as mandated by the 2012 General Law on Climate Change.

Brazil consulted with representatives from government, industry, non-governmental organisations (NGOs) and the scientific community in the preparation of its mitigation scenario. However, this consultation was not extended to the process of preparing the baseline scenario.

Although the process of preparing a baseline is at an early stage in Indonesia, stakeholder involvement is anticipated. All levels of government – local, regional and central – emphasise the need for transparency and inclusive consultation.

In India, TERI normally consults with stakeholders to reach consensus on key assumptions in its modelling work. These consultations typically involve interaction with several experts in the energy sector and include one-to-one meetings, as well as group discussions.

Stakeholder consultation can take the form of a quality assurance procedure (through which experts validate specific technical aspects of the baseline scenario development process) or a data collection effort (to complete and verify available information). Stakeholder engagement around broader, structural issues, such as the definition and purpose of the baseline, or the key assumptions behind it, is largely absent, but can be important for credibility and acceptance, and thus for ensuring the support of stakeholders in the policy development process (including key industry or other lobby groups).

> ❝ ... in retrospect, it would likely have been more instructive for the development of the baseline to carry out a stakeholder engagement process along with its construction.
> *Mexico*

Peer review

Peer review is another means by which outside view-points may be taken into consideration in the baseline-development process. A review can take place at a number of levels, from domestic to international. The IEA's energy-policy review process represents a long-established example of the latter. Reviewers may be drawn from within the country for which the baseline is being estimated, or from an international set of peers with experience in similar work. Peer review can provide an impartial critique of methods, input/output and results by knowledgeable experts in the field and can be invaluable for establishing high-quality, well-respected baseline scenarios that enjoy broad credibility nationally and internationally.

Comparing in-country and supra-national model projections

Another form of review entails the comparison of baseline scenarios modelled in-country against scenarios for that same country generated by supra-national models. In most cases, the results differ markedly. An examination of these divergences can help to identify key uncertainties in the underlying assumptions.[22]

Country experiences

Few baseline scenarios have undergone a formal peer review. In the case of Brazil, it is argued that the political nature of the baseline discouraged transparency measures of this kind, which might otherwise have been considered.

India's TERI distinguishes between two types of peer review – one related to improvements in the model and the other to model inputs and outputs. Only the former involves external peer reviewers.

South Africa has gone significantly beyond all other countries in its efforts to carry out a peer review of its baseline scenario: an international energy modelling company was engaged to review both the structure of the model and some sample results, an independent expert reviewed the general equilibrium model and a team of practitioners convened by the World Bank reviewed the broader process set up to prepare the Long Term Mitigation Scenarios. The World Bank report commended the approach, suggesting that it be shared with other developing countries. This motivated the inception of the Mitigation Action Plans and Scenarios (MAPS for short) project. The World Bank peer review report was not made publicly available, but is described at some length in Raubenheimer (2011).[21]

> ❝ The methodologies used in the research were consistent with international best practice and the results are robust
> *South Africa (ERC),*
> *quoting the World Bank review*

South Africa's ground breaking initiative to conduct an independent and thorough peer review of its baseline scenario significantly raises the standards in this area. Peer review brings to the fore questions about ownership and legitimacy of the results. For example, to what extent should an essentially technical exercise accommodate political priorities? For this reason, the design of the peer review mechanism is crucial to ensure that it can meaningfully serve its purpose: reviewers need to be presented with all information and fully understand the context of the baseline development process, while users of the review need to be clear about its scope and limitations.

Country experiences

In partnership with the Danish Energy Agency, Mexico has engaged in a comparative study aimed at understanding the differences between Mexico's own baseline scenario and that generated by using a different model (POLES). The goal of this work is to increase the transparency and credibility of the Mexican baseline, through a detailed analysis of the impact of different assumptions on key drivers in the two models.

In a similar vein, in 2009 the OECD/IEA Climate Change Expert Group conducted a study to compare baseline and mitigation scenarios across several models for several OECD countries, including Mexico. In each country, the study found significant differences in the modelling results, some of which could be explained through differences in scope.[23]

In China, the US-based Lawrence Berkeley National Laboratory, Tyndall Centre in the United Kingdom and the IEA, among others, have for several years undertaken comparative studies at both the sectoral and economy-wide levels. Although the objectives and resources varied from one study to another, this work is generally seen as having contributed to increasing the quality of the scenarios developed both by these institutions and the Chinese government.

Comparisons using international (multi-country) models are probably of most interest to countries with limited modelling capabilities, in that the relevant country module in the international model may have a level of complexity that is similar to that of the national model. For countries with sophisticated modelling tools and extensive experience, structural and data limitations of the international model may reduce the value of the comparison. Nonetheless, the peer review element inherent in exchanges among experts can be of mutual benefit when it is conducted in an open manner, with both parties having

> ❝ The Danish Energy Agency (DEA), in partnership with Mexico, will undertake a [model] comparison study [...]. The aim is to increase transparency and credibility
> *Mexico*

access to each other's data and models. Also, it can be useful to analyse the national baseline scenario in a global context, for example to better understand the sensitivity of demand for fossil fuels to GDP in different regions.

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21. Facing Climate Change: Building South Africa's Strategy, by Stefan Raubenheimer (2011), Cape Town.

22. ADAM, a European Union-funded research project, conducted a thorough comparison of five energy-environment-economy models. Central to this project was an effort at harmonising baselines, which highlighted the diversity in definitions and approaches documented in this report. A summary of the latter is included in Edenhofer et al., 2010: The Economics of Low Stabilization: Model Comparison of Mitigation Strategies and Costs, in The Energy Journal, Volume 31 (Special Issue 1). The Economics of Low Stabilization.

23. National and Sectoral GHG Mitigation Potential: A Comparison across Models, by C. Clapp et al. (2009). A OECD/IEA Information paper available at: http://www.oecd.org/env/cc/44050733.pdf

Chapter 6: Reflections on key aspects of developing a baseline scenario

In the coming years, the role that baseline scenarios may play in climate change policy planning, both domestically and internationally, is likely to grow. The importance of these scenarios in the international climate-change regime might grow if more governments choose to express mitigation pledges as relative reductions against baseline scenarios or if agreement is reached on more stringent requirements for reporting to the UNFCCC. Domestically, the uncertainty and political sensitivity associated with future emissions-mitigation policies, combined with the need for decision-support tools, means that reliance on scenarios for policy-making is likely to grow.

Scenarios are not intended to be predictions: they are representations of plausible future developments for certain variables of interest, recognising that the future is obviously unknowable. However, scenarios can be constructed in ways that make them credible and robust to a greater or lesser extent, depending on the choices made concerning the various constituent elements described in this report.

The diversity of national circumstances means that there is no single correct approach to any one decision concerning the above mentioned choices. Therefore, multilateral agreement on detailed international guidelines for baseline scenario development is difficult. Nevertheless, the extent to which certain 'good practice' considerations are taken into account can greatly enhance the robustness of national baseline scenarios and, by extension, improve the quality of the decision-making processes they support.

Transparency in baseline setting

Transparency and information disclosure are essential if, in the absence of formal international guidance, governments wish to demonstrate the credibility of their baseline scenarios to domestic stakeholders and to the international community. The global nature of climate change means that the better governments understand the positions of other governments, the more likely cooperative action becomes. Increased transparency would help interpret, in particular, national pledges defined as emissions reductions against the baseline.

In addition, sharing experiences in developing baselines can be beneficial to all parties, as many countries face similar challenges when putting together baseline scenarios. Preferably, public disclosure should include full documentation of the baseline-development process, including a clear definition of the purpose of the baseline, as well as making available all of the important modelling choices, as described in previous chapters.

Key defining factors in baseline scenarios

The experiences documented above highlight that a small number of factors have a major impact on baseline scenarios. Chief amongst these is the GDP projections used and, to a lesser extent, whether (and which) existing policies and measures are included in the baseline, and how the impacts of those policies and measures are estimated. However, the latter will become increasingly important over time as more policies are likely to be implemented. The overwhelming importance of GDP projections is demonstrated by the strong correlation that is usually observed between them and the resulting rate of growth in emissions in the baseline. This underscores the importance of the method used to generate GDP growth rate projections.

What 'existing policies' means depends on national circumstances and the intended use of the baseline scenario. In some cases, scenarios used for similar purposes currently use different approaches. It should be possible to reach international agreement on common applications, notably for baselines used to define a national mitigation pledge submitted to the UNFCCC. At the very least, countries could document which policies are included in the baseline and which are not (up to a certain cut-off date), as well as the reasons behind these choices.

Uncertainty in baseline scenarios

Scenario development is always subject to large uncertainties of different kinds. There are ways of better understanding, quantifying and minimising those uncertainties, which should be a goal of baseline-scenario development. The practices documented in this report suggest that this is far from always being the case at present.

Sensitivity analyses, which are run mainly with the purpose of testing assumptions that are deemed to be particularly uncertain or that play a major role in determining the results of the scenario, are the main approach used to quantify uncertainty at present. A range of other tools are available, including expert judgment elicitation, Monte Carlo simulations and different types of 'model ensemble' analyses. Having different teams work simultaneously on developing national baseline scenarios can also help to 'raise the bar' and to some extent reduce, or at least quantify, the uncertainty associated with baseline scenarios. These tools are often underutilised at present.

In the future, irrespective of the analytical tools and approaches used, national baseline scenarios might evolve from single to multiple pathways, to reflect both the range of plausible assumptions and the uncertainty associated with any one given assumption. Increased consistency with related planning efforts (for example, by agreeing upon a common set of basic assumptions) might also be expected.

Towards elements of 'good practice'

Drawing on the experiences outlined in Part 2 of this report, Table 5 overleaf summarises the views of the authors of Part 1 regarding guiding principles of 'good practice' in the context of baseline scenario development. A list of this kind cannot be comprehensive or universally applicable, but it can provide examples that are likely to be broadly relevant to different national contexts. In spite of its inherent limitations, this summary can be of use both directly, to help government agencies interested in developing or improving a national baseline, and indirectly, to highlight the potential mutual benefits of sharing information between countries in this area.

Table 5: Views of the authors of Part 1 regarding possible guiding
principles for 'good practice' in developing baseline scenarios

Topics	Guiding principles
Model choice	Consider the relative importance of emissions sectors, balancing sophistication/accuracy with resource constraints
Institutional arrangements	Integrate baseline scenario setting into an inter-ministry institutional framework (such as a central climate change committee or agency, covering data management, emissions inventories and climate-related policies) that clarifies responsibilities and ensures that the specificities of baseline scenario development are taken into consideration
Definition and purpose	State the precise definition, purpose and intended use of the baseline
Inclusion of the effects of policies	State which existing policies are included in the baseline scenario, how they are accounted for and what the cut-off date is. Seek consistency across the same types of application (e.g. a national communication to the UNFCCC)
Exclusion criteria	State and explain the exclusion criteria used
Base year	State the base year and whether this coincides with the latest emissions inventory (not necessarily the one used for the latest National Communication)
	If the base year is subject to emissions estimation, provide the reasons for choosing the base year
Updates and revisions	State any plans for revising or updating the baseline scenario, as well as the criteria for making such a decision, for example by using a predetermined frequency of updates or by evaluating the changes in certain key drivers on a continuous basis
Key driver projections	State how projections of key drivers are developed and explain the choices made
	Develop projections specifically for the baseline, relying on appropriate analytical methods (forecasts of key drivers used as inputs to climate change models are intended to provide an indication of what is most likely to happen as opposed to aspirational or politically determined goals)
	Compare projections of key drivers with international data sources and forecasts (keeping in mind that internationally conducted forecasts are not necessarily more reliable than national ones)
Technology development and learning	Specify the extent to which technology development has been included in the baseline scenario across different technologies and how this is linked to existing policies
Assessing uncertainty	Identify key drivers and quantify their relative impact on emissions levels
	Conduct sensitivity analyses or use other procedures such as seeking expert elicitation or 'model ensemble' analysis on key drivers in order to indicate the robustness of a baseline scenario
	Use multiple models (or multiple modelling teams) to provide additional information on the level of uncertainty

Topics	Guiding principles
Data management	Improve historical data in a structured way by enhancing cooperation with various stakeholders, for example by establishing a coordinating committee
Emissions factors	State whether IPCC default emissions factors are used, and/or for which emissions sources country-specific emissions factors have been developed
	Develop and use country specific emissions factors, when resources are available
Stakeholder involvement	State which national stakeholders have been involved in the development of the baseline scenario and how
	Make public information about the consultation process and whether and how recommendations have been acted upon
International peer review	State whether international peer review has been done and by whom
	Make the full review report publicly available and indicate whether recommendations have been acted upon
Comparisons with international scenarios	State whether the baseline scenarios have been compared with corresponding baseline scenarios calculated by international models, as well as the findings from such studies

Part 2: Country Contributions

This part of the report contains the individual country contributions written by country experts in Brazil, China, Ethiopia, India, Indonesia, Kenya, Mexico, South Africa, Thailand, and Vietnam. These countries account for approximately 40% of current global GHG emissions,[24] and this share is expected to increase in future. Furthermore, as shown in Figure 1 in Chapter 1, the countries represent a wide variety of sectoral compositions of GHG emissions. For some countries the energy sector is the most important emissions sector, whereas for others the land-use and/or agricultural sector dominate the emission generation.

The contributions should be indicative of current practices and experiences of baseline scenarios in the 10 countries, and do not necessarily represent governmental positions.

All contributors were given a list of key questions for reference. However, it was agreed that the contributors did not have to cover all topics or touch upon all key questions.

Mexico   Brazil   South Africa   Kenya   Ethiopia   India   China   Thailand   Vietnam   Indonesia

24. Based on estimated total GHG emissions in 2010 by the IEA (World Energy Outlook, 2012).

Brazil (UFRJ)

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Brazil´s greenhouse gas emission inventories

Brazil's Second National Communication to the UNFCCC provides greenhouse gas emission inventories for the period of 1990 to 2005, presented in Table 1.

The main source of greenhouse gas emissions in Brazil is deforestation, caused by the expansion of agricultural frontiers, predominantly in the Amazon region. Accurate estimates of deforested land surface are available from satellite image recovery. The corresponding CO_2 emissions, however, are very hard to quantify due to lack of reliable data on the biomass densities of the different kinds of forests and savannahs affected.

Agriculture and husbandry are key sectors of the Brazilian economy, which explains why they rank second as main greenhouse gas emitters. Because of the country's vast agricultural and grazing lands, it is one of the largest agricultural producers in the world, ranking second in soybean production, with 18% of the global total. It also has the second largest bovine herd in the world, with 12% of the global total. In this sector, CH_4 emissions are dominant, as a result of enteric fermentation of the huge cattle herd and other ruminant herbivores.

The energy sector ranks only third as a main source of greenhouse gas emissions, as 45% of Brazil's total energy supply is generated by renewables, due to the contribution of hydropower and renewable biomass (ethanol from sugar cane, wood and charcoal from forest plantations, and biodiesel from vegetable oils cultivation).

Brazil´s voluntary greenhouse gas emission mitigation goals

Brazil has been making a strong effort to limit its greenhouse gas emissions, including initiatives to curb Amazon deforestation, and important investments in renewables. The National Climate Change Policy Law, approved by the Congress and sanctioned by the President on 29 December 2009 (Federal Law no 12187), included voluntary goals to limit the country's GHG emissions – as presented the month before, at COP15 in Copenhagen. Brazil's voluntary goals were established to reduce between 36.1 and 38.9% of the country´s projected 2020 GHG emissions. Preliminary estimates of business-as-usual and mitigation emissions scenarios for 2020 were made by several government bodies prior to COP15, discussed in the Brazilian Forum on Climate Change (FBMC), and eventually constituted the basis of this pledge. These preliminary estimates are presented in Table 2. The finalized mitigation goals, however, had to await the completion of the Second National Communication, in 2010. Therefore, it was only on 9 December 2010, during COP16 in Cancún, that the Brazilian government published a decree (Federal Decree no 7390) regulating the articles of Law no 12187 regarding final voluntary goals for 2020 – as shown in Table 3.

Table 1: Greenhouse gas emissions in Brazil, 1990 – 2005

GHG Emissions (Mt CO_2eq / year)	1990	1994	2000	2005	Percentage change from 1990 to 2005	Share of 1990 emissions	Share of 2005 emissions
Land Use Change	813	883	1328	1,329	63%	58%	61%
Agriculture/Husbandry	304	329	348	416	37%	22%	19%
Energy	192	217	301	329	71%	14%	15%
Industrial Processes	53	59	72	78	47%	4%	4%
Waste	29	32	39	41	41%	2%	2%
TOTAL	1,389	1,520	2,088	2,193	58%	100%	100%

Source: Brasil, 2010

Table 2: Preliminary estimates of Brazil's greenhouse-gas emissions and mitigation actions for 2020

Emissions / Mitigation actions (Mt CO$_2$eq / year)	2005 Inventory data	2020 BAU scenario	2020 Mitigation scenario	Reduction in 2020 Mt CO$_2$eq	Contribution to the total reduction from BAU in 2020 (%)
Land Use Change	1268	1084	415	669	24.7%
Agriculture/Husbandry	487	627	461 – 494	133 – 166	4.9 – 6.1%
Energy	362	901	694 – 735	166 – 207	6.1 – 7.7%
Energy efficiency				12 – 15	0.4 – 0.6%
Biofuels increase				48 – 60	1.8 – 2.2%
Hydropower increase				79 – 99	2.9 – 3.7%
Small Hydro, Biomass, Wind				26 – 33	1.0 – 1.2%
Others	86	92	82 – 84	8 – 10	0.3 – 0.4%
TOTAL	2,203	2,703	1,652 – 1,728	975 – 1,052	36.1 – 38.9%

Note: Mt CO$_2$eq = million tons of CO$_2$eq
Source: Brazilian Ministries of Environment and Science and Technology, in La Rovere, 2009

Table 3: Final figures of Brazil's greenhouse-gas emissions and mitigation actions for 2020

Emissions (Mt CO$_2$eq / year)	2005 Inventory data	2005 Inventory data	Variation 1990 – 2005 (%)	2020 BAU scenario	Variation 2005 – 2020 BAU (%)	Mitigation Actions / Avoided Emissions in 2020
Land Use Change	813	1,329	63%	1404	6%	
Amazon				948		
Savannahs				323		
Others				133		
Agriculture and Husbandry	304	416	37%	730	75%	
Energy	192	329	71%	868	164%	234
Industrial Processes + Waste	82	119	45%	234	97%	
TOTAL	1,389	2,193	58%	3,236	48%	1,168 - 1,259

Source: Brasil, 2010; Federal Decree no 7390, 2010

Compared to the preliminary estimates, these final figures increased the 2020 business-as-usual emissions from 2.7 to 3.2 g tons of CO$_2$eq due primarily to:

- The inclusion of greenhouse gas emissions from land-use change in the savannahs ("cerrado"), which were not yet accounted for, as the satellite monitoring system only focused on the Amazon region; this led to an addition of 0.3 g tons of CO$_2$eq to the business-as-usual emissions from land-use change in 2020.

- A review of the 2005 inventory estimates and the business-as-usual 2020 projection of greenhouse gas emissions from IPPU and waste, leading to an addition of 0.1 g tons of CO$_2$eq to the BAU GHG emissions from industrial processes and waste in 2020.

- A review of the assumptions about future growth of greenhouse gas emissions from agriculture and husbandry, given the substantial increase of Brazilian exports in recent years, leading to an addition of 0.1 g tons of CO$_2$eq to the sector's business-as-usual emissions in 2020.

Unlike the preliminary estimates made in 2009, the decree does not establish a full mitigation scenario with voluntary goals for each main source of emissions. The only exception is the energy sector. The government considers the current Ten-Year Energy Plan to be its mitigation scenario, as it includes a number of efforts to increase the role of renewables, nuclear and energy efficiency in the nation's energy policy.

The main contribution to curbing the country's greenhouse gas emissions will come from efforts to reduce deforestation in the Amazon, following the successful record of recent years. The initial goal set for the agricultural sector in the preliminary estimates (133 - 166 Mt CO$_2$eq of avoided greenhouse gas emissions in 2020, down from 627 in the business-as-usual scenario – see Table 2) seemed very ambitious, considering the recent growth of the country's grains and meat exports. The final business-as-usual figures (Table 3) for agriculture and husbandry are now considerably higher, making the assumed mitigation efforts more reasonable. Economically feasible mitigation alternatives already exist and have great potential: recovery of degraded pasture lands, agroforestry schemes, more intensive cattle raising

activities (given the current low average ratio of 0.5 heads per hectare), biological nitrogen fixation and low tillage techniques, which cover more than 20 million hectares of the country, and are rapidly spreading. The main difficulty lies in establishing incentives to disseminate these lower carbon options.

In the case of the emissions of industrial processes and waste disposal, grouped under Other Sectors due to its minor contribution to the total, the business-as-usual scenario already shows a low growth trend, and the voluntary commitments aim to keep emissions roughly constant. Again, there are feasible mitigation options in these sectors, such as the capture, burning and/or fuel use of biogas in sanitary landfills.

Methodological choices

Energy and Emissions Modelling

The Brazilian Energy Planning Agency (EPE), as part of the Ministry of Mines and Energy, is responsible for drafting Ten-Year Energy Plans (updated annually) and the Long-Term Expansion Energy Plan of the country (updated every five years). The general bottom-up approach uses exogenous GDP growth rates as an input to energy modelling. The energy supply and demand projections are checked for macroeconomic consistency.

The business-as-usual emissions projection from the energy system for 2020, presented by the Brazilian government at COP15, was calculated as a deviation from the official energy projection established in the Ten-Year Plan, which is considered to be a mitigation plan.

EPE runs a customized "in-house" energy model, similar to MESSAGE, to draft the Ten-Year and Long-Term Expansion Energy Plans. This same tool was used to simulate a baseline emissions projection from the energy system for 2020.

EPE is a new institution that inherited the models traditionally used in Brazilian energy planning. A MARKAL version was developed for Brazil in the framework of the Brazil/Germany Agreement on Nuclear Energy, during the seventies. More recently, the International Atomic Energy Agency supported the development of a MESSAGE/

MAED version for Brazil, used at PPE/COPPE/UFRJ[25], which was eventually made available to EPE.

It will be necessary to build a computerized general equilibrium macroeconomic model consistent with the National Energy Balance to strengthen the analysis of social and economic implications of GHG emission mitigation scenarios. This tool is not available yet, and its construction would require a joint effort between the government and economic planning agencies, together with leading universities and research centres.

As is usually the case when using bottom-up approaches, the in-house model used by EPE has allowed for a detailed representation of the energy system and direct costs related to mitigation measures, helping to identify the most cost-effective options. Conversely, the macroeconomic consistency of the energy scenarios, and the social and economic implications of mitigation policies are not appropriately addressed. For example, the energy demand resulting from the assumed GDP growth leads to a substantial amount of investments in energy supply to meet it, but the consistency of this financial effort, with the availability of resources to maintain this level of GDP growth, is not verified. In addition, no results about the impacts of mitigation efforts on GDP growth and employment levels are made available to decision-makers.

The development of the baseline emissions projection from the energy system for 2020 was done under a tight timeframe during the political process in 2009, leading to the governmental decision of presenting voluntary greenhouse gas emission mitigation goals at COP15 in Copenhagen. The costs were negligible and the choice of models was dictated by the tools already available at EPE.

Forestry and Land-Use Emissions Modelling

The Ministry of Environment is responsible for the emissions projection from forestry and land-use change. The baseline chosen was simply based on the annual deforestation surface in the Amazon, according to the historical average during the period 1996 to 2005, and the annual deforestation surface in the savannahs ("cerrados") during the period 1999 to 2008. There was no need

to use a mathematical model for this projection. This approach was in line with a previous effort of the Brazilian government at the UNFCCC, leading to the proposal of a Forest Fund to support the efforts to curb deforestation – presented at COP13 in Nairobi. This proposal was supported by most forest countries and was based on the same metrics.

Calculations of historical averages of deforestation are done in-house by the Ministry of Environment, based on the national inventories of land-use change and forestry greenhouse gas emissions developed at the National Spatial Research Institute (INPE).

Accurate estimates of land-use change and forestry greenhouse gas emissions are available for the period covered by the GHG inventories presented to the UNFCCC (1990 to 2005). Estimates with lower accuracy are made by the Ministry of Environment for more recent years, based on the annual change in the surfaces of forests and savannahs. The main challenge is to estimate the biomass density in areas where vegetation coverage was removed. Currently, this is done using the results of a detailed aerial photographic survey covering the Amazon region, which was done during the sixties and serves as a proxy of untouched forest.

Institutional issues

The Ministry of Environment is responsible for scenarios of land-use change and forestry greenhouse gas emissions. The Ministry of Mines and Energy, through EPE, is responsible for energy-related greenhouse gas emissions scenarios. The Ministry of Agriculture, with technical support from the Agricultural Research Agency (EMBRAPA), is responsible for agriculture and husbandry greenhouse gas emissions scenarios. The Ministry of Development, Industry and Trade released a Sectoral Mitigation Plan in 2012 covering the mitigation of GHG emissions from industrial processes and detailing the mitigation of emissions from energy use in industry. The Ministry of Cities is responsible for scenarios of GHG emissions from waste.

The Brazilian Climate Change Committee gathers representatives of all concerned ministries, and its Executive Group regularly to coordinate efforts towards the

implementation of the Brazilian Climate Change Plan, facilitated by the Ministry of Environment.

The Brazilian government presented a single greenhouse gas emission baseline scenario through to 2020, to the UNFCCC. Several independent studies have produced other baselines up to 2020, 2025 and 2030, according to different approaches and assumptions: La Rovere et al, 1994; IEA, 2006; La Rovere et al, 2006; McKinsey & Company, 2009; Gouvello et al, 2010; Margulis et al, 2010; La Rovere et al, 2011.

Assumptions and sensitivity analysis

Underlying Principles

The key political context for defining the baseline was the international climate regime, and particularly the preparation for the negotiations at COP15, in Copenhagen. Implementation of the National Climate Change Policy Law was approved by Congress and sanctioned by the President on 29 December 2009 (Federal Law no 12187). This law included the voluntary goals to limit the country's greenhouse gas emissions, presented the month before at COP15. On 9 December 2010, during COP16 in Cancún, the Brazilian government published a decree (Federal Decree no 7390) regulating Law no 12187. The 2009 National Climate Change Plan is currently being updated. There are no NAMAs announced so far.

For land-use change and energy, the government provided an official definition of what is included in the baseline. For LULUCF, the baseline chosen was the extension of the annual historical average for the Amazon region, for the period 1996 to 2005; and for the "cerrado" ecosystem, for 1999 to 2008, up to 2020. Power generation from natural gas, instead of hydropower, and gasoline and diesel oil, instead of ethanol and biodiesel, are included in the energy sector baseline to meet the expected increase in energy demand. The reasons for these choices were the challenge of building new hydropower plants when the bulk of the hydropower potential is located in the Amazon region, and the governmental incentives required to increase ethanol and biodiesel production. Renewable energy and energy efficiency are assumed to remain constant in future years, at the same production level reached in 2008 – with the exception of

some large hydropower plants with construction already approved by the government, included in the baseline.

The expected future increases in renewable energy production and energy efficiency were not included in the baseline. This was due to the fact that the Brazilian government perceived these to be resulting from a voluntary mitigation effort, supported by policies and measures, to overcome a number of barriers to the penetration in the market, of these technologies. This rationale was in line with previous negotiations within the UNFCCC that considered all the projects implemented through new public programmes (e.g. PROINFA, a Brazilian governmental programme supporting power generation from small hydro, wind and biomass, launched in 2004) eligible for CDM, provided that they would explicitly include climate change mitigation among their goals.

The case of the energy sector deserves special attention. Due to the use of fossil energy, Brazilian emissions have been increasing significantly in the form of oil, natural gas and coal. These fuels play a basic role in running the modern part of the economy, such as industry, transport, and agribusiness, as well as the residential, commercial and service sectors. Fossil energy's share in power generation has been increasing to complement the use of the huge Brazilian hydropower potential, which is by far the dominant energy source for generating electricity in the country. Therefore, due to energy use, the emission of greenhouse gases – especially CO_2 – grew by 71% from 1990 to 2005. Indeed, economic growth, rising urbanization, and the dominance of road transportation in the country are the driving forces to the increasing fossil energy consumption and its associated CO_2 emissions.

In contrast to other sectors, consumption of fossil fuels is expected to result in a significant increase in business-as-usual emissions by 2020, fostered by GDP growth projected at 5% per year.

The levels of emission mitigation in hydropower generation, energy efficiency and alcohol production were those included in the Ten-Year Energy Expansion Plan for 2020 (EPE, 2010). Other mitigation actions included were the production and use of biodiesel in a 5% blend (B5) with diesel oil, and the increase in power generation from other renewable sources: small hydropower plants, biomass (especially sugarcane bagasse) and wind energy.

25. Energy Planning Programme of the Institute for Research and Graduate Studies in Engineering at the Federal University of Rio de Janeiro.

Nevertheless, greenhouse gas emissions resulting from the use of fossil fuels in the country will be 93% higher in the mitigation scenario, compared to 2005 emissions. Achieving the mitigation scenario goals will require implementation of public policy tools capable of stimulating a substitution of renewable energy sources for fossil fuels. The need for this substitution will be even more acute in the mitigation scenario aimed at driving the Brazilian economy towards a low-carbon path.

The energy baseline includes an assumption of autonomous energy efficiency improvements based on historical trends. Some policy-driven energy efficiency measures are also included in the baseline. The 2005 production level of biofuels (ethanol from sugar cane, biodiesel from soybeans, and other vegetable oils) is considered part of the baseline. Other power generation plants using renewable energy sources, such as hydropower, wind and small hydro, are already under construction.

The main challenge of this choice is the subjectivity of the additionality of investments in hydropower and ethanol, as the historical trend illustrates a certain level of governmental effort to support these renewable energy sources. In the future, higher oil prices can make ethanol more competitive, however, sugar production may become more profitable than ethanol, depending on the ratio between sugar and oil prices. The cost of hydropower is competitive with power generation from oil and gas, but upfront costs and risks are much higher, requiring substantial governmental support in facilitating public/private partnerships to undertake the huge investments.

The 2005 base year was chosen because the last official greenhouse gas emissions inventory is available for that year. More recent figures are available for the energy system, as well as estimates of GHG emissions from deforested surfaces, although the accuracy of these figures will be lower than that of the inventories.

The government has not announced any plans to revise the baseline. The main contribution to GHG emission reduction in 2020 is expected from the land-use change sector, where a fixed baseline (historical averages from 1996 to 2005 in the Amazon, and from 1999 to 2008 in the "cerrado" region) was adopted. An update of the baseline derived from a mobile average of the last ten

years would certainly reduce the level of GHG emissions from LULUCF in the baseline, as recent data shows that government has been successful in curbing deforestation. The same applies to the energy sector, where the government has been able to make additional investments in new hydropower plants feasible, while ethanol production has stalled due to the sector's financial crisis implications. With a lower baseline, the claimed overall reduction from 36.1 to 38.9% in the mitigation scenario would be lower. The absolute-level target in the 2020 mitigation scenario, however, would remain 6 to 10% lower than the country's 2005 greenhouse gas emissions.

The government has not announced any provision to update and/or revise the baseline. The main emphasis was put on reaching the greenhouse gas emission level in 2020, in the mitigation scenario, and not on the baseline. Within the Kyoto context, the metrics of voluntary targets to be pledged by non-Annex I parties was designed as a deviation from business-as-usual, allowing for some growth of GHG emissions in the future. That seems to be the main purpose for the calculation of a business-as-usual scenario in the case of Brazil. In a new process, started by the Durban Plan of Action, the challenge will be to define new criteria for setting the baseline, while the assumptions made in preparation for COP15 may not necessarily be the same.

Key Assumptions

Population projections follow the demographic studies of the Brazilian Institute of Geography and Statistics and are not subject to large fluctuations, as population growth rates have been substantially reduced to just above 1% per year. Therefore, its relevance as a key driver of GHG emissions has been reducing over time. Urbanization, particularly the share of large cities with more than one million inhabitants, is also an important and growing emissions driver, although the rate of increase in the share of urban population has slowed in the last decade – since it reached 85%.

GDP growth is the most critical GHG emissions driver. Governments must be optimistic about this – and the Brazilian government is no exception to the rule, putting forth an ambitious 5% average annual rate of economic growth through 2020. This is the main source of

discrepancy with other independent studies. For example, the IEA (2006) assumes an economic growth rate of 3% per year for Brazil.

Assumptions for key drivers such as GDP growth and international oil prices are established as exogenous inputs to the energy model. Rather than historical values, the assumptions reflect expert judgment about international oil prices and politically defined economic growth targets. EPE conducts technical studies and runs discussions with independent experts on the appropriate level for international oil price projections, and follows the guidelines on GDP growth assumptions from the economic planning area of the federal government. The benefits and challenges of this choice are the same as the country's energy planning, which follow the same approach and are well known (e.g. risk of planning for an overinvestment on power generation). Adjustments can be made in due course: for example, the Ten-Year Energy Plan 2012-2021, recently released for public consultation, uses an annual average GDP growth rate of 4.5% up to 2021. This has not led to any announcement by the government for a review of the business-as-usual GHG emission scenario presented at COP15.

