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DEPARTMENT OF ENVIRONMENT, FORESTRY AND FISHERIES

NO. 1103 19 OCTOBER 2020

environment, forestry & fisheries

Department: Environment, Forestry and Fisheries REPUBLIC OF SOUTH AFRICA

Correction Notice for the Incorrect Publication of Notice 546 of 2020 for Draft Biennial Update Report-3 for the Republic of South Africa in the National Government Gazette 43784 09-10.

On 9 October 2020, the Department of Environment, Forestry & Fisheries (DEFF) incorrectly published, the Notice by former and late Minister of the Department of Environmental Affairs, Minister Edna Molewa to publish the Draft Biennial Update Report-3 (BUR-3) of South Africa for Public Comments. It is in error that the scope of the notice refers to draft BUR-3 instead of draft Biennial Update Report-4 and that this Notice 546 of 2020 was published.

The correct notice as below, signed by Minister Barbara Creecy to publish the Draft Biennial Update Report-4 For the Republic of South Africa for Public Comments should be the one considered. The Draft Biennial Update Report-4 of South Africa can be accessed through the following link on the DEFF website.

https://www.environment.gov.za/sites/default/files/reports/biennialupdatereport04tounfccc_zeroorderdraft.pdf

The Department of Environment, Forestry and Fisheries would like to sincerely apologise for this error and inconvenience to the public as well as to the family of the late Minister Molewa.

DRAFT BIENNIAL UPDATE REPORT-4 FOR THE REPUBLIC OF SOUTH AFRICA

I, Barbara Creecy, Minister of Fisheries, Forestry and the Environment hereby publish the draft Fourth Biennial Update Report (BUR-4) to the United Nations Framework Convention on Climate Change (UNFCCC) for public comments. Members of the public may download the draft BUR-4 from the Department of Environment, Forestry and Fisheries' website at **www.environment.gov.za**.

Members of the public are invited to submit to the Minister, within 30 days of publication of this notice in the *Gazette*, written representations on or objections to the draft Biennial Update Report-4 to the following addresses:

By post to: The Acting Director-General: Department of Environment, Forestry and Fisheries
Attention: Ms Sandra Motshwanedi
Department of Environmental Affairs
Private Bag X447
Pretoria
0001

By email to: SMotshwanedi@environment.gov.za or MSteleki@environment.gov.za; or

Hand delivered to the Department of Environment, Forestry and Fisheries, Environment House, 473 Steve Biko Road, Arcadia, Pretoria.

Any inquiries in connection with the draft BUR-4 can be directed to Ms Sandra Motshwanedi at Tel: 012 399 9155 or smotshwanedi@environment.gov.za.

Kindly note that comments received after the closing date may not be considered.

BARBARA CREECY
MINISTER OF FORESTRY, FISHERIES AND THE ENVIRONMENT

SOUTH AFRICA'S 4th BIENNIAL UPDATE REPORT TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

DEPARTMENT OF ENVIRONMENT, FORESTRY AND FISHERIES

MARCH 2020

PREFACE

[To be completed once chapters are finalised.]

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The DEFF and Gondwana Environmental Solutions worked with several stakeholders in developing the 4th Biennial Update Report of South Africa. In this regard, the DEFF as the coordinating entity would like to thank all the stakeholders who worked with the DEFF and Gondwana Environmental Solutions teams to ensure that the country can report transparently on:

• the 2000-2017 emissions inventory,

• progress on mitigation policies, measures and actions for the same period, including quantification of emission reductions to the extent possible, and

• financial, capacity and technological support received including support for reporting needs.

In this regard, the government of South Africa would like to thank and acknowledge the following stakeholders for their assistance with data provision and development of the 4th BUR:

South African Government:

Department of Mineral Resources and Energy (DMRE), Department of Agriculture, Land Reform and Rural Development (DALRRD)

State Owned Entities:

South African National Energy Development Institute, Industrial Development Corporation, Transnet, South African Petroleum Industry Association, ESKOM, Passenger Rail Agency of South Africa and Gautrain Management Agency.

Non-Government Organisations

Forestry South Africa (FSA), Promethium Carbon, Council for Scientific and Industrial Research (CSIR), Agricultural Research Council (ARC), United Nations Environment Programme (UNEP), Global Environment Facility (GEF), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Carbon Disclosure Project (CDP).

MINISTERIAL FOREWORD

[To be completed once chapters are finalised.]

Executive summary

ES1 NATIONAL CIRCUMSTANCES

Information on the country's population, economy, energy dynamics and climate variability impacts provide an updated account on the overview of the country's progress and challenges in addressing climate change. South Africa is located at the southern tip of Africa and is bordered by the Atlantic Ocean to the west, and the Indian Ocean to the south and east. Its neighboring countries are Namibia, Botswana, Zimbabwe, Mozambique, Swaziland and Lesotho. The country experiences both subtropical and temperate climates and the land area is dominated by shrublands and grasslands. South Africa had a population of 56.52 million in 2017, growing to 58.78 million in 2019. Unemployment grew by 2.4% between 2017 and 2019. South Africa has an emerging economy and is the world's largest exporter of gold, platinum and natural resources. Mining, finance, trade and government services are the main drivers of economic growth. Key indicators for the country are provided in Table ES 1.

Table ES 1: Key indicators for South Africa in 2017.

Key indicator	2017	Source
General		
Latitude	22° S – 35° S	
Longitude	17° E – 33° E	CGIS, 2019
Area	1 219 602 kms²	
Environment		
Mean daily temperature	20°C	
Annual average rainfall	470mm	
Social		
Population	56.52 million	StatsSA, 2017
Population growth rate	1.46%	StatsSA, 2019
Female life expectancy at birth	66.7	
Male life expectancy at birth	61.2	StatsSA, 2017
Infant mortality rate	32.8 per 1000 live births	
Unemployment rate	26.7%	StatsSA, 2018
Total number of people living with HIV	7.06 million	StatsSA, 2017
Human development index	0.704	
Economic		
GDP	349 554 Billion USD	World bank, 2019a; World Bank, 2019b
GDP per capita	6 132.48	
GNI per capita, PPP (current international $)	12240	
Energy sector		
Primary energy supply	6 658 368 TJ	DoE, 2017
Access to electricity (% of population)	84.2%	StatsSA, 2019

Energy power consumption (kWh per capita)	4365.92	World Bank, 2019b
Land and agriculture		
Total commercial agricultural area	46.4 million ha	StatsSA, 2020
Grazing land	36.5 million ha	
Arable land	7.6 million ha	
Total forest area	21.1 million ha	DEA, 2019
Forest plantation area	12 124 km^2	FSA, 2018
Cattle population	13 million	DAFF, 2019
Commercial sheep and goats	21.5 million	
Commercial swine	1481000	
Waste		
Waste generated	54.2 million tonnes	DEA, 2018a
Waste to landfill	61.7%	
Waste recovered and/or recycled	38.3%	

South Africa's CO_2 emissions per capita is amongst the highest per capita emissions in the developing world. This is due to South Africa's strong reliance on a coal-based energy production system, and heavy emissions from the transport sector. The increase in the number of floods and droughts recorded around the country currently are projecting the future narrative of climate change impacts – deepening the conditions of poverty and food insecurity for many South Africans living in rural and urban poor communities. It is in the interest of the country to invest in the transitioning to a low carbon society, which will reduce the risks and impacts of climate change, alleviate poverty and improve livelihoods and wellbeing. South Africa, as a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), remains committed in stabilizing the greenhouse gas (GHG) concentration in the atmosphere and halting the global average warming below 2°C above pre-industrial levels.

The Department of Environment, Forestry and Fisheries (DEFF) formerly known as the Department of Environmental Affairs (DEA) plays a central coordinating and policy-making role as the designated authority for environmental conservation and protection in South Africa. The work of the DEFF is underpinned by the Constitution of the Republic of South Africa (Act 108 of 1996), the National Development Plan (NDP) (NPC, 2011), National Environmental Management Act (NEMA) (Act No. 39 of 2004), National Climate Change Response Policy (NCCRP) (DEA, 2011) and other relevant legislation and policies applicable to government to address environmental management, including climate change.

The DEFF coordinates the work on the preparation of the Biennial Update Reports (BURs) under the Chief Directorate: International Climate Change Relations and Negotiations. This function has been restructured as it was previously under the Climate Change Monitoring and Evaluation Chief Directorate. The Project Steering Committee (PSC), established by the Director General of the DEFF, continues to support contributing authors in providing technical inputs and oversight on the compilation of these reports. This includes reviewing and commenting on the reports' content to ensure that they correctly reflect the national circumstances.

