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Low Emissions Development Program

CASE STUDY

Climate Action Planning: Developing a Provincial Greenhouse Gas Inventory and Emissions Scenarios Modeling

Launched in 2015, USAID's SA-LED Program strengthens the capacity of the public sector to plan, finance, implement, and report on low emissions development projects and to accelerate the adoption of low emissions technologies.

In 2018 and 2019 the USAID South Africa Low Emissions Development (SA-LED) Program provided support to the Mpumalanga Provincial Government in South Africa on the development of the Mpumalanga Climate Change Mitigation Strategy and Implementation Plan (MCCMS). The Program supported Mpumalanga Province in responding to the National Climate Change Response Strategy's (2011) recognition of the role of subnational governments in contributing to the national efforts to reduce greenhouse gas (GHG) emissions[1]. Notably, Mpumalanga is also one of the highest emitters of GHGs among South Africa's provinces. To ensure appropriate climate action planning at a regional level, the SA-LED program supported the development of a provincial-wide GHG inventory, which provides an evidence base of GHG emissions in the province as well as a set of scenarios showing how GHGs might evolve in the future.

This case study describes what GHG inventories and emissions scenarios are and what their value is to policy and decision makers. It then presents the approaches used to develop the Mpumalanga inventory and scenarios, discusses the key data sources and challenges, and summarizes learnings for others developing sub-national inventories and future scenarios.

WHAT ARE GHG INVENTORIES AND FUTURE EMISSIONS SCENARIOS, AND HOW CAN THEY BE USED?

GHG INVENTORIES

A greenhouse gas **inventory** determines baseline emissions and identifies key emission sources in a country, province, or city over a particular time period, usually a year. Once this data has been collected, the inventory can be used to help identify priority emissions reduction activities, set goals and targets, and measure progress for reducing GHG emissions. Future inventories, if they are constructed using the same methodologies as the original inventory, can be compared to the initial

[1] Protection of the natural environment is a joint function between provincial and national government, and provinces will coordinate provincial adaptation and mitigation responses across their own line departments, as well as between municipalities within the province. Each province will develop a climate response strategy, which evaluates provincial climate risks and impacts and seeks to give effect to the National Climate Change Response Policy at provincial level (National Climate Change Response Strategy, 2011)

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inventory, to determine which emissions have grown, remained the same, or reduced, thereby providing a measure of the success of mitigation action and where further action is needed. Developing a GHG inventory requires the collection of emissions data from a range of activities.

FUTURE EMISSIONS SCENARIOS

Scenarios are often constructed which show how emissions could change over time using different assumptions, starting from **the base year**: the year with the best or most complete data. Assumptions used in constructing scenarios could include those around:

- population growth
- economic growth and changes to economic activity
- energy supply
- transport modes

Scenarios thus provide policy and decision makers with a tool for exploring how individual decisions could impact future emissions. For example, how would a transition to electric vehicles impact emissions, and what would the implications of a rapid transition be? Is it preferable to spend limited resources on solar water heater or photovoltaic (PV) programs, from an emissions perspective? Should a new coal or gas fired power station be built, which will lock in emissions for upwards of fifty years, and reduce the opportunity for adopting renewable energy? A further way in which scenarios can be used is to identify flags or signals that the world, country, or province is moving in one direction rather than another. Adjustments in policies and plans can be made to account for the direction being taken towards ultimately reducing emissions. It is important to note that a scenario provides a view of a potential future that could occur under a certain set of conditions, rather than making a prediction of what will happen.

In addition to supporting decision making, scenarios can be used to support GHG emissions monitoring. Over time, assessments can be made of how emissions are tracking relative to a desired emissions trajectory through looking at the updated inventory. The reasons for emissions not following a desired scenario can be explored, and actions can be taken to get emissions back on track.