Most of the recent independent scenario studies (La Rovere et al, 2006; McKinsey & Company, 2009; Gouvello et al, 2010; Margulis et al, 2010; La Rovere et al, 2011) adopt the same assumptions for population and economic growth as the country's official GHG emissions baseline. The exception is the above-mentioned study by IEA (2006), which uses a lower economic growth rate of 3% per year for Brazil.

Sensitivity Analyses

The government has presented a single scenario as the official baseline emissions projection, although sensitivity analyses conducted on the projection have not been made public. The main reason for the lack of sensitivity analyses may be that decisions regarding how to model the baseline were more political than technical. For LULUCF, the background information on the previous proposal to the UNFCCC, using the historical average as the metric for future commitments, was available.

Regarding energy, the Brazilian government has been keen to maintain that renewable energy and energy efficiency deployment are not a business-as-usual trend but, rather, the result of a number of public policies.

Use of emission inventories and data management

Emission Inventories

The national greenhouse gas inventories available from 1990 to 2005 (described above) are the main source of information to project future emissions. These inventories are prepared by a network of more than 50 institutions, with expertise in each relevant field, ensuring the generally good quality of the data. There is no formal verification process for the inventories. The Ministry of Science and Technology coordinates the efforts of the network of institutions involved, ensuring that good practices and IPCC guidelines are followed.

Energy emissions are well disaggregated into sectors according to national energy balances, updated yearly.

Emissions from land-use change are available for the Amazon region, savannahs ("cerrados") and the Atlantic Forest. Better information about changes in the vegetal coverage of other ecosystems (e.g. "caatinga" in the North-eastern semi-arid region) would be desirable, but emissions from these regions are less important.

National inventories are available on the internet; the Ministry of Science and Technology has a very informative website that is a helpful tool to all stakeholders in the field of climate change.

The key issue is the estimate of GHG emissions due to deforestation. The National Spatial Research Institution (INPE) is a well-known centre of excellence in the field of satellite imagery collection, processing and interpretation, for all of South America. The main difficulty is obtaining data on biomass densities of deforested areas, disaggregated for small surfaces. Aerial photographic surveys of the Amazon, made during the sixties, currently provide

the data about original forest coverage and biomass density. The underlying assumption is that the Amazon tropical forest was at equilibrium in the sixties, and that deforestation in subsequent periods removed part, or all, of the original vegetal forest coverage.

Most emission factors used in the inventories are customized to national circumstances, and IPCC default emissions factors are only used in a few cases. The quality is usually very good.

In mitigation analyses, estimating emission factors for biofuels is always controversial, due to assumptions about indirect GHG emissions in land-use change resulting from cultivation of feedstocks for biofuels production.

Socio-Economic and Other Data

National statistics are available from the National Institute of Geography and Statistics (IBGE), with periodical census and surveys. Socio-economic data are disaggregated in national statistics, according to the guidelines of United Nations statistical systems. An ideal breakdown would match energy balances with economic sectors, making it possible to build input/output tables of the economy with energy sectors/products disaggregated. However, this method would require a great deal of estimation as data collection in international statistical systems, as well as Brazilian data sources, are not organized that way.

Most of the information required is publicly accessible and further data disaggregation is available from IBGE for a reasonable fee. The quality of the socio-economic data available in Brazil has substantially improved in recent years, after the end of hyperinflation in 1994. Estimates of the size of informal activities are already available. The usual verification process is adopted by IBGE, according to international best practices.

Sectoral data about activity levels from industry, transportation and the waste sectors are important in projecting future demand for services in baseline and mitigation scenarios. Data on income, price elasticities of energy goods bought by household (broken down by income levels), and saturation effects are also important. The national GHG inventories ensure a reliable source of data for the base year, on which projections are based.

Capacity Building to Improve Data Processes

It is particularly difficult to have primary data required to build baseline scenarios and mitigation cost curves in the transport sector. Transportation agencies at the federal level and for the main capital cities would be appropriate depositaries of the technical data required in this crucial sector for GHG emissions projections.

The Brazilian government has recently announced that the (re)creation of these bodies is under consideration.

Available data for the transport sector, both in intercity freight transportation and in urban passenger transportation, is very limited. The (re)creation of transportation agencies at the federal level and for the main capital cities would be appropriate.

Primary surveys would be required to improve data availability and quality in the transport sector, and financial resources would be needed to this end. The transportation agencies, at the federal level and for the main capital cities, could be responsible for funding these surveys.

In general, useful energy balances with updated performance of end-use equipment would be important in improving energy demand projections. Current useful energy balances available in the country still refer to end-use equipment performance measurements made during the eighties. Consequently, updated measurements are badly needed.

Transparency, stakeholder involvement, and review

Stakeholder Involvement

A discussion of the voluntary goals that would be presented by the government in COP15 was held at the Brazilian Climate Change Forum. Among representatives of all stakeholders were government, industry, NGOs and the scientific community.

The main discussions in preparation for COP15 focused on the mitigation scenario and, in particular, on the level of ambition corresponding to the voluntary targets for 2020, rather than the baseline. The final decisions were

made by the President, based on the outcome of political negotiations held within the government (e.g. between the ministers of Agriculture and Environment), while taking into consideration comments from stakeholders involved in the Brazilian Climate Change Forum.

The Brazilian Climate Change Forum was already established with representatives of all stakeholders. The proposals resulting from previous negotiations between different ministries were presented and debated in the Forum, in the presence of the President of the country (Lula) and the minister of the Civil House (Dilma Roussef) at the time. The position was finally agreed on and taken to COP15, supported by the stakeholders represented in the Brazilian Climate Change Forum.

Peer review

There was no national or international peer review conducted on the Brazilian baseline emissions projections. The main challenge of soliciting peer review seems to be that the government considers it a very delicate matter, as it involves national sovereignty.

Comparing In-Country and Supra-National Model Projections

There is no available study that includes an overview and comparative analysis of the governmental official GHG emissions baseline up to 2020 with other independent studies previously mentioned (La Rovere et al, 1994; IEA, 2006; La Rovere et al, 2006; McKinsey & Company, 2009; Gouvello et al, 2010; Margulis et al, 2010; La Rovere et al, 2011).

As previously noted, IEA's study considers a lower GDP growth rate (3% per year instead of 5% per year).

The World Bank Low Carbon Study (Gouvello et al, 2010) included some options in the baseline considered by the government as belonging to the mitigation scenario – such as new hydropower generation and the increase in biofuels production.

As previously indicated, one can challenge the government's choice of the baseline, particularly in the energy sector (leaving all new hydropower and increase in biofuels production out of the baseline). Different baseline

assumptions might reach a lower departure of the mitigation scenario from BAU in 2020 than the official figures (36.1 to 38.9%).

The most significant feature of the Brazilian voluntary GHG emissions reduction goals is that the mitigation scenario corresponding to the governmental policy in place will lead to an absolute reduction of 6 to 10% of GHG emissions in 2020, compared to the 2005 level. While this is mainly due to the reduction in emissions from land-use change and forestry, it is unparalleled by any other non-Annex I country commitment.

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Introduction

Several research teams in China and other countries have published detailed reports comprising energy and emission scenarios for China. Chinese modelling teams include ERI (IPAC model), Tsinghua University, Renmin University, and Policy Science Research Institute of Chinese Academy (CAS).[26] International research teams include Lawrence Berkeley National Laboratory (LBNL), Tyndall Centre, and IEA. Figure 1, below, presents selected emission scenarios in recently published papers and reports reviewed in a Chinese meta-analysis (forthcoming), similar to the IPCC assessment reports. In the review process, key driving forces including, economic development, population and urbanization, technology progress, and policy measures were analysed. This review was designed to make the underlying basis of emission scenarios more accessible.

All scenarios presented depend heavily on the scenario developer. Scenarios are defined based on many key factors, such as economy growth, population, urbanization and technology progress. China is in a period of rapid change in all these key factors, resulting in differing CO_2 emission scenarios.

26. There are several detailed reports and papers from these research teams, especially from the IPAC modelling team at ERI.

Figure 1: Emission scenario for China: selected scenarios with report in detail

Legend:
IEA2007 RS, IEA2007 APS, IEA2007 HGS, IEA2008 RS, IEA2009 RS, IEA2009 450
IEA2010 NPS, IEA2010 450, IEA2010 CPS, IEA2010 BAU, IEA2010 EC, IEA2010 EA
IEA2009 BAU, IPAC-BAU, IPAC-LC, IPAC-ELC, THU2010LA, THU2010LB
THU2010LC, THU2010HA, THU2010HB, RMU2010BAU, RMU 2010EC, RMU2010Ea
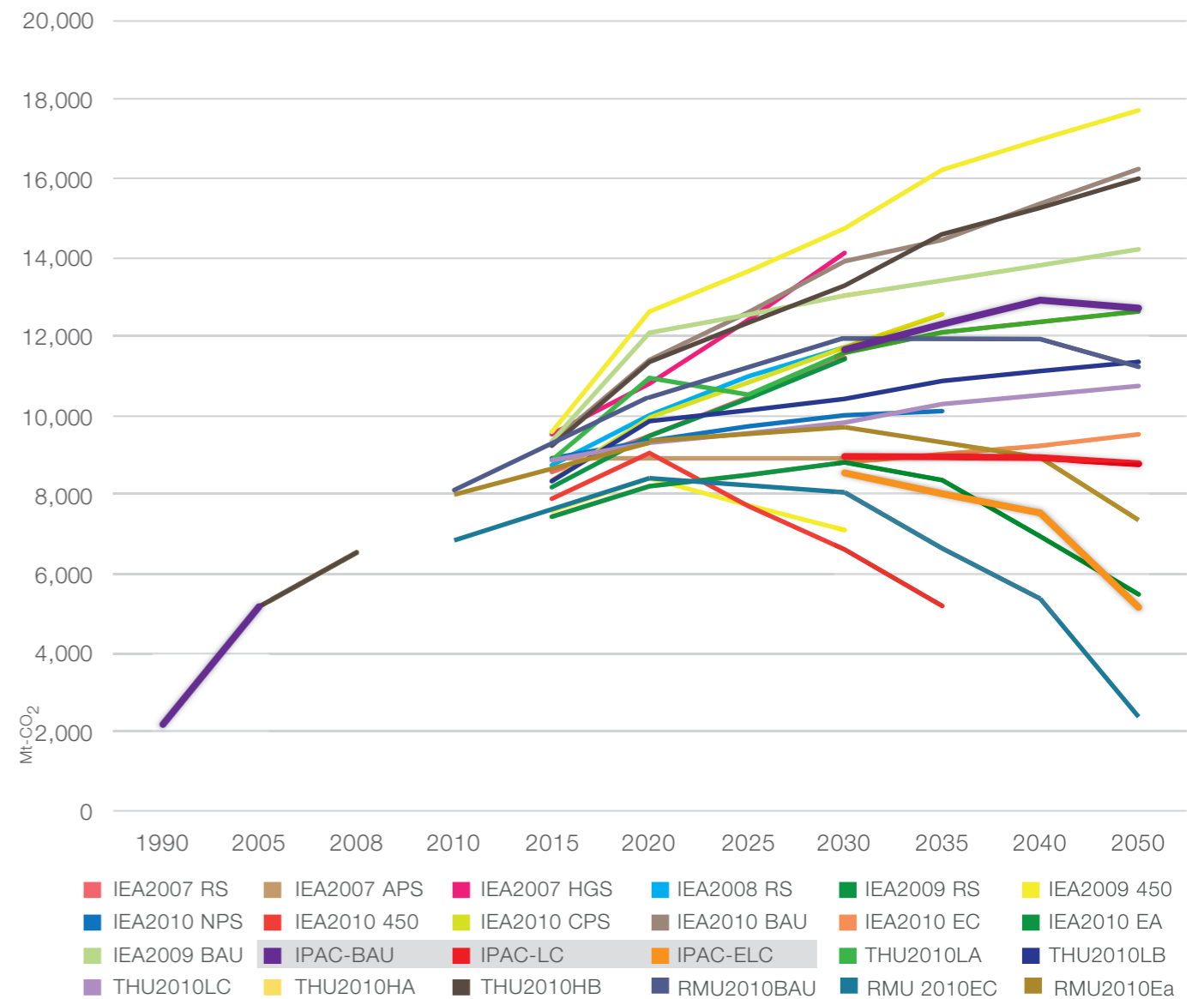
Note: IEA=International Energy Agency, RMU=Renmin University, ERI=Energy Research Institute (previous scenario), THU=TsingHua University

IPAC modelling study

In this section, the IPAC modelling study, which was developed by ERI and is well documented, is presented to demonstrate how modelling is done at ERI. The IPAC study in ERI can be considered a typical modelling activity in China for CO_2 emission scenario analysis. The study resulted in three scenarios: a baseline scenario, a low-carbon scenario and an enhanced low-carbon scenario (labelled "IPAC-BAU", "IPAC-LC" and "IPAC-ELC", respectively, in Figure 1). Key strengths of the IPAC model are that it has been developed over 20 years, is well published, and has contributed to many policy studies in China. A weakness of the IPAC model is that it is becoming very large, with extensive data, and, therefore, hard to maintain the data system (especially technology data).

The IPAC model

IPAC is a multi-model framework consisting of the IPAC-Emission model, the IPAC-AIM/technology model and the IPAC-SGM model.

The IPAC-Emission model is an extended version of the AIM-Linkage model used in Integrated Policy Assessment for China (IPAC) Special Report on Emission Scenarios (SRES). This model links social and economic development, energy activities and land-use activities, and forms the emission analysis across a spectrum of activities. The timeframe of the IPAC model can be up to 100 years. The first 50 years have a more detailed analysis, with the time interval of 5 years. The last 50 years have the time interval of 25 years.

As the main component of the IPAC model, the function of IPAC-AIM/technology model is to give a detailed

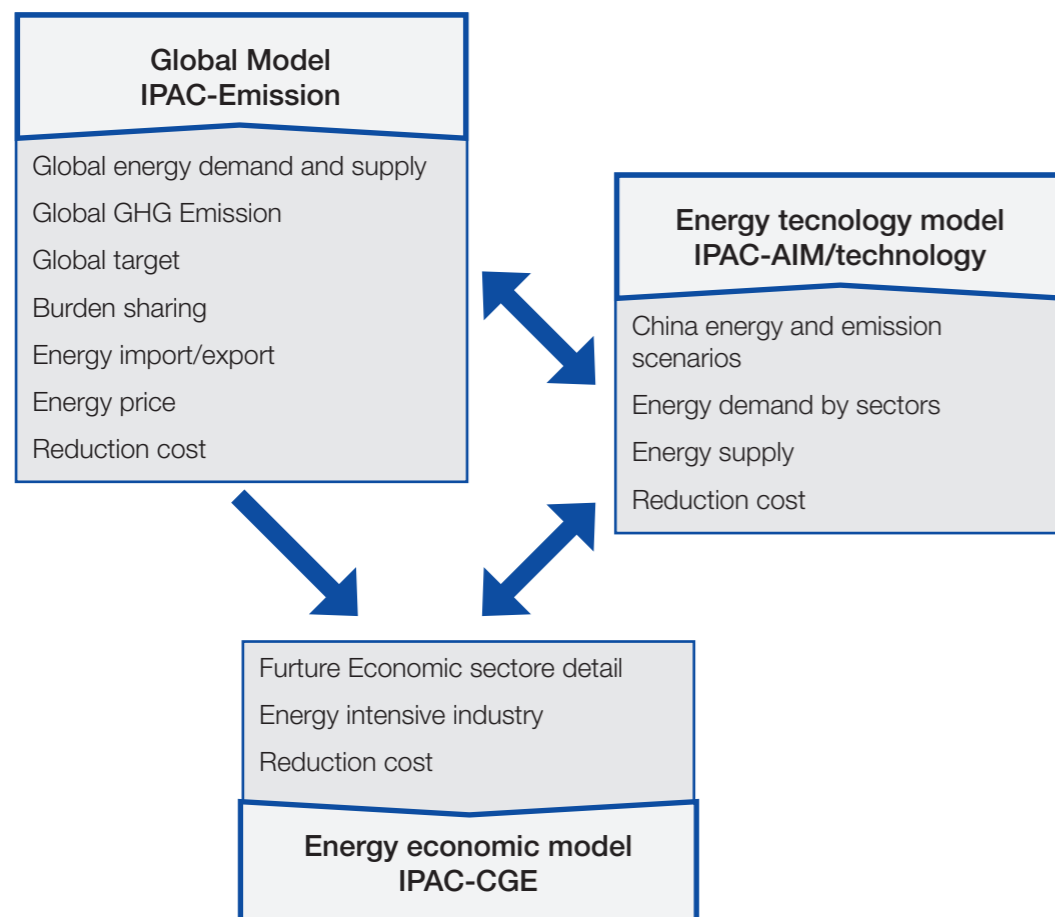description of the current status and future development of the energy service and the technologies, and to simulate the energy consumption process sequentially. Under different scenarios, the model can calculate the future demand of different types of energy in every energy end-use sector, and further calculate their CO_2 emissions. One of its important functions is to evaluate the effect that different technology policies would have on the introduction of technologies and GHG reduction. The current version of the IPAC-AIM/technology model deals with 42 sectors, their products, and nearly 600 technologies, including existing and potential technologies.

The IPAC-SGM is a general equilibrium model (CGE model), modelling the impacts and interactions among various economic activities. This model is used primarily to analyse the economic impacts of different energy and environmental policies, as well as the mid and long-term energy and environment scenarios. IPAC-SGM divides the economic system into household, government, agriculture, energy and other production sectors; the sectors could be further sub-divided when necessary. The decision makers of economic behaviours include households, government and producers. The primary factors in the production sectors include capital, labour and land. The production sectors produce goods according to the combination of factors.

Scenario building

Scenario definitions and assumptions

Baseline Scenario: The Baseline scenario reflects existing policies and measures, including current efforts of the Chinese government to increase efficiency and control emissions.

Low Carbon Scenario: The Low Carbon (LC) scenario assumes China will make an effort to achieve a relatively low-carbon future, by making CO_2 emission control one of its domestic environmental targets and by implementing domestic policies. These include, economic structural reform away from energy intensive industries, the

widespread dissemination of currently available energy efficiency technologies, and the aggressive diversification of the electricity generation mix. By 2020, the energy efficiency level of major high energy consuming industries in China would reach or surpass that of developed countries, and new building constructions would need to obtain a high level of energy efficiency standards. In general, this would reflect a shift towards highly efficient and clean production in the industrial sector, and aggressive standards that would encourage a public focus on energy efficiency in the home and workplace.

Enhanced Low Carbon Scenario: The Enhanced Low Carbon (ELC) scenario assumes that by partaking in global efforts to achieve low GHG concentration targets, China will make a much bigger effort towards GHG emission control. The potential of lower carbon emission technologies would be further explored. Zero emission vehicles, low emission buildings, renewable energy and nuclear power would reach their maximum potential. Decentralized power supply systems would be widespread, and some coal-fired power plants would employ carbon capture and storage (CCS). Under this scenario, China becomes one of the global leaders of low-carbon technology.

Key assumptions

IPAC's economic scenarios were mainly developed by reviewing related research of Chinese economists. The population forecast used in the IPAC model is largely based on several recent plans and research results. In IPAC's population scenario, the government will continue controlling the population growth in China, with the goals of improving birth conditions in rural areas and decreasing unplanned births. In later years, along with the gradual development of China's economy and negative population growth, the government will loosen its control of population growth. IPAC uses the population growth scenario from China's national family planning commission. In this scenario, China's population will reach a peak between 2030 and 2040. The table below shows some key assumptions and details about the scenarios.

Global Model IPAC-Emission

Global energy demand and supply

Global GHG Emission

Global target

Burden sharing

Energy import/export

Energy price

Reduction cost

Energy tecnology model IPAC-AIM/technology

China energy and emission scenarios

Energy demand by sectors

Energy supply

Reduction cost

Energy economic model IPAC-CGE

Furture Economic sectore detail

Energy intensive industry

Reduction cost

Table 1: Details of the three scenarios in 2050

	Baseline (BAU)	Low Carbon (LC)	Enhanced Low Carbon (ELC)
GDP	Realizing the national target of three-step development. Annual average growth rate is 9% between 2005 and 2020; 6% between 2021 and 2035; 4.5% between 2036 and 2050. Annual average growth rate is 6.4% between 2005 and 2050.	Similar to baseline	Similar to baseline
Population	Reaching maximum of 1.47 billion. In 2050, the population decreases to 1.46 billion.	Similar to baseline	Similar to baseline
Per capita GDP	About 270,000 yuan in 2050 (38,000 USD).	Similar to baseline	Similar to baseline
Industry structure	Economic structure is optimized to a certain extent. The tertiary industry is the main component. The development of secondary industry has great consumption. The heavy industry still holds an important role.	Economic structure is further optimized, similar to the pattern of developed country today. New industries and tertiary industry develop quickly. IT industry plays an important role.	Similar to LC
Urbanization	70% by 2030; 79% by 2050.	Similar to baseline	Similar to baseline
Configuration of export and import	Primary products begin to lose competitive power by 2030. Energy intensive products mainly satisfy domestic demand, rather than export.	Primary products begin to lose competitive power by 2020. Energy intensive products mainly satisfy domestic demand, rather than export. The exports of high added value and service industries increase.	Similar to LC
Energy Intensive Manufacturing	Reaches maximum output in 2030, and begins to decrease subsequently.	The maximum output is attained between 2020 and 2030, followed by a decrease. The maximum is lower than baseline.	Similar to LC
Demands of the primary energy sources	About 6.5 billion tons of coal equivalent (tce) in 2050.	About 5.3 billion tce in 2050.	About 5.1 billion tce in 2050.
CO_2 emissions by 2050	About 3.4 billion tons of carbon (12 billion tons of CO_2).	About 2.2 billion tons of carbon (8 billion tons of CO_2).	Peaking by 2030 and 5.5 billion tons of CO_2 by 2050.

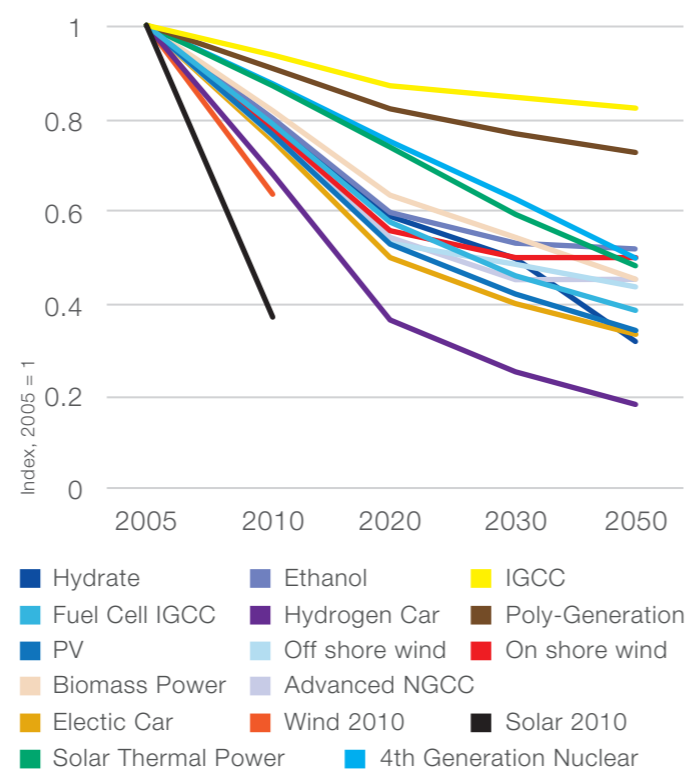|	Baseline (BAU)	Low Carbon (LC)	Enhanced Low Carbon (ELC)
Domestic environment problem	Much improvement in local environment. Could reach environmental standard similar to developed countries, but the pathway for local environment improvement still follows pollution first then reduction pathway, as a result of environmental Kuznetz curve.	Similar to baseline	Fully improved local environment by 2020. Better pathway for local pollutant emission, follows the effects of environmental Kuznetz curve.
Energy technology progress	Advanced energy technology is widely available in 2040. China becomes the technology leader; there will be 40% higher energy efficiency than present.	Advanced technology is widespread in 2030. The state of industry and technology in China are the highest in the world. China becomes the technology leader; there will be 40% higher energy efficiency than present.	Similar to LC
Application of non-conventional energy resources	Exploitation of non-conventional oil and gas after 2040.	Similar to baseline	Almost no need to exploit non-conventional oil and gas.
Electricity generation from solar energy and wind energy	The cost of solar energy is 0.39 yuan/kWh in 2050; the land wind generating sets are widely deployed.	The cost of solar energy is 0.27 yuan/kWh at 2050. The land wind generating sets are widely deployed. The offshore generating sets are constructed in large-scale.	Similar to LC
Nuclear power generation	Generating capacity is more than 200 million kW in 2050. The cost is lowered from 0.33 yuan/kWh in 2005 to 0.24 yuan/kWh in 2050.	Generating capacity is more than 330 million kW in 2050. The cost is lowered from 0.33 yuan/kWh in 2005 to 0.22 yuan/kWh in 2050. Large-scale construction of 4th generation nuclear power plants begin after 2030.	Generating capacity is more than 380 million kW in 2050. The cost is lowered from 0.33 yuan/kWh in 2005 to 0.2 yuan/kWh in 2050. Large-scale construction of 4th generation nuclear power plants begin after 2030.
Electricity generation by coal	Mainly supercritical (SC) and ultra-supercritical (USC).	Mainly the SC and USC before 2030, and subsequently integrated gasification combined cycle (IGCC).	Mainly IGCC after 2020.
CCS	No consideration	The typical projects begin in 2020 and some low cost CCS subsequently. Matching the newly built IGCC plants from 2050.	Integrated with IGCC plants; CCS is also used in industry of iron, cement, electrolytic aluminum, synthesis ammonia, ethylene, coal chemical. Extensive use after 2030.

Policy measures

The treatment of policy and measures is also well re-
ported for these scenarios, including baseline scenarios.
IPAC is a multi-model framework; therefore, policies can
be represented at different levels of detail in different sub-
models. By using a CGE-type model in IPAC, national
level fiscal policies including carbon tax, energy pricing,
subsidies, and emissions caps can be analysed. Similarly,
IPAC's bottom-up technology model can analyse energy
efficiency policies, subsidies, carbon tax, renewable
energy policies, energy efficiency standard, and emission
standards. This capability is quite similar to that of other
modelling teams in China. In IPAC's baseline scenario,
policies and measures before 2005 were considered, and
would be continuously implemented in the future, without
further policies and measures.[27]

Technological learning

Technological learning cost curves have been a key
research topic for IPAC, including a study that provides
detailed analysis on selected technologies, such as elec-
tric cars, nuclear energy, renewable energy, and electric
appliances. Figure 2 shows the learning curve used in
the IPAC model, indexed to 2005, and using actual data
for 2010. Technological progress has caused the cost
of wind and solar power to decrease substantially in the
past two years. In baseline scenarios, the learning curves
were used with slower learning effects when utilization of
these technologies was not that high, in contrast to faster
learning in mitigation scenarios.

Figure 2 Technology learning curve used in the IPAC/AIM-
technology model and data for 2010.

Legend:
- Hydrate
- Fuel Cell IGCC
- PV
- Biomass Power
- Electic Car
- Solar Thermal Power
- Ethanol
- Hydrogen Car
- Off shore wind
- Advanced NGCC
- Wind 2010
- 4th Generation Nuclear
- IGCC
- Poly-Generation
- On shore wind
- Solar 2010

How to make emission scenarios more transparent

It is always difficult to distinguish between baseline and
mitigation (or policy scenario).

First, to improve transparency, a detailed report explain-
ing the emission scenarios is crucial. Very few modelling
teams reported their emission scenarios in detail, and
only those that did were included in the review process.

Second, modelling teams' emission scenarios were
selected if they participated in academic workshops and
forums, and had significant experience with modelling
methodologies.

Third, the modelling team also joined policy research on
energy and climate change, understanding the circum-
stances of related policy-making needs.

A comment on China's second National Communication

The projection in China's Second NC for CO_2 emission
comes from a working group, including several modelling
teams, in which the IPAC model's study was a leading
analysis. Using the IPAC model, two scenarios were
developed: policy scenario and enhanced policy sce-
nario. In these two scenarios, policies and measures were
included to analyse the efforts to reduce CO_2 emissions
compared with the baseline scenario. The baseline sce-
nario in the NC is simply assuming that the CO_2 intensity
will not change until 2020.

27. Detailed information on which policies and measures are included, is available in "Potential Secure, Low Carbon Growth Pathways for the
    Chinese Economy" working paper by Jiang Kejun 2011.

Ethiopia

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Background

Like most countries, Ethiopia is experiencing the effects of climate change. Aside from direct effects, such as an increase in average temperature or change in rainfall patterns, climate change has been seen to present an opportunity to tap into a new and sustainable development model. Consequently, the Government of the Federal Democratic Republic of Ethiopia initiated the Climate-Resilient Green Economy (CRGE) Strategy with a view to withstanding the adverse effects of climate change, while building a green economy. The CRGE Strategy, developed in 2010, was constructed as an offshoot of a five-year plan to reach middle income status before 2025.

In the CRGE model, emissions were compared between business-as-usual growth and low-carbon growth across potential emitting sectors. Ethiopia's BAU greenhouse gas emissions are expected to more than double from 150 Mt CO_2e in 2010 to 400 Mt CO_2e in 2030; the low-carbon growth model limits 2030 emissions to 2010 levels. Meanwhile, the country's development path could face resource constraints such as:

• Reaching carrying capacity levels of essential ecosystems.

• Locking into out-dated technologies that would imply very high costs for switching to newer technologies.

• Locking into unsound policy measures, such as subsidizing fossil fuels that already absorb a large share of the country's GDP.

Built on this conceptual framework, the CRGE initiative follows a sectoral approach focusing on five critical high-emitting sectors chosen through a consultative process. These sectors are: agriculture (including forestry, soil-based emissions, and livestock), green cities and buildings, industry, transport, and energy. After emissions were projected under a business-as-usual scenario, abatement measures were selected with the aim of making sector-wide emission growth carbon neutral by the year 2025. These abatement measures are prioritized based on cost efficiency, short-run feasibility, and high value – in terms of contributions to the country's five-year development plan.

Conceptually, the CRGE plan is based on four pillars:

1. Improving crop and livestock production practices for higher food security and farmer income, while reducing emissions.

2. Protecting and re-establishing forests for their economic and ecosystem functions, including as carbon stocks.

3. Expanding electricity generation from renewable sources for domestic and regional markets (to export electricity).

4. Leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings.

These priority measures, spanning 60 sectors, increase Ethiopia's ability to achieve its development goals, while limiting 2030 greenhouse gas emissions to approximately current levels of 150 Mt CO_2e. Ethiopia's "baseline target" is to stabilise emissions.

Analytical methods

In the development process of the CRGE Strategy, the government of Ethiopia used a mixture of top-down modelling for the growth in business-as-usual emissions, and a bottom-up approach using marginal abatement cost curves to specify the costs of specific technologies.

The top-down modelling approach for estimating business-as-usual emissions, consisted of simple spreadsheet extrapolation, using estimated levels of key drivers of emissions (GDP, population, fuel prices, etc.). Key drivers were then disaggregated into those sectors identified as making the largest contribution to Ethiopia's emissions. Experts from the five selected sectors generated data used to calculate business-as-usual projections, and to identify possible abatement measures. The following table outlines important factors for emission projections in each sector. This top-down, spreadsheet-based approach was used for all emissions sectors.

Table 1: Emission drivers by sectors

Sectors	Drivers
Agriculture: Forestry	• Deforestation • Forest degradation
Agriculture: Livestock	• Methane from enteric fermentation • N_2O from manure left on pastures
Agriculture: Soil	• Crop production • Fertilizer use • Manure management
Transport	• Passengers (inner-city, intra-city, and international) • Freight (dry, construction and mining, and international cargo)
Industry	• Chemicals, agro-processing • Pulp and paper, leather and textile • Cement, mining
Buildings and cities	• Solid waste • Liquid waste • Off-grid fossil fuel
Energy	• Conventional and renewable sources

Bottom-up estimates of marginal abatement curves provide a technology-and-action-specific map of feasible reductions and costs. The combination of the top-down model and the marginal abatement curves allowed Ethiopia to set its baseline.

The strength of this approach is its relative simplicity, given the very short timeframe for completing these projections – the work began in February 2011 and culminated in November 2011. Limited data availability rendered a more detailed approach infeasible, and the spreadsheet-based methods were deemed to be especially user friendly.

As stated above, results of the business-as-usual projection demonstrate that the current pathway for economic development will more than double GHG emissions from the present 150 Mt CO_2e to 400 Mt CO_2e in 2030. On a per capita basis, business-as-usual emissions are projected to increase from the present 1.8 t to 3.0 t in 2030. In absolute terms, the highest increase – adding around 110 Mt CO_2e in GHG emissions – will come from agriculture, followed by industry at 65 Mt CO_2e and forestry at 35 Mt CO_2e. In relative terms, Ethiopia's development path will manifest in an annual emission increase of more than 15% from the industrial sector and about 11% from transport.

Assumptions

After taking into consideration the availability of data from sectors, 2010 was selected as the "base year". Historical data are used to quantify emissions of the base year. For example, a ten-year historical period is used for REDD+ to calculate the rate of deforestation, fuel wood consumption, agricultural expansion, land-use change, and population growth. However, no historical data was considered for the other sectors.