ES2 NATIONAL GHG EMISSIONS INVENTORY

The national greenhouse gas (GHG) inventory for South Africa is presented for the period of 2000 to 2017. The inventory covers all four sectors, namely, Energy; Industrial Process and Product Use (IPPU); Agriculture, Forestry and Other Land Use (AFOLU); and Waste. South Africa's GHG emissions (excl. FOLU) have increased by 27.9% since 2000, and emissions (including FOLU) have increased by 24.2% (Table ES 2). Between 2000 and 2017 the average annual growth was 1.5%. The Energy sector is the main contributor to this increase. South Africa's GHG emissions (excluding FOLU) increased by 1.1% since the 2015 inventory submission and if the FOLU sink is included, there was a decline of 0.5% in emissions since 2015.

Table ES 2: Summary of South Africa's GHG emissions between 2000 and 2017 by sector.

GHG source or sink sector	Emissions (Gg CO_2e)		Difference (Gg CO_2e)	Change (%)
	2000	2017		
Total (incl. FOLU)	428 653	532 173	103 520	24.15
Total (excl. FOLU)	449 181	574 696	125 516	27.94
Energy	345 309	458 610	113 301	32.81
IPPU	34 071	43 229	9 159	26.88
AFOLU (excl. FOLU)	56 243	51 608	-4 635	-8.24
AFOLU (incl. FOLU)	35 715	9 085	-26 630	-74.56
Waste	13 558	21 249	7 691	56.73

CO_2 gas is the largest contributor to South Africa's emissions, contributing 82.5% of emissions (excl. FOLU) in 2000 and 85.2% in 2017. This is followed by CH_4 and N_2O contributing 9.0% and 4.7%, respectively, in 2017. The contribution from CH_4 and N_2O declined between 2000 and 2017, while CO_2 and F-gases increased over the same period. The F-gas contribution is, however, still below 1.5%.

Energy emissions have increased over time (Figure ES 1) due to increased demand for liquid fuels in the road transportation, manufacturing, construction, civil aviation, residential and the commercial sectors, but are stabilising. There has been a slow increasing trend in emissions from the IPPU sector, except for the reduced emissions during the recession. The main drivers in the IPPU sector are the metal industries, particularly iron and steel production and ferroalloy production. Emissions from agriculture (equivalent to AFOLU excl. FOLU) are fairly stable but have declined slightly due to a slight reduction in the livestock population, particularly cattle. The land sector (FOLU) sink has increased in recent years due to increasing forest land area (particularly thickets and woodlands/open bush) and a decline in wood losses. Waste emissions have increased due to the growing population.

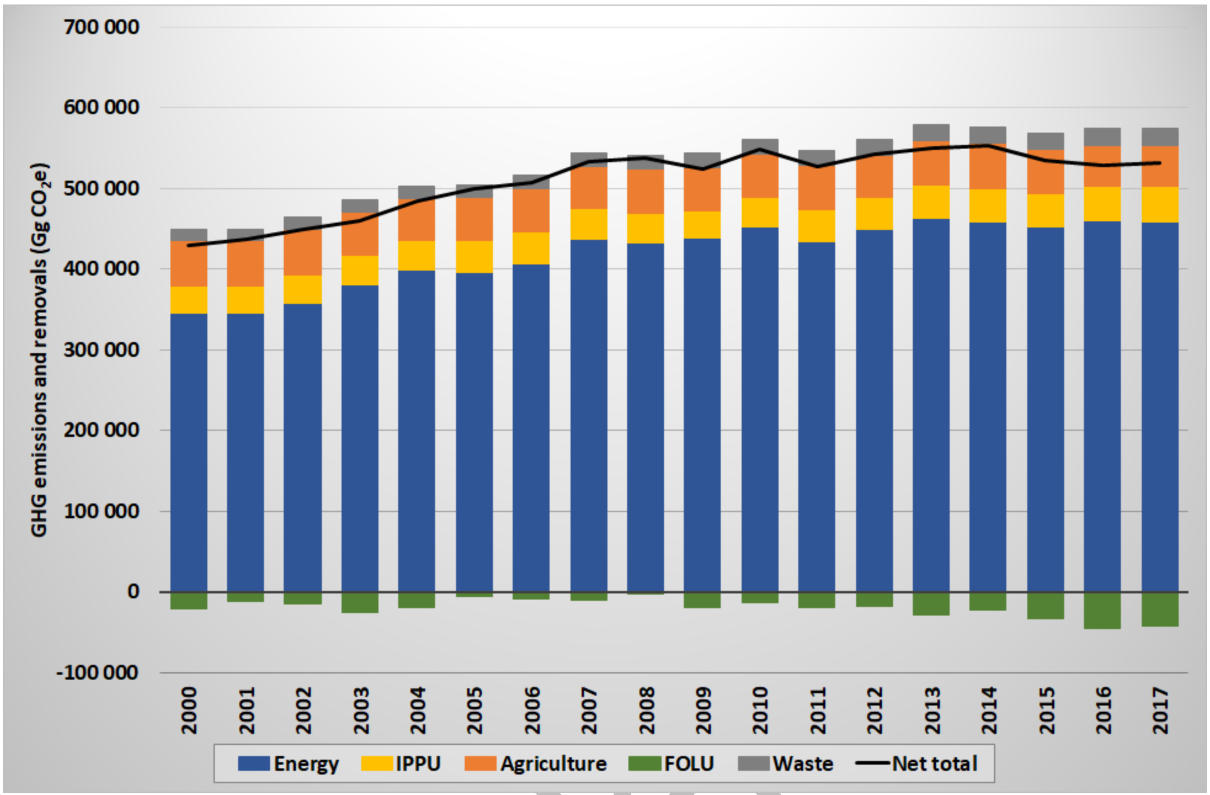

Figure ES 1: Trend in South Africa's GHG emissions between 2000 and 2017 by sector.

South Africa has conducted uncertainty analysis across all sectors, which is progress from the last BUR submission where analysis was only completed for Energy and IPPU. The IPCC good practice tier 1 (Approach 1) method was used to determine the overall aggregated uncertainty on South Africa's inventory estimate for 2017. The analysis (Annex A3) shows that the overall uncertainty on the 2017 estimate is 9.8%, while the uncertainty in the emission trend is estimated at 8.23%. If FOLU is excluded, then the overall uncertainty is reduced to 8.76% with the uncertainty on trend being 7.61%.

The main challenge in the compilation of South Africa's GHG inventory remains the availability of accurate activity data. Due to the recent introduction of the GHG Regulation, companies will be reporting data and emissions through the South African GHG Emissions Reporting System (SAGERS) system. In the next inventory, updated and improved information from this reporting will be included. South Africa has still not included SF6 emissions and emission estimates for the period 1990 to 2000, however, these are in progress and are expected to be included in the 2021 inventory.

ES3 MITIGATION ACTIONS AND THEIR EFFECTS

An introduction to the policy background for climate change and mitigation is provided. The driving policies for climate change (National Development Plan, National Climate Change Response Policy and the Climate Change Bill) are summarised and updates on the National Emissions Trajectory and Nationally Determined Contributions are provided. The Low Emissions Development Strategy, which is the policy through which the mitigation activities will be implemented, is highlighted.

South Africa's mitigation system is based on three pillars, namely the GHG inventory, Mitigation Potential Analysis and Sectoral Emission Targets. Several policies and measures, both cross-sectoral (Carbon Budgets, GHG Reporting Regulation, Carbon Tax Act together with Carbon Offset Regulation) and sectoral, are identified in order to assist South Africa in achieving its emission reduction targets. In the Energy sector, eleven measures have been identified (Table ES 3) with the main policy drivers being the Integrated Resource Plan, National Energy Efficiency Strategy and, for transport, the Green Transport Strategy. In the IPPU sector it is the Carbon Budgets and Pollution Prevention Plans for process emissions which support the identified measures. In the AFOLU sector five measures (afforestation, forest rehabilitation, thicket restoration, grassland rehabilitation and conservation agriculture) are provided and these are supported through the Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries, the Draft Conservation Agriculture Policy and the DEFF Strategic Plan. The policies in the AFOLU sector are not strictly designed for mitigation purposes but are aimed more at improving biodiversity and sustainability. The National Waste Management Strategy is the main driver for mitigation in the Waste sector. Challenges, gaps and constraints related to these mitigation measures and policies are discussed for each sector.

Table ES 3: Sectoral policies and measures.