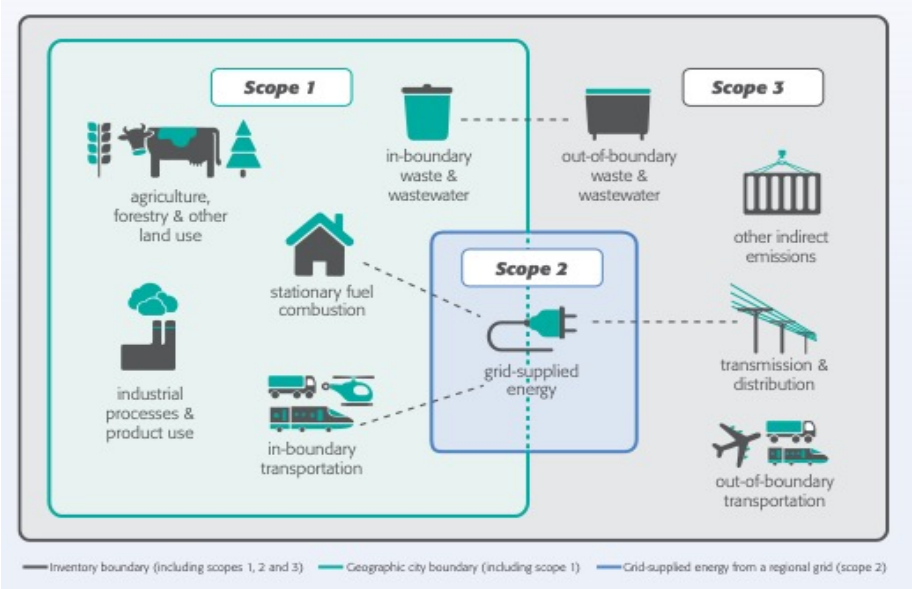
WHAT APPROACH WAS USED FOR THE DEVELOPMENT OF THE MPUMALANGA PROVINCIAL INVENTORY?

To ensure that inventories are comprehensive, consistently compiled, and comparable, it is important that they be developed using a standardized approach. A selection of approaches has been developed around the world, with perhaps the widely used being the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)[2]. While the GPC refers largely to application to "cities", it is also applicable to other geographically defined subnational area, and so was suitable for this study.

The GPC provides clear instructions on how emissions can be calculated. Typically, emissions are calculated by determining the level of an **activity** in the region—for example, the number of tons of coal or liters of fuel that is burned, waste that is disposed of in landfill, or number of livestock kept—and then multiplying that by an **emissions factor**, which is a measure of the emissions per unit of activity. The GPC makes provision for some regions having more data available than others, and where data is missing it provides suggestions for how data gaps could be filled.

2 The GPC was developed by the Greenhouse Gas Protocol at WRI, C40 and ICLEI. It is available for download at https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

The GPC requires regions to report emissions in two different ways, as shown in the Table below:



- According to **scopes**, as shown in the figure above; and
- According to the "**province-induced**" framework, which totals GHG emissions of activities that occur as a result of activities in the province.

The province-induced framework has two levels of reporting:

- BASIC, which includes: all **Scope 1** emissions from stationary energy (excluding electricity supplied to the grid), transport and waste sources, all **Scope 2** emissions from stationary energy sources and **Scope 3** emissions from the treatment of exported waste; and
- BASIC+, which includes all the BASIC sources as well as all Scope 1 emissions from Industrial Processes and Product Use (IPPU) and Agriculture, Forestry and Land Use (AFOLU) and Scope 3 emissions from stationary energy sources and transportation.

Scope framework	**Province-induced framework**
Comprehensively report all GHG emissions from: • Emissions from in-boundary sources (**Scope 1**, or "**territorial**") • Emissions from the use of grid-supplied energy (**Scope 2**) • Emissions from out-of-boundary sources as a result of activities in the province (**Scope 3**)	Report only GHG emissions that are attributable to activities in the province: • **BASIC** level reporting: Cover sources that occur in almost all provinces/ municipalities and calculation methodologies/data are more readily available • **BASIC+** level reporting: More comprehensive coverage of emissions sources.

The GPC requires emissions to be reported by **gas**, for the seven GHGs currently required for most national GHG inventory reporting under the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

To support inventory calculations, an Excel-based tool called the City Inventory Reporting and Information System (CIRIS) tool has been developed[3]. CIRIS supports the user in completing a GPC compliant inventory in a clear and simple way. Both a pdf user's manual and guidance within the tool itself are provided.