The business-as-usual scenario estimates what would happen to base year emissions, across the five sectors up to the year 2030, under a conventional development path. Marginal abatement curve analysis then highlights abatement opportunities to reduce emissions, including an assessment of technical and realistic potential. Three types of barriers are considered in differentiating the full technical potential from the realistic potential:

- Technical barriers – existing obstacles to implementing the technology. For example, the technology could be very costly to implement.

- Institutional barriers – obstacles related to the absence of necessary institutions, or the existence of counter-productive institutions. For example, if there were currently no network for the distribution of the technology.

- Other barriers – any additional barriers. For example, in the abatement lever of new agricultural land through irrigation (as a means to reduce deforestation), there might not be a tradition of water harvesting in certain areas.

The Ethiopian Environmental Protection Agency (EPA) is committed to periodically revising base year emissions, in order to have a full and robust understanding of the relationship between emissions and the domestic economy. Indeed there are a number of projects in progress that will examine the base year in greater detail. The EPA is also committed to validating the analyses and assumptions used in the CRGE business-as-usual and low-carbon scenarios, and recognises the need to conduct sensitivity analysis on its models to ensure that decisions are being made in a robust way.

In order to calculate business-as-usual emissions projections, population growth and GDP growth were considered. As a conservative midpoint between the governmental assumption of 11% annual GDP growth, and estimates by the IMF and The Economist of just above 8%, the business-as-usual emission projections assume 8% annual GDP growth. Population growth is assumed to be 2.6% annually in the BAU scenario, as estimated by the Central Statistical Agency with respect to the 2007 national census.

Projections were made on the basis of the Central Statistics Authority's five-year Growth and Transformation Plan, data from a number of institutions (including the Food and Agricultural Organization, Deutsche Gesellschaft für Internationale Zusammenarbeit - GIZ, etc.), sectoral plans, and energy and emissions data on middle income countries (e.g. their level of electricity consumption assumed per capita).

Institutions

The CRGE process established an institutional arrangement that placed emphasis on building the capacity of civil servants within each ministry, while also ensuring political buy-in right up to the Prime Minister's Office (see Figure 1).

Figure 1: Organization of the Climate Resilient Green Economy initiative
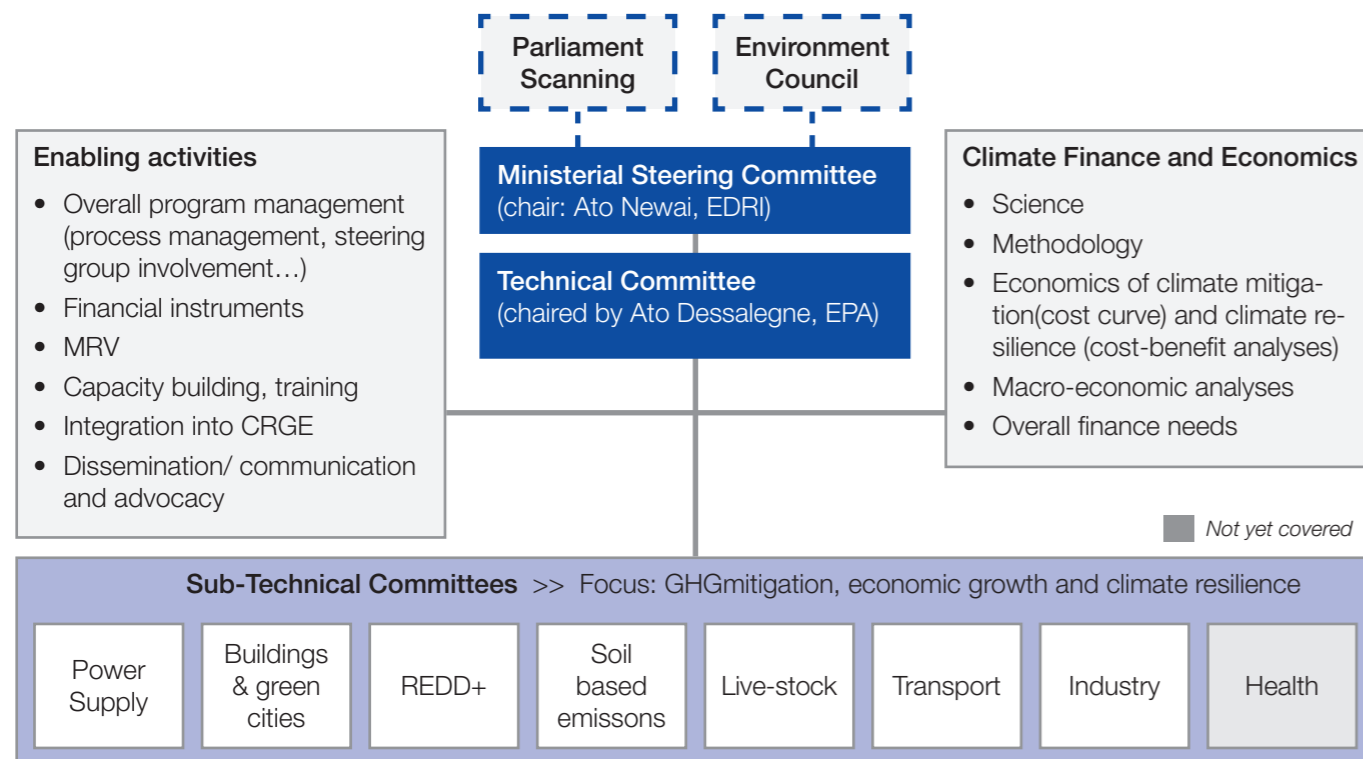
Ministerial Steering Committee (MSC): The MSC – the principal governing body of the CRGE – convenes every other month, or as needed. During each meeting, the leaders of the Technical Committee (described below) present the progress of the CRGE process. Some of these meetings are focused on approving project approach, timeline and deliverables. Other meetings are used to present interim progress in the development of sectoral strategies, or to advance cabinet submission strategies and other matters that need higher guidance.

Technical Committee (TC): The TC is the principal technical body of the CRGE, tasked with synthesizing and presenting its findings to the MSC. The TC meets every two weeks. The chair of each Sub-Technical Committee (discussed below) reports on the progress of their working team, raises potential issues and discusses next steps. Leaders of the TC present the technical elements of the CRGE strategy relevant to the Sub-Technical Committees and provide the information and direction required to lead the CRGE process.

Sub-Technical Committees/Working Groups (STCs): Each STC is the analytic engine of its respective sectoral strategy, spending three to four days, full time, on the CRGE. The EPA and the Global Green Growth Institute (GGGI), who has supported the government of Ethiopia throughout the CRGE process, together with their external service providers meet with each STC for one to two days per week, as well as outside these fixed time slots on an "as needed" basis. The focus of these interactions are to: (1) explain in greater detail the methodology used to assess the sectoral strategies, for example the GHG abatement levers; (2) prepare for the different meetings; and (3) provide support in the development of the sectoral strategies. The members of the Sub-Technical Committees, chosen from relevant ministries and organizations, usually meet in the same room to ensure maximum interaction and exchanges.

References

1. EPA, 2011, Climate Resilient Green Economy Vision, Addis Ababa, Ethiopia.

2. EPA, 2011, CRGE Strategy, Addis Ababa, Ethiopia.

3. MoFED, 2010, Growth and Transformation Plan, Addis Ababa, Ethiopia

India (TERI)

Authors: Atul Kumar, Ph. D., and Ritu Mathur, The Energy and Resources Institute (TERI)

Note: This paper provides TERI's understanding and experience of setting baselines for national planning in the Indian context. The views do not necessarily reflect a Government perspective for India.

Methodological choices

Organizations in India are using a variety of models to undertake energy and emissions modelling at the national level. At The Energy & Resources Institute (TERI), for energy and emissions modelling, the organization moved from the TEESE model (which was developed in-house) to the MARKAL model, after it was procured by TERI during the Asia Least-Cost Greenhouse Gas (ALGAS) project in the mid-1990s. The choice of MARKAL was based on the suitability of the modelling framework to the particular needs of the studies required at that time, the availability of project funds for procuring software, and the availability of training assistance received from the Energy Centre of Netherlands.

Since MARKAL's procurement, TERI has worked continuously to keep its database up-to-date and to develop and analyse alternative energy scenarios focusing on sustainable development, energy security and emissions mitigation considerations. The model is used to provide inputs to various government departments/ministries for energy sector planning and mitigation analysis for national level policy-making and climate change negotiations. Some of

TERI's studies, based on inputs from MARKAL, include:

1. Asia Least-Cost Greenhouse Gas Abatement Strategy: India Country Report (1998)

2. National Energy Map of India: Technology Vision 2030 (2006)

3. Mitigation Options for India: The role of the International Community (2008)

4. India's Energy Security: New opportunities for a sustainable future (2009)

5. National and International Policy Responses to the Carbon Budget Approach: An Indian Perspective (2010)

TERI is now also assisting other countries, such as Malaysia, in setting up national level MARKAL models to examine business-as-usual and alternative scenarios, in order to analyse the prospects for mitigation and opportunities for low-carbon growth.

The MARKAL model framework allows for optimized solutions, in terms of minimising overall energy system

costs, and covers both the demand and supply-side of the economy. Therefore, it is able to choose from a selection of technologies that are most optimal for the economy-subject to various constraints that can be reflected on supplies, investment levels, consumption choices or technology availabilities ect.

For these reasons, MARKAL/TIMES is preferred over accounting or simulation frameworks such as LEAP that do not optimise or lend themselves easily to the development of internally consistent scenarios. Over the years, MARKAL has also developed front and back ends that make data entry from spreadsheets relatively easy, allowing for quick extraction of data outputs in formats suitable for analysis. MESSAGE, while largely similar to MARKAL/ TIMES in terms of its equations, does not allow for easy data entry directly from spreadsheets.

Overview of TERI's MARKAL model

MARKAL/TIMES belongs to a family of partial equilibrium linear optimization models capable of representing the entire energy system (see Figure 1). A comprehensive and detailed description of the modelling framework is provided on the IEA-ETSAP website (www.iea.etsap.org).

Figure 1: MARKAL framework overview
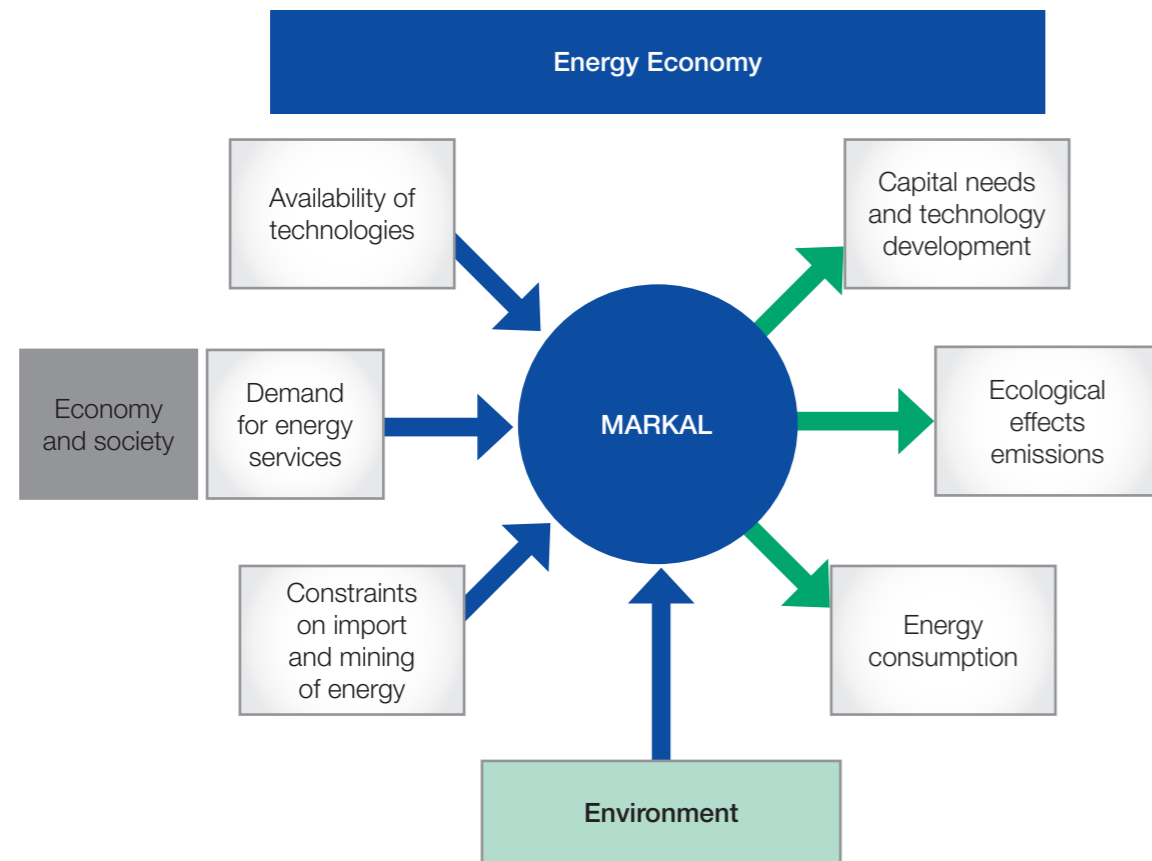
Source: ETSAP

MARKAL, by itself in its standard form, is a bottom-up modelling framework with system cost optimization as the overall objective function. It provides a generalised framework for representing a national energy system, thereby, providing a great deal of flexibility in the level of detail that can be incorporated into the model structure. Moreover, it maintains the complete representation of the energy system in an integrated manner, across the energy demand and supply-sides. TERI has over two decades of experience working with bottom-up energy system models, and using them to examine alternative trajectories of development and implications of different policy and technology scenarios on national level energy and emissions.

While the MARKAL model allows for a fair degree of flexibility in the level of detail and structure, it requires an in-depth understanding of the country's energy system in terms of resource availabilities, flows and resource use across consuming sectors at the national level. This implicitly requires in-depth knowledge and understanding of the country's socio-economic profile, existing market dynamics, and availability of statistical time series data on several aspects. These include: socio-economic dimensions; fuel supply and use patterns across sub-sectors; state of technology progress and level of policy implementation and success. Accordingly, while the model structure allows enough flexibility, the quality of the database affects model outputs and the reliability of results.

TERI's MARKAL model includes around 400 technologies, representing both the energy demand and supply-sides.

TERI has an extremely rich technology database that it has been able to develop over the years, through stakeholder discussions, detailed interactions with experts, surveys and secondary data from published sources.

TERI's multidisciplinary focus and presence of experience and technical knowledge across sectors has also resulted in a rich energy database. Additionally, it ensures that the data will be updated from time to time, based on inputs from TERI's end-use sectoral models, and technology- and resource-specific data inputs from sector experts.

Over the last two decades, TERI has updated the MARKAL model database every couple of years with detailed sector inputs in a consistent manner, in order to represent developments realistically. The institute has also maintained continuity in its modelling team to ensure consistent development of the model and its use in various studies at the national and international level.

Drivers and assumptions

Energy demands are estimated exogenously from the MARKAL model, based on econometric models, using exogenous projections of socio-economic drivers of growth and past trends of final demands in each of the energy consuming sectors.

Population and GDP are the basic drivers that influence energy consumption patterns. Data on these basic drivers is disaggregated by rural and urban areas and by income classes, to enable a better representation of variations in usage patterns, as well as the differences in lifestyles and energy consumption trends over time. Similarly, disaggregation of GDP by sector provides a better representation of the structural changes assumed in the economy over time, and its implication for growth in various sectors.

While historical data are compiled from reliable government sources, projections are also discussed and validated with in-country experts so that future socio-economic developments are representative of country-specific plans. Energy prices are exogenous to the model and generally aligned with the IEA fuel price trajectory for the reference case.

Assumptions on availability of resources, technology development and diffusion vary across scenarios and are aligned with plans, policies, investments and actual progress in technology developments.

TERI's perspective on baselines

A report entitled "India's GHG emission profile: Results of Five Climate Modelling Studies" was published in 2009 as part of the work done by the Climate Modelling Forum (including TERI, NCAER, IRADe and Jadavpur University), supported by the Ministry of Environment and Forests (MoEF), and the government of India. This report summarized the initial results of five studies, using the following models:

1. India Computable General Equilibrium (CGE) model: developed by the National Council of Applied Economic Research and Jadavpur University (NCAER-CGE)

2. India MARKAL model: adapted from the generic version by TERI (TERI-MoEF)

3. India Activity Analysis model: developed by Integrated Research and Action for Development (IRADe-AA)

   Apart from these models, two other studies conducted outside the forum were included in this report to provide comparison. These included:

   1. Results of the MARKAL model analysis by TERI (with assumptions and data distinct from TERI-MoEF) presented at COP14 in Poznan, in December 2008 (TERI-Poznan)

   2. A bottom-up study by McKinsey and Co., based on the McKinsey GHG Abatement Cost-Curve for India (McKinsey)

While the models used by the sub-group were not hard-linked, some of the outputs of the CGE model fed into the MARKAL model. The structure of IRADe's activity analysis model did not lend itself to similar inputs from the CGE model. All models used the Registrar General's population projections, the International Energy Agency's global energy prices, and a similar approach to several policy and parameter assumptions. The assumptions used in these studies are provided as tables and the annex to this chapter.

Figure 2 shows the GHG emissions resulting from the five studies listed above. As can be seen, national baselines, or reference trajectories, can vary significantly in the future depending on the assumptions used regarding driving parameters, policy level and technology progress.

Table 1, next page, provides the results for the illustrative scenarios (see the Annex to this chapter for details of the assumptions and methodologies adopted in each of the models).

Figure 2: GHG emissions projections for India from five studies in illustrative scenarios
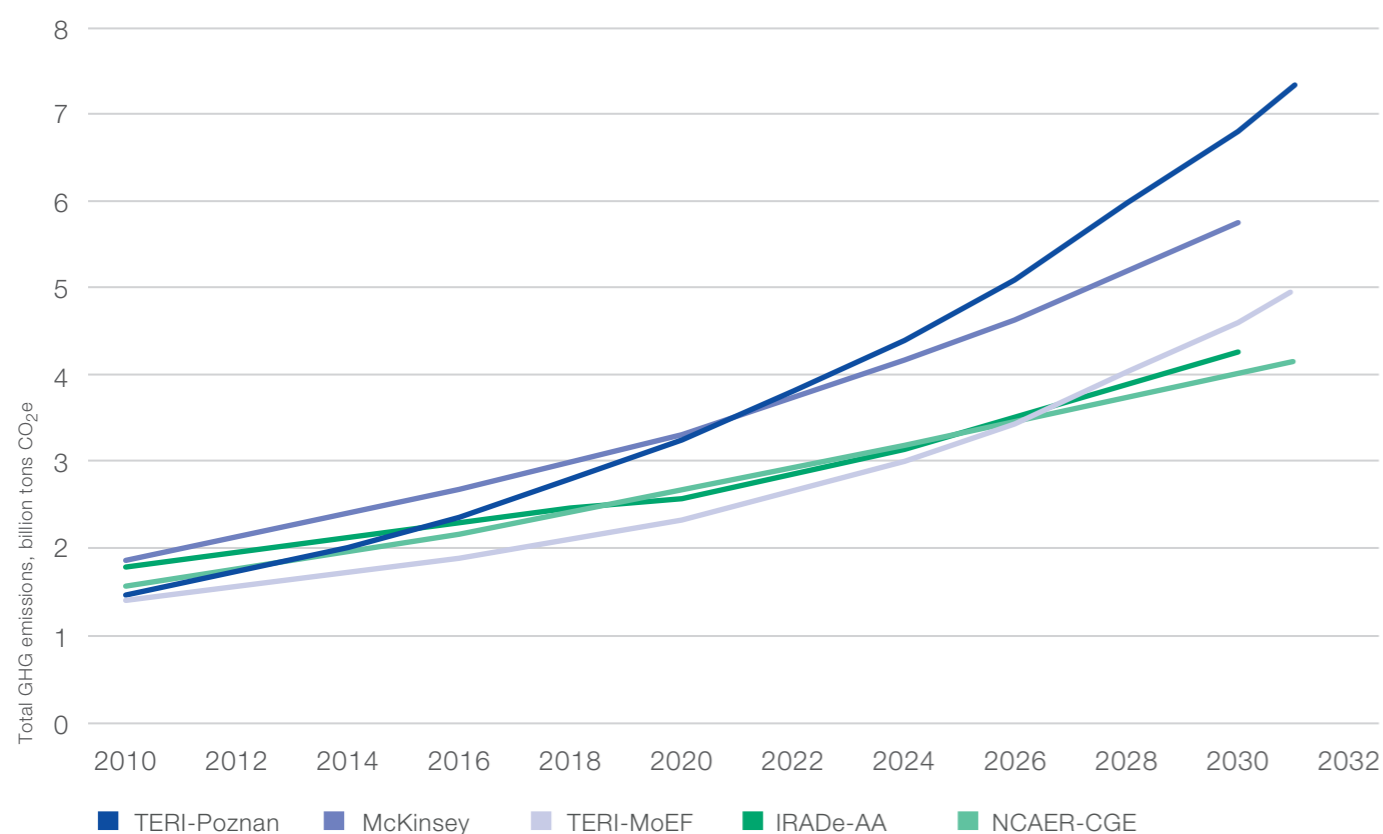
Source: Ministry of Environment and Forests, 2009

Table 1: Results for illustrative scenarios

	NCAER CGE Model	TERI MoEF Model	IRADe AA Model	TERI Poznan Model	McKinsey India Model
GHG emissions in 2030-31 (CO_2 or CO_2e) (billion tons)	4.00 billion tons of CO_2e	4.9 billion tons in 2031-32	4.23 billion tons	7.3 billion tons in 2031-32	5.7 billion tons (including methane emissions from agriculture); ranges from 5.0 to 6.5 billion tons if GDP growth rate ranges from 6 to 9%
Per capita GHG emissions in 2030-31 (CO_2 or CO_2e)	2.77 tons CO_2e per capita	3.4 tons CO_2e per capita in 2031-32	2.9 tons CO_2e per capita	5.0 tons CO_2e per capita in 2031-32	3.9 tons CO_2e per capita (2030), all GHGs
CAGR of GDP in 2030-31 (%)	8.84%	8.84% (Exogenous-taken from CGE)	7.66% (Endogenous, 2010-11 to 2030-31)	8.2% 2001-2031 (Exogenous)	Exogenous – 7.51% (2005-2030) from MGI Oxford Econometric model
Commercial energy use in 2030-31 (mtoe)	1087 (Total commercial primary energy forms)	1567 (Total commercial energy including secondary forms) in 2031-32	1042 (Total commercial primary energy)	2149 (Total commercial energy including secondary forms) in 2031-32	NA
Fall in energy intensity	3.85% per annum (compound annual decline rate)	From 0.11 in 2001-02 to 0.06 in 2031-32 kgoe per $ GDP at PPP	From 0.1 to 0.04 kgoe per $ GDP at PPP	From 0.11 in 2001-02 to 0.08 in 2031-32 kgoe per $ GDP at PPP	Approximately 2.3% per annum between 2005 and 2030 (at PPP GDP, constant USD 2005 prices)
Fall in CO_2 (or CO_2e) intensity	From 0.37 kg CO_2e to 0.15 kg CO_2e per $ GDP at PPP from 2003-04 to 2030-31	From 0.37 to 0.18 kg CO_2 per $ GDP at PPP from 2001-02 to 2031-32	From 0.37 to 0.18 kg CO_2 per $ GDP at PPP from 2003-04 to 2030-31	From 0.37 to 0.28 kg CO_2 per $ GDP at PPP from 2001-02 to 2031-32	Approximately 2% per annum between 2005 and 2030 (at PPP GDP, constant USD 2005 prices)

Source: Ministry of Environment and Forests, 2009

At present, India does not have a national baseline developed. Several studies have been undertaken in the country, and across various organizations, to evaluate development trajectories using a series of modelling approaches, which has resulted in a range of scenarios. Based on the experience related to setting baselines, the following issues have been identified as the most discussed, from divergent points of view:

1. With regard to the use of models and the setting of baselines using models, it is clear that any discussion regarding commitments or target setting cannot be based on models.

2. Models can help examine the consequences of emissions and/or can help provide a visualization of how emission trajectories may evolve and change over time. However, these are based on several inherent assumptions that vary, depending on the choice of model and values ascribed to the multitude of parameters associated with the model. This point is exemplified through a discussion of the illustrative scenarios for India, presented by the Ministry of Environment and Forests (India) in 2009.

It is apparent that, in India, the choice of a particular baseline, if targets were indeed set from these, could result in significantly different levels of emission reduction requirements.

The same concern could be echoed if IEA's reference scenarios were to be applied to represent India's baseline, as is generally the case when global models and databases are used. Data, especially in developing countries like India, often requires careful analysis and possible re-distribution, as there are definitional changes, groupings of sub-data heads, missing data, and assumptions in published data.

In-country reviews of planned versus likely activity data become an extremely important element in baseline setting, especially in the next decade or two. Moreover, integrated frameworks become increasingly relevant as baselines extend over longer periods. Statistical/econometric projections may no longer be valid on a stand-alone basis and require judicious and systematic delineation of possible structural changes, such as changes in investment and trade patterns.

The composition of a baseline is another issue that could be quite nebulous. For example, trajectories with and without climate policy could result in fairly different interpretations. In the case of India, several policies and measures have been undertaken during the last two decades that are not specifically climate policies but have had a bearing on reducing the energy and emissions intensity of India's development path.

Furthermore, the success of policies, in terms of achieving goals and timelines, is also an issue for consideration: how the actual achievement should be viewed in relation to the planned target in a baseline.

Skills and resource requirements of the MARKAL model

While the benefits of a strong database are clear, bringing the model database to the current level of detail, and frequently updating it to reflect India's dynamic energy system, is a continual challenge. This is the case both in terms of maintaining modelling and data analysis skills within TERI and in keeping abreast of latest technology shifts, consumer behaviour patterns, and the play of national and international market forces on energy supplies and demands.

The costs of developing a baseline include procuring modelling tools and supporting software, training, professional services for database development and consultative workshops with experts and stakeholders. Accordingly, while the cost of procuring and maintaining the MARKAL model would generally need to be covered through project costs, several other costs (which are not easily accounted for) are also an integral part of the model development and the setting up of baseline and alternative scenarios.

Transparency, stakeholder involvement, and review

As discussed earlier, TERI's MARKAL model is continuously updated every couple of years through projects that address various issues related to India's energy sector. The updating process normally involves interaction with several experts in the energy sector and

includes one-on-one meetings, as well as stakeholder discussions, to achieve consensus on some of the assumptions. Moreover, there is always an internal TERI review process where the inputs, the outputs and results undergo peer review.

The level of detail regarding the description of model inputs, however, depends on the nature of the exercise and the requirements of the client for whom the study is undertaken.

The 2006 study under for the Office of the Principal Scientific Advisor to the Government of India, for example, included several rounds of stakeholder consultations with at least 100 domain experts. All assumptions and

projections were detailed and published in the report. This report is still widely used in India as teaching material to understand the country's energy sector. The five studies, published by the MoEF, have made several of the macro-economic assumptions, used in the studies, transparent. Other released reports that used the MARKAL model as a supporting framework to visualise scenarios, however, did not focus on the data and assumptions as much. Instead, they made a broad outlined through a description of scenarios. Consequently, the level of detail that is published about the data and assumptions in the model varies according to the requirement of the particular publication, client, intended audience, and focus of the study.

Appendix (India)

Table A1: Assumptions & data sources for illustrative scenarios

	NCAER CGE Model	TERI MoEF Model	IRADe AA Model	TERI Poznan Model	McKinsey India Model
Assumptions	TFPG = 3.0% AEEI = 1.5% No new GHG mitigation policy	TFPG = 3.0% Energy Efficiency improvement consistent with AEEI assumption in corresponding CGE run but constrained by limits to energy efficiency improvements in specific technologies as given in internationally published literature No new GHG mitigation policy; discount rate = 15% Financial costs	TFPG = 3.0% AEEI = 1.5% (amounting to 36.5% improvement in specific energy consumption from 2003 to 2030) No new GHG mitigation policy, max. savings rate = 35%, Social discount rate = 10%, Govt. annual consumption increase = 9%	Efficiency improvements as per past trend and as per expert opinion considering level of maturity of specific technology in India. Discount rate = 10% Economic Costs, No new GHG mitigation policy	Sector by sector assumptions of demand and technology mix leading to illustrative scenario emissions
Data Sources					
Population	Registrar General of India (until 2026, extrapolated at same rates until 2030)	Registrar General of India (until 2026, extrapolated at same rates until 2030)	Registrar General of India (until 2026, extrapolated at same rates until 2030)	Registrar General of India (until 2026, extrapolated at same rates until 2030)	Registrar General of India (until 2026, extrapolated at same rates until 2030)
Global/domestic energy price projections	International Energy Agency (WEO 2007) for international; endogenous for domestic	International Energy Agency (WEO 2007) for international; price indices from CGE model for domestic fuel prices; taxes and subsidies included to compute financial prices	International Energy Agency for international; endogenous for domestic	TERI estimates for both international and domestic prices based on prevailing market conditions	International Energy Agency for international energy prices
GDP growth rates	Endogenous	Exogenous – from CGE output	Endogenous	Exogenous – 8.2% (2001-2031)	Exogenous – 7.51% (2005-2030) from MGI Oxford Econometric model

	NCAER CGE Model	TERI MoEF Model	IRADe AA Model	TERI Poznan Model	McKinsey India Model
Foreign savings projections	Study by Bhide et.al. (2006)	NA	Endogenous	NA	NA
Domestic savings rates	National Accounts Statistics	NA	Max 35%	NA	NA
Specific Energy Technologies Data	NA	Data set of >300 technologies compiled by TERI in study for Principal Scientific Adviser, and technology diffusion consistent with AEEI assumptions as reflected in CGE model	8 electricity generation technologies (thermal, hydro, natural gas, wind, solar, nuclear, diesel, wood and more efficient coal technology)	Data set of >300 technologies compiled by TERI in study for Principal Scientific Adviser with recent update	Data set of 200 technologies incorporated in the McKinsey Global Cost Curve model, adapted for Indian volumes, capex and cost
GHG emissions coefficients	National Communications	National Communications	National Communications	National Communications	National Communications + IPCC + own estimates for power sector
Various other key parameters	Published literature, NCAER and Jadavpur University estimates	Govt. of India data, other published literature	Govt. of India data	Govt. of India data, own estimates, expert opinion, published literature	Govt. of India data, own estimates

Source: Ministry of Environment and Forests, 2009

Table A2: Models methodology description

	NCAER CGE Model	TERI MoEF Model	IRADe AA Model	TERI Poznan Model	McKinsey India Model
Model/Methodology Type	Computable General Equilibrium	Linear Programming minimizing discounted energy system cost	Linear programming maximizing discounted value of consumption over defined time horizon	Linear Programming minimizing discounted energy system cost	Proprietary McKinsey India Cost Curve model to estimate GHG emissions from the 10 largest emitting sectors
Key features of model/methodology	Top-down, sequentially dynamic, non-linear, market clearance, endogenous prices of commodities and factors	Bottom-up optimization over defined period, detailed energy technologies matrix, set of energy system technical and non-technical constraints, including limits to enhancement in energy efficiency of different technologies	Top-down optimization model over defined period (over 30 years with 3 years for each sequential run) with various resources, capacity and economic constraints	Bottom-up optimization over defined period, detailed energy technologies matrix, set of energy system technical and non-technical constraints with limits to energy efficiency enhancement based on past trends	Factors in estimates of bottom-up improvements in technology levers; analyses potential of a selected set from over 200 technologies to increase energy efficiency and reduce emissions; Includes CO_2, N_2O and CH_4 emissions (from agriculture) Demand feedback between sectors; between consuming sectors and power/petroleum sectors
Key inputs	Population, global energy prices, foreign capital inflows, savings rates, labour participation rates	GDP growth rates, final demands of commodities (both from CGE model), global and domestic energy prices both consistent with the CGE model), population, and detailed technology characterization	Population, global energy prices, savings rates, discount rates, minimum per capita consumption growth rates	GDP growth rates based on doubling of per capita incomes every decade, final demands of energy end-use services, technology characterization, global and domestic energy prices, population based on government projections	• GDP growth rates • Projected demand (for number of inputs – e.g. steel, power, automotive) • Population • Global energy costs • Base and non-base load demand

	NCAER CGE Model	TERI MoEF Model	IRADe AA Model	TERI Poznan Model	McKinsey India Model
Key outputs	CO_2e (CO_2 + N_2O weighted by GWPs) emissions, GDP, energy and CO_2e intensities, final demands of commodities, costs of mitigation policies	CO_2 emissions, energy use patterns, energy and CO_2 intensities, operating level of each technology, energy system costs, investment and marginal costs for each technology	CO_2 emissions, energy and CO_2 intensities, commodity-wise demand categorized by end-use, income-class wise commodity demand, costs of mitigation policies, poverty impacts	CO_2 emissions, energy use patterns, energy and CO_2 intensities, operating level of each technology, energy system costs, investment and marginal costs for each technology	Estimates illustrative Scenario emissions across GHGs (CO_2, N_2O, CH_4) over time by sector
Number of sectors	37 production sectors + government	35 energy consuming sub-sectors + energy supply options including conventional and non-conventional	34 activities with 25 commodities + government	35 energy consuming sub-sectors + energy supply options including conventional and non-conventional	10 sectors; Power, Cement, Steel, Chemicals, Refining, Buildings, Transportation, Agriculture, Forestry, Waste
Greenhouse Gases included	CO_2 + N_2O (energy and industry only)	CO_2 (energy and industry only)	CO_2 (energy, industry, households, and government consumption only)	CO_2 (energy and industry only)	CO_2 + N_2O + CH_4 (energy, industry and agriculture)
Primary Energy forms	Coal, oil, gas, hydro, nuclear, and biomass	Coal, oil, gas, hydro, nuclear, renewables, and traditional biomass	Coal, oil, gas, hydro, nuclear, wind, solar and biomass	Coal, oil, gas, hydro, nuclear, renewables, and traditional biomass	Coal, oil, gas, hydro, nuclear, wind, solar, geothermal and biomass

Source: Ministry of Environment and Forests, 2009

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Indonesia

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Methodological choices

The development of the greenhouse gas baseline scenario in Indonesia has been a long journey with very interesting twists. It started with differing views on the definition of the greenhouse gas baseline, itself, and continued with the debate on where to put REDD+, under the concept of NAMAs and the national action plan for mitigation. Some actors argued that REDD+ should be inside the national action plan for mitigation, while others argued for it to be outside – anticipating it would be a stand-alone UNFCCC-based mechanism with its own rules and modalities. Considerable debate took place regarding whether the baseline should be established in a top-down (i.e. national level data and scenario broken down, and allocated to local level) or bottom-up process. Discussions regarding how to develop the baseline have gained more attention since the Indonesian President's 2009 commitment, at the G20 Leaders Summit in Pittsburgh, to set a national target to reduce emissions by 26% unilaterally under business-as-usual by 2020, and a further reduction of up to 41% if there is international support.