Sector	Measures	Supporting policies and legislation
Energy	12L tax incentive programme	National Climate Change Response Policy (DEA, 2011a). Income Tax Act (Act No. 58 of 1962). 12L Regulations (National Treasury, 2013).
	Energy Efficiency Standards and Appliance Labelling project	SANS 941 for Energy Efficiency of Electrical and Electronic Equipment, (SABS, 2014). National Energy Act (Act No. 34 of 2008).
	Eskom IDM programme	White Paper on Energy Policy (DME, 1998). Post-2015 National Energy Efficiency Strategy (DoE, 2016b). Integrated Energy Plan (DoE, 2016a).
	Municipal Energy Efficiency and Demand-side Management programme	White Paper on Energy Policy (DME, 1998). Post-2015 National Energy Efficiency Strategy (DoE, 2016b). Integrated Energy Plan (DoE, 2016a).
	The National Cleaner Production Centre South Africa (NCPC) Industrial Energy Efficiency programme	National Climate Change Response Policy (DEA, 2011a). Industrial Policy Action Plan (DTI, 2018).
	Private Sector Energy Efficiency (PSEE) programme	National Climate Change Response Policy (DEA, 2011a). Industrial Policy Action Plan (DTI, 2018).
	Landfill Gas to Energy Activities	Regulations Regarding the Exclusion of a Waste Stream for a Portion of a Waste Stream from the Definition of Waste (DEA, 2018e). National Environmental Management: Waste Act (Act No. 5 of 2009).
	Renewable Energy Independent Power Producer Procurement programme	Integrated Resource Plan (DoE, 2019). Electricity Regulation Act (Act No. 4 of 2006). National Energy Act (Act No. 59 of 2008). National Climate Change Response Policy (DEA, 2011a).
	Bus Rapid Transport System	Green Transport Strategy (DoT, 2018).

		National Land Transport Act (Act No. 5 of 2009).
	Electric vehicles	Green Transport Strategy (DoT, 2018). National Land Transport Act (Act No. 5 of 2009).
	Transnet Road-to-Rail programme	Green Transport Strategy (DoT, 2018). National Land Transport Act (Act No. 5 of 2009). Transnet Long-term Planning Framework (Transnet, 2017).
IPPU	**Nitrous oxide reduction projects**	
	Carbon budgets and pollution prevention plans (only process emissions)	National Pollution Prevention Plans (PPP) Regulations (DEA, 2017c). National Climate Change Response Policy (DEA, 2011a). Draft Climate Change Bill (DEA, 2018b).
AFOLU	**Afforestation**	National Climate Change Response Policy (DEA, 2011a). National Environmental Management: Biodiversity Act (Act No. 10 of 2004). DFFE Strategic Plan 2019/20 – 2023/24 (DFFE, 2020).
	Forest rehabilitation	DFFE Strategic Plan 2019/20 – 2023/24 (DFFE, 2020). Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries (DAFF, 2015b).
	Thicket restoration	DFFE Strategic Plan 2019/20 – 2023/24 (DFFE, 2020). Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries (DAFF, 2015b).
	Grassland rehabilitation	National Climate Change Response Policy (DEA, 2011a). National Environmental Management: Biodiversity Act (Act No. 10 of 2004). Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries (DAFF, 2015b). DFFE Strategic Plan 2019/20 – 2023/24 (DFFE, 2020). Land Degradation Neutrality Targets (DEA, 2018d).
	Conservation agriculture	Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries (DAFF, 2015b). Draft Conservation Agriculture Policy (DAFF, 2018). Draft Climate Smart Agriculture Strategic Framework (DAFF, 2018a). DAFF 2015/16 to 2019/20 Strategic Plan (DAFF, 2015a). Integrated Growth and Development Plan (DAFF, 2012).
Waste	**Waste Management Flagship programme**	Regulations Regarding the Exclusion of a Waste Stream for a Portion of a Waste Stream from the Definition of Waste (DEA, 2018e). National Environmental Management: Waste Act (Act No. 59 of 2008).
	National Waste Management Strategy	National Waste Management Strategy (DEA, 2019b)

An update to the information on mitigation actions with quantified effects since the BUR3 are presented for the period 2000 to 2017. The annual greenhouse gas emission reductions were estimated at 16.8 Mt CO_2e, 18.5 Mt CO_2e and 24.3 Mt CO_2e in 2015, 2016 and 2017, respectively (Figure ES 2). The energy sector reductions account for 79.1% of the total emission reductions in 2017, while the IPPU sector contributed 10.3%. The AFOLU and Waste sectors contributed 8.2% and 2.2%, respectively. In this BUR, any action that had projects which are also included under the International Market Mechanisms were excluded from these totals and reported separately. These projects are all in the Energy sector and these projects would add an additional 49.5 Mt CO_2 in 2015 and 64.6 Mt CO_2 in 2017. A list of IMM projects, along with their emission reductions is provided. These projects, across all sectors, contribute 24.0 Mt CO_2 in 2015 and 25.7 Mt CO_2 in 2017, with the energy sector contributing 77.8% to the total in 2017

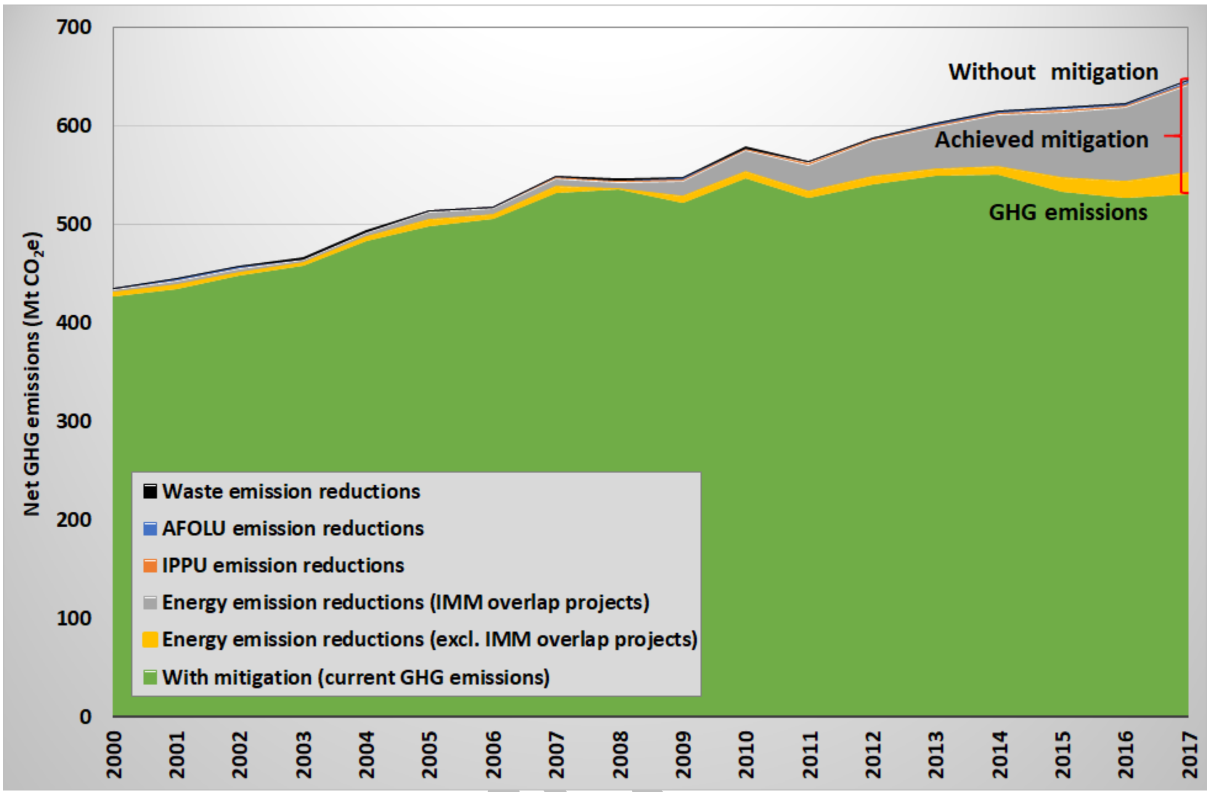

Figure ES 2: South Africa's emission reductions between 2000 and 2017.

ES4 FINANCE, TECHNOLOGY AND CAPACITY-BUILDING NEEDS AND SUPPORT RECEIVED

International and domestic climate-related finance flows, alongside non-monetised support received between January 2018 and December 2019 are reviewed to assess the financial, capacity and technical support South Africa received to transition to a lower-carbon and climate resilient economy and society. Needs for the future are also analysed.