For the Mpumalanga inventory and scenarios, a combination of CIRIS and Analytica was used. Analytica is a software tool that is suited to collating and analysing information in a structured and clear way. Analytica was used in this study because it could also be used to build the emissions scenarios. Excel can also be used for the scenarios where an Analytica license is not available. Where an inventory is developed without exploring scenarios, only CIRIS is needed.

HOW WERE THE EMISSIONS SCENARIOS CONSTRUCTED?

Scenarios provide a picture of how emissions might change in the future, under different assumptions. A reference or business as usual (BAU) scenario is usually constructed, which shows what might happen without any actions to reduce emissions. Here, emissions usually grow, as a result of population and economic growth, under largely the same economic structure and technology mixes as for the base year.

Different mitigation scenarios are then constructed. These might represent different combinations of:

- Increased government and citizen action;
- Increased uptake of renewable energy technologies;
- New industrial processes being implemented to replace high emitting ones;
- Increased penetration of alternative transport options, such as electric vehicles and public transport;
- Changes to economic structure, such as a growth in the services sector; and
- Behavioural changes.

EXAMPLE QUESTIONS TO GUIDE SCENARIO DEVELOPMENT

- How do you expect this sector to grow over the next 5. 10, 15 and 20 years?
- Do you think technologies will change? If so, what new technologies will be adopted, to what extent and over what timescales?
- What will the impacts of new technologies be in terms of lock in? For example, building coal fired power stations or gas infrastructure locks in emissions from fossil fuel for many years.
- What will the impacts of new technologies be in terms of emissions/ mitigation potential in other sectors?

There are a number of ways to construct scenarios, none of which are necessarily mutually exclusive. One option is to assume past trends continue into the future, similar to what was used for the baseline scenario in this work. A second option is to analyse in detail what could happen to each source of emissions, through looking at whether the activity giving rise to the emissions may grow or shrink, what technology options may be adopted and when, and what the implications of pursuing one activity or technology might be for another mitigation option. Such approaches require detailed analysis from experts on different topics, with the analysis needing to be brought together in a coordinated fashion. A third approach is to develop different storylines or narratives about the future, and what might bring the alternative futures about, and then provide a high-level quantification of what this might imply for emissions.

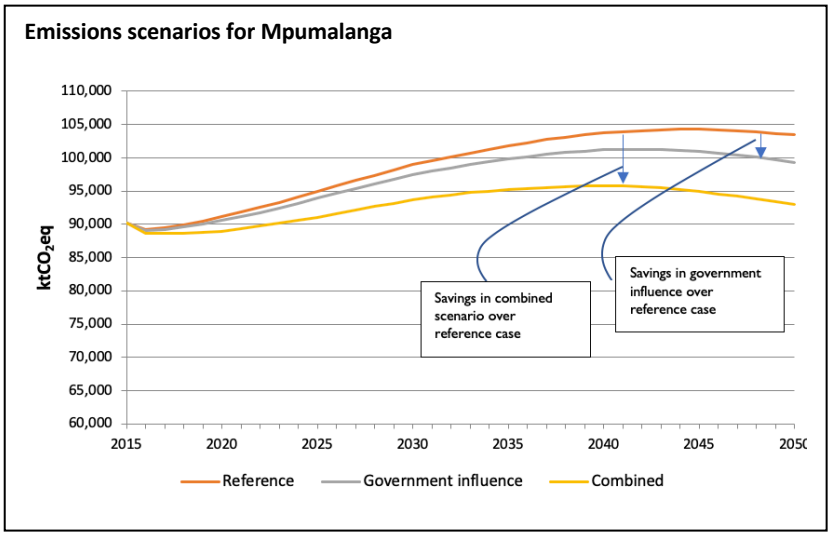
During the stakeholder engagement processes that guided the development of scenarios for the Mpumalanga Provincial government study, a key issue that stakeholders grappled with was what the Province could do directly, and what actions outside of their control would impact on the Province's emissions profile. It was thus decided that there was value during the scenario analysis in exploring