Considering Indonesia's decentralized political system, it was generally agreed that the better approach to setting a baseline is bottom-up. The bottom-up approach is important in ensuring ownership by sectors and local governments, as the feasible sub-targets for GHG emission reductions will be established on the basis of business-as-usual scenarios, and actors will have to agree on the magnitude and implications of the proposed mitigation actions. Using a bottom-up approach means that data collection and compilation is undertaken by provincial and city/district government levels. Therefore, it is expected that data will be more detailed and more accurate. By contrast, the top-down approach is usually based on sectors, resulting in aggregate numbers, by sector. With the top-down approach, some relatively small sources will "disappear" from the calculation. The 33 provinces in Indonesia are characterized by diverse sector profiles (i.e. emissions from transport/industry in Javanese provinces, emissions from forestry/peatlands in Kalimantan provinces) and emission paths. The calculation of GHG inventories and emission trajectories, at the provincial level, enables provincial governments to pursue lower carbon development paths based on more accurate sources, beginning with the earliest stages. However, before all regions (provinces/districts/cities) could calculate their business-as-usual baselines, a national baseline was calculated using a top-down approach; this approach was more expedient, and provided a general overview of the magnitude of Indonesia's emissions.

This was faster, since the sectoral ministries have been collecting data at the national level, while some local governments have yet to either collect the important data or estimate emissions in their regions. It is expected that in the near future these approaches will complement one another (as the power sector, among others, primarily has national data), so that Indonesia could have a better and more reliable calculation of its baseline.

For Indonesia, the business-as-usual concept is central, given the announcement of a target of 26 or 41% emission reductions relative to BAU (Presidential Decree No. 61/2011). There is no single objective business-as-usual scenario; it depends on projections of future economic growth, structure and technology development. In agreeing to emissions targets, the underlying business-as-usual scenario and the deviation from it are both crucial.

Reducing emissions means changing production systems and technologies throughout a large part of the economy, which can be both a challenge and an opportunity. Indonesia's energy supply needs to grow in order to facilitate economic growth and improve livelihoods, but there is a high potential for carbon emission growth. While shifting to a low-carbon pathway could improve economic efficiency, it could also result in some foregone

profit. Land conversion is important for regional economic development, however it is also a very large source of carbon emissions.

Indonesia enacted Presidential Regulation Number 61/2011, establishing a national greenhouse gas reduction target and a related action plan supported by the local mitigation actions from provinces, districts, and cities. To support local mitigation plans, the Ministry for National Development Planning (Bappenas), together with related ministries such as the Ministries of Home Affairs, Environment, Energy, Transportation, Forestry, Industry, Agriculture and Public Works, and supported by development partners such as GIZ, JICA, AusAID, UKCCU and USAID, conducted a series of discussions in consultation with local governments. The aim was to determine which model would be used to calculate the baseline, and provide capacity building for calculation of 2010 GHG inventory, provincial baseline calculations, and local mitigation scenarios. In accordance with Presidential Regulation No. 61/2011, all provincial governments must submit their local mitigation action plans by the end of 2012.

There are many options of models to calculate the baseline. The Climate Change Working Group[30] members have agreed that Indonesia will choose an 'official standard' model, which will make it easier to compile and compare results among provinces. The criteria for choosing the model are:

1. Local data exists to run the model properly.

2. The model is relatively simple but widely used internationally, and complies with IPCC standards.

3. Many people, especially government officers, are already familiar with the model.

4. Relevant agencies already possess the competency to promote the model and provide trainings at the provincial and local levels.

As the result of these criteria, basic baseline development in Indonesia could be summarized as follows:

• Approach: a combination of the bottom-up and top-down approach

• Model:

> Energy: LEAP

> Land-based: LUWES/Abacus – Spatial Planning Approach

> Waste: simple spreadsheet model

• Base year: starting projection/mitigation action in the year 2010[31]

• Forecasting method:

> Energy: extrapolation linear projection. The Ministry of Energy will lead modelling and provincial government's training on LEAP. LEAP was chosen because it requires less data, compared to MARKAL; Indonesia has enough data to run LEAP properly. It is easier to introduce this kind of model to provincial governments, because of its relative simplicity. Furthermore, many Indonesians, both at the national and local level, are already experienced in using the LEAP model. The Ministries of Transport and Industry will support this process by providing more detailed data to the Ministry of Energy, to run LEAP. Moreover, the Ministries of Transport and Industry may develop specific models for each sub-sector (such as cement industry: using the BEST model; land-transport: modified from the IPPC model; steel: linear projection model, etc.) to provide inputs to LEAP, and also compare its results for each sub-sector. The aim is to use IPCC tier 1-2 for data and algorithms, for the energy sector.

> Land-based: Markov chain transition matrix (which calculates the land cover distribution at two different points of time)

> Waste: linear projection

• Frequency of revisions: will be updated at least every five years – in line with mid-term development plans – and reviewed every year, based on the yearly MONEV (monitoring and evaluation) results of mitigation actions, as listed in the RAN/RAD-GRK (national/local mitigation action plans).

More detail about the calculation of the baseline, which is in line with local mitigation action plans developed by provincial governments in 2012, is described below:

Methodological choices – Energy sector

• Approach: a combination of the bottom-up and top-down approach, which is expected to capture a different policy at national and local level

• Model: LEAP, considering data availability, capacity and resources both at national and local level

• Basic data requirements: volume of fuel use per type of fuel for transportation and industrial sectors, fuel and LPG storage capacity, volume of fuel use per province per type of fuel for transportation and industrial sectors

• Assumptions for projection: GDP and population

• Institutional and technical capacity: Ministry of Energy, Ministry of Transport, Ministry of Industry, Government-owned Electric Power Company (PLN), relevant SKPD (Local Government Working Unit)

• Benefits: a likely higher degree of implementation by local government

• Challenges: scattered data in different institutions, data verification, data access for local government, capacity building for local government. The costs of developing the baseline – fairly expensive to conduct coordination process and intensive capacity building for all the local government officers.
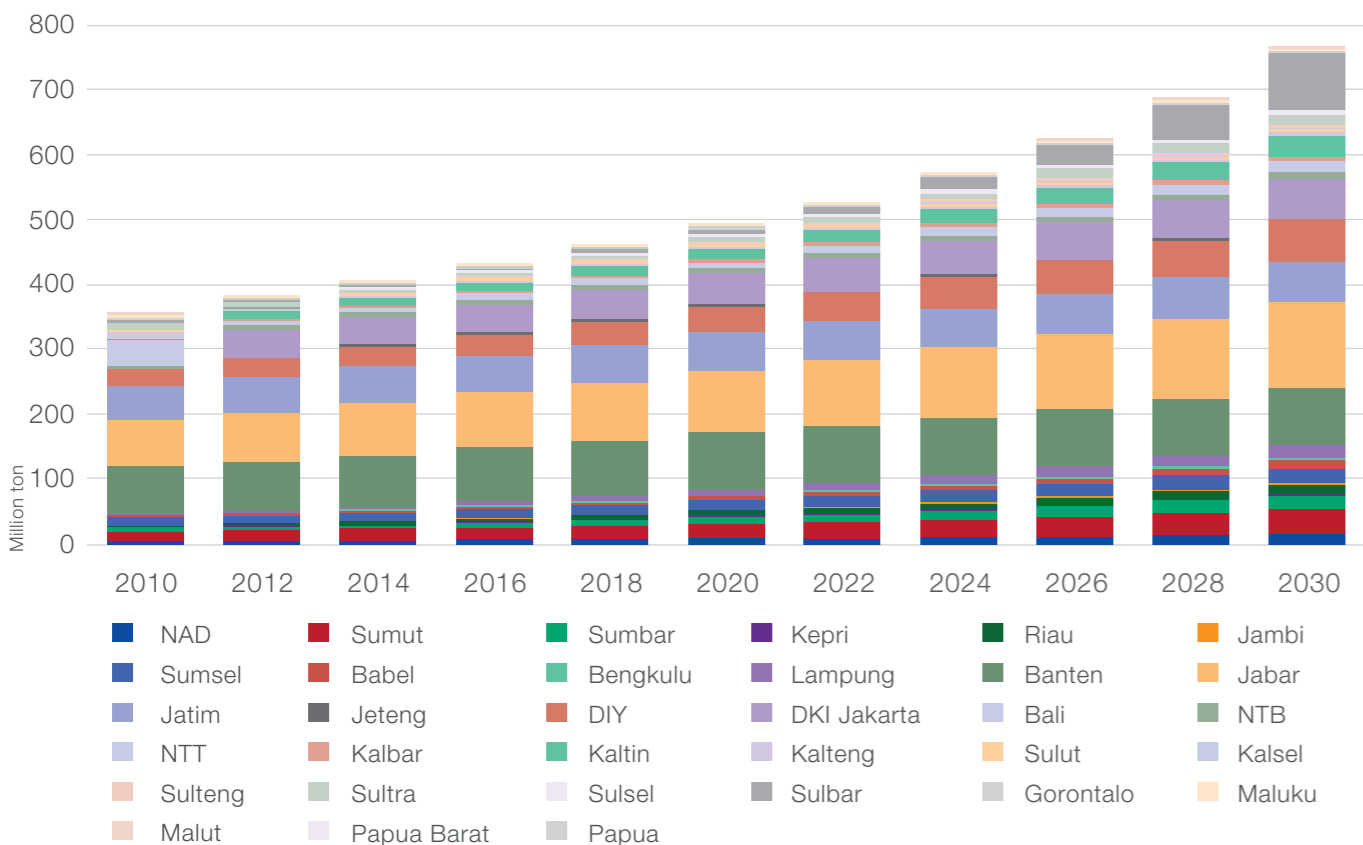
30. In 2012, Bappenas created a Climate Change Working Group to support, monitor and evaluate the implementation of the national and local mitigation action plans.
31. Both RAN-GRK and RAD-GRK use the year 2010 as the base year for starting mitigation actions. Only mitigation actions from 2010 and beyond are considered in the calculation.

Excerpt from an assessment for energy suitability conducted at local government level in Indonesia (East Kalimantan province, February 2012): LEAP is a long range energy planning model, simulates energy scenarios, consists of several modules (demand and supply-sides), user-friendly, can be accessed through internet (fee-based), utilized in several national and local governments in Indonesia (i.e. Ministry of Energy and Mineral Resources, Province of Jakarta for developing their local action plan for mitigation (RAD GRK)). For the demand-side module, it requires activities data (energy consumption) and future energy development plans, as well as demographic, and socio-economic estimates (e.g. Population, GDP growth rate, etc.). This type of data should be available in East Kalimantan province (i.e. local development plans, statistics bureaus etc.).

Figure 1: Baseline for Energy Sector of 33 provinces in Indonesia (Bappenas, 2012), million tons of CO_2e [32]

■ NAD	■ Sumut	■ Sumbar	■ Kepri	■ Riau	■ Jambi
■ Sumsel	■ Babel	■ Bengkulu	■ Lampung	■ Banten	■ Jabar
■ Jatim	■ Jateng	■ DIY	■ DKI Jakarta	■ Bali	■ NTB
■ NTT	■ Kalbar	■ Kaltin	■ Kalteng	■ Sulut	■ Kalsel
■ Sulteng	■ Sultra	■ Sulsel	■ Sulbar	■ Gorontalo	■ Maluku
■ Malut	■ Papua Barat	■ Papua			

Land-based

LUWES/Abacus – Spatial Planning Approach. GHG inventory is an important part of the development of baseline, which is to determine historical emissions, and project likely future emissions. In the discussion, there are two approaches for GHG Inventory, based on IPCC Guidelines 2006 on AFOLU sector: whether to use 'gain-loss' method or 'stock-difference' method.[33] However, the Climate Change Working Group members for land-based chose the stock-difference method, considering the data and reliable information available in Indonesia: 'Indonesia wall-to-wall forest cover maps' and national forest inventory data, currently administered by the Ministry of Forestry. Furthermore, it was agreed that, to calculate baseline, both historical and future development planning should be considered. Based on the discussions regarding the land-based sectors, Indonesia will use the land-use planning approach for low-carbon development, since for countries such as Indonesia it is obvious that reducing the land-based emissions are related to spatial and land-use planning. Globally, Indonesia is one of the largest forested areas affected by high rates of deforestation and forest degradation, with significant variations among regions as well as over time. Consequently, it would not be appropriate to employ a model that only considers historical trends, but, rather, one that includes spatial aspects and forward-looking planning documents.

To help the provincial government, the Climate Change Working Group decided to use a modified LUWES model that was developed jointly by Ministry of Forestry, Ministry of Agriculture and ICRAF. LUWES (Land Use planning for Low Emission Development Strategy) offers a set of principles, steps, and tools (called Abacus) that could help the planner estimate emissions associated with the development path scenarios, such as the historical projected scenario or forward-looking scenario. Different scenarios could consider various policies and programs such as land-use restrictions, plantation development targets, land swap, improved land management, or any other land-use policies and strategies.

To project the likely land-use/cover change, and future emissions based on historical and/or future planning,

the model used "Markov Chain Transition Matrix", which calculates the land cover distribution by comparing two different times (the distribution of time-2, based on the initial land-use/cover distribution at time-1, by means of a transition matrix). The transition matrix data are mainly derived from land cover maps that are provided by the Ministry of Forestry, on the basis of 23 land classifications.[34] The target for calculation of baseline for land-base is tier-3 approach.

The current development plans of the land-based sectors show that many activities, such as mining, agriculture expansion, and human settlements, will likely have a huge impact on land-use and land-use change; this should also be taken into account when formulating the baseline. Relying only on the use of econometric models would also lead to high uncertainty, as the current available data are limited. Therefore, it is recommended for Indonesia, at the current stage, to employ a spatial approach to formulate the baseline. Another argument for deploying a model using spatial approaches, such as LUWES, is that much of the staff from the Ministry of Forestry and Ministry of Agriculture are already familiar with this model and use it in day-to-day work. Furthermore, the model has already been tested in several districts and provinces in Indonesia, such as Jambi and Papua.

To project the likely future emissions for the land-based sector, the following activities should be carried out:

• Analysing all planning documents which will have influence on land-use and land-use changes. Consistency and likely implementation should be checked. The planning documents, such as local mid-term development plans, contain local activities (by government and private sector) in their region for 5-years and provincial spatial planning.

• Formulating assumptions based on the analysis of document plans, as well as the trends of deforestation and degradation from the analysis of historical data. This will also include discussions with government-led working groups and relevant stakeholders (such as local communities, local university experts, local government officers, local private businesses).

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32. Baseline calculation result by Climate Change Working Group from 'Potret Rencana Aksi Daerah Penurunan Emisi Gas Rumah Kaca (RAD-GRK), Bappenas, draft version on December 2012

33. Gain-Loss Method based on estimates of annual change in biomass from estimates of biomass gain and loss and a Stock-Difference Method which estimates the difference in total biomass carbon stock at time t2 and time t1
34. Using historical data 2006-2011, since the newest BAU Baseline calculation is done in 2012.

- Inserting all the inputs (data and assumptions) into the LUWES model

- Running the model to simulate the baseline

- Analysing the results, including the uncertainties/errors

- Interpreting the baseline, and identifying several mitigation scenarios related to policies and strategies, such as land-use restriction, land swap policy or plantation development target

- Identifying the likely 'trade-off' of various options

Methodological choices – Land-based sector

- Approach: a combination of the bottom-up and top-down approach, which is expected to capture a different policy at national and local level

- Model: modified LUWES/Abacus, considering data availability, capacity and resources both at national and local level

- Basic data requirements: wall-to-wall land cover maps, management units related to land-based sector, national forest inventory data, spatial and land-use planning, deforestation & degradation drivers
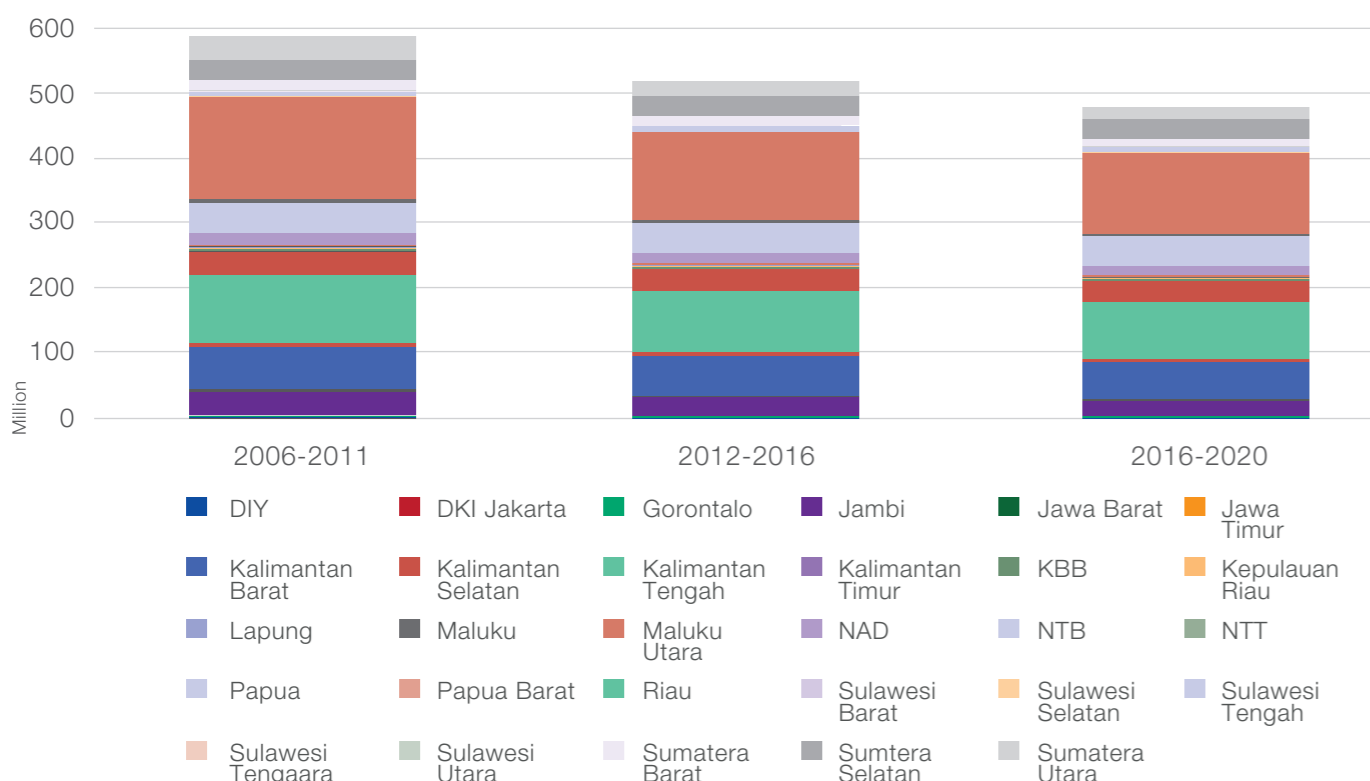
- Assumptions: historical trends and future land-use planning

- Institutional and technical capacity: Ministry of Forestry, Ministry of Agriculture, BAPPENAS (National Planning Agency), Public Works, BAPPEDA (Local Planning Agency) and relevant SKPD (Local Government Sectoral Working Unit)

- Benefits: a likely higher degree of implementation by local government

- Challenges: scattered data in different institutions, data verification, data access for local government, capacity building for local government

- The costs of developing baseline: fairly expensive to conduct coordination process and intensive capacity building for all the local government officers

Waste

Simple Model. The waste sector in Indonesia relates to several ministries such as public works, environment, and industry. However, the waste sector is highly localized, with waste disposal and treatment mostly handled by the local government, making much of the data locally specific. Based on the 2006 IPCC Inventory Guidelines, the main GHG emissions from the waste sector are methane, carbon dioxide and nitrous oxide, mainly resulting from the following activities: (1) Solid waste disposal, (2) Biological treatment of solid waste, (3) Incineration and open burning of waste, and (4) Wastewater treatment and discharge. Methane emissions from solid waste disposal at landfills are likely the main source of emissions in the waste sector – especially in Indonesia, where most

final waste disposal systems still use open dumping. Moreover, there are still many open burning practices, mainly in rural area, which produce carbon dioxide emissions.

Currently, there is no internationally developed model applied for the Indonesian waste sector. As a result of expert and government consultations, the development of a basic domestic model was preferred over an internationally developed one – given the particular situation in Indonesia (ICCSR, 2010). Based on expected waste generation volumes in each region (as included in official regional waste management plans), future emissions resulting from the waste sector are estimated. For example, the methane emissions from solid waste at landfills are determined from the amount and type of waste accumulated, and how it is being treated in the landfill area (i.e. anaerobic/semi-aerobic). The amount of waste accumulated in the future is calculated from the projected population and waste generation estimates, in given area and time. The methane emissions are then estimated using the same method as GHG inventory calculation of emissions from solid waste disposal sites (SWDS). Furthermore, the projected methane emissions will be different, depending on the development plans for solid waste treatment at final disposal sites, due to the change in the methane correction factor (MCF). The same principle is also used for calculating the projected emissions from other activities, mentioned above.

The results of emissions calculations from solid and liquid waste (domestic and industrial) are summed up to get the overall baseline emission from the waste sector. Due to the limited availability of locally specific activity data, the aim for the Indonesian waste sector, currently, is to consider using the IPCC tier-1 approach, while efforts are taken to improve the data quality.

Figure 2: Baseline for forestry and peatland sector of 33 provinces in Indonesia (Bappenas, 2012), million tons of CO_2e [35]

Legend:
- DIY
- DKI Jakarta
- Gorontalo
- Jambi
- Jawa Barat
- Jawa Timur
- Kalimantan Barat
- Kalimantan Selatan
- Kalimantan Tengah
- Kalimantan Timur
- KBB
- Kepulauan Riau
- Lapung
- Maluku
- Maluku Utara
- NAD
- NTB
- NTT
- Papua
- Papua Barat
- Riau
- Sulawesi Barat
- Sulawesi Selatan
- Sulawesi Tengah
- Sulawesi Tengaara
- Sulawesi Utara
- Sumatera Barat
- Sumtera Selatan
- Sumatera Utara

35. Baseline calculation result by Climate Change Working Group from Potret Rencana Aksi Daerah Penurunan Emisi Gas Rumah Kaca (RAD-GRK), Bappenas, draft version of December 2012 – using 23 land classifications.

Methodological choices – waste sector

- **Approach**: a combination of the bottom-up and top-down approach (local government has responsibility but little capacity – need for national government assistance in terms of capacity building, data and information, and additional investment)

- **Model**: simple Excel-based extrapolation

- **Basic data requirements**: waste volume (domestic solid waste and wastewater), waste composition for solid waste, existing and future waste treatment

- **Assumptions**: population and future waste treatment

- **Institutional and technical capacity**: Public Works, Ministry of Environment, Ministry of Industry

(for industrial waste), and relevant SKPD (Local Government Sectoral Working Unit)

- **Benefits**: simple and easy to calculate a likely higher degree of implementation by local government (Tier 1)

- **Challenges**: data at national level is limited, since it should be compiled by local government, which has almost no existing data

The national baseline (using bottom-up approach) will be the result of the sum of calculations of the three approaches (energy, land-use management and waste), using the same unit of measurement (ton CO_2eq per year). Moreover, it will include calculation results of emission reductions from other sub-sectors, such as industry process (as LEAP only calculates the energy-related), utilization of organic fertilizer, livestock, etc.

Figure 3: Baseline for waste sector of 33 provinces in Indonesia (Bappenas, 2012), million tons of CO_2e [36]
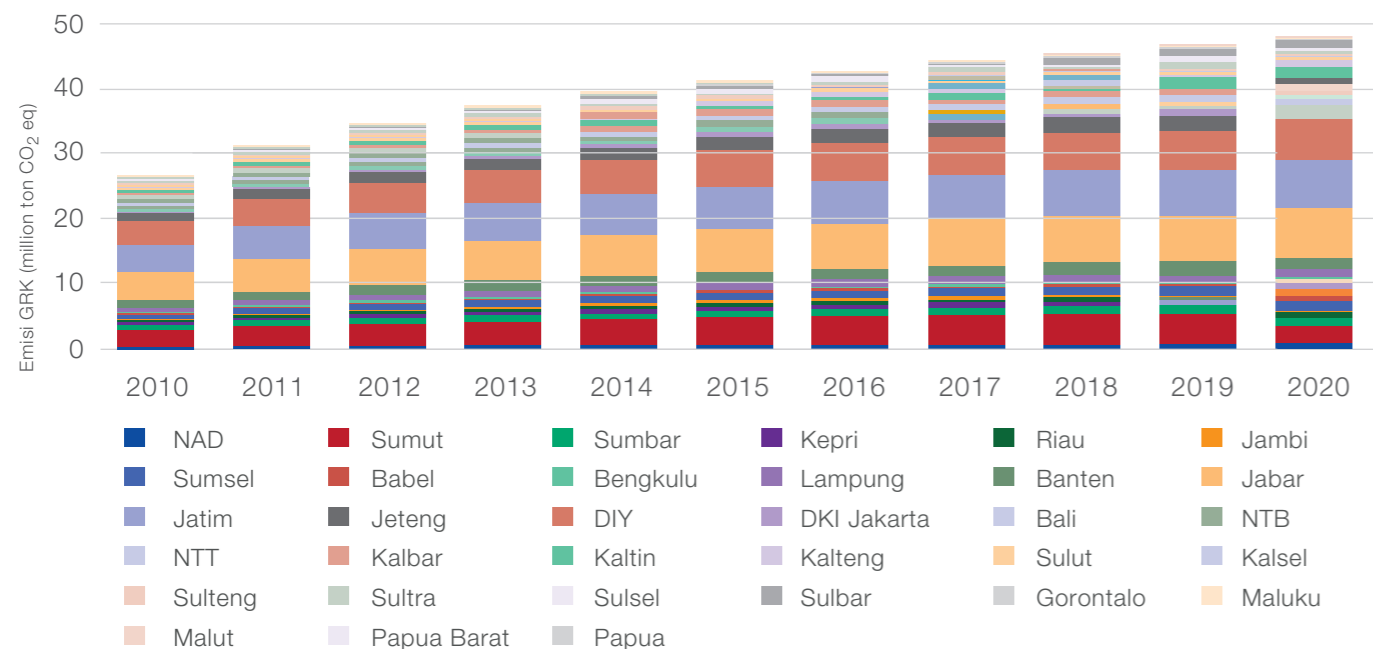
Assumptions and sensitivity analyses

The Government of Indonesia has shown serious attention to climate change impacts by its commitment to GHG emission reductions of 26%, through its own efforts, and a further reduction of up to 41%, with international support, by 2020. As a concrete follow-up to its commitment, the government has set its National Action Plan for Greenhouse Gas Emission Reduction (RAN-GRK), which is included in the Presidential Regulation No. 61/2011. The RAN-GRK commitment to GHG emissions reduction includes:

- Allocation of emission reduction targets into five key sectors, namely: Forestry and Peatlands, Agriculture, Energy and Transportation, Industry, and Waste Management

- A government program to facilitate implementation of GHG emission reductions, nationally, at both the federal and local level
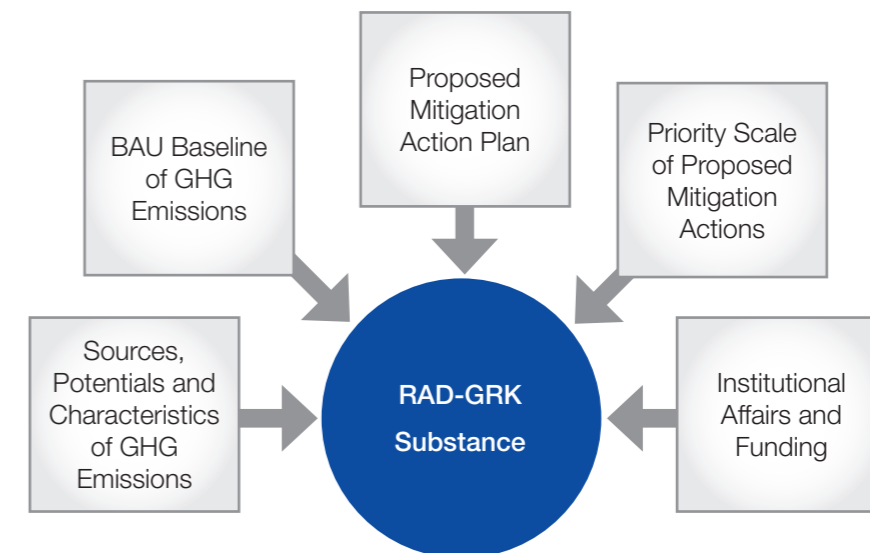
RAN-GRK is a national guide for emission reduction programs, activities, and policies, to be conducted together by the central government, local government, business actors, and society.

To take active steps towards achieving the national GHG emissions reduction target, Bappenas published guidelines for local government to develop local climate change mitigation action plans (RAD-GRK). The local RAD-GRK will be developed by the provincial government, in line with their mandate to coordinate, facilitate, monitor and report mitigation actions, developed and undertaken by district and city governments. Since the beginning of 2012, they have been taking the first steps towards developing the RAD-GRK scoping and baseline setting, which follows the recommended steps by the guidelines, and the subsequent completion of the RAD-GRK report by September 2012. By December 2012, 32 out of 33 provinces are able to finish their RAD-GRK. Therefore, in 2013, Bappenas will focus on monitoring and reviewing the implementations of the action plans – both for RAN-GRK and RAD-GRK.

The provincial and district/city governments play very important roles in GHG emission reductions, at the local level. RAD-GRK must be in line with local long-term and mid-term development plans and provincial/district-city regional spatial management plans, which then become inputs to local planning documents.

RAD-GRKs are developed through a participatory process that addresses multi-sector GHG emission reduction efforts, by considering local characteristics, potential, and authority, which must be integrated into a local development plan. Activities for GHG emission reductions that are carried out or facilitated by governments use program and activity titles that are in line with local strategic plans.

36. Baseline calculation result by Climate Change Working Group from Potret Rencana Aksi Daerah Penurunan Emisi Gas Rumah Kaca (RAD-GRK), Bappenas, draft version of December 2012 – using 23 land classifications and historical period 2006-2011.

Mitigation actions must relate to the following development principles:

- Be an integrated part of the development strategy, and be based on policies and national/local strategic plans.

- Not hamper economic growth and poverty reduction initiatives, and prioritize people's welfare.

- Consider all sustainable development aspects in a cross-sectoral integrated action plan.

- Have a local development plan with new approaches that focus on GHG emission reduction efforts.

- Involve local developmental actors from various parts of society to enrich the substance, improve ownership, and improve engagement in the action plan implementation within the timeline.

- Follow the monitoring, evaluation and reporting systems that are based on the prevailing government regulations, and are measurable, reportable and verifiable.

In Indonesia, the baseline is the projected GHG emission level for 2010 to 2020, without policy intervention and mitigation technology, for specified sectors. For each sector, it must be decided which policies will be considered an intervention for reducing emissions, and which will not. For example, in the power sector, the baseline assumes that coal will be used for power generation. The "crash program II" to construct 50% (5000 MW) of the power plants, built from 2010-2014, using geothermal, is considered to be a mitigation action. This kind of review should be done one by one for every activity, program, and policy proposed to be included in RAN-GRK and RAD-GRK.

Programs and activities that will be prioritized are those whose implementations are funded by their own resources (Unilateral/Nationally Supported NAMAs) from the state budget, the regional budget (including government loans from foreign sources), the private sector and the community. They will be based on the following general criteria:

1. Conformity with sustainable development principles;

2. The effectiveness of cost utilization for integrated GHG emission reductions, based on the lowest cost principle;

3. The ease of implementation, by taking into account the political, social and cultural aspects;

4. Alignment with the national and regional development priorities in the activity location;

5. Mutually beneficial, by prioritizing development programs that contributed to the GHG emission reductions (co-benefit).