The bilateral and multilateral support received was analysed and 88.9% of the funds are in the form of loans. In terms of bilateral funds, 48.4% (USD 2 019 million) was contributed by Germany, and the largest amount of multilateral support (USD 543 million) received during the reporting period was the Green Climate Fund administered by the Development Bank of Southern Africa (DBSA) and the South African National Biodiversity Institute (SANBI). These funds are mostly used for energy efficiency and renewable energy projects, but the Waste Management Flagship Programme is also included.

The South African government still plays a vital role in the creation of conditions for inclusive economic growth and development, and in establishing an appropriate economic framework to encourage and facilitate the country's shift to environmentally cleaner technologies and low carbon activities. The South African government has invested approximately USD 238 million to support climate action at the national level. The national government, through the DEFF and managed by the DBSA, established the Green Fund in 2012 with an initial USD 60 million. The fund's objective is to lay the groundwork for the country's transition to a low-carbon, resource efficient and climate resilient development path.

Technical and capacity building needs were identified related to both the GHG inventory and mitigation needs. Priority technologies for mitigation were identified and these are in the IPPU and Waste sectors. For IPPU the priorities are the aluminium industry (energy monitoring and management, secondary production and recycling) and the use of waste material as fuel in cement production. In the Waste sector the priorities are around by-products from food waste, waste recovery and anaerobic digestion. Priority technologies for adaptation were also identified and these include urban forestry, conservation agriculture, wetland restoration, biorefinery, early warning systems, disaster risk reduction, rainwater harvesting and desalination technologies. Barriers to both mitigation and adaptation technologies are discussed and interventions for overcoming the barriers are proposed (Table ES 4).

Table ES 4: Technology barriers and interventions to overcome the barriers.

Barriers	Interventions to remove barriers
Weak policy and regulatory frameworks	• Review existing policies, regulations and bylaws to identify specific issues in policies and regulations causing the barriers with the view for policy and regulatory reform. • Create an enabling environment for effective policy implementation. This may involve conducting SIAs (social impact assessments) and RIAs (regulatory impact assessments) for policies before they are submitted. • Policy exemption period until implementation and validation of technology (sector specific) (exemptions with conditions) e.g. carbon tax bill (specific sectors exempt because of the validation process, postponed for 5 years if implemented).
Weak co-ordination between (public) R&D and industry	• Establish mandatory coordination requirements and integrate them in regulations and laws. • Explicitly provide provisions requiring public-private coordination in such legislation as the proposed climate change bill. • Establish common technology missions and platforms for climate change bringing all stakeholders together, including private sector and civil society.
Underdeveloped markets for climate-smart technologies	• Create and provide incentives to grow markets (at varying levels), e.g. subsidies for selected technologies. • Establish public sector technology development grants.
Declining private sector investment in climate change R&D and innovation	• Strengthen private sector intellectual property development and management.
Weak public knowledge on some of the smart climate technologies	• Establish public awareness and information provision programmes on specific technologies.

Barriers	Interventions to remove barriers
Weak skills-based training, implementation and maintenance (e.g. engineering capability)	• Design and provide accreditation for middle-level programmes for technical training (specialised courses; development of and sustaining scarce skills such as engineering and technology). • Integrate technical training into all (or be a core component of) sector roadmaps and be linked to specific technology missions.
Weak technical standards for technology performance and quality management	• Institute and enforce specific technical standards in terms of hardware (within the country and for imports and exports). • Review existing technical standards.
High costs of technology procurement and implementation; high costs of R&D	• Conduct/commission a study to review economic costs of R&D and technology development in priority sectors. • Provide subsidies for R&D and technology development for mitigation and adaptation.

ES5 SUPPORT RECEIVED FOR PREPARATION OF BUR

Bilateral financial support was received from the German Government for the development of the 4th South African BUR. Funding was administered through the Gesellschaft für Internationale Zusammenarbeit (GIZ) as part of the Climate Change Support Programme to South Africa. Chapters of the BUR4 were drafted internally by DEFF personnel, and the CSIR, Promethium and Gondwana Environmental Solutions provided additional technical support.

ES6 MEASUREMENT, REPORTING AND VERIFICATION IN SOUTH AFRICA

South Africa is developing a comprehensive, integrated National Climate Change Information System (NCCIS), also referred to as the National Monitoring and Evaluation (M&E) system. This is a web-based platform for the tracking, analysis and enhancement of South Africa's progress towards the country's transition to a low-carbon economy and climate-resilient society. It showcases vital climate action to inform domestic and international reporting and includes information on GHG emission reductions achieved, observed and projected climate change, impacts and vulnerabilities, impact of adaptation and mitigation actions, financial flows and technology transfer activities. It, therefore, encompasses the MRV of the GHG inventory, mitigation actions and support. The system is composed of several modules, which include the National Climate Change Response Database, National Desired Adaptation Outcomes, Climate Information Centre, Tracking and Evaluation System and various maps and search capabilities. This platform will provide a visualisation capability for the various outputs and products of the M&E system and enhance the DEFF's capacity to communicate national information on climate change to a wide range of audiences.

Institutional arrangements for the MRV of GHG inventories and mitigation actions is discussed in this chapter. With the introduction of the National Greenhouse Gas Emission Reporting Regulations (NGERs) in 2017, the South African GHG Emissions Regulation Reporting System (SAGERS) data collection system has been put in place. This will formalize the data collection process for the energy and IPPU sectors and will also allow for the collection of inventory input data from forest plantations.

GHG data collected through SAGERS will be utilized for inventory estimates for the next inventory cycle. Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry have been developed by the DEA in consultation with industry, and the details of the verification process are provided.

In addition to the SAGERS system, the Carbon Offset Administration System has also been developed, and this allows for the approval of projects, listing of projects, transfer of ownership and retirement of credits. This system is aimed at tracking the carbon credit projects in South Africa.

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LIST OF ABBREVIATIONS

AFOLU	Agriculture, Forestry and Other Land Use
ARC	Agricultural Research Council
BRT	Bus Rapid Transit
BUR	Biennial Update Report
BUR3	Third Biennial Update Report
BUR4	Fourth Biennial Update Report
CBIT	Capacity-Building Initiative for Transparency
CCM&E	Climate Change Monitoring and Evaluation Unit
CCS	Carbon Capture and Storage
CDM	Cleaner Development Mechanism
CDP	UK based organisation - formerly the Carbon Disclosure Project
CERs	Certified emission reductions
CH_4	Methane
CHP	Combined Heat and Power combustion systems
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CPI	Consumer Price Index
CS	Country Specific emission factor
CSA	Climate Smart Agriculture
CSIR	Council for Scientific and Industrial Research
CSP	Concentrated Solar Power
CTLs	Coal-to-liquids
DAFF	Department of Agriculture, Forestry and Fisheries (Now DEFF and DALRRD)
DALRRD	Department of Agriculture, Land Reform and Rural Development
DAOs	Desired Adaptation Outcomes
DBSA	Development Bank of Southern Africa
DEA	Department of Environmental Affairs (Now DEFF)
DEFF	Department of Environment, Forestry and Fisheries
DF	IPCC Default emission factor
DMR	Department of Minerals and Resources (now DMRE)
DMRE	Department of Mineral Resources and Energy
DoE	Department of Energy (now DMRE)
DOM	Dissolved Organic Matter
DoT	Department of Transport
DPWI	Department of Public Works and Infrastructure
DST	Department of Science and Technology
DTI	Department of Trade and Industry
EF	Emission Factor
EGIP	Embedded Generation Investment Programme
FAO	The Food and Agriculture Organization of the United Nations
FASA	Fertilizer Association of South Africa
FOD	First Order Decay
FOLU	Forestry and other land use
FSA	Forestry South Africa
GCF	Green Climate Fund
GDP	Gross Domestic Product