[3] CIRIS was developed by C40 cities. It is available for download from https://resourcecentre.c40.org/resources/reporting-ghg-emissions-inventories

the control that the government has over emissions reduction activities in the Province. The resulting scenarios were:

- **(Provincial) Government Influence Scenario:** includes only mitigation actions under direct control of the Provincial and Local Governments. Examples of mitigation actions here are energy efficiency and renewable energy interventions in government buildings, introducing more stringent building standards, introducing improved public transport and capture of methane from waste disposal sites.
- **Combined Scenario**: includes the mitigation actions from the first scenario, as well as mitigation actions over which the provincial government could only influence through engaging with the emitters – both in the public and private sectors - in the Province. Here mitigation actions included engaging with government on early decommissioning of coal fired powers stations that are located in the Province but supply to the national grid, promoting energy efficiency and embedded renewable energy generation in the private and residential sectors, and promoting increased biofuels uptake.

The scenario building was thus undertaken through a combination of the second and third approaches described previously: narratives were developed about what the Province could and could not have influence over, and then expert judgment was used to develop assumptions about the level to which each of the mitigation actions was taken up under these scenarios.



DATA SOURCES AND CHALLENGES

As noted, **activity data** and **emissions factors** are required to compile a GHG inventory. **Activity data** was mainly obtained from documents published by Department of Mineral Resources and Energy (DMRE)[4], Statistics South Africa (StatsSA) and Eskom, with other sources being found where needed (see Table overleaf). Where budget and resources allow, however, it is ideal to collect primary sources of data, or at least check published data with stakeholders, rather than relying on publications alone. Not all the information required for a full inventory could be found in literature, including:

- Certain **process emissions:** Emissions from industrial processes were estimated for iron and steel, ferroalloys and cement production. However, for other processes, such as ammonia and nitric acid production in the chemicals sector, publicly available data is often not disaggregated to the level required, and/or many companies do not report production data to the public.
- **Land use:** Although the data is available, it had not been released by the National Department of Environment, Forestry and Fisheries (DEFF)[5] at the time of the study.

[4] Previously the Department of Energy
[5] Previously the Department of Environmental Affairs

- **Waste:** Emissions from hazardous waste and other waste facilities, as data is not publicly available.

Examples of data sources used in compilation of the inventory

Sectors and sub-sectors	Activity data sources and gaps
Stationary energy	
Residential buildings; commercial and institutional buildings and facilities; manufacturing industries and construction; agriculture, forestry and fishing activities; non-specified sources	Department of Mineral Resources fuel sales data and energy balances, general household survey and other documents published by Statistics South Africa, Eskom and NERSA published data and personal communications
Energy industries	Published operating performance data and disaggregated electricity data provided by Eskom
Energy generation supplied to the grid	Eskom published data and Integrated Energy Plan
Fugitive emissions from coal mining, processing, storage and transportation	Publications by Department of Mineral Resources
Transportation	
On-road and aviation	Department of Mineral Resources fuel sales data
Railways	Department of Mineral Resources fuel sales data, Eskom and NERSA data
Waste: Disposal of solid waste generated in the province and wastewater generated in the province:	General household survey published by Statistics South Africa and the National Waste Information Baseline Report and State of Waste Report published by Department of Environmental Affairs, Forestry and Fisheries
Industrial processes and product use (IPPU)	Company data and annual reports and fuel sales data
Agriculture, forestry and other land use (AFOLU)	Provincial livestock numbers from 1996 to current published by Department of Agriculture, Land Reform and Rural Development. Other sources not estimated

In an attempt to fill the gaps, a data request sheet was distributed to key stakeholders. However, no responses were received[6] and hence the provincial inventory remains incomplete with respect to these categories. The emissions that are not included in the inventory are by default also excluded from the baseline and mitigation scenarios. The GPC provides a standardised set of notation keys to indicate the reasons why certain emissions are not included in the inventory.