In order to ensure involvement and a sense of ownership, the RAN-GRK uses a participatory method, involving all relevant ministries and national institutions. In the early stages, more focus is given to governmental institutions, but later it will involve more local governments, private sectors and local communities. In this way, the resulting priority actions in the current version of the RAN-GRK reflect the vision and priority of each government ministry and institution. Furthermore, Bappenas conducts policy development and analysis process that are integrated with the national development planning. This process will improve involvement of local governments, private businesses and community, so that all stakeholders can contribute positively to achieving the GHG emissions reduction target.

Baseline emissions are projected, based on the following:

- Historical GHG emissions inventory data.

- Activities that would be implemented if only financial benefits and emission reductions were considered. In the power sector, for example, if there were no goal to reduce emissions, the power company in Indonesia would likely construct many more coal power plants than in the baseline scenario.

- Although the base year is 2010, historical data can be used as a reference in calculations for the mitigation activities and projections made to the year 2020 and onward.

The approach to setting a baseline in Indonesia can be seen as a dynamic process. It is intended to gather new information every year, including data on the progress of implementing the RAN-GRK and RAD-GRK (i.e. monitoring and evaluation), which will then be integrated into the process to help sharpen and correct assumptions about baseline characteristics and effectiveness of mitigation actions. The dynamic baseline approach was chosen in order to arrive, over time, at more realistic quantitative targets for mitigation in Indonesia. Furthermore, assumptions for GHG emission trajectories for 2020, made in 2010, might be subject to considerable adjustments and corrections. Therefore, by using a dynamic approach, Indonesia's baseline will be updated regularly with better data, information and methods.

Use of emissions inventories and data management

To develop proper national and local mitigation actions, data and information to be collected should, at least, include: [37]

Public Data and Information

Public data and information are general local descriptions, along with local policies, strategic plans and local spatial management to be used. The required data include:

- General profile or description of planning region. For example: human, economic, physical and environmental resources.

- Development policies and programs related to activities/sources that produce GHG emissions in the region. Therefore, the calculation must enable the indication of spatial management planning activities related to GHG emission contribution activities, which can potentially be intervened. In relation to this, local governments can also indicate the content of development policies and programs pertaining to emission producers, as well as the opportunities for GHG emission reduction efforts.

Technical Data and Information

Technical data and information are data, information and assumptions by sectors needed to develop baselines, proposed actions/activities of GHG emission reductions and calculation of mitigation costs. The types of data and information needed will be different, according to the sectors and activities that produce GHG emissions. These data and information are commonly differentiated into activity data and emission factors, according to the different models used for the five sectors listed in Presidential Regulation No. 61/2011.

Data Collection of Public Institutions

The development of mitigation action plans need lists of public institutions (namely, agencies and government regulations) related to GHG emission reduction efforts – both directly and indirectly. The information is obtained by listing: 1) government agencies related to emission reductions, the functions and key tasks (service/body/office), 2) institution's work programs, 3) regulations related to environmental conservation, land-use and land-use conversion, and energy saving. Then, the data and information is further analysed to determine whether they have connection and opportunity to those agencies/regulations/programs categorized as being relevant to the reduction of GHG emissions.

Data Collection of Privately Owned Enterprises

To scale-up cooperation with various parties, it is necessary to identify institutions and activities of private sectors/businesses and community groups that have positive (potential for supporting emission reduction efforts) or negative connections (not having potential for supporting reduction efforts). To this end, it is necessary to carry out data collection of existing activities (previous/on-going) conducted by the parties. Data and information for conducting the analysis are obtained directly (through meetings) from business actors' institutions, and indirectly from published reports (through print or electronic media, including websites).

37. Source: Guideline of RAD-GRK, Bappenas, 2012.

Table 1: Identification of Institution for Data Sources of
GHG Emission, for Local Action Plan (RAD-GRK)[38]

Provincial Characteristics (physical, environmental, economic and social aspects)
For example: area width, number of districts/cities, population, forestry width, agricultural and plantation land width, type and number of industries/enterprises, number of employees and local government Sectoral Working Unit, Local Budget (APBD), etc.

Sector	Local Government Emission source potential	Public/Business Actors Emission source potential
Forestry and peatland Data source: Forestry service, Center for Forestry Research, Forest Employers Association, Province's Statistic Data, statistics bureau (BPS)	For example: • Forest fires • Transfer function of peatland • Forest cutting	For example: • Opening of forest land for development of shifting cultivation • Forest clearing for other land uses (e.g. cash crops)
Agriculture Data source: Forestry service, Faculty/Center for Agricultural Research, Agricultural Employers Association, BPS, Province's Statistic Data	For example: • Expansion of agricultural land • Land use for farming	For example: • Land burning for agricultural land preparation
Energy Data source: Ministry of Energy and Mineral Resources (ESDM) service, State Owned Electricity Company (PLN), Power Plant Employers Association, BPS, Statistic of 'Province in number'	For example: Number and capacity of power plants operated by local government that are not connected to PLN[39] network (off-grid); number of power and fossil fuel users for power plants managed by local governments	For example: Number and capacity of private power plants that are connected to PLN network; amount of power energy and fossil fuel use by business actors and the people
Transportation Data source: Transportation service, 'One-Roof Administration System' (Police Office), Vehicle Dealers Association, Pertamina[40], BPS, Statistic of 'Province in number'	For example: Number, type and consumption of fuel from land transportation means operated by local governments	For example: Type and consumption of fuel from land transportation means operated by the people and business actors
Industry Data source: Industry service, Industry Association, PLN, Pertamina, BPS, Statistic of 'Province in number'	For example: Energy (number, type and consumption), waste (number and type) coming from small and medium industries (IKM); local governments enterprises that have contribution to GHG emission (pulp and paper industry and sugar industry)	For example: Number, type and consumption of energy coming from small and medium industries (IKM) managed by the people/private (e.g. clothes, soya bean cakes – tahu-tempe-industries, etc.)
Waste Management Data source: Public Works service, environmental protection agency (BPLHD), NGOs, BPS, Province's Statistic Data	For example: Volume and type of garbage produced by activities of local governments	For example: Volume, type of garbage produced by the people and private parties

Problems:
• Limited dissemination of mitigation action examples to the public and business actors, so in general public and business actors are unaware of which activities fall in the mitigation action category which do not • Unavailability of system and procedures for reporting of mitigation activities between the communities/business actors and local governments • Challenge of coordinating the data collection throughout the government levels and various actors

Developing a baseline scenario is a new task for the provincial government, and will pose quite a challenge in terms of: data identification and compilation, applying the scenario building methodologies and models, linking the baseline scenario with the mitigation action scenarios, and establishing the appropriate monitoring and reporting system. Certain sectors are tasked with developing the baseline scenario, both at the national and local level, due to the multi-level and multi-stakeholders nature of the sectors (e.g. the land-based sector).

The baseline scenario will be the basis for determining provincial GHG reduction targets, enabling development planners and practitioners to re-think development scenarios of their provinces, and helping them to detect data gaps at the provincial level.

Currently, there is no single methodology approved at the international level, although some methodologies have been developed and recognized, both nationally and internationally. Furthermore, every country is allowed to develop its own baseline based on its national circumstances, and submit their methodology to SBSTA. To be consistent, and ease the task of local governments, the national level should provide clear guidelines and training for local governments on the standard methodology that would be employed to formulate the baseline. Therefore, Bappenas assigned these tasks to the Climate Change Working Group,[41] giving clear guidance and assistance to local governments.

The general objective is to increase the capacity for local stakeholders to participate in the national goal to reduce GHG emissions. As stated in Presidential Regulation No. 61/2011, Bappenas, the Ministry of Home Affairs, the Ministry of Environment, and other related ministries should assist the local government in developing their RAD-GRK.

One important capacity program is training the provincial government officials in the calculation of sectoral and multi-sectoral baselines, through practical exercises.

38. Source: Guideline of RAD-GRK, Bappenas, 2012.
39. PLN is the state-owned company for electricity.
40. Pertamina is the state-owned company for oil and gas supply.

41. In 2012, Bappenas created a Climate Change Working Group which will support, monitor and evaluate the implementation of the national and local mitigation action plans.

From the first training in Bandung in May 2012, which was supported financially by central and local government institutions, development partners and research centres, it is expected that the local government officials and experts will be able to use the models for calculating the baseline. Their results will be the basis for further discussions with the relevant authorities in their provinces, when they go back to their regions after the training. Since Indonesia has 33 provinces, and trainings are attended by an average of seven people per province and include presentations from more than 40 trainers, the costs are high and the logistics are challenging.

The seminars are interactive, between experts and participants, using a guided and coached learning-by-doing approach. It is intended to invite participants from all sectors relevant to the RAN-GRK, i.e. forestry, agriculture and peatlands (land-based sectors), energy (power, industry and transport) and waste sectors. Selected officials from all provincial governments, as well as national government representatives and experts, will be invited to the seminar. National and international experts in mitigation actions, baseline models and sectoral and regional issues, will guide and coach the participants. The detailed baseline capacity building process and local mitigation action development can be accessed at www.sekretariat-rangrk.org.

The national seminar for GHG baseline development will provide the opportunity for provincial government officials to apply the recommended scenario-building models and methods, build draft baseline scenarios and design an action plan for future steps. In the trainings coordinated by Bappenas, local government officers and local experts have the opportunity to hold discussions with ministry officers and national experts, about which mitigation scenario is most suitable for their region (related to specific policies and boundaries of authorities between central governments versus local ones).

Below are a series of capacity building programs,[42] coordinated by Bappenas, to assist local governments in developing their local mitigation action plans.

- Since the beginning of 2012, the Climate Change Working Group and the Secretariat of RAN-GRK have carried out about six FGDs (Focus Group Discussion) for central government institutions to discuss technical issues, and agree on a methodology, data set and technical guidelines for local government to develop their local baseline.

- The national government held three training programs that involved all local governments from the 33 provinces – seven participants for each province, representing five sectors and local planning units. There were instructors from sectoral ministries and experts from universities and research organizations, supported by development partners. The last training took place in Bandung city from 10-14 September 2012.

- Following that training, several regional trainings have been conducted. The Secretariat for RAN-GRK in Bappenas will develop "custom made" trainings, based on requests from particular provinces, districts, or cities. For example, some provinces in Java wanted further training for LEAP (since the energy sector is the main source of emissions there), while most of the provinces in Kalimantan Island asked for LUWES training. East Nusa Tenggara (NTT) and the Papua provinces requested a full-program of training.

- Provinces with the least capacity were visited by the Secretariat of RAN-GRK and sectoral ministry officers, allowing them to consult more intensively.

- To assist local governments, Bappenas also facilitated the review of the RAD-GRK draft in July 2012.

Transparency, stakeholder involvement, and review

Indonesia's approach to setting a baseline suggests general principles for combining a top-down approach with a bottom-up approach, while integrating the baseline and RAD-GRK as much as possible into the Indonesian system of development planning – including related legal and fiscal systems.

The appropriate involvement of stakeholders at all relevant levels and sectors is indispensable to assure ownership and strength of these processes. Depending on the process for developing and implementing the baseline, different stakeholders and actors are expected to play various roles and be involved to a certain degree.

As the national coordinator, Bappenas will play a major role in identifying all relevant stakeholders. In the early stages of baseline drafting, this might involve the planning, and structural bureaus of the sectoral ministries, local government institutions, and related institutions. Bappenas is expected to lead and coordinate the baseline development process, which may mean undertaking intensive and regular consultation meetings with private sectors and civil society stakeholders, about proposed concepts and strategies. This part of the baseline development is expected to take a top-down approach, in the sense of providing a national framework and principles in which sectors and local governments could act according to their own development priorities.

A top-down approach should not be mistaken for the exclusion of stakeholders, but instead should be understood as a coordination process to establish the national baseline by selected institutions with strong involvement of stakeholders. Likewise, the bottom-up approach does not imply stakeholder engagement without coordination, but rather that sectoral and local government actors become primary stakeholders in the process. Exact roles and responsibilities in the baseline development process should be fine-tuned by the national coordinator in order to get the best results for the process, in terms of substance, strategies, strength and ownership of the process.

At the national level, Bappenas and sectoral ministries have held several consultations with private national organizations, such as pulp and paper association, cement association, steel association, oil and gas association, etc. However, the frequency and content of this communication still needs to be improved, along with increasing interest from private sector, and the importance of their role in reducing GHG emissions. With regard to RAD-GRK development, so far, stakeholder engagement has considered government agencies at all three levels, nationwide. During the process of local action plans development, the local governments are encouraged to conduct public-private dialogues at provincial levels, to streamline private sector strengths and weaknesses with the intended actions in the RAD-GRK. The Government of Indonesia will focus on those sectors with the highest mitigation potential in the province. In mid-term, there is a plan to establish a systematic approach to involving the private sector, academia and civil society. For example, Bappenas has initiated the network of universities, which aims to facilitate the exchange of information between those universities. Moreover, it is intended to help local governments with the development and implementation of local action plans. Another example would be, the process of RAD-GRK development in the East Kalimantan (Kaltim) province in July 2012, where the provincial government initiated "Kaltim Carbon Partnership/KCP" as a forum for consultation on how the private sector could contribute to provincial emission reduction targets. Since its launch by the provincial government, KCP has received positive responses from many private companies, which should be followed by more concrete activities.

As a conclusion, the next step for Indonesia in developing its baseline process is monitoring, evaluation and reporting of the implementation of RAN-GRK and RAD-GRK at the national and local level. The system will be improved over time so that it will be in line with international standards.

Kenya

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Introduction

The Government of Kenya developed a business-as-usual emission pathway through to 2030, for its National Climate Change Action Plan (NCCAP).[43] The technical mitigation analysis, including the "Preliminary Greenhouse Gas Inventory", reports on this business-as-usual pathway, and includes a detailed documentation of the methodologies, data, assumptions used, results, and discussions on uncertainties.[44] The NCCAP analysis contains emission projections from agriculture, forestry, electricity generation, energy demand, transportation, industrial processes, and waste. In a holistic analysis, the NCCAP provides the evidence base for: prioritizing low-carbon development options, developing proposals for nationally appropriate mitigation actions (NAMAs), developing actions to reduce emissions from deforestation and forest degradation, and clarifying the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+).

In accordance with OECD, UNEP and DEA, this chapter extracts some important points and lessons learned from the NCCAP for Kenya, regarding assumptions and uncertainties. The chapter focuses on the assumptions made about the expected future of select emission sectors, and the sensitivity analysis undertaken in the NCCAP.

Figure 1 presents the resulting business-as-usual emissions pathway.

Figure 1: Emissions baseline reference case
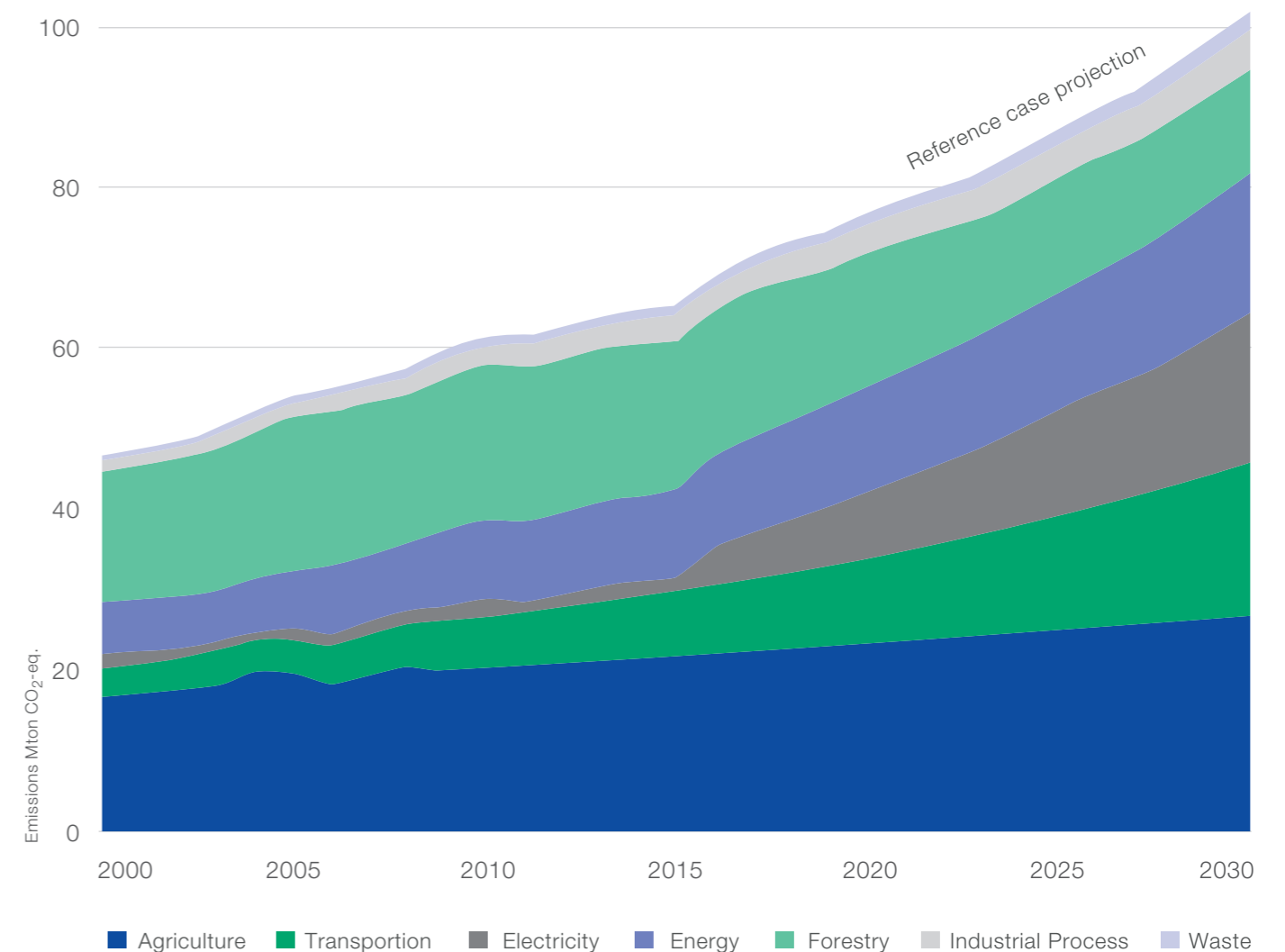
Source: Government of Kenya. 2013. National Climate Change Action Plan 2013-2017: Executive Summary. Nairobi: Government of Kenya. page 9.

43. Government of Kenya. (in publication). National Climate Change Action Plan. Nairobi: Government of Kenya.
44. The underlying technical analysis that informed, and is part of, the NCCAP, can be found at: http://www.kccap.info.

The first section, below, discusses the assumptions used to identify the growth rate in electricity supply. The second section reviews the uncertainties and sensitivity analyses completed for the agricultural and forestry sectors.

Growth assumptions in electricity generation[45]

Developing a reference case for Kenya's electricity sector is challenging, as there are considerable uncertainties regarding how the sector may grow to meet a large suppressed demand for electricity. Specific plans are in place but they assume very high growth rates. The Updated Least Cost Power Development Plan (ULCDP) presumes a 14% per annum growth rate in electricity supply between 2010 and 2030, in the reference case.[46] This compares to a 7% per annum historical growth in electricity supply between 2000 and 2010. The cost to achieve this dramatic projected growth is estimated at 41.4 billion USD (excluding committed projects). Generation technologies that are expected to make up the vast majority of the new supply still face considerable barriers to implementation.[47]

The emissions baseline for the electricity sector is developed by estimating the total fossil fuel consumption of different generation technologies, and then multiplying the total consumption by appropriate emission factors. This method is the same as the Tier 1 approach used in the 2006 IPCC Guidelines[48] for stationary combustion sources. Information about the Kenyan situation is taken, for the most part, from the ULCDP[49], and personal communications with officials in the Ministry of Energy[50] who update projections for the Medium Term Plan.[51] In addition, expert judgment and opinion was provided during stakeholder consultations and meetings.

The baseline outlined in this section is not identical to the reference case in the ULCDP. This is because the objective of the baseline emissions forecast is to consider a scenario based on existing policies and regulations, and assume no growth in international aid and related international investments. Specifically, any additional international support and investment for electricity generation projects that may be tied to low-carbon development are not included in the emissions reference case, unless the international support and related investments have already been committed.

Comparison of installed electric capacity between 2010 and 2030
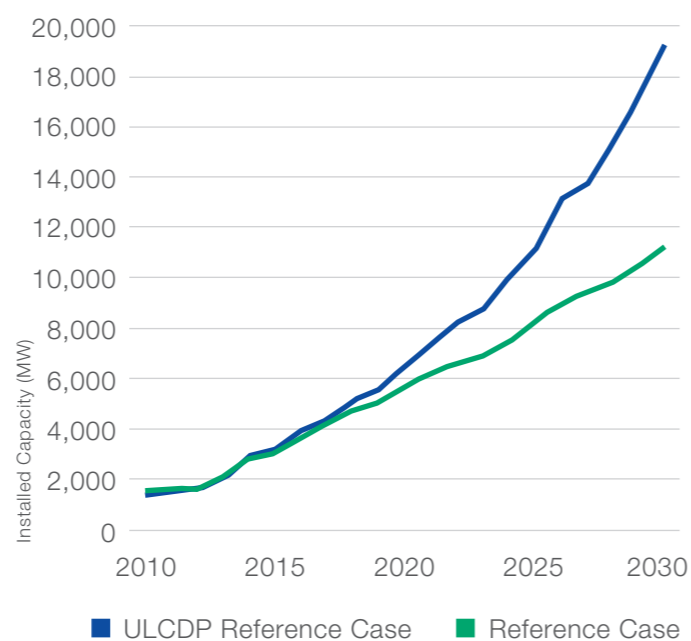
Source: Government of Kenya. (in publication). "Mitigation – Chapter 2: Preliminary Greenhouse Gas Inventory", National Climate Change Action Plan. Page 20.

Including such international support would mean that the substantial renewable generation investment in geothermal, wind and small hydro in the Kenya Vision 2030[29] reference case could not be part of a NAMA. Consequently, including this potential investment in the baseline would mean that billions of dollars in investment opportunity, through NAMA project development, could not be considered in the mitigation scenario. The figure below compares the total installed electric capacity between 2010 and 2030 presented in the reference case – adopted in this low-carbon analysis – to the reference case in the ULCDP.

The NCCAP reference case deviates from the ULCDP reference case, in order to reflect a baseline that is based on existing policies and regulations, and assumes no growth in international aid or related international investments – specifically assuming no additional international support that would be tied to NAMAs. Therefore, total generation capacity under the GHG emissions reference case is 11,287 MW in 2030, versus that of the ULCDP, from 17,220 MW. This represents an annual average growth rate in capacity of 11%, versus 14%. The growth rate assumed in the low-carbon scenario reference case is still considerably higher than historic growth in the economy and the sector.

45. Government of Kenya. (in publication). "Mitigation – Chapter 2: Preliminary Greenhouse Gas Inventory", National Climate Change Action Plan. Nairobi: Government of Kenya. Pages 19-22.
46. Ministry of Energy. 2011. Updated Least Cost Power Development Plan. Nairobi.
47. Ministry of Energy. 2011.
48. IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 2 Energy. Geneva
49. Ministry of Energy. 2011.
50. Ministry of Energy. 2012. Petroleum Sales Data from 2008 to 2010. Excel spreadsheets provided by Ministry of Energy in personal communication March 13, 2012.
51. Government of Kenya. 2012. Electricity Sub-Sector Medium Term Plan (2012-2016). Friday 9th March 2012 - Draft. Vision 2030.

Uncertainty and sensitivity analysis

The NCCAP reviewed and discussed data availability and uncertainty for the six mitigation sectors. This section highlights the sensitivity analyses and discussions on uncertainties for the agriculture and forestry sectors.

Agriculture [53]

The agricultural sector is the largest source of GHG emissions of the seven sectors considered in the report. Despite the size and prevalence of the sector, data required to calculate GHG emissions is lacking, and considerable uncertainty remains in the calculation of emissions when compared to the energy demand, energy supply, industrial processes and waste sectors. Livestock emissions account for approximately 30% of total emissions in Kenya, yet it is necessary to use default emission factors that are not country-specific to estimate these. The uncertainty of these emission factors is reported to be in the range of ± 30% to 50%.[54] There is even greater uncertainty in the projected baseline emissions, as estimates of future livestock populations are also very uncertain. Decreasing the annual growth rate of all livestock, even by a small amount, from 1.3% to 1.0%, would reduce overall agricultural emissions in 2030 by 5% (1.4 megatons).

The burning of agricultural residues on grazing and croplands also has considerable uncertainty, as there are only poor estimates of the total areas of these lands where this practice occurs. Increasing the assumed area burned, by 20%, would result in the rise of overall agricultural emissions in 2030 by 1% (0.4 megatons).

Uncertainties related to other emission sources, including rice flooding and nitrogen fertilizer use, are also high, but because of the small contribution of these sources to the total, even an increase of 100% in these emissions would raise 2030 total agricultural emissions by less than 1%.

Forestry[55]

Greenhouse gas emission trends in the forestry sector are hard to determine because of the difficulty in accurately measuring biomass carbon pools for the entire country. In the NCCAP, data and projections from the 1994 Kenya Forestry Master Plan[56] are used and extrapolated to estimate carbon sinks and releases of forests in Kenya, although changes in carbon stocks in non-forested areas are not included in the estimates. The emissions baseline reference case was developed using PATH modelling software – a state-and-transition model that accounts for land-use/land cover change. Use of this model allows information on states and transitions to be calibrated against FAO projections, greatly increasing the confidence in the projections.

The emissions baseline is based on aggregated estimates of the carbon intensities (tons of carbon per hectare) of different land-use categories over time, which are products of a limited number of measurements that have not been updated in more than a decade. While no information is available to estimate the range of uncertainty, the high variability of the abatement estimates cited in the literature indicates that it is certainly higher than most other sectors (e.g. electricity, transportation, and industrial processes).

Small changes in model input values for the emissions baseline can lead to drastically different results. For example, if the aboveground biomass of the "farms with trees" land-use category increases by 20% from 16 to 19 m3/hectare between 2010 and 2030, rather than remaining constant, the total emissions in 2030 would decline by 36% (3.9 megatons). Uncertainty would be greatly reduced by applying consistent, spatially explicit observations of land-use and land-use change, using remote sensing and geographic information systems. The Kenya Forest Service is engaged in a forest mapping initiative using remote sensing and ground-based inventories. The results, expected in 2013, will improve on current estimates that are not reliable and have a high degree of uncertainty. Variations of carbon intensity, per hectare, for different climatic regions, and improved data to estimate losses or gains in soil carbon for the various land-use categories would also improve the analysis.

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Mexico

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Context for baseline development

Mexico's Special Program on Climate Change (PECC, for its Spanish acronym) was published in August 2009 (Semarnat, 2009). The PECC established unilateral actions by the federal government to cover three major areas: mitigation, adaptation, and cross-cutting elements of policy. With regard to mitigation, quantitative reduction targets from 53 actions amounted to annual reductions of 50.66 Mt CO_2e by 2012.

Mexico's commitment to reducing greenhouse gas emissions, however, is not limited to its 2012 achievements. The PECC also set a "long-term vision" with ambitious mitigation trajectories for 2020 and 2050, subject to international finance and technology transfer (see Figure 1).

- The 2050 target is consistent with a potential stabilization of atmospheric GHG concentrations at a level not to exceed 450 parts per million (ppm), which is equivalent to a 50% emissions reduction in relation to emission levels for the year 2000.

- The 2020 target was originally equivalent to a 20% reduction from the baseline, but was raised to 30% at COP15, and has been set as such in Mexico's recently approved General Law on Climate Change.

Therefore, the construction of the baseline is very relevant for setting, measuring and tracking mitigation efforts and commitments in Mexico.
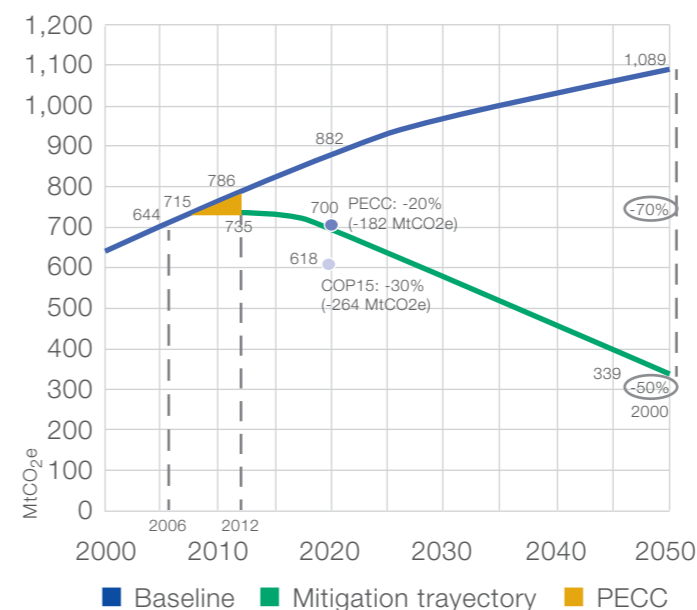
Figure 1: National baseline and mitigation scenarios 2000-2050

Source: Based on figures from Semarnat's 2009-2012 Special Climate Change Program (2009)

Description of models used

Constructing national baselines is an inherently complex task, due, in part, to the difficulty of accurately incorporating growth in energy demand, technology penetration and energy use efficiency in the long term, among other factors. Mexico originally developed a baseline (currently included in the PECC program) using an in-house model in 2009, which was then updated in 2010 to make it more comprehensive, and to respond to stakeholder contributions. This section describes the original model and baseline produced, and then goes on to describe the second baseline and the reasoning behind its development.

Original baseline

The baseline set in the PECC was built using a top-down modelling approach because of the information available and the short timeframe. It considered information from the Energy Sector Prospects 2008-2017 (electricity, oil, natural gas and liquefied petroleum gas). These included the prospective markets for a wide range of energy sectors, including oil, crude oil, LPG, natural gas and electricity. These forecasts take into account the international market projections for the sectors, as well

as consumption, national and international reserves, worldwide production and underground storage available in different countries (SENER, 2008). Consequently, they include analyses on market prices, projections of demand and supply through 2020, and the International Energy Agency (IEA) projections for different industries. Several of the reports also consider the expected environmental impacts and emissions for different energy types in the future (SENER, 2008).

For 2020, 2030 and 2050, the baseline maintains growth and an evolving rate of sectoral distribution of emissions, in alignment with the OECD average global emissions baseline (OECD, 2008). The 2006 base year was chosen in accordance with the latest available National Greenhouse Gas Emissions Inventory in Mexico, developed for the Fourth National Communication to the UNFCCC.

Revised baseline

In 2010, the Mexican government decided to revise its baseline with updated information. This reconsideration of the baseline from the top-down towards a bottom-up approach was carried out because it would give more specificity to particular sectors, and would be more comprehensive. The Ministry of Environment and Natural

Resources (Semarnat) worked in partnership with the National Institute of Ecology and with external consultants to make the new baseline solid enough to be scrutinized in every sector and sub-sector. As a consequence, the revised baseline was built using this bottom-up approach for all GHG emitting sectors in Mexico,[57] which required a substantial amount of information with a high degree of granularity.

The baseline revision sought to incorporate GHG emission drivers from key sectors in a traceable way. The 2006 starting point (base year) from the original baseline was maintained, as the value calculated by the INEGEI, and the period covered was up to 2030, including particular detail for 2008, 2012, 2020 and 2030 (McKinsey, 2009).

Replicable sector-specific methodologies and information sources were used, mainly based on IPCC recommendations (McKinsey, 2009). Calculation trees were built for every sector following IPCC guidelines and included official, local, publicly available information sources for the projection of key variables. This can be observed in Figure 2, where the methodology for the baseline revision is presented through an example of the Iron and Steel sector, specifically through the volume production indicator which was part of the industry analysis.