GEF	Global Environment Facility
Gondwana	Gondwana Environmental Solutions International
Gg	Gigagram = 10^9 grams or 10^3 tonnes
GHG	Greenhouse Gas
GHGIP	National Greenhouse Gas Improvement Programme
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GS	Gold Standard
GTCs	Gas-to-chemicals
GTI	GeoTerraImage, Pty Ltd.
GTLs	Gas-to-liquids
GWh	Gigawatt hours
GWPs	Global Warming Potentials
HFCs	Hydrofluorocarbons
HWP	Harvested Wood Products
IDM	Integrated Demand Management
IDP	Integrated Development Plan
IMM	International Market-Based Mechanisms
IMCCC	Inter-Ministerial Committee on Climate Change
IPCC	International Panel on Climate Change
IPP	Independent Power Producers
IPPU	Industrial Process and Product Use
IPTN	Integrated Public Transport Network
KCA	Key Category Analysis
LEDS	Low Emissions Development Strategy
LFG	Landfill gas
LPG	Liquefied Petroleum Gas
LULUCF	Land Use, Land-Use Change, and Forestry
M&E	Monitoring and Evaluation
MCA	~~m~~Multi-criteria Analysis
MJ	MegaJoule
MODIS	Moderate Resolution Imaging Spectroradiometer
MPA	Mitigation Potential Analysis
MRV	Measurement, Reporting and Verification
MtCO2e	Megatonnes of carbon dioxide equivalents
MTN	Mobile Telephone Networks
MW	Megawatt
N	Nitrogen
N_2O	Nitrous oxide
NAEIS	National Atmospheric Emissions Inventory System
NC	National Communications
NCCAS	National Climate Change Adaptation Strategy
NCCIS	South African National Climate Change Information System
NCCRP	National Climate Change Response Policy
NCPC	The National Cleaner Production Centre
NDC	Nationally Determined Contribution
NDMC	National Disaster Management Centre
NDP	National Development Plan
NE	Not estimated
NEM:AQA	National Environmental Management: Air Quality Act
NEMA	National Environmental Management Act
NGERs	National Greenhouse Gas Emission Reporting Regulations

NGHGIS	National GHG Inventory Management System
NGOs	Non-governmental organizations
NH_3	Ammonia
NIRs	National Inventory Reports
NLTTA	National Land Transportation Transition Act (repealed)
NMVOCs	Non-methane Volatile Organic Compounds
NO	Not occurring
NOx	Oxides of Nitrogen
NPC	National Planning Commission
NRF	National Research Foundation
NTCSA	National Terrestrial Carbon Sinks Assessment
NLTA	National Land Transport Act
NWMS	National Waste Management Strategy
ODS	Ozone depleting substances
PAGE	Partnership for Action on Green Economy
PAMs	The Policies and Measures
PFCs	Perfluorocarbons
PPP	Pollution Prevention Plans
PSEE	Private Sector Energy Efficiency programme
PSC	Project Steering Committee
PSEE	Private Sector Energy Efficiency programme
PV	Solar Photovoltaics
QA	Quality Assurance
QC	Quality Control
REIPPPP	Renewable Energy Independent Power Producers Procurement Programme
SAGERS	South African Greenhouse Gas Emissions Reporting System
SAISI	South African Iron and Steel Institute
SALGA	South African Local Government Association
SAMI	South African Minerals Industry
SANAS	South African National Accreditation System
SANBI	South African National Biodiversity Institute
SANEDI	South African National Energy Development Institute
SANOCEAN	SA/Norway joint research programme on ocean research including blue economy, climate change, the environment and sustainable energy
SANS	South Africa National Standard
SAPIA	South African Petroleum Industry Association
SAR	Second Assessment Report
SARS	South African Revenue Service
SAWS	South African Weather Services
SDG	Sustainable Development Goal
SET	Sectoral Emission Target
SF_6	Sulfur hexafluoride
SME	Small to Medium Enterprise
SMME	Small, Medium and Micro Enterprises
SOC	Soil organic carbon
SPIPA	Strategic partnerships for the implementation of the Paris Agreement
StatsSA	Statistics South Africa
T&E	Tracking & Evaluation system
tCO2e	Tons of carbon dioxide equivalent
TJ	Terajoule
toe	tonne of oil equivalent

TPES	Total Primary Energy Supply
TWh	Terawatt-hour, a measure of electrical energy, 10^{12} watt-hours
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UP	University of Pretoria
USD	United States Dollar
VCS	Verified Carbon Standard
VCUs	Verified Carbon Units
VERs	Verified Emissions Reductions
VKT	Vehicle Kilometres Travelled
WWF	World Wide Fund for Nature (World Wildlife Fund)
ZAR	South African Rand

1. NATIONAL CIRCUMSTANCES

1.1. Introduction

South Africa is making substantial progress towards becoming a low carbon and climate resilient society. As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), the South African government, in partnership with climate change stakeholders and role players, continue to strengthen their efforts of achieving and stabilizing greenhouse gas (GHG) concentrations in the atmosphere, hence reducing carbon footprints and preventing harmful human activity interference in the climate system.

Climate change remains a threat to sustainable development and livelihoods, thus there is a greater need to scale up efforts to address the effects of climate change and further adhere to the UNFCCC convention. South Africa continues to transition to a low carbon and climate resilient economy. This is evident through the many projects and programmes targeted at addressing climate change, mainstreaming of climate change into development policies and the effective monitoring and reporting on GHG emissions, mitigation and adaptation actions (DEA, 2018b).

The information reported in this Biennial Update Report (BUR) on national circumstances builds on the work initiated and included in the BUR3 and the third National Communication.

1.2. Environmental context

1.2.1. Geography

South Africa, located on Africa's southern tip (22°S - 35°S; 17°E – 33°E), is bordered by the Atlantic Ocean along the west coast and by the Indian Ocean along the south and east coast. The coastline stretches for more than 2 850 km. To the north, South Africa is bordered by Botswana, Namibia, Zimbabwe and to the east, Swaziland and Mozambique. It surrounds the small Kingdom of Lesotho. South Africa covers an area of 1 219 602 km^2 (GCIS, 2019) and can be divided into the interior plateau and land between the plateau and the coast. These two areas are divided by the Great Escarpment which varies between 1 500 m and 3 482 m above sea level. The interior plateau has an average height of 1 200 m above sea level and is characterised by wide plains.

1.2.2. Land cover

Shrublands and grasslands dominate South Africa's vegetation (Table 1.1) (GTI, 2015; DEA, 2019). Indigenous forests cover only 0.4% of South Africa, while plantations cover just over 1%. Plantations have been declining in area over the last 10 years, but productivity has been increasing (FSA, 2018). Forest land and shrubland area has been increasing since 1990, while grassland area shows a decline. The country has more than 290 conservation parks. The Cape Floristic Region, which is in the south western regions of South Africa, is one of the most diverse regions on earth and is home to about 9 000 vascular plants of which 69% are endemic.

Table 1.1: Area, percentage cover and change for the various vegetation types in South Africa between 1990 and 2014 (Data source: DEFF, 2020: Modified from GTI, 2015).

	1990		2014		Change (%)
	Area (kha)	Percentage	Area (kha)	Percentage	
Indigenous forest	400	0.33	424	0.35	0.02
Thickets/dense bush	6 660	5.44	8 064	6.58	1.15
Woodlands/open bush	11 382	9.29	12 692	10.36	1.07
Plantations	1 241	1.01	1 233	1.01	-0.01
Low shrubland	40 561	33.11	41 016	33.48	0.37
Grassland	26 979	22.02	24 801	20.24	-1.78
Cultivated	13 865	11.32	13 801	11.26	-0.05
Wetlands/waterbodies	2 572	2.10	2 459	2.01	-0.09
Settlements	2 750	2.24	2 896	2.36	0.12
Mines	290	0.24	325	0.27	0.03
Bare ground/Degraded land	15 818	12.91	14 806	12.09	-0.83
Total	122 518		122 518		

1.2.3. Climate

South Africa's climate is influenced by the oceans to the east, south and west. The warm Agulhas current found to the east leads to warmer coastal temperatures than those experienced on the west coast which is influenced by the cold Benguela current. The country has both subtropical and temperate climate conditions. Cool, wet climate is found in the Drakensberg region, with warm, subtropical conditions in the north east. The south west of the country experiences Mediterranean climate conditions and there is a warm dry desert environment in the central west and north west. Average temperatures in South Africa range from 15°C to 36°C in summer and -2°C to 26°C in winter (GCIS, 2019). South Africa is a relatively dry country, with an average annual rainfall of 464 mm. The country receives summer rainfall, except in the Western Cape where most of the rain falls in winter.

South Africa continues to be subjected to extreme weather events, which is a consequence that can be attributed to observed changes in the climate system. The mean annual temperature for 2018 for South Africa was in general 0.52 °C above the 1981-2010 climatological normal. Based on the 1981-2010 climatological normal, 2018 is ranked the 4th warmest year for the 68 years from 1951 to 2018 (Figure 1.1).