Where possible, South African-specific **emission factors** were used, sourced from the National Greenhouse Gas Inventory and the Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry[7], published by the Department of Environmental Affairs. The remaining emission factors are taken from the United Nations' Inter-Governmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories. Methane (CH_4) and nitrous oxide (N_2O) were converted to carbon dioxide equivalents (CO_2eq) using the IPCC Third Assessment Report (TAR) global warming potentials (GWP).

The list of **mitigation measures** that were modelled under the two trajectories was sourced from the national Mitigation Potential Analysis (MPA) and National Terrestrial Carbon Sinks Assessment, with only those relevant to the province and the emissions categories in the inventory being included. Mitigation measures across the economy were considered, such as energy efficiency in various sectors,

[6] Distributing data requests typically results in low response rates. Government officials and industry representatives are often very busy, and such requests get lost in their email inboxes. Face-to-face meetings are more efficient at obtaining data. However, time and resource constraints prevented the such meetings from being possible in this project.

[7] Available for download at: https://www.environment.gov.za/sites/default/files/legislations/technicalguidelinesformrvofemissionsbyindustry_0.pdf

renewable energy generation, electric vehicles, transport modal shift and landfill gas recovery for flaring or energy recovery. Assumptions about the extent and timing of adoption were based on a

combination of MPA assumptions and knowledge of the analytical team. These assumptions are subjective, and are always the subject of debate between those with different vested interests.

For the scenarios, the main assumptions were growth in population and GDP. The future population projection was based on data from the 2016 and 2017 General Household Survey until 2017, and then the population growth rate used in the 2018 IRP was used. The moderate GDP growth rate from the 2018 IRP was used as an indicator of how the sectors could grow, to align with how emissions are projected in the national Mitigation Potential Analysis and Pathways emissions models.

LESSONS FOR THE PREPARATION OF SUB-NATIONAL INVENTORIES AND SCENARIOS

A number of lessons can be identified from the Mpumalanga study that may be of use to those starting similar processes in the future:

- An inventory is often compiled by individuals that have limited knowledge of the local context and data availability. Effective stakeholder engagement provides the opportunity for those with deep local knowledge to help guide the inventory development. In Mpumalanga, large stakeholder workshops consultations were held, with upwards of 60 people, many of whose roles and responsibilities were not directly relevant to the project. Although these were useful, more targeted engagement, with smaller focus groups would have been even more effective in guiding inventory development and data collection.

- The value of building an inventory and future emission scenarios should be communicated to stakeholders early in the project. Not only will this help to secure their buy-in, but can help to focus further discussions. In Mpumalanga, for example, much time was spent discussing the closure of Eskom's power stations. As the provincial government has no mandate to shut power stations (electricity generation planning is a national government), such actions could not be built into the "Provincial Government Influence" scenario. Communicating such considerations early on could have helped streamline discussions.

- Data is key – early stakeholder engagement and buy-in to facilitate data access helps to improve the integrity of the inventory. Ideally, telephonic or face-to-face interviews should be held with key individuals to obtain data for any missing or uncertain activities that have been prioritized due to their potential contributions to GHG emissions in the region, to supplement that found in the open literature. In this study, however, constraints required that a data request sheet be emailed to individuals without opportunity for follow up. Sufficient resources should thus be set aside in a study such as this one for supporting data collection, recognizing that in future iterations of GHG inventories the task is typically more streamlined, resulting in improvements in the quality and completeness of data.

- Similarly, given the subjectivity involved in establishing future scenarios, sufficient resources should be set aside for engagements with small groups of key stakeholders to co-develop the scenarios. In this study, the scenarios were developed by the analysts based on the discussions in the large stakeholder workshops. The result was that there was limited transfer of understanding of the intricacies of scenarios construction, as well as of the implications of the scenarios themselves and how they could be used.

- To support inventory compilation and emissions planning processes on an ongoing basis, there is value in sub-national governments developing and implementing strategies for filling data

gaps and ensuring sustainability of data collection and management. Given capacity and human resource constraints in many jurisdictions, development and implementation of such strategies may require dedicated individuals to be recruited to fulfil this role.

- The value of having buy in from senior leadership and dedicated climate change champions to provide continued support to inventory and scenario development, updating and utilization should cannot be emphasized strongly enough.