Figure 2: Baseline revision methodology:
Example of "Iron & Steel" volume production indicator, as part of the industry analysis
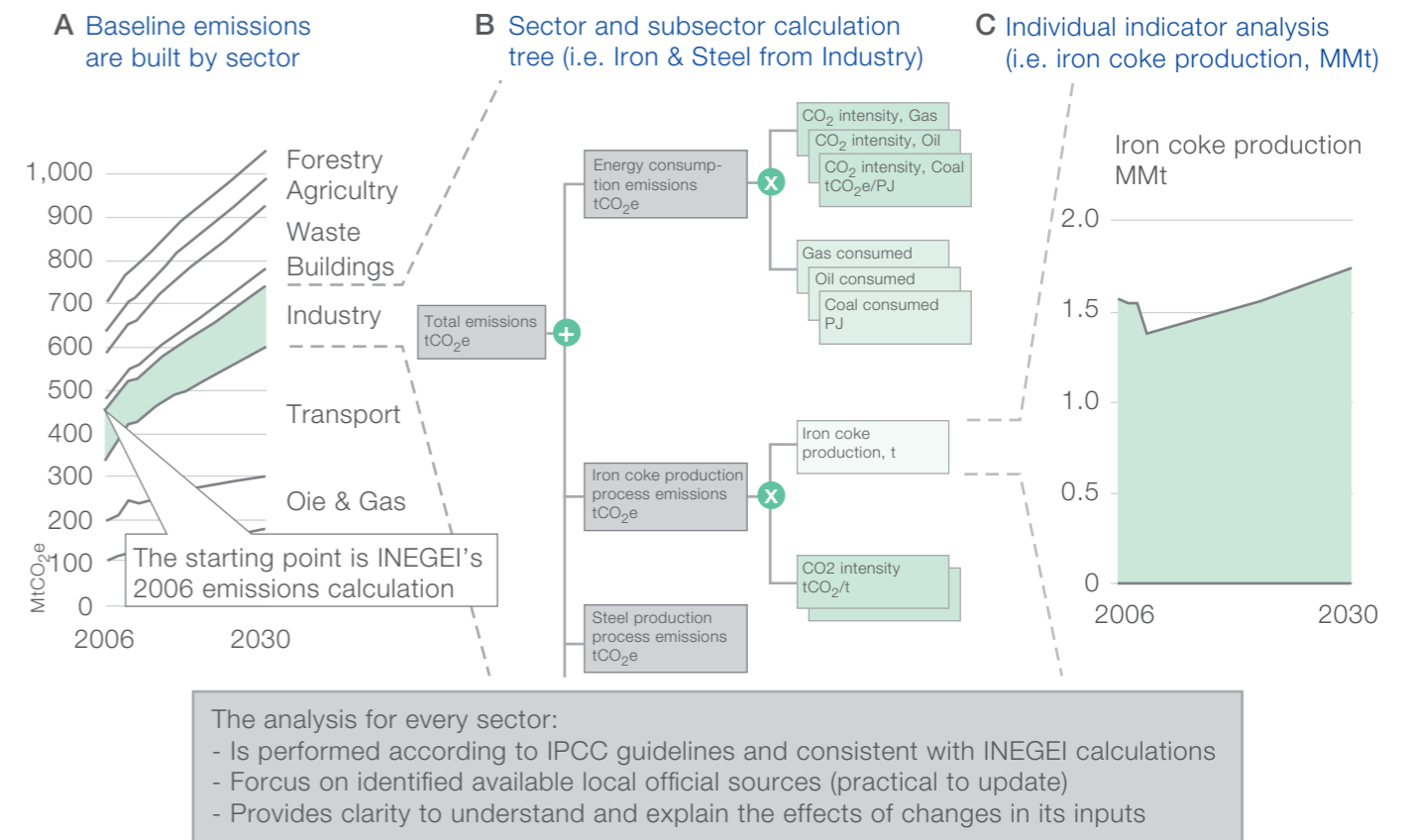
To integrate all of this information coherently and transparently, a tailor-made model was used. The model uses standardized criteria for long-term projections (such as GDP per capita), and its structure is flexible to adjust to new and more detailed information, as it becomes available.

Comparison of baselines

Although the approaches and assumptions are different, the two baseline trajectories are quite similar. The revised emissions baseline projects slightly lower emissions in 2012 and 2020 than the original baseline (2% and 1%, respectively) and higher emissions in 2030 (3%) (see Figure 3).

Figure 3: Original PECC Baseline versus revised Baseline
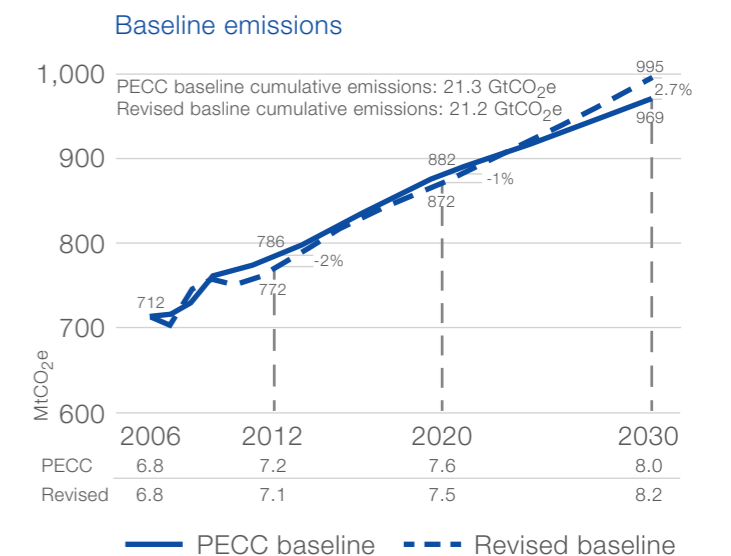
57. Emissions are classified into 8 sectors: 1) Electricity Generation (by fuel type), 2) Oil and Gas (fuel refining and fugitive emissions), 3) Transportation (automobile and railway transport, maritime and aviation), 4) Buildings (residential and commercial), 5) Industry (cement, steel, petrochemical and other industries), 6) Waste (garbage and residential, and industrial wastewater), 7) Agriculture (including livestock), and 8) Forestry (including deforestation and reforestation).

As shown in Figure 4, differences are mainly due to increases in emissions from the transport and waste sectors. The transport sector is the biggest contributor to emissions in Mexico, and it is predicted that it will continue to be so. The waste sector is the fourth largest contributor to emissions in Mexico. This sector is predicted to grow, as the methane generation from landfill (the biggest emission contributor in this sector) depends largely on the amount of waste disposed. Moreover, this sector is expected to expand with projected population and economic growth. Differences also result from a significant projected decline in the oil and gas sector emissions, which the Mexican Petroleum Company (PEMEX) predicts will contribute only 7% of national emissions by 2030.

Figure 4: Original PECC baseline by sector versus revised baseline by sector
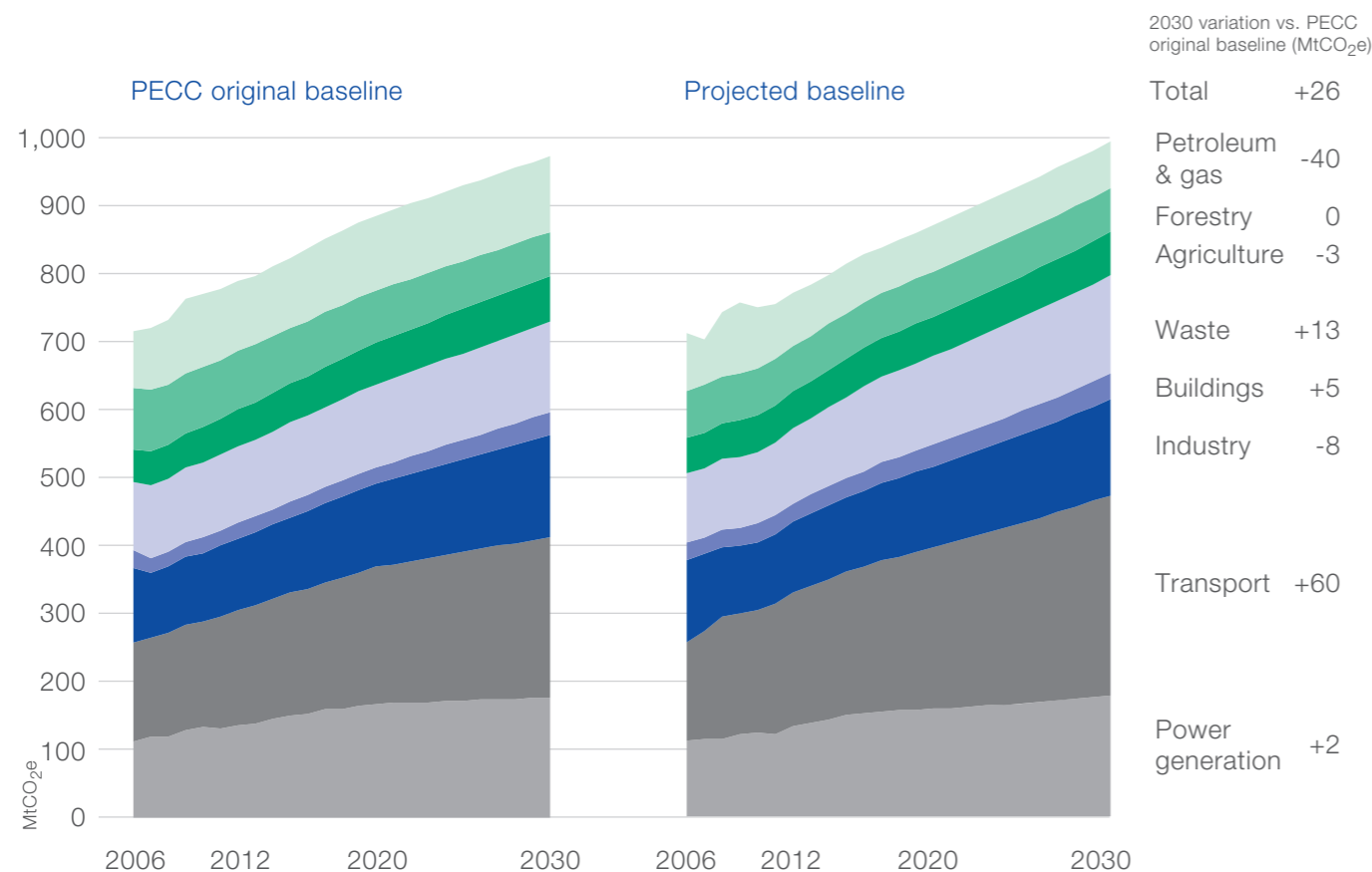
Assumptions

While a number of variables are considered for estimating Mexico's revised baseline, both population growth and GDP have a notable impact and are the two most significant inputs for this model.

One of the main assumptions of the baseline is that it represents a GHG emission dynamic in line with the belief that there are no fundamental changes in public policy. However, it takes into account current trends, both in terms of public and private investment, in technological developments.

The methodology for the baseline includes all GHG emitting sectors in Mexico, but does not consider the inter-relations between the different sectors. Furthermore, the methodology does not consider the migration of economic activity from productive sectors, based on manufacturing, to service-intensive sectors with the development of GDP in the long run.

In order to avoid the risk of overestimating actual growth trends in GHG emissions – such as unduly inflating expectations or generating 'hot air' – a key consideration throughout the construction of the baseline was to have a more conservative approach in specific cases where more exact data were not available. This would aim to guarantee environmental integrity and real mitigation actions in the long term.

Sensitivity analysis

Estimates from the National Population Committee (Conapo – in Spanish) predict population growth and a stabilization period after 2040, with 122 million inhabitants. Because estimates in population growth are more reliable, due to available official statistics, sensitivity analyses were focused on GDP.

The revised baseline considers a long-term constant economic growth of 2.3% per year between 2009 and 2017, following projections published by Mexico's Ministry of Energy, and extends the same growth from 2017 to 2030. This particular GDP growth was chosen as it signified a conservative approach in baseline construction. For the sensitivity analysis, a very high and ambitious

GDP growth scenario of 5% per year was chosen. This 5% scenario assumed that Mexico's growth would be approximately one standard deviation above its ten-year growth mean (between 2000 and 2010), and that no financial crises would occur within this foreseeable future (INEGI, 2011). The results of this comparison are discussed below.

The total emissions baseline in this scenario shows important deviations from the revised baseline: 7% in 2012, 18% in 2017, 25% in 2020, and 55% in 2030 (Figure 5). This increase is driven by the sectors that are most sensitive to economic growth, which are described in more detail below.

Figure 5: Sensitivity of emissions with economic growth of 2.3% versus 5%
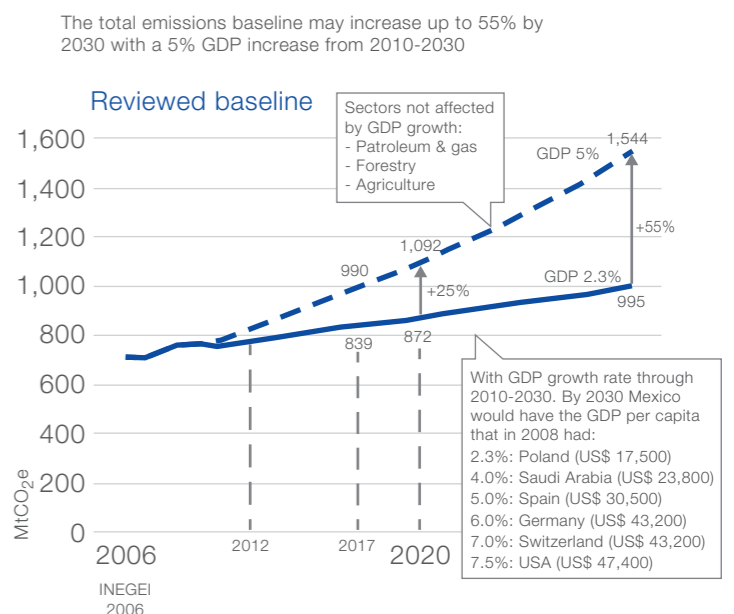
The power generation, transport and industry sectors, which were the leading emission sectors in 2006 (INEGEI, 2006), are highly linked with economic growth. In the power sector, energy demand rises with GDP growth. In the transport sector, all vehicle segments are affected by GDP growth, even though the sector is also sensitive to variations in the size and efficiency of the vehicle fleet. In the industry sector, both fuel consumption and process emissions increase with economic activity.

In fact, for the three sectors described above, the 5% annual GDP growth would imply a 74% increase in emissions in relation to the baseline. Such an increase would mean reaching 2030 emissions of 308 Mt CO_2e for the power sector, 512 Mt CO_2e for the transport sector, and 245 Mt CO_2e for the industry sector (see Figures 6 and 7).

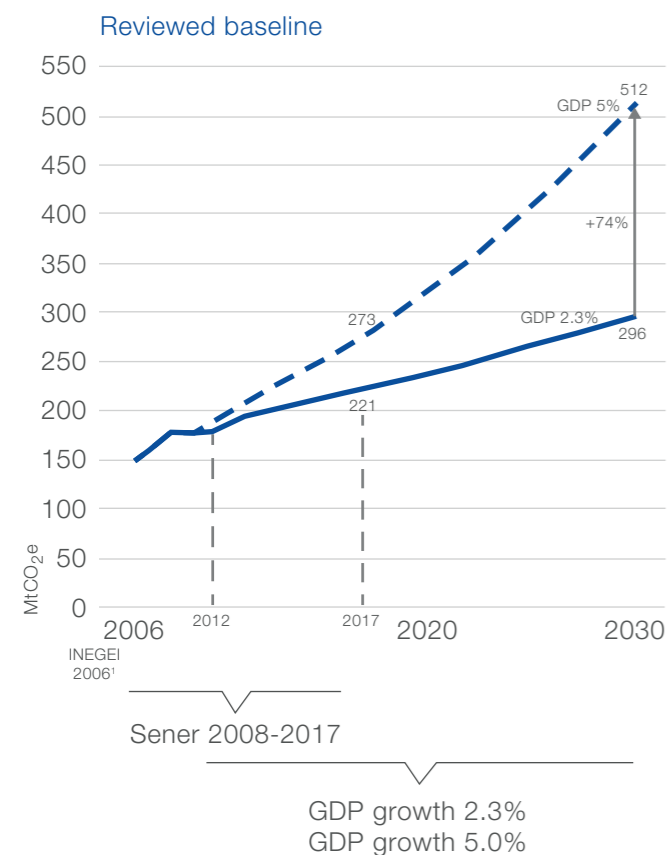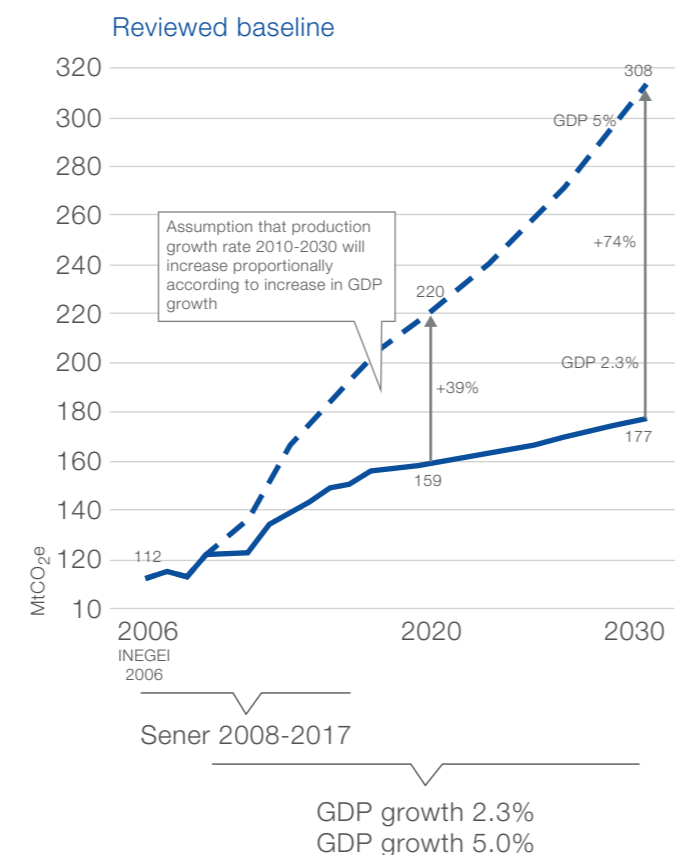Figure 6: Baseline emission in the power sector

Figure 7: Baseline emission in the transport sector

The baseline scenario for the waste sector increased by 65%, with the assumption of an additional 5% increase in GDP growth. Only domestic wastewater is expected not to grow with GDP. Population growth and the proportion of treated wastewater also affect emissions in the sector.

The building sector's growth is affected to a lesser extent by increases in GDP. Economic growth affects the number of commercial and public sector buildings and, to a higher degree, population growth affects the number of residential buildings. A 5% GDP scenario would mean a 16% increase in emissions.

In the remaining sectors, forestry and agriculture have no relevant sensitivity to GDP. In the oil and gas sector, emissions are strictly linked to oil exploration and subject to planning and execution of long-term investments.

The sensitivity analysis gave an indication of how large emissions would be if GDP were to increase very rapidly in the foreseeable future. The aim of this exercise was to test how much of the uncertainty in the model was due to GDP projections. It was important to test the robustness of the model in relation to GDP, as it was one of the biggest contributors to the baseline model.

Stakeholder engagement

In 2009, Mexico's Climate Change Program (PECC) went through a public consultation stage before being published, but the baseline construction, itself, did not go through a stakeholder engagement process. In 2010, Semarnat engaged in discussions with the private sector, to tackle concerns on the variables and values considered for the construction of the baseline. The private sector had a different viewpoint on how to address uncertainties within the baseline – essentially, with a less conservative approach.

Baseline revision results were already available at that time, and the very similar trajectories obtained with the

original baseline, and its revision, had given confidence on the certainty of the baseline trajectory. However, in retrospect, it would likely have been more instructive for the development of the baseline to carry out a stakeholder engagement process along with its construction.

The concerns raised over the baseline triggered further analysis on how other institutes or agencies were tackling baseline construction for Mexico (see Figure 8). A comparison of the PECC baseline and the revised baseline was made against six other baseline exercises, with different approaches (see Table 1). To allow for the comparison, only energy-related sectors were considered.

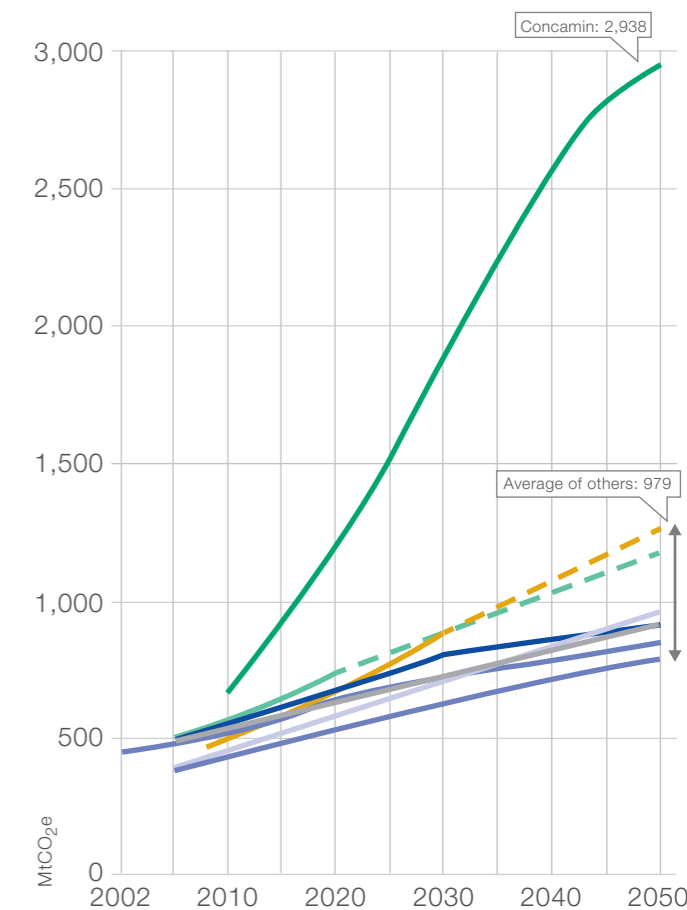Figure 8: Comparison of different baselines constructed for Mexico

Table 1: Description of the different baselines constructed for Mexico

Study/Institution	Elaborated by:	Publication Year	Model type	Period considered
PECC	Intersecretarial Commission on Climate Change	2009	Top-Down	2008-2050
PECC-revised	Intersecretarial Commission on Climate Change	2009	Bottom-up	2008-2030
Project Catalyst	McKinsey & Co.	2009	Bottom-up	2008-2050
MEDEC	World Bank	2009	Bottom-up	2008-2030
Greenpeace México	CIE-UNAM/EREC	2008	Bottom-up	2008-2050
CGD	Centre for Global Development	2009	Top-Down	2008-2050
UBA	German Ministry for the Environment	2009	Top-Down	2008-2020
CONCAMIN	Intersecretarial Commission on Climate Change	2010	?	2008-2050

The analysed baselines show emission values for 2050 in the range of 790 and 1259 Mt CO_2e (see Figure 7). The private sector (CONCAMIN) baseline shows the major divergence from all others. Nonetheless, most of the baselines presented show similar trajectories, which reinforces Mexico's official PECC baseline.

Mexico's General Law on Climate Change states that the participation and consultation of the private sector and society is required in the construction and updating process of the Climate Change National Strategy. Baseline scenarios, emissions mitigation trajectories, and specific mitigation goals must be included in the Strategy. Therefore, a stakeholder engagement process must be considered beforehand, with a clear communication and approach.

Action being taken now, and the future vision

To date, the original baseline construction and the revised baseline model have served as an initial platform for the development of more robust tools for climate change mitigation policy assessment. For example, the 'Mexican

> … The Danish Energy Agency (DEA), in partnership with Mexico, will undertake a comparison study trying to understand the differences in baselines for Mexico (Semarnat and INECC) using different models. The aim is to increase transparency and credibility by better understanding the impact from using different assumptions on key drivers and across different models.

Institute for Competitiveness' (IMCO) in partnership with Semarnat, and support from the United Nations Environment Programme, have developed a 'calculator' tool that can create abatement scenarios by incorporating additional mitigation measures, giving the potential of current measures towards 2030. This tool can quantify changes in the baseline, modify it accordingly, and get the return on investment for each technology or action considered. If the expectation for 2025 electricity generation were to change, the tool would allow the user to adapt this prediction in line with new information, and observe what changes it would come up with. The tool has been independently evaluated by the University of Cambridge, which provided additional recommendations and support on how to improve it (IMCO, 2011).

Currently, Mexico's National Institute of Ecology and Climate Change, with support from Mexico's Low Emission Development, in partnership with USAID, is developing a model using LEAP to produce a single baseline generation methodology. This initiative will also produce a new national baseline that will incorporate the most recent data.

Continuity of baseline projections is guaranteed in the General Law on Climate Change, which establishes the obligation to include baseline scenarios, emissions mitigation trajectories, and specific goals in a 10, 20 and 40-year timeframe in the National Climate Change Strategy. These scenarios must be periodically updated and will most likely address uncertainties with the development of different scenarios.

With this in mind, and the work that has already been carried out in the area of baseline development, Mexico is committed to continuing to strengthen its baseline. Further efforts will continue towards building capacity and technical knowledge in this area, in order to support the national obligation towards reducing greenhouse gas emissions.

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South Africa (ERC)

Authors: Thapelo Letete, Harald Winkler, Bruno Merven, Alison Hughes, Andrew Marquard, ERC

**Methodological choices: Experiences
of the Energy Research Centre**

The Energy Research Centre (ERC) undertook the modelling framework, as part of a stakeholder process of South Africa's national greenhouse gas baseline, which was a key component in the country's Long-Term Mitigation Scenarios (LTMS). The MARKAL framework was used to model the energy sector, while for emissions in non-energy sectors, a variety of spreadsheet models were used, as described in more detail in the reports on waste, agriculture and forestry sectors (Taviv et al. 2007), and industrial process emissions (Kornelius, Marquard & Winkler 2007). The LTMS methodology was unique in that it comprised research and process elements, producing evidence-based scenarios which key stakeholders had reviewed in detail, a number of times, during the process. Technical work, from inception to completion, was presented, discussed, and reviewed in a facilitated process by a large 'Scenario Building Team'. Members of the team were drawn from businesses, state utilities, government departments, unions and civil society – as experts, and stakeholders. Smaller expert groups were set up on the same basis, to tackle specific areas where more detailed consultation and review were needed.

More details on this methodology can be found in a book by Stefan Raubenheimer (2011), and in the section below on Transparency, Stakeholder involvement, and Review. This section outlines the ERC's experiences with the MARKAL/TIMES family of models, including reasons behind this choice of framework, skill and data requirements, and cost implications.

The ERC has over a decade of experience in bottom-up optimization modelling, specific to the South African energy sector, and the development of national and regional models for medium to long-term policy analysis. Through various projects and teachings, the ERC has experience in three different modelling frameworks: LEAP, MARKAL/TIMES and MESSAGE, as well as their own spreadsheet-based model of the South African electricity sector, SNAPP. For modelling of the national energy system and, subsequently, the national greenhouse gas emissions, the

MARKAL/TIMES framework was preferred to LEAP for its ability to optimize. This was important not only for the solution of more complex modelling problems, but also because of the additional efficiency and versatility, which an optimizing model provides in running large numbers of scenarios with small changes. While MESSAGE has the advantage of being readily available, and is an optimization model with comparable functionality to MARKAL, its user interface and the cumbersome process involved in setting up and running different scenarios renders it far less efficient. Table 1, below, outlines the specific advantages of the MARKAL/TIMES framework, which have made it the modelling framework of choice for the South African baseline.

A complete comparison of the different energy modelling frameworks can be found on the UNFCCC website (UNFCCC, 2006).

Table 1: Advantages of MARKAL/TIMES modelling framework, over LEAP and MESSAGE, in modelling the energy sector of the South African greenhouse gas emissions baseline

| General	MARKAL/TIMES is able to optimize (in terms of minimized system cost) both the demand and supply-side of the energy system. Different supply-side and end-use technologies can compete, and optimal configurations are chosen by the model, subject to user-defined constraints.
Compared to MESSAGE	• MESSAGE does not allow easy entry of data from Excel spreadsheets straight into the model • The free solver that comes with MESSAGE takes a long time to run model databases that have a large number of technologies and constraints
Compared to LEAP	• LEAP takes a simulation approach, and does not optimize for least-cost or any other criterion. Therefore, LEAP does not allow the development of a large number of internally consistent scenarios as easily and as rapidly as optimization models, nor the solution of more complex modelling problems such as a carbon constraint, or the imposition of a carbon tax.

Overview of the South African MARKAL/TIMES model

MARKAL/TIMES is a family of partial equilibrium linear optimization models, capable of representing the whole energy system, including its economic costs and emissions – making it particularly useful in modelling potential mitigation policies. These models seek to supply energy services at minimum global cost, subject to constraints, by simultaneously making decisions on equipment investment, equipment operation, primary energy supply, and energy trade decisions, by region. Therefore, they provide a technology-rich basis for estimating energy dynamics, and associated greenhouse gas emissions, over a long-term, multi-period time horizon (Loulou, Remme,

Kanudia, Lehtila, & Goldstein, 2005). A complete description of this modelling framework, including the differences between MARKAL and TIMES, can be found on the IEA-ETSAP website (www.iea-etsap.org/).

The MARKAL/TIMES model structure is contained in a database, and constructed via a user-interface, which provides a framework for both structuring the model and scenarios, and for interpreting results. The two types of user-interfaces available for the MARKAL/TIMES model are: ANSWER and VEDA (Front End - FE and Back End - BE). Figure 1 shows the model structures with the ANSWER and VEDA user-interfaces. The user-interface compiles model data into a set of linear equations, which are then solved by a linear solver in GAMS.

Figure 1: MARKAL/TIMES model structure using the ANSWER and VEDA user-interfaces (ETSAP, 2011)
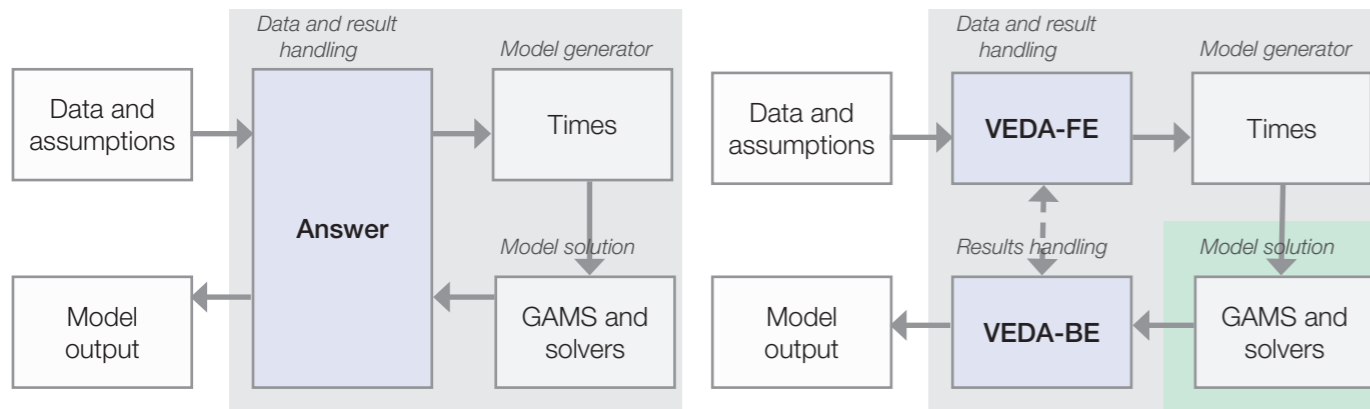
A MARKAL model of the South African Energy Sector was developed for the first Integrated Energy Plan (IEP) for the Department of Minerals and Energy (DME) in 2002, and completed in 2003 (DME 2003). Building on this seminal work for the IEP, further models and databases were developed in subsequent years, including

MARKAL models for various studies (Hughes & Haw 2007; Winkler, Howells & Alfstad 2005), a version used in the LTMS process (Hughes & Haw 2007; Winkler 2007), and the current SATIM model (ERC 2011). The ANSWER user-interface was used in all of these models, with optimization in GAMS carried out using the CPLEX solver.

The choice of the ANSWER interface was due to three primary reasons:

- Because it is cumbersome to develop and update an entire database for a model using the user-interface alone, ANSWER allows for the development of the model structure, as well as scenarios, in Excel spreadsheets, which can then be imported into ANSWER as a single complete package.

- A single ANSWER interface is able to handle both input data and results, while two interfaces, VEDA-FE and VEDA-BE, are required if the VEDA user-interface is to be used.

- ANSWER is more intuitive than VEDA for a first-time user, and is, therefore, preferable in an academic research institution like the ERC, where use of the model is not limited to experts.

Figure 2 presents a summary of the South African MARKAL/TIMES energy model. In total, the complete model consists of over 500 technologies.