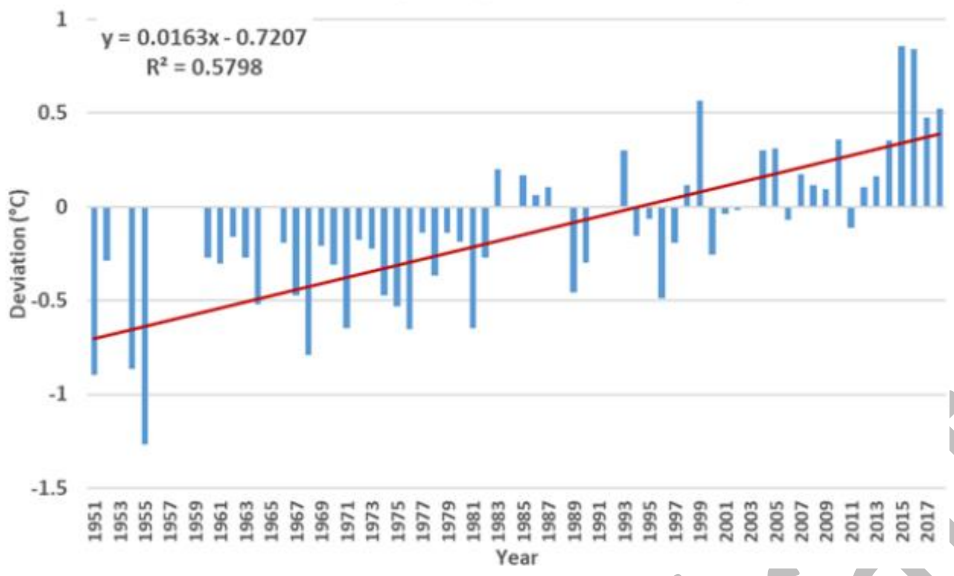

Figure 1.1: Mean temperature deviations of 26 climate stations from 1951 to 2018 (base period: 1981 – 2010) (Source: SAWS 2019).

The country is experiencing significant increases in temperature, as well as increased variability in rainfall and vulnerability to extreme weather events. Drought, fire and floods have been some of the extreme events experienced since 2017. South Africa has been exposed to prolonged, intensified drought conditions since 2013 which has devastated a number of sectors and jurisdictions in the country. The Intensity of the drought in the period 2016–2017 saw 8 provinces in the country declare drought as a disaster (NDMC, 2017). Following the consistent assessments of drought-stricken areas, particularly in the provinces of the Western Cape, Eastern Cape and Northern Cape, the minister declared drought a national disaster for South Africa (NDMC, 2018).

The prolonged and severe drought condition in the Western Cape together with the gale-force winds are considered to have set the conditions for the Knysna fires in 2017. These were the most extreme wildfire disaster recorded in the history of South Africa. During the fire blaze, natural vegetation, forest, homes and livelihoods were destroyed over a stretch of 19 000 ha and seven people died (Le Maitre et al., 2019). The insurance and forestry industry were the most impacted by the fire disaster. Together with government they suffered at least R3 billion in direct costs as result of the disaster.

1.3. Social context

1.3.1. Population

The population of South Africa increased from 40.6 million in 1996 to 51.7 million in 2011 and 55.6 million in 2016. According to the most recently released 2019 mid-year population estimates, South Africa’s population is estimated at 58.78 million (StatsSA, 2019a). The population grew by 1.43% in 2019.

1.3.1.1. Population distribution

The youth (aged 18–34) is estimated to constitute a third of the population (17.84 million) in South Africa (Figure 1.2), with 8.80 million females and 9.04 million males. An estimated 28.6% of youth (or 5.10 million) are based in Gauteng, 19.4% (or 3.47 million) in KwaZulu-Natal, 4.7% are in The Free State and the Northern Cape (2.0%) has the lowest percentage of youth. Figure 1.3 shows that a quarter of the population reside in Gauteng.

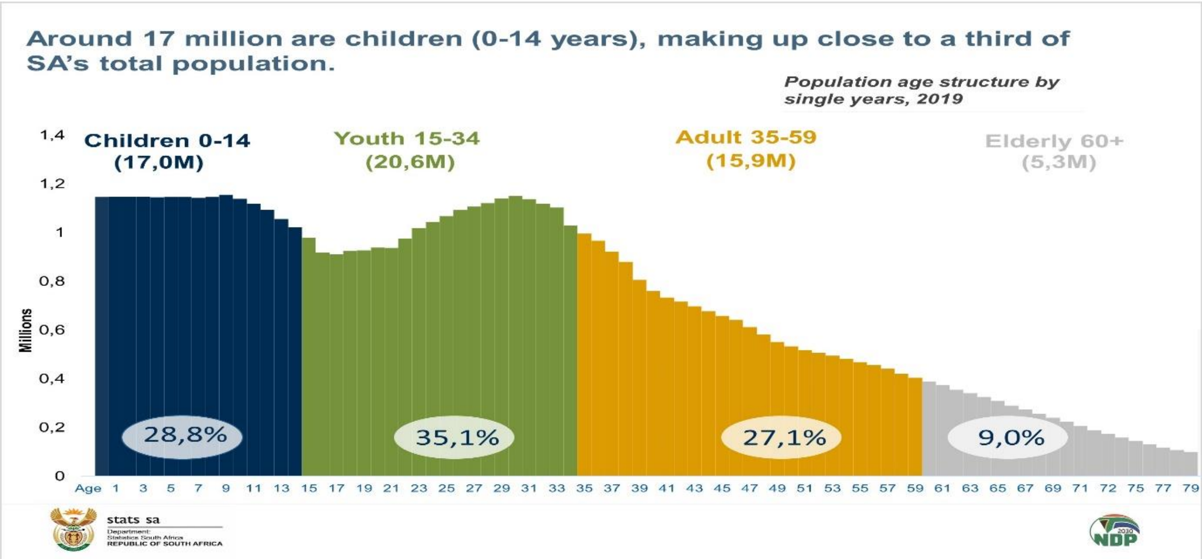

Figure 1.2: Population structure of South Africa (Source: StatsSA, 2019b).

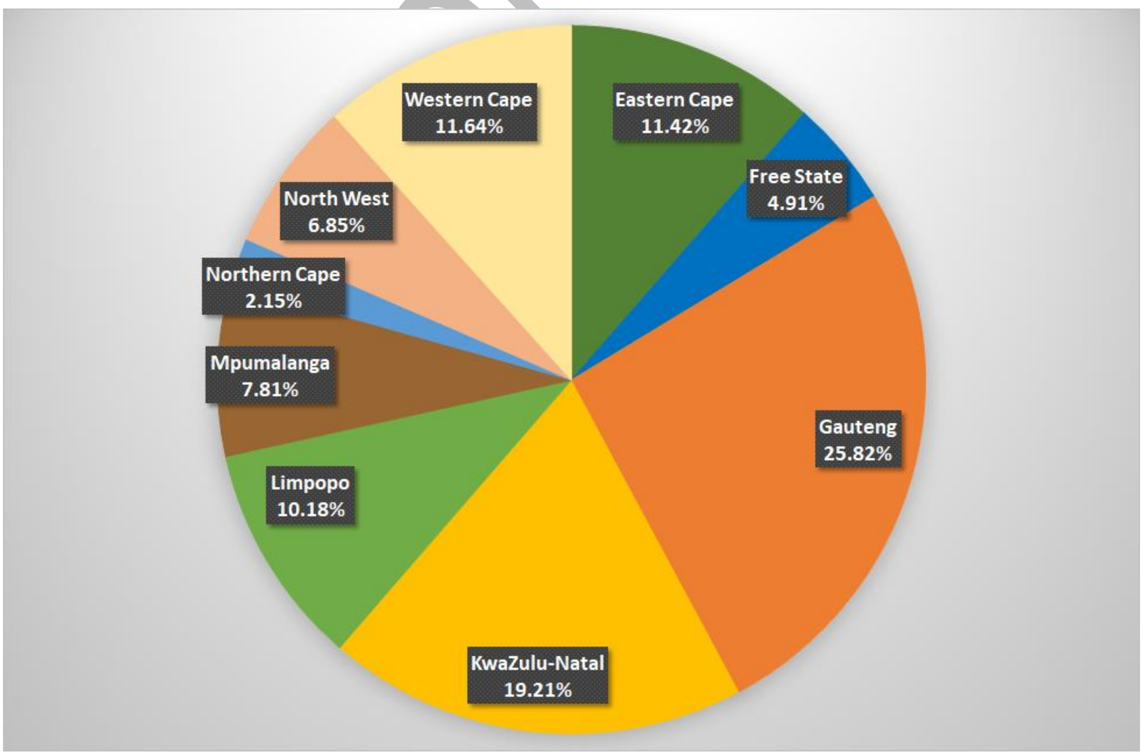

Figure 1.3: South Africa's population distribution across the provinces in 2019 (StatsSA, 2019c).

1.3.2. Social development

Poverty in South Africa remains a key development challenge in social, economic and political terms even though the country's development framework is anchored in the alleviation of poverty and addressing inequality. Poverty is closely linked with unemployment and the unemployment rate currently sits at 29.1% (StatsSA, 2020c). According to the national poverty line for 2019, over half of South Africa's population (55.5%) are living below the upper-bound poverty line (R1 227) from a series low of 53.2% in 2011, with 81.3% of people residing in rural areas and 40.6% in urban areas. This is in spite of poverty alleviation measures implemented by government departments and other public sector agencies in providing access to no-fee government services and social grants. The post-apartheid government has committed to implementing various anti-poverty policies and programs in meeting with the objectives of the sustainable development goals and continues to pledge to fight against the struggle of poverty (StatsSA, 2017b).

The current life expectancy of males and females at birth is 61.5 and 67.7, respectively. The infant mortality rate has declined from 32.8 to 22.1 per 1000 live births between 2017 and 2019 (StatsSA, 2018b). In addition, there are 7.97 million people living with HIV in South Africa (StatsSA, 2019c).

The Human Development Index is an average measure of basic human development achievements in a country comprising of expectancy, education and income in the index. South Africa, through its National Development Plan (NPC, 2011), identifies human development as a critical part of inclusive growth. In 2018, the Human Development Index value for South Africa was at 0.705 which represents an improvement relative to 2016 (0.666) (Figure 1.4). This has been boosted by life expectancy at birth, mean schooling years increased as well as gross national income per capita.

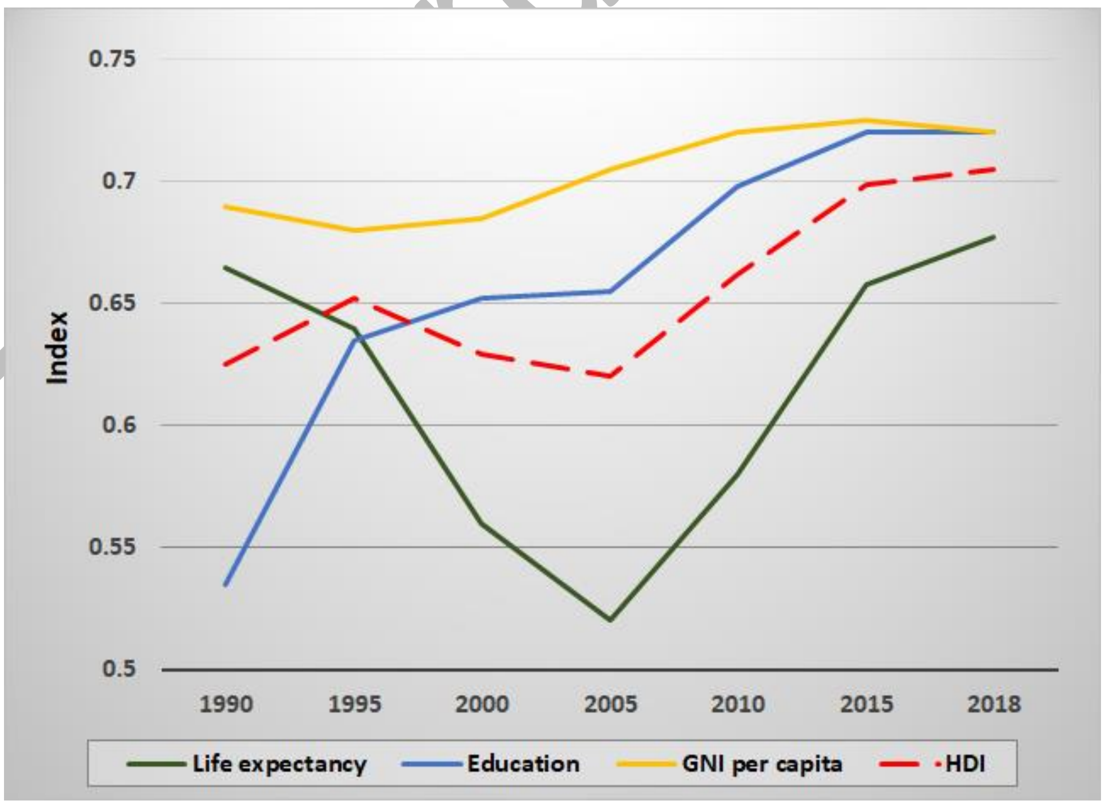

Figure 1.4: South Africa Human Development Index (Data source: UNDP, 2019).

1.3.3. Education

South Africa's education system is a three-tier system; elementary (13.6%), secondary (68.2%) and tertiary (12.1%) of the eligible population receiving education. The education system is governed by the department of Basic Education and Higher Education and Training. Education remains a major priority in South Africa accounting for 41% of its provincial government expenditure in the 2017/18 financial year (StatsSA, 2018a). There were approximately 14.2 million learners at school in 2018 and 736 820 students were enrolled at higher education institutions (universities and universities of technology). The largest percentage of these learners attended schools in KwaZulu-Natal (22.2%) and Gauteng (19.6%). Attendance of pre-school has increased from an estimated 949 000 in 2002 to 2 059 000 in 2015; attendance of Grade R has increased from an estimated 686 000 in 2010 to 1 222 000 in 2015 indicating that policy measures aimed at increasing participation in early childhood development are beginning to bear fruit. The number of people aged 15 and more who have completed Grade 12 has increased from an estimated 3.7 million in 1996 to 11.6 million in 2016; and the number of people aged 15 and more who have completed higher educational institution courses has increased from an estimated 1.3 million in1996 to 3.6 million in 2016. Educational attainment outcomes continue to improve with improved access to educational facilities and services (StatsSA, 2017a).

1.4. Economic profile

South Africa's economy is categorized as 'upper-middle income' in capital markets and as an 'emerging economy'. The country remains one of the largest economies on the African continent known to be the world's largest exporter of gold, platinum and natural resources and over the years has progressed in establishing mining, finance, trade and government services as the main drivers of growth. Unemployment, poverty and inequality are amongst the key socio-economic challenges that South Africa is dealing with.

1.4.1. GDP

South Africa's GDP increased from 349 554 billion USD to 358 839 billion USD between 2017 and 2019 (World Bank, 2019a). The country's GDP growth has been trending downward since 2011, with unstable growth due to several events of inflation, recession, declining investments, and unemployment yielding the economy into slower economic growth (StatsSA, 2020a). Currently, the GDP is at its lowest and has not recovered much since the 2008 recession (Figure 1.5). The years 2010–2013 showed some promise as the growth rate hovered slightly above 2%, albeit still below the policy expected growth rate of 5%. South Africa's economy grew by 0.2% in 2019, in particular – the growth rate of the 4th quarter shifted the economy into technical recession.

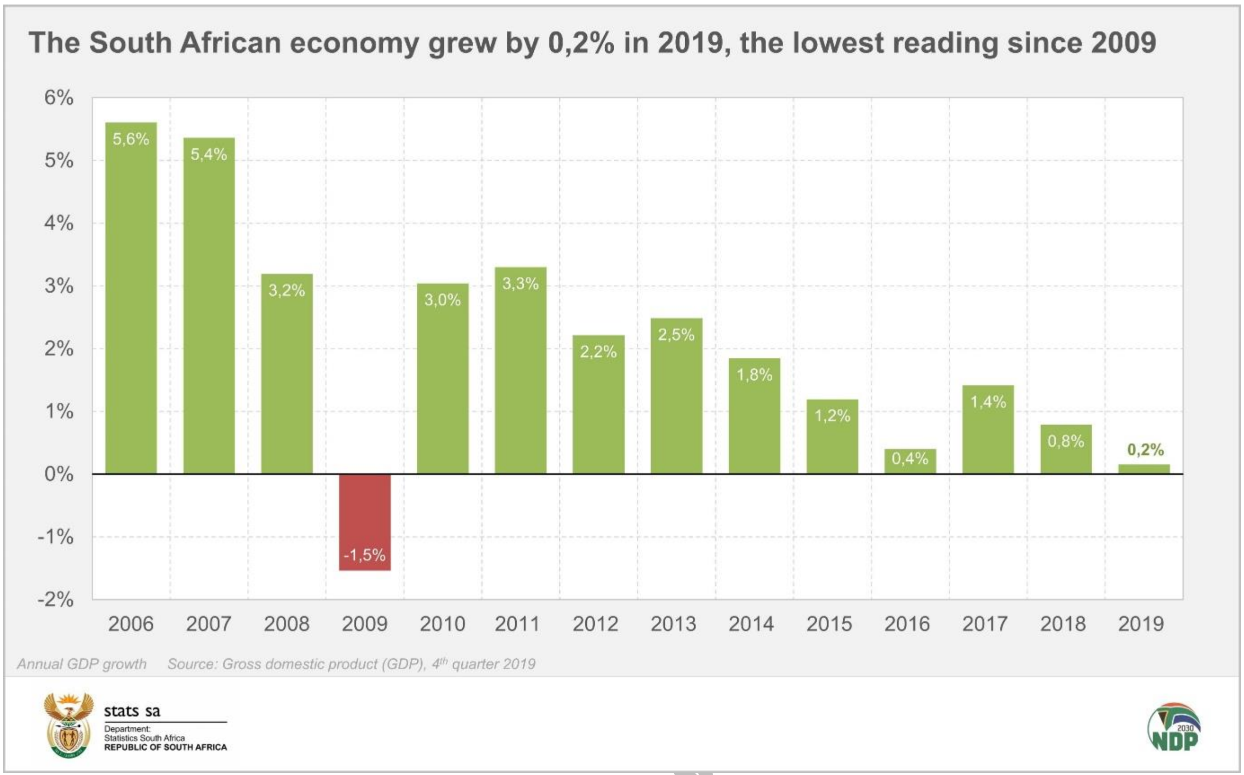

Figure 1.5: South Africa's annual GDP growth since 2006 (Source: StatsSA, 2020a).