Figure 2: A summary of South Africa's energy model
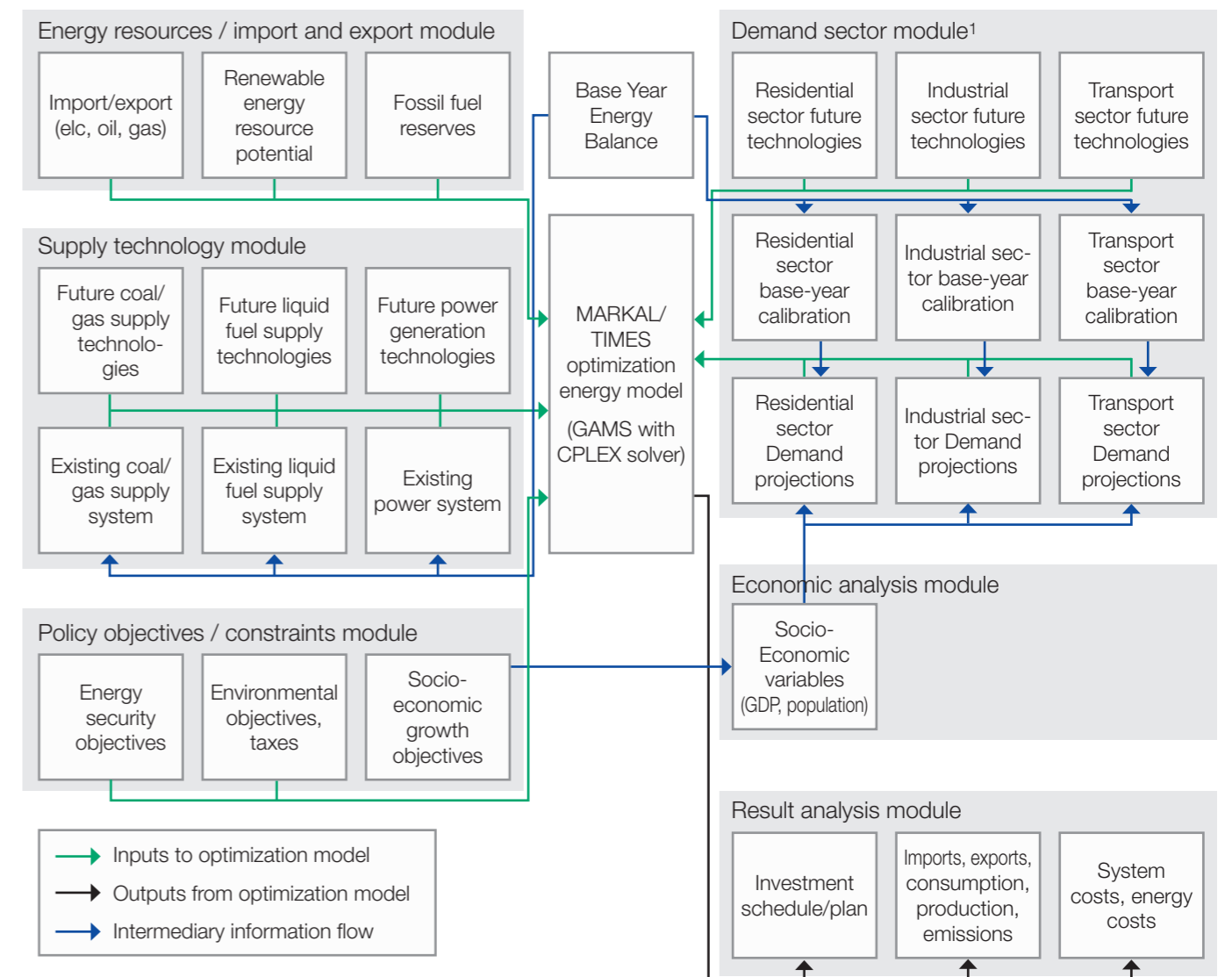
1: Commercial and agriculture omitted from diagram

Skills and resource requirements of the MARKAL/TIMES model

MARKAL/TIMES models are generally data-intensive. For the LTMS model, it took two Senior Researchers, together with several other ERC staff members, all new to MARKAL, a period of more than a year to complete the model with some ad-hoc assistance from international researchers experienced in MARKAL. The core team spent most of their time on the modelling process. During this period, only half of their time was committed to actual modelling and model design, with the other half taken up by data gathering and processing. Building the database for the base year, and then developing an internally consistent reference case, took most of the time. Data is likely the biggest challenge for any energy modelling process in South Africa, especially demand-side data. Subsequent modelling processes undertaken in the ERC have demonstrated that while experience does make a big difference to the efficient completion of a complex modelling framework, the data challenges remain. Although the technical expertise required to run the model can be acquired quite quickly by any one expert in a related field (for instance, with an IT background in a relevant area), model and scenario design, as well as the interpretation of results in a policy-relevant way, can only be mastered through experience.

Generally, the ERC makes use of a small group (5 - 10 users) of academic-user licenses for modelling software. A summary of the software costs incurred by the ERC in modelling the South African energy sector, using the MARKAL/TIMES framework, is presented in Table 2, below.

Table 2: Summary of software costs associated with the MARKAL/TIMES model

SOFTWARE	Once-off costs (USD/license)	Annual Costs (USD/license)
ANSWER	630.00	180.00
MARKAL/TIMES	Free	Free
GAMS (CPLEX solver)	384.00	77.00

Overall, while the development of a complete national energy model in MARKAL/TIMES is a data-intensive exercise that has licensing cost implications associated with it, the experience of the ERC is that these costs are outweighed by the benefits of having a detailed and high quality energy model, capable of generating numerous scenarios with ease. Moreover, the licensing costs are dwarfed by the cost of the time of researchers working on the model; thus, inefficiency or inflexibility has a very high cost.

Assumptions and sensitivity analyses

In 2005, South Africa held the first consultative National Climate Change Conference, which identified the need for transparent, participatory and scientifically informed assessments of the country's mitigation potential. The LTMS process was initiated with a mandate from Cabinet in March 2006, and concluded with outcomes agreed upon by a Cabinet meeting, lekgotla,[59] in July 2008.

This process had objectives at both the national and international level:

- Nationally - developing robust and broadly supported scenarios to lay the basis for long-term climate policy

- Internationally - providing South African negotiators with well-founded positions for negotiations on the future of the climate regime after 2012.

The reference scenario, or baseline, in the LTMS was named 'Growth Without Constraints' (GWC), which was assumed to be a future where no specific climate policies were implemented, that is to say, the GWC scenario assumed that not even then-existing policies to limit emissions were implemented, and that there was no change from the country's current trends. It outlines the country's emissions as if there were no constraints on growth, and energy plans continued to be based purely on least-cost options, without internalizing external costs. It assumes that there are no highly damaging climate impacts to the economy, no significant oil supply constraints, and that the country's energy economy continues to evolve around the mining and minerals processing sectors (SBT 2007).

Figure 4 presents the GWC scenario, with emissions disaggregated by sector. In this baseline scenario, South Africa's emissions are 446 Mt CO_2 equivalent (CO_2eq) in the 2003 base year, and increase to 1,637 Mt CO_2eq by 2050. Most of the emissions continue to come from fuel combustion for energy supply and use, with non-energy emissions (industrial processes, waste, agriculture and LULUCF) contributing roughly a fifth throughout the entire period. Overall fuel consumption grows more than five-fold, from 2,365 petajoules (PJ) in 2003 to 11,915 PJ in 2050, with the largest growth observed in the industry and transport sectors (Winkler 2007).

Figure 4: Emissions in the GWC scenario, disaggregated by sector. (NEE = Non Energy Emissions; IPE = Industrial Process Emissions; CTL = Coal-to-liquids)

Source: LTMS Technical Report (Winkler 2007)

59. A Setswana word meaning consultative process.
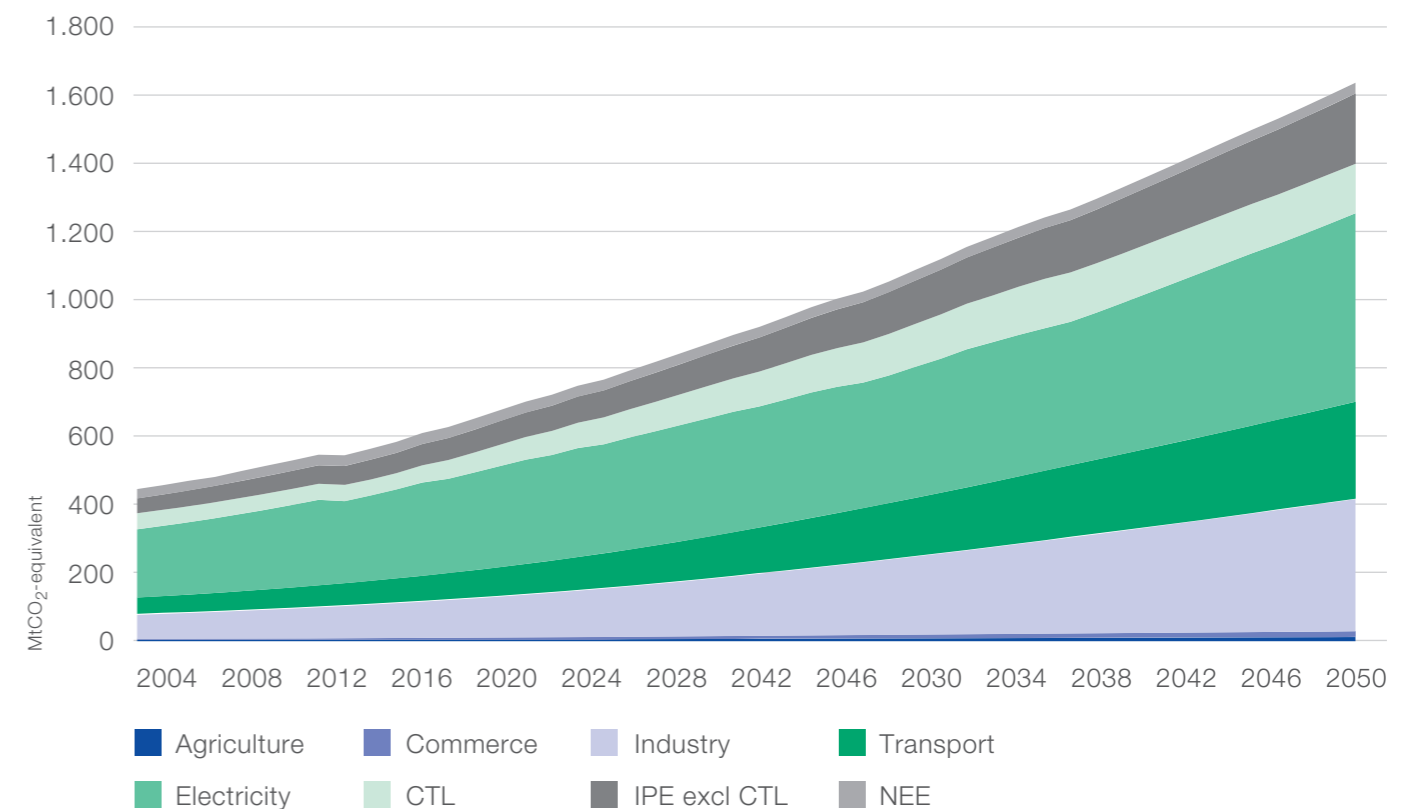
Electricity generation continues to be predominantly from coal, in the GWC scenario, with all new coal-fired plants using either supercritical steam technology, which comes into the generation mix starting in 2016, or integrated gasification combined cycle, which comes into the generation mix starting in 2020. Nine new conventional nuclear plants and 12 modules of the Pebble Bed Modular Reactors are also built for electricity generation during this period. Renewable energy technologies for electricity generation remain limited, ranging from 2.18% of installed capacity in 2003 to 0.74% in 2050, and comprising only of existing hydro and biomass capacity, and a small landfill gas capacity (ERC 2007; Hughes et al. 2007).

Crude oil refining and synfuels dominate liquid fuel production in the GWC scenario, with five new crude oil refineries and five new low-temperature Fischer-Tropsch CTL plants built within the period (Hughes et al. 2007). A more detailed description of the GWC can be found in the LTMS technical report (Winkler 2007) and subsequent publications (Winkler 2010; Winkler et al. 2011).

The 2003 base year was primarily motivated by the goal of compatibility with the Department of Minerals and Energy's (DME's) integrated energy planning. At the time, 2003 was the latest year in which the official national energy balance data was available from the DME. For industrial process emissions, the years for which the most reliable data was available varied from 2002 to 2006, consequently, modelling had to be used to bring all this to a common base year of 2003.

Drivers and assumptions

Gross domestic product (GDP) and population growth are the two major drivers of emissions modelled in the LTMS. Based on a study by Vessia (2006), which looked at a historical growth trend of South Africa's GDP and compared it to trends in other countries, a time-dependent GDP projection (Figure 5) was developed for the GWC scenario. This trend was consistent with targets for GDP growth rates that were set as part of the Accelerated and Shared Growth Initiative for South Africa (AsgiSA, 2006). Based on discussions with economic experts, it was projected that the majority of this GDP would continue to be generated by the services sub-sector of the commercial sector throughout the entire period, with the contribution of the mining sector declining over time. The projected composition of the GDP over the entire period is presented in Figure 5 – the projected growth rate is represented by the 'GDP-E' line in the graph.
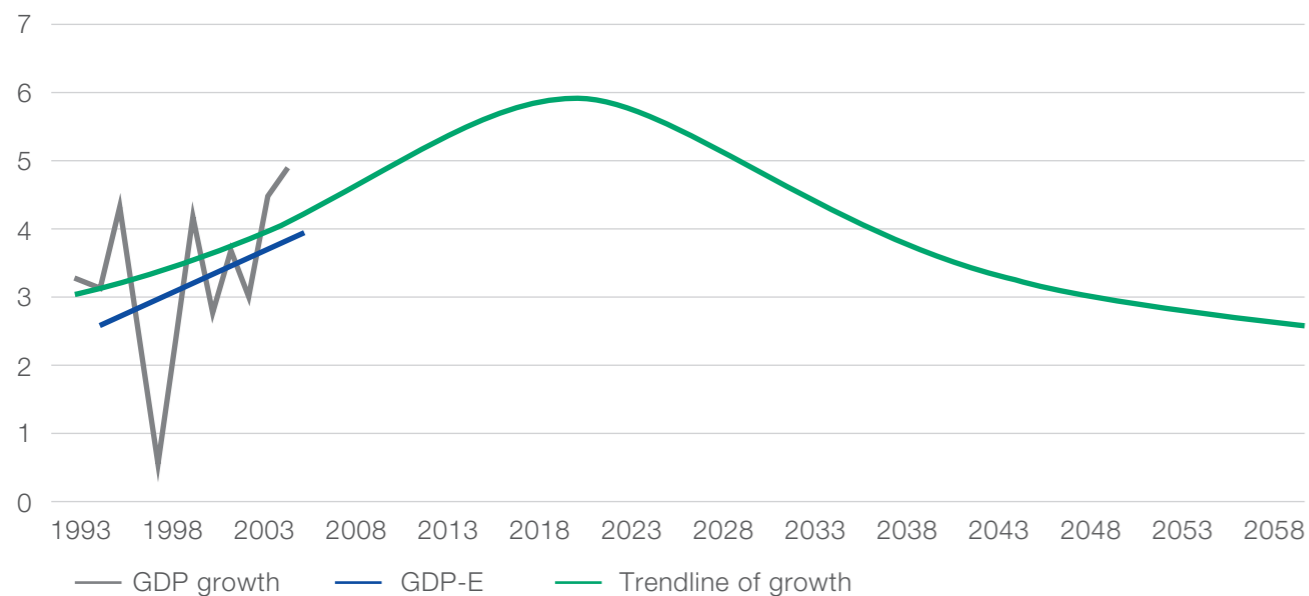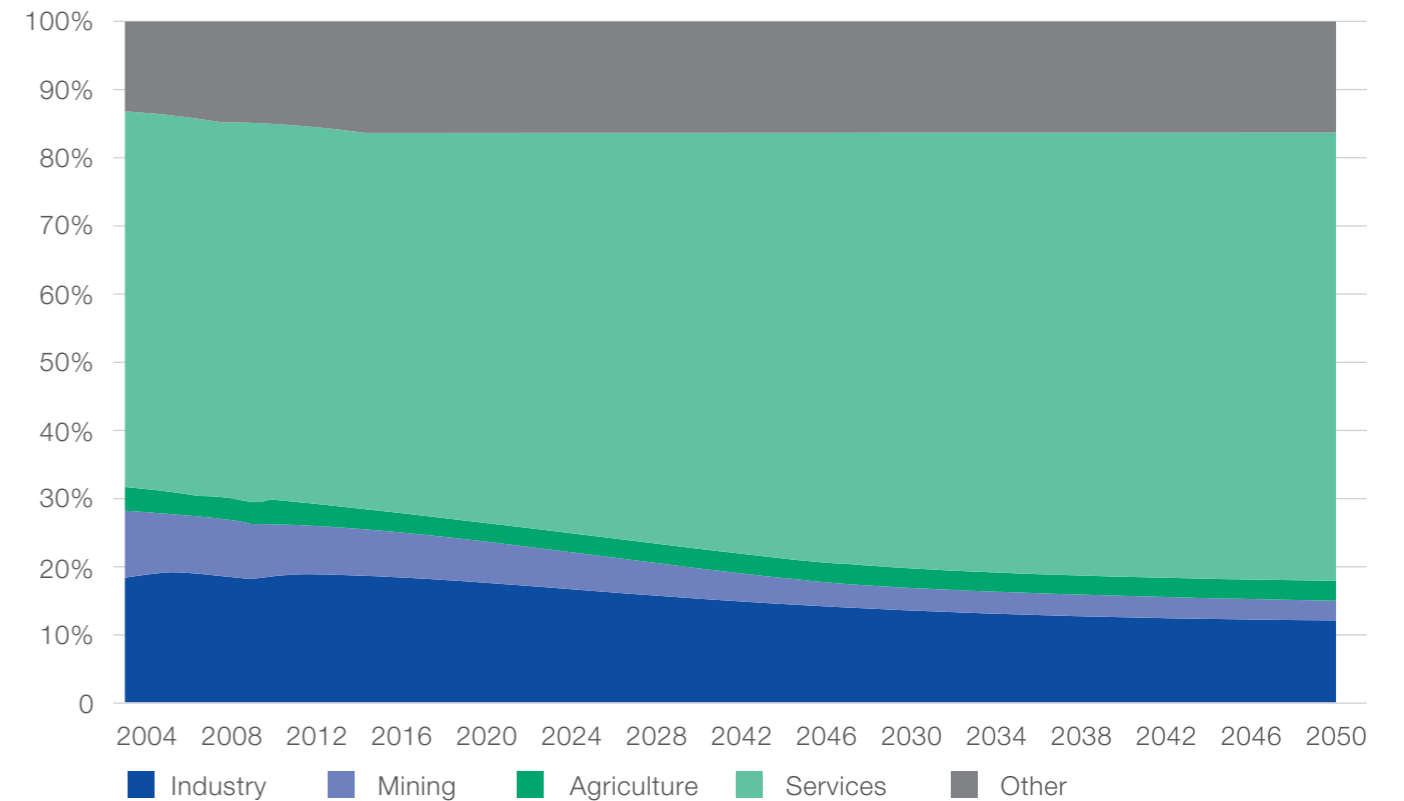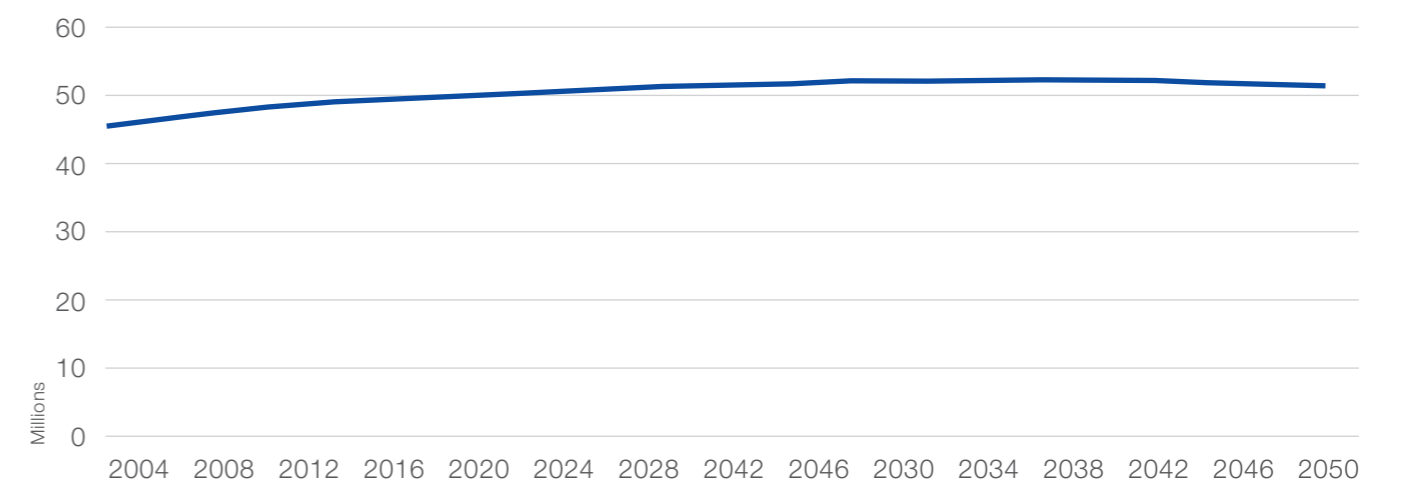
Figure 6: The composition of GDP (Winkler 2007)

A well-respected study of population projections, with the influence of HIV/AIDS taken into account, by Professor Dorrington (ASSA, 2002) was used in the LTMS model (Figure 7).

Figure 5: Historical and projected GDP growth trends (Winkler 2007)

Figure 7: Population projection from the ASSA model: 2001-2050 (ASSA, 2002)

A real discount rate of 10% was used after some discussion in the SBT. Results were reported for some other discount rates, as well as a compromise (15%, 3%, 0%). Projected future energy prices are presented in Table 3, below.

Table 3: Projected future energy prices used in the LTMS

Energy type	Price projections
Oil	From $30 per barrel in 2003 to $97 /bbl in nominal terms in 2030. Same trend beyond 2030.
Gas	From R28 per GJ in 2003 to R140 per GJ in 2030. Same trend beyond 2030.
Coal	From R3 per GJ in 2003 to R6 per GJ in 2030, after which they increase further.

Although a great deal of work was done on applying technology-learning rates to technology costs in the model, a decision was made not to apply these, as learning rates were not available for some technologies.

Sensitivity analyses

Sensitivity analyses in the LTMS were carried out for the assumptions about GDP and future energy prices (Winkler 2007). A "low GDP growth rate" scenario was modelled, which unsurprisingly resulted in lower emissions, since GDP was the major driver for the most important sectors in the model.

Sensitivity analysis of energy price assumptions were carried out as follows:

1. Oil / gas / petroleum product sensitivity

    a. On the oil prices
      i. First, starting from $55 / bbl rising in 2003 to $100 / bbl in 2030 and extrapolated at the same rate beyond

      ii. Secondly, from $55 / bbl rising in 2003 to $150 / bbl in 2030 and extrapolated at the same rate beyond

    b. The ratios of increase in energy prices were then used to make equivalent adjustments to import prices for liquid fuels, as well as local and import prices for natural gas. This was run together with the oil prices, i.e. one sensitivity on crude oil, all imported petroleum products and natural gas.

2. Coal price sensitivity

    a. A separate sensitivity analysis was done on the coal price, increased at the ratio of the first oil price sensitivity analysis.

3. Nuclear fuel price sensitivity

    a. A separate sensitivity analysis was done on the price of imported nuclear fuel, increased at the ratio of the first oil price sensitivity analysis.

The impact of this analysis on emissions in the GWC was found to be minimal, with the exception of coal – where an increased coal price resulted in a total emissions reduction of around 1,400 Mt, mainly resulting from the reduced built capacity of synfuel plants (Winkler 2007).

Transparency, stakeholder involvement, and review

Stakeholder involvement in the LTMS process occurred in two phases. In the first, or technical phase, the process of analysis was periodically reviewed, debated and directed by the Scenario Building Team, as outlined above. Following the completion of this process, after six full meetings of the SBT (mostly two days for each), and the finalization of the technical analysis, the outcomes were presented to leaders of government, business, labour and civil society in a so-called "high-level" phase. This took the form of roundtables for each constituency, with additional consideration by the Cabinet - in the case of government. This phase was consultative rather than participatory, since the detailed work had been completed by the SBT.

The Technical Level Phase: In this phase, a group of stakeholders were put together to make up what was referred to as a Scenario Building Team (SBT), to drive the technical work. These stakeholders worked in partnership with the four research teams (Energy modelling, Non-energy emissions, Economy-wide implications, and Climate change impacts) throughout the entire LTMS

process. The following criteria were used in selecting stakeholders for the SBT (Raubenheimer, 2011):

- Selected as individual leaders and strategic thinkers in particular sectors of the economy, with a high level of technical skill;

- Do not require a mandate to represent their sector (i.e. they must be willing to act without a mandate in their personal capacity);

- No proxies or replacements, unless by arrangement;

- Sourced from four sectors of society: government, business, labour, and civil society;

- In the case of business and state-owned enterprises, participants were selected to broadly represent the sectors of the economy responsible for the most emissions in the country, contribute their expertise in these sectors, and, if possible, assist in the provision of data from these sectors to the research teams.

Figure 8, below, outlines the involvement of the SBT in the LTMS process, and their relationship with the research process.

Figure 8: Involvement of the SBT in the LTMS process (SBT1 = 1st SBT meeting)
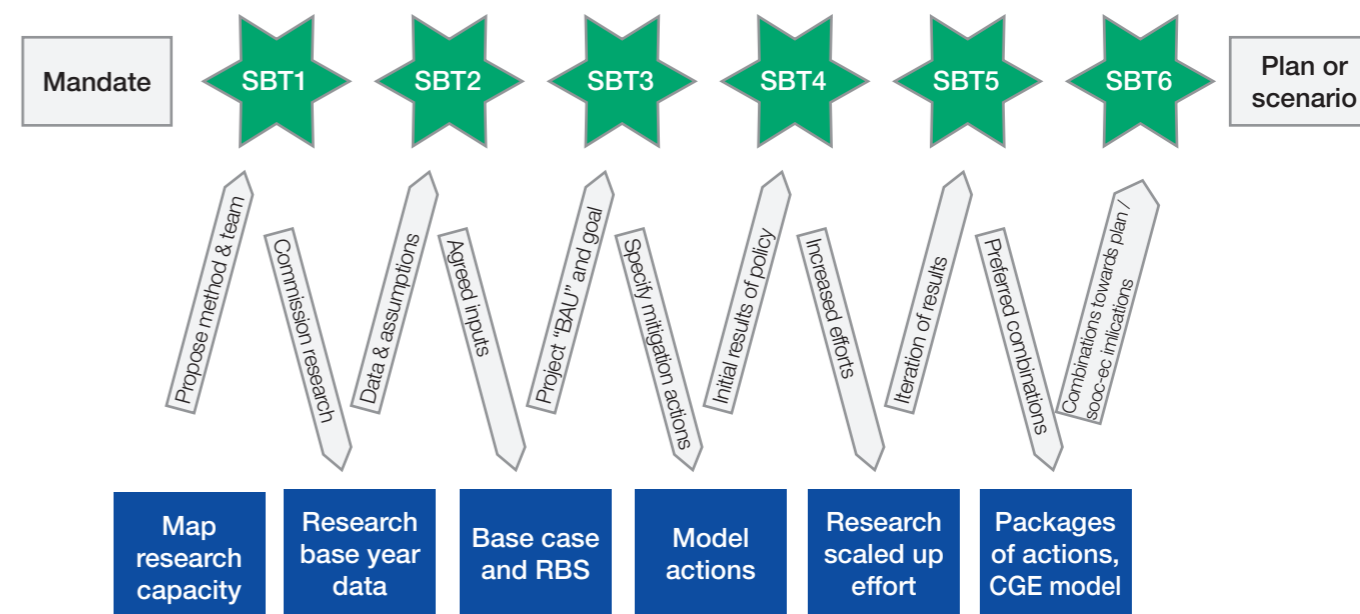
Independent facilitators and process administrators co-ordinated each SBT, with the lead facilitator also involved in the selection of the SBT. One of the main duties of the facilitators was to seek consensus in all decisions, including "sufficient consensus", for every input and assumption, and where agreement was not possible, to omit split positions and move on without such inputs. A total of 54 stakeholders were part of the first SBT, which was broadly composed of people from four sectors of society. A detailed description of the LTMS process can be found in a book by the LTMS lead facilitator, Stefan Raubenheimer (2011).

The High Level Phase: This second phase of stake-holder involvement was carried out at the end of the modelling process, and was structured in the form of four roundtables (Raubenheimer, 2011):

1. Government roundtable: This involved presentations to the Directors General of a number of government departments and agencies, and at the Parliamentary level, aimed at securing buy-ins for the study results, at the highest level of government.

2. Civil Society roundtable: This involved 12 major NGOs, research organizations, faith-based organizations and civil organizations.

3. Labour roundtable: This roundtable involved the lead-ership of the two federations that essentially represent the country's entire labour movement: the Congress of South African Trade Unions (COSATU) and the National Council of Trade Unions (NACTU).

4. Business/Industry roundtable: A preparatory meeting was called, in which technical advisors of 40 business CEOs and sector leaders were first briefed and moti-vated to secure the attendance of their leaders, after which a final meeting of CEOs was convened, with the assistance of the Minister of Environmental Affairs and Tourism.

Expert review

In addition to the SBT process, the LTMS involved three independent review processes:

1. MARKAL Review: The MARKAL model, its structure, and sample results were independently reviewed by an energy analysis consultancy – AEA Energy and Environment, based in the UK – who were experiences in using MARKAL to analyse similar policy goals in the UK.

2. CGE model Review: Economy-wide modelling was reviewed by Dirk van Seventer, who has many years of experience in the use of CGE models for policy analysis, both in South Africa and elsewhere.

3. World Bank Review: The complete LTMS process was peer-reviewed by an international review team, comprising of Xiaodong Wang (team leader, World Bank), Emilio La Rovere (energy and climate change expert, COPPE, Federal University of Rio De Janeiro, Brazil), Ming Yang (energy and climate change expert, World Bank) and Catherine Fedorsky (South African energy-environment analyst). The World Bank team held consultations for several days with participants from the LTMS, including the research teams, in South Africa.

The LTMS process received positive feedback and commendations from all the review teams. In particular, the report of the World Bank Review (World Bank, 2008) noted that:

"Overall, the review team believes that the LTMS is the first of its kind in developing countries with South Africa a leader in this area. The team found that the combi-nation of research-based Scenarios with stakeholder consultation processes was a pioneering effort to provide high-quality information for decision-making on Climate Change response strategies in South Africa. The method-ologies used in the research were consistent with interna-tional best practice and the results are robust."

The World Bank's assessment suggested that the LTMS experience be shared with other key developing coun-tries, such as those in the Southern African region, as well as Brazil, China, and India. These final suggestions motivated the inception of Mitigation Action Plans and Scenarios (MAPS) – a collaborative platform between developing countries, supporting the establishment of climate-compatible development plans, based on the LTMS methodology of participatory stakeholder engage-ment, working together with the best indigenous and international researchers (MAPS, 2012).

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Thailand

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Background on climate change issues and institutional set up

After ratification of the UNFCCC in 1994, Thailand established a national sub-committee on climate change under the National Environment Board. The sub-committee served as a climate change policy-making body, and guided Thailand's positions in the climate change negotiation process. Thailand ratified the Kyoto Protocol in 2002. In 2006, the sub-committee on climate change was upgraded to become the National Climate Change Committee, chaired by the Prime Minister. Under the National Climate Change Committee, two sub-committees, technical and negotiation, were established, as shown in Figure 1.

Figure 1: Institutional Framework for Climate Change in Thailand

National Climate Change Committee
(Chaired by the Prime Minister)

Climate Change Negotiation Sub-Committee
(Co-chaired by Secretary General, Office of Natural Resources and Environmental Policy and Planning and Director General, Department of International Organizations)

Climate Change Technical Sub-Committee
(Co-chaired by Permanent Secretary, Ministry of Natural Resources and Environment)

Ministry of Natural Resources and Environment is the National Focal Point for UNFCCC

Source: Thailand's SNC 2011

The Office of National Resources and Environmental Policy and Planning (ONEP) and Thailand Greenhouse Gas Management Organization (TGO) serve as co-secretariat for the National Climate Change Committee. Thailand's institutional framework for climate change policy planning and implementation, like that of most countries in the world, includes competences divided among various institutions in different ministries, covering renewable energy, agricultural waste, transportation, and forestry, among others.

As a Non-Annex I party, Thailand has been actively involved in greenhouse gas mitigation. Policies and Measures pertaining to investment in energy efficiency, energy switching from fossil fuel and coal to natural gas, improvements in the public transport network, and promotion of energy savings and use of renewable energy,

have contributed to global efforts to mitigate greenhouse gases.

Together with other parties, Thailand has fulfilled its obligations and commitments under the UNFCCC to address climate change. The Thai Government has formulated and implemented policies and plans to accelerate GHG mitigation in all sectors. There are lead institutions responsible for policy advocacy, implementation, and monitoring the successive impact of those policies. Figure 2 presents the status of the national climate change plan, which integrates national policies and plans on climate change and environment, with the specific plans of each related ministries (energy, transport, industry, and agricultural). This chapter describes only the plans that have already been implemented.
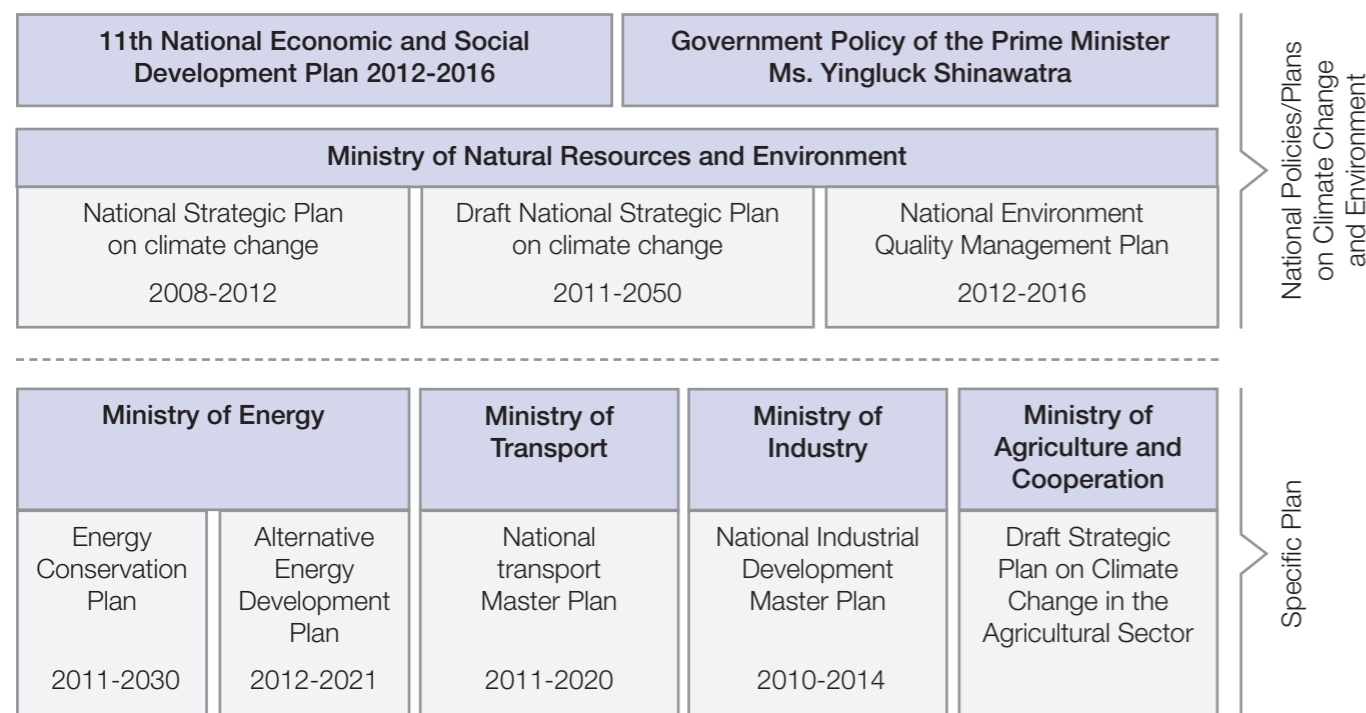
Figure 2: The status of national climate change plans

11th National Economic and Social Development Plan 2012-2016	Government Policy of the Prime Minister Ms. Yingluck Shinawatra

Ministry of Natural Resources and Environment		
National Strategic Plan on climate change 2008-2012	Draft National Strategic Plan on climate change 2011-2050	National Environment Quality Management Plan 2012-2016

National Policies/Plans on Climate Change and Environment

Ministry of Energy		Ministry of Transport	Ministry of Industry	Ministry of Agriculture and Cooperation
Energy Conservation Plan 2011-2030	Alternative Energy Development Plan 2012-2021	National transport Master Plan 2011-2020	National Industrial Development Master Plan 2010-2014	Draft Strategic Plan on Climate Change in the Agricultural Sector

Specific Plan

Development of the baseline scenario

In order to develop a baseline scenario for Nationally Appropriate Mitigation Actions (NAMAs), and be able to compare it with IPCC's climate change scenario, Thailand commissioned a study on mitigation modelling in 2008, to formulate a long-term baseline emission scenario from 2008 to 2050. Due to time constraints and institutional capacity, it was agreed upon to use an available existing model, rather than develop a new in-house model. The advantages and disadvantages of top-down and bottom-up approaches were investigated, in order to select the appropriate model for Thailand (e.g. MARKAL, ENPEP, LEAP, RETScreen, etc.). The business-as-usual emission level for all sectors was developed using the bottom-up Long-range Energy Alternatives Planning System (LEAP), because of its flexible data structure, past experience, transparency and accessibility. To set up the baseline, a base year and sector-level parameters were selected. The year 2008 was selected as the base year due to information availability. The major drivers, including GDP and population growth, were used to estimate future emissions. The baseline emission level was projected, mainly using GDP and population growth at 4.1% and 0.6% per year, respectively, from a study by the Office of National Economic and Social Development Board. Based on a discussion among local experts during the stakeholder consultation meeting, it was agreed that the baseline scenario would be developed without inclusion of climate policies, due to the high uncertainty in the implementation of those policies. For the electricity sector, Thailand's fuel mix for electricity generation in the year 2008 was maintained through to 2050.

In conclusion, developing the baseline emission level depends on the model used, input parameters and assumptions, base or reference year, and inclusion of existing policies and measures, which all have impacts on the projection. It is essential to address these issues by using the same methodology. International guidelines and standards may be required, to assist countries in setting baseline emission levels.

Improving emissions inventory

Under the Ministry of Natural Resources and Environment, ONEP and TGO share most of the responsibilities related to climate change. TGO is directly in charge of the GHG inventory system, through broad cooperation of various government agencies, private sector, research and academic institutes on system maintenance, data management, reporting, and assessment.

For the existing national greenhouse gas inventory system, King Mongkut's University of Technology Thonburi (KMUTT) was commissioned by ONEP to prepare the Second National GHG Inventory, submitted to the UNFCCC in 2011. The relevant information was coordinated, managed, translated, estimated, and complied

as activity data of the inventory by KMUTT, with TGO support.

In the past, the GHG information was collected from government agencies and the private sector, through a top-down approach that had those government agencies and businesses reporting to TGO – the agency in charge of the GHG inventory system. Currently, the related agencies still do not have a mandatory requirement to report GHG information for supporting the national inventory; there are no dedicated human resources responsible for GHG related tasks.

The activity data has been supported by relevant agencies, as shown in Table 1.

Table 1: Activity data supported by relevant agencies

Sector	Activity Data	Major Data Source

Energy	Thailand Energy Report
	  Electricity
	  Oil & Gas
	  Others
		Department of Alternative Energy Development and Efficiency

IPPU	Industrial Production Statistics Report	Office of Industrial Economics
AFOLU	Thailand Agriculture Report	Department of Livestock Development
	Land-use Statistics Report	Office of Agricultural Economics
	Forest Area and Forest Restoration Report	Department of Land Development
		Royal Forest Department
		Department of National Parks, Wildlife and Plant Conservation
Waste	Municipal Waste Survey Report	Pollution Control Department
	Industrial Wastewater Statistics	Department of Industrial Work
	Waste Statistics Report from Local Government	Local Government

The methodologies used for calculating emissions in National Greenhouse Gas Inventory in the Second National Communication of Thailand, were the Revised 1996 IPCC Guidelines for National Inventories, 2000 IPCC Good Practice Guidelines, and 2003 Good Practice Guidelines for LULUCF. The emission factors used in the calculation were mainly from IPCC guidelines, with the exception of some local emission factors such as the net calorific value of fossil fuels. The quality control of activity data was performed by the data source agencies, before they published their official statistics report. Meanwhile, the quality controls of emission calculation procedures for each sector were reviewed by expert groups comprised of government officials and university lecturers, in a process managed by ONEP. At the end of the national inventory preparation process, the emission calculation report was reviewed by the project steering committee, as part of the quality assurance process, prior to submitting the report to the National Climate Change Committee.

The main barrier to the success and effectiveness of the national greenhouse gas inventory is the information management system, since the relevant information comes from different sources, various organizations, and many standards. Furthermore, the information is collected in different formats, from various sources that are not directly providing to the national greenhouse gas

inventory system. In order to improve the national inventory, data standardization system, national database, and information collecting guidelines and protocols are critical elements that must be present to ensure updated and applicable GHG information, resulting in a more efficient and high quality greenhouse gas inventory system. These requirements, however, need a large amount of financial support and manpower for developing and continuing system operations, which are the key challenges of the national inventory system.

In the future, the collection procedure for GHG information will be modified to become more integrated, by cross-checking the relevant information between local reports (bottom-up approach) and central sources (top-down approach). This will help to make the information more consistent, while upgrading the level of methodology to a higher tier. The local emission factors should be developed in conjunction with relevant ministries, for more accurate emission results.

In terms of capacity building of national greenhouse gas inventory systems, although several training workshops regarding GHG emission calculations have been organized for both governmental agencies and private sectors, there is a continued need for more capacity building programs for all stakeholders.

Vietnam

Authors: Tran Thuc, Huynh Thi Lan Huong and Dao Minh Trang, Institute of Meteorology, Hydrology and Environment

Institutional arrangements for national greenhouse gas inventory

Vietnam signed the UNFCCC in 1992, and ratified it on 16 November 1994. The Ministry of Natural Resources and Environment (MONRE) was designated as the national focal point, to coordinate the national greenhouse gas inventory with other relevant ministries and sectors. Vietnam has yet to put in place a national greenhouse gas inventory department, which would be responsible for periodically implementing the national GHG inventory – much like the Greenhouse Gas Inventory Office in Japan. The National Communication to the UNFCCC, including the national greenhouse gas inventory, is implemented intermittently with international support. As Vietnam has yet to establish an office that takes responsibility for its GHG inventory and related database, the specific departments under MONRE that conduct the national greenhouse gas inventory vary by year.

In order to fulfil the commitments described in articles 12.1 and 12.5 of the UNFCCC, and following the "Preparation of the Initial National Communication" guidelines for Non-Annex I Parties, approved at COP2, the Government of Vietnam assigned the Hydro-Meteorological Service – now MONRE – as the national

authority to implement the project "Vietnam: Preparation of the Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) - GF/2200-97-54". This was done with financial and technical support from the Global Environment Facility and the United Nations Environment Programme (UNEP).

The Second National Communication to the UNFCCC, which included the national greenhouse gas inventory and emissions projections for the year 2000, was implemented by the Department of Meteorology, Hydrology and Climate Change (DHMCC), in consultation with other national consultants.

Currently, with the technical and financial assistance of the Japan International Cooperation Agency (JICA), Vietnam is implementing a "Capacity Building for National Greenhouse Gas Inventory in Vietnam" project. Outputs of this include an enhanced institutional arrangement for inventories, and the national greenhouse gas inventory by sector for energy, LULUCF, industrial process, agriculture and waste, in 2005 and 2010. In this project, the DHMCC will act as the coordinator, in cooperation with: the Institute of Meteorology, Hydrology and Environment (IMHEN), the Vietnam Environmental Agency (VEA) and

the Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE). IMHEN is in charge of the inventory of energy, LULUCF and industrial processes, while VEA is responsible for the agriculture and waste sectors. ISPONRE is responsible for designing an institutional arrangement for periodic national greenhouse gas inventory, in the future.

The Third National Communication of Vietnam to the UNFCCC (TNC) is also being prepared by MONRE, with financial support from UNEP. MONRE expects that the TNC will be available to submit to the UNFCCC by 2014 or 2015.

Vietnam national baseline setting

Vietnam's GHG inventories for the years 1994 and 2000 were carried out in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and IPCC Good Practice Guidelines for the energy, industrial processes, agriculture, LULUCF and waste sectors – covering the main greenhouse gases. Activity data for the inventory was compiled from the National Statistical Yearbooks, ministries, agencies, and published research results from institutes, research centres, companies and

private businesses. The majority of the emission factors used were default values taken from the Revised 1996 IPCC Guidelines. In addition, certain country-specific emission factors were also developed and used for the inventory, such as the CH_4 emission factor for rice paddies, which is an important source of emissions in Thailand.

The Initial and Second National Communications of Vietnam to the UNFCCC apply different methodologies for GHG emission projections for energy and agriculture, but the same methods as the TNC for LULUCF.

Vietnam second National Communication

Based on the results of Vietnam's 2000 greenhouse gas inventory, the primary sources and sinks for the country include energy, agriculture and LULUCF; the GHG emission projections for 2010, 2020 and 2030 were implemented for these three sectors.

Energy

Methodology

The Long-range Energy Alternatives Planning system (LEAP) model was used to forecast energy demand

for development and evaluation of both baseline and mitigation scenarios. LEAP is a modelling tool used to systematically analyse energy-environment interdependence, from primary energy development (i.e. extraction, production, transformation, distribution) to end-use energy consumption, based on the assumed inputs. LEAP's main strengths reside in its flexibility, ease of use, and capacity to project GHG emissions from energy, and choose appropriate policies. Therefore, the model was picked for the development and evaluation of energy emission mitigation options. Model choice also depended on the preferences of donors who support financial and technical assistance.

Baseline scenario

Economic growth is assumed to lead to increased energy consumption. According to the predictions of the Ministry of Planning and Investment, baseline scenario GDP growth rates are projected at 7.6%, 7.2% and 7.0% per year for 2005-2010, 2010-2020 and 2020-2030, respectively. GDP growth projections in the baseline scenario serve to adjust forecasts of Vietnam's energy demand. Vietnam's population is projected to reach 104 million by 2030, with 45.2 million living in urban areas (National Committee for Population and Family Planning, 2005).

Baseline GHG emission projections for Vietnam's energy sector are shown in Table 1.

Table 1: Greenhouse gas emission estimates by source

Source	2010	2020	2030	Growth rate for 2010 – 2030 (%)
1. Energy industries	31,841	110,946	238,039	10.58
2. Energy use	81,280	140,062	232,748	5.40
Industry	31,340	52,992	76,544	4.57
Transportation	28,236	48,601	86,037	5.73
Agriculture	2,066	2,444	2,901	1.71
Residential sector	13,994	25,313	49,373	6.32
Commercial/Institutional sector	5,644	10,712	17,893	5.94
Total (1+2)	113,121	251,008	470,787	7.39

Unit: thousand tons of CO_2e. Source: Output of LEAP model

Agriculture

Methodology

The 2000 national greenhouse gas inventory reveals that the largest sources of agricultural emissions come from rice cultivation, agricultural soils and animal husbandry – predominantly through the emission of methane. The methods used to identify greenhouse gas mitigation opportunities in the agricultural sector are in line with related IPCC guidelines. Greenhouse gas mitigation options for this sector are built on the business-as-usual scenario, driven by Vietnam's agricultural development policy linking mitigation objectives with national agricultural development targets – to avoid any adverse impact on agricultural productivity targets and product quality.

Baseline scenario

The baseline scenario for agriculture is based on the sector's developmental orientation for the early decades of the 21st century, which aims to build the foundation for diversified and sustainable agricultural commodities, applying scientific knowledge, techniques and new technologies. Table 2 summarizes some of the sector's set targets for the coming years.

Table 2: Agricultural targets set by the government

Target	2010	2020	2030
Agricultural soils (%)	26.6	26.6	26.6
Wet-seeded rice area (million ha)	7.1	6.8	6.6
Maize area (million ha)	1.2	1.5	1.6
Dairy cattle (thousand head)	200.0	490.0	735.0
Buffalo and beef cattle (million head)	9.5	12.9	16.4
Contribution to GDP (%)	17.0	13.0	

Source: Decision 150/2005/QD-TTg dated 20 June 2005 by Prime Minister-Government, and Statistical Yearbook 2002

The baseline scenario originates from the development strategy for agriculture and rural development sectors, leading to 2020, in consultation with sector experts and policy makers.

Potential GHG mitigation options were identified as: water management of rice fields, improvement of food for animals, and utilization of biogas. These have the highest potential for CH_4 mitigation options, and are suitable for sustainable development in rural areas, promoting production, and bringing economic and environmental benefits to farmers.

LULUCF

Methodology

The Comprehensive Mitigation Analysis Process (COMAP) model was used in the development and evaluation of LULUCF mitigation options. COMAP supports forestry sector policy and development strategy analysis, and provides basic information on changes to carbon sinks, mitigation potential, mitigation costs and cost-efficiency. This model is appropriate to the national circumstances of Vietnam and depends on the interest of donors. Vietnam also has experience with this model, from the Initial National Communication of Vietnam to the UNFCCC.

Baseline scenario

The baseline GHG emission scenario for LULUCF was built on Vietnam's Forestry Development Strategy for 2006-2020. The strategy sets specific goals for the sustainable management of 7.78 million ha of production forests between 2001 and 2020, including 4.15 million ha of planted forests and 3.63 million ha of natural forests; quality control, planning and utilization for 5.68 million ha of protection forests and 2.16 million ha of special forests; reforestation of 0.8 million ha in depleted woodlands; and afforestation of 2.5 million ha of land. In this regard, the baseline includes current mitigation policies.

Challenges to Vietnam national baseline setting

Data challenges

Data categories required by the IPCC Guideline differ from the ones in the National Statistics Yearbooks. The solution might be that the data disaggregation of the National Statistics Yearbooks be implemented consistently with the data classification of the IPCC Guidelines. Related information and activities data for GHG inventory are inadequate, and built-in uncertainties and data management lack coherence. Furthermore, the data collection process is slow; data verification and validation are not undertaken on a continuous basis. Research, assessment and verification for certain country-specific emission factors remain incomplete, and a database supporting the inventory is not yet available.

The appendix to this chapter lists specific data challenges in more detail.

Institutional, technical, and financial challenges

Vietnam has yet to establish or design a focal agency responsible for the national inventory's data collection, analysis, verification and update. In order to improve the GHG inventory, Vietnam must establish a national agency that regularly conducts GHG inventories, and issue a legal document that requires all relevant ministries to submit data to that agency.

There is an inadequate pool of greenhouse gas inventory technical experts in the ministries and agencies. The technical capacity to apply models, such as MARKAL, LEAP, EFOM-ENV, STAIR, DSSAT, and COMAP, for the development and assessment of mitigation options and projects remains limited. Therefore, capacity building to establish a professional greenhouse gas inventory team, with technical and financial assistance from developing countries, is critical.

The implementation of a national greenhouse gas inventory in Vietnam only occurs with international financial support; it is not embedded in the state budget of the country. Furthermore, some data needs to be purchased from relevant ministries – a challenge which can be solved if the ministries were legally required to submit data to the national greenhouse gas inventory team.

Appendix

Vietnam Initial National Communication

Energy demand projections

Methodology

The MEDEE-S model was used to project energy demand. This model was appropriate for the national conditions in Vietnam, and was suggested by donors. The structure for energy demand assessment in MEDEE-S is based on the division of energy consumption into synchronous modules. Vietnam's energy consumption is divided into five sectors: industry, agriculture, transport, household, and commercial and services. The years 1996 to 2020 were divided into three periods based on the scenario of medium economic growth, developed by the Institute of Strategy and Development, Ministry of Planning and Investment (Table A1).

The GDP and population growth were projected by the staff of the Ministry of Planning and Investment, with assistance from Japanese experts. Projections were based on the current status of national and international economic developments, and possible future trends. Population forecasts were based on the government's population control plan.

Projections were implemented for three scenarios: low, high and medium. The medium scenario is reported in Vietnam's communications.

Table A1: Projections of GDP growth, by sectors, during the period 1996 – 2020

(*Unit: %*)	1996 - 2000	2001 - 2010	2011 - 2020
GDP	8.0	7.8	6.5
Sectors:			
Industry and Construction	12.5	10.0	8.0
Agriculture	4.2	4.2	3.0
Services	7.6	7.3	7.1

Source: Institute of Strategy and Development, Ministry of Planning and Investment, 1999

Results

MEDEE-S outputs reveal that demand for commercial energy increased during the period 1994-2000 from 6,641.50 ktoe to 12,420.40 ktoe. It further increased to 19,626.30 ktoe in 2005, 29,496.00 ktoe in 2010 and up to 53,001.20 ktoe in 2020. The 1994-2005 annual growth rate was fairly high at 9.45%, but would fall to 8.49% during the period 2005-2010, and 6.04% during the period 2010-2020.

Commercial energy, including electricity, coal, oil and gas, is managed energy and has a market price.

Table A2: Commercial energy outputs

	1990	1995	1996	1997	1998	1999	2000
Production electricity (million Kwh)	8,790	14,665	16,962	19,253	21,694	23,806	26,722
Commercial electricity		11,185	13,374	15,303	17,739	19,592	22,241
Coal (million tons)	4,600	8,350	9,823	11,388	11,672	9,629	10,857
Oil (million tons)	2.7	7.6	8.8	10.1	12.5	15.2	16.3
Gas (million m3)		250	285	600	900	1,100	1,500

The Energy Flow Optimization Model (EFOM-EVN) was used to estimate the effectiveness of the whole energy system, for application of energy saving measures to mitigate GHG emissions, from 2000 to 2020. Mitigation options were developed on the basis of surveys in recent years, or assumptions under certain conditions.

Agriculture

The business-as-usual scenario for the agricultural sector follows the agricultural development in Vietnam from the end of the 20th century to the beginning of the 21st century. In the agricultural sector, the potential GHG mitigation options identified were water management of rice fields, improvement of food for animals, and utilization of biogas. These have the highest potential for CH_4 mitigation options, and are suitable for sustainable development in rural areas, promoting production, and bringing economic and environmental benefits to farmers.

Forestry and Land-Use Change

In the business-as-usual scenario, 5 million hectares of forest will be planted by 2010, and Vietnam's total forest area will increase to 14.2 million hectares, with 43% forest coverage. In addition, the existing natural forest area would be actively protected from unsustainable and unregulated forest exploitation, and other land-use changes.

The program for planting 5 million hectares of forest, and protecting the existing natural forest, guarantees that there would be more appropriate investment for these activities to preserve and enhance carbon sinks in the forestry sector. The COMAP model was used in development and evaluation of forestry GHG mitigation options. The model is appropriate for the national circumstances of Vietnam, and was suggested by donors.

The COMAP model was also used in the development and evaluation of LULUCF mitigation options. COMAP supports forestry sector policy and development strategy analysis, and provides basic information on changes to carbon sinks, mitigation potential, mitigation costs and cost-efficiency.

Data Challenges

Energy [60]

- Activity data:

  > Lack of detailed activity sectors, and kinds of fuel used according to the categories of IPCC

  > The uncertainty of the total amount of coal, oil, gas projection and export – import from the national statistical data is about ±2%

  > Division of data by sectors is not exact:

    > Energy Industry, machinery manufacturing, construction: U = ±5-7%

    > Agriculture, Services: U = ±10%

    > Transportation: U = ±15-20%

- Uncertainties of emission factors of fuels:

  > Using default emission factors of IPCC: U = ±2%

  > Fugitive emission factors from oil and gas exploitation are default factors of IPCC: U = ±15-20%

  > CH_4 fugitive emission factors from coal mining: U = ±10-15%;

  > Some IPCC emission factor defaults for energy technologies may not be suitable when applied to Vietnam's current circumstances

- Difficulties in taking into account the technology development for long projection periods.

Agriculture

- There is difficulty in collecting:

  > Detailed data on animal population: categories, weight, milk production, feed intake

  > Data on rate of processing, storage of animal waste in different regions

  > Data on agricultural residues used in burning biomass for fuels, making mushrooms

- Emission factor of agricultural soil in local conditions with different canopy, farming system, fertilizer application

- Need for detailed activities data and emission factors of rice paddies

- Difficult to take technology development into account for long-term sector projections.

LULUCF

- There is a lack of documentation on exact biomass assessment because forest resources are abundant and diverse.
- Need for policy to encourage people in sustainable, long-term forest protection.
- Data collected from official statistics often incorrect, and not as detailed as IPCC categories.
- Lack of national and international cooperation and experience-sharing.
- IPCC default values and coefficients in grassland conversion sector may not be appropriate for Vietnam.

Projections

- PA1 (Medium scenario) Economic projection 2001-2020 (used for the Initial National Communication)

Table A3: Commercial energy outputs

	2000	2005	2010	2015	2020
Population (million people)	77.686	82.664	87.311	91.538	95.495
GDP (billion VND, price in 2000)	444,139	636,680	918553	1330000	1859205
Agriculture	107913	131293	157827	187449	219955
Industry	162595	261861	402905	592000	830311
Services	173631	243526	357820	550551	808940
Currency exchange (VND/USD)	14280	18225	22174	25706	28381
GDP (million USD)	31102	46733	72453	115599	182068
GDP per capita	400	565	830	1263	1907
GDP growth rate (%)		7.47	7.61	7.68	6.93
Agriculture		4	3.75	3.5	3.25
Industry		10	9	8	7
Services		7	8	9	8
GDP inflation (%)		5.99	5.51	5.02	4.46

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60. The methodology provided in IPCC Guidelines for National Greenhouse Gas Inventories was used to calculate uncertainty levels in the national greenhouse gas inventory. Tier 1 approach was chosen, in consultation with experts.

	2000	2005	2010	2015	2020
Agriculture		4	3.75	3.5	3.25
Industry		6	5	4	3
Services		7	6.5	6	5.5
GDP (billion, price)	444139	851725	1606565	2971547	5167290
Agriculture	107913	159738	230828	325605	448324
Industry	162595	350429	688143	1230168	2000182
Services	173631	341558	687594	1415773	2718784
GDP structure (%)	100	100	100	100	100
Agriculture	24.3	18.75	14.37	10.96	8.68
Industry	36.61	41.14	42.83	41.4	38.71
Services	39.09	40.1	42.8	47.64	52.62
ICOR		4	4.5	4.25	4
The total investment (billion VND, price in 2000)		770164	1268427	1748651	2116822
Currency exchange (VND/USD, 2000)	14.28	14.28	14.28	14.28	14.28
Total investment (million USD, 2000)	40,000	53,933	88,825	122,455	148,237
I/GDP (%)		30	34	33	28
Investment increase compared to the past 5 years		1.35	1.65	1.38	1.21

Economic forecasts

Scenario: Medium Growth

GDP AND VALUE ADDED (Whole Country)

Order	Sectors	1995	2000	2005	2010	2020
	GDP	195567	272389	385624	545916	1024708
	By group					
1	Industry & Construction	58550	97673	150282	222935	459513
2	Agriculture	51319	61391	71863	83278	112931
3	Services	85698	113325	163479	239703	452264

Currency Unit: Bill. Vietnamese dong

ECONOMIC STRUCTURE (Whole Country)

Order	Sectors	1995	2000	2005	2010	2020
	GDP	100.0%	100.0%	100.0%	100.0%	100.0%
	By group					
1	Industry & Construction	29.9%	35.9%	39%	40.8%	44.8%
2	Agriculture	26.2%	22.5%	18.6%	15.3%	11.0%
3	Services	43.8%	41.6%	42.4%	43.9%	44.1%

ECONOMIC GROWTH RATE (Whole Country)

Order	Sectors	1996-2000	2001-2005	2006-2010	2011-2020	1996-2020
	Total	6.9%	7.2%	7.2%	6.5%	6.8%
	By group					
1	Industry & Construction	10.8%	9%	8.2%	7.5%	8.6%
2	Agriculture	3.6%	3.2%	3.0%	3.1%	3.2%
3	Services	5.7%	7.6%	8.0%	6.6%	6.9%

Appendix: Background information

About us

DEA: The Danish Energy Agency (the regulating authority on energy in Denmark), part of the Danish Ministry of Climate, Energy and Buildings, engages nationally and internationally in the administration of production, supply and consumption of energy - as well as the efforts to reduce emissions of greenhouse gases. Recently, the Low Carbon Transition Unit (LCTU) has been established, based at the Danish Energy Agency, to assist developing and emerging economies in a low-carbon transition as part of the Danish Fast Start Finance. Its focus is on sharing Danish know-how and experience in the field of energy efficiency and use of renewable energy, through specific bilateral energy sector programs, and by developing policy tool kits for a broader audience. Furthermore, international and global modelling tools (COMPARE, using essentially the POLES model) have been designed and used at the DEA (including the LCTU) for studies on national and sectoral baseline emissions, as well as mitigation potentials and costs, enabling, for example, key driver analysis and baseline comparison studies.

Organisation for Economic Co-operation and Development: The OECD is a unique forum where

governments work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies. The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Union takes part in the work of the OECD.

The Climate Change Expert Group (CCXG), formerly called the Annex I Expert Group, is a group of government delegates and experts from OECD and other industrialised countries. The aim of the group is to promote dialogue on, and enhance understanding of, technical issues in the international climate change negotiations. The

group normally meets twice a year. In addition, it holds seminars which bring together government representatives, the private sector and civil society, in order to share information on climate policies and issues, and develop papers in consultation with a wide range of developed and developing countries. The CCXG Secretariat is jointly run by the OECD and the International Energy Agency (IEA).

UNEP Risø Centre: The UNEP Risø Centre (URC) is a leading international research and advisory institution on energy, climate and sustainable development. Through in-depth research, policy analysis, and capacity building activities, URC assists developing countries in a transition towards more low-carbon development paths, and supports integration of climate-resilience in national development. URC is located in Denmark at the Danish Technical University (DTU) Risø Campus, and boasts a team of 45 scientists and economists from 16 countries. Building on a large network of partners worldwide, URC conducted seminal work in the early days of the Kyoto Protocol's Clean Development Mechanism, including baseline development. At present, URC is engaged in a collaborative project with centres of excellence in Mexico and South Africa, to quantify the uncertainty in these countries' baseline emission scenarios. This is a three-pronged effort that will consider: (i) model input uncertainty, (ii) model output uncertainty, and (iii) uncertainty in the structure of the models used.

The Baseline Work Stream

In June 2011, OECD and the Danish Energy Agency (DEA) invited a number of non-Annex I countries to share information on how they had set national emissions baselines. The Ministry of Environment in Vietnam hosted the first workshop in August 2011, where 5 countries (Ethiopia, Kenya, Mexico, South Africa and Vietnam)

participated along with representatives from OECD, DEA, UNEP Risø Centre and GGGI. Participants shared their views on assumptions and choices made in preparing baselines and emissions projections, with a view to identifying lessons learned, challenges and gaps, as well as aspects of good practice for baseline setting.[61] Results of this workshop were presented in the form of a Draft Discussion Document at the OECD/IEA Climate Change Expert Group (CCXG) Global Forum in September 2011.[62]

At COP17 in Durban, the group met with other interested countries (Brazil, China, Chile, India, Thailand and Indonesia) to learn about experiences from a wider group of countries. It was here that the idea of a collaborative publication showcasing current practice in baseline setting, convened by OECD, UNEP Risø Centre and DEA, was born. In March 2012, a workshop was held in Paris to discuss and agree on the content and structure of the publication on setting national baselines. The outline of the publication was complimented by questions, which were used as inspiration by the countries. The idea of a collaborative publication, and its outline was presented at a side-event at the UNFCCC meeting in Bonn, in May 2012. Baseline setting was also a central theme at the OECD CCXG Global Forums in March and September 2012, where progress and lessons learned from this work stream were shared with a wider group of both Annex and non-Annex I countries.

Preliminary findings of the publications were presented at a side-event at COP18 in Doha, in November 2012, including presentations on national baseline setting by Indonesia, China, Mexico and Chile. A draft of the final publication was circulated.
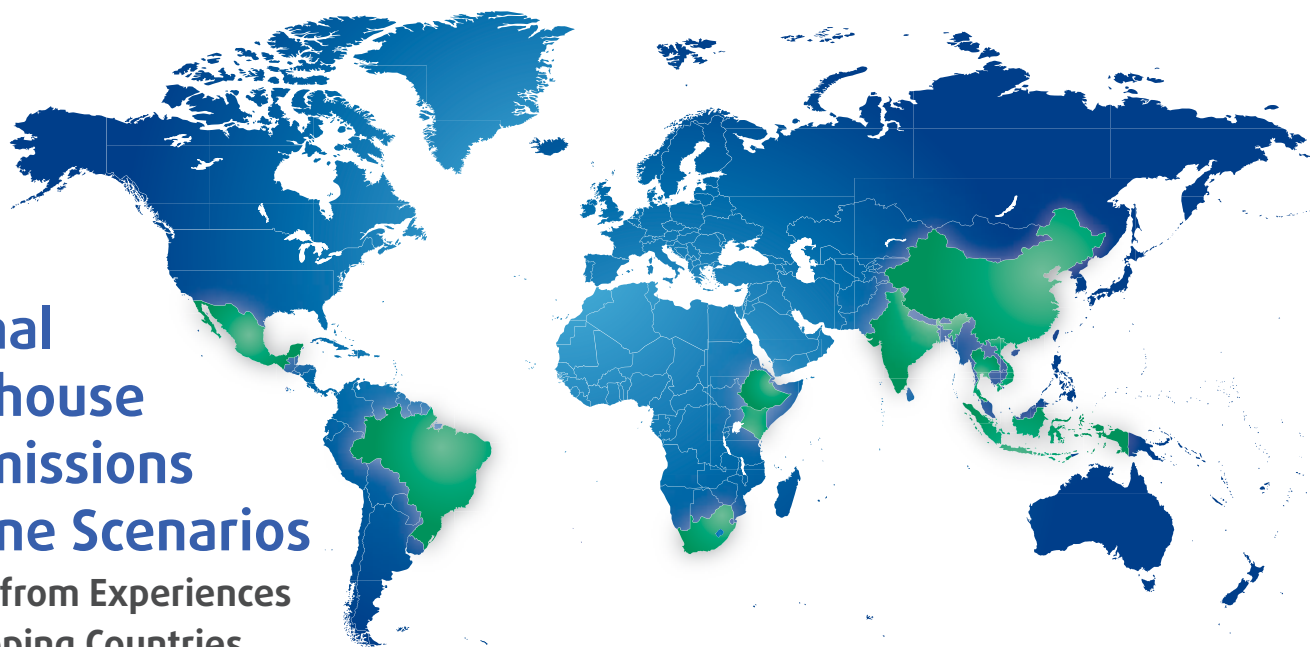
Presentations from the seminars and workshops, and related documents can be found at: http://www.ens.dk/lctu.

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61. A questionnaire was developed for this workshop.
62. The draft document can be found here: http://www.oecd.org/environment/climatechange/49639001.pdf

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