Debt as a percentage of GDP increased from 48.9% in the 2015/16 financial year to about 56.2% for the year 2019/20, and is projected to increase to 60% in the medium term (Figure 1.6). This means that the borrowing costs will increase, but the key point is that the money would be used for infrastructure investment. It will, therefore, be strategic for South Africa to factor in mitigation and adaptation related infrastructure, thereby creating employment whilst dealing with climate change challenges.

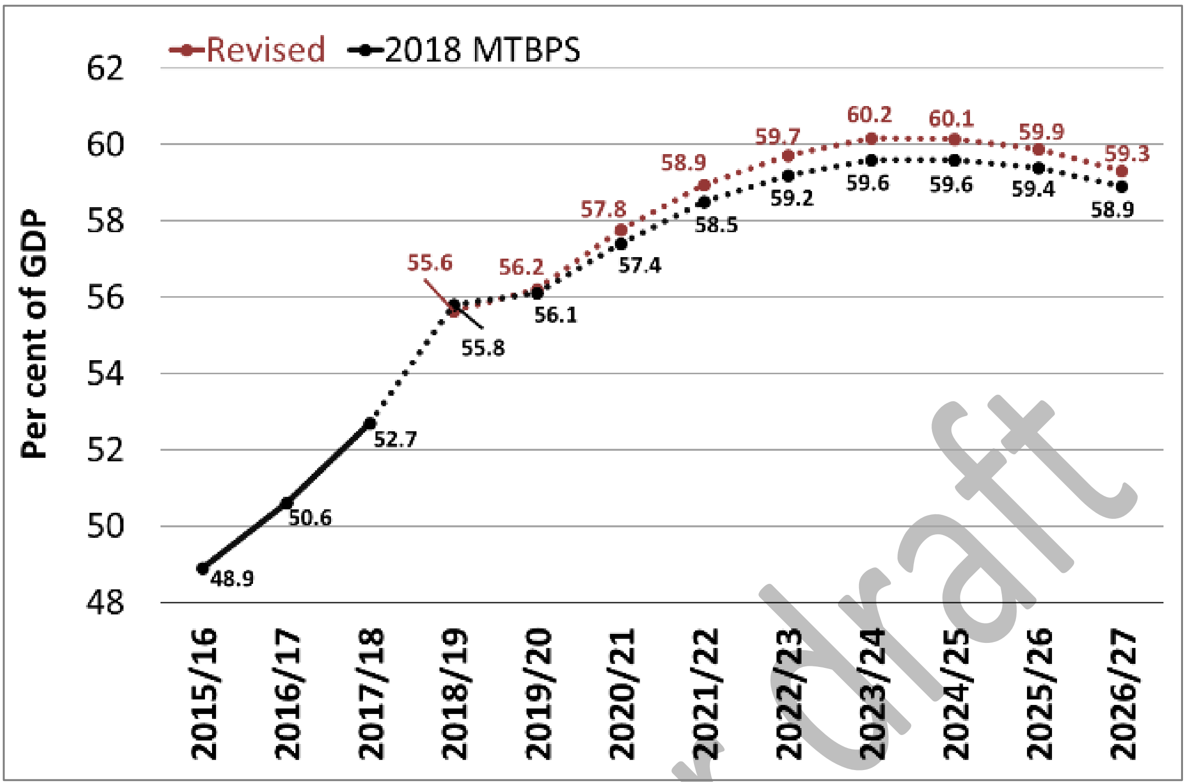

Figure 1.6: Gross debt-to-GDP outlook (National Treasury, 2019).

1.4.2. Sectoral performance

Historically, South Africa's economy was built mainly on primary and secondary industries, such as mining and manufacturing, but over time, and in line with global trends, growth has shifted to services (Figure 1.7) which accounts for a significant proportion of GDP. The main service industries are finance, real estate and business services; government services; wholesale, retail and motor trade; catering and accommodation; and transport, storage and communication. In terms of the real sectoral contribution to GDP, the tertiary sector contributes 68%, the secondary sector contributes 21% and the primary sector contributes approximately 11%. According to Statistics SA, when it comes to the contribution to GDP by provinces, Gauteng, Western Cape and KZN collectively contribute an estimated 60% to the country's GDP.

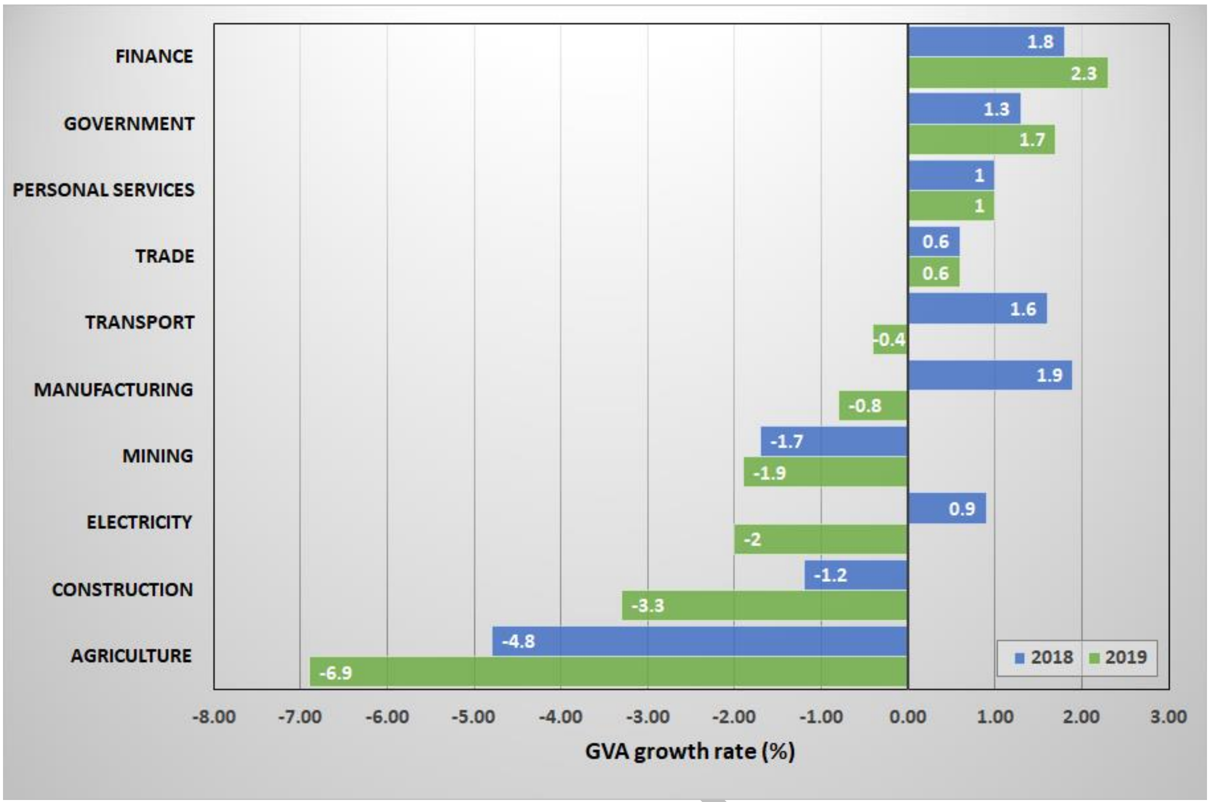

Figure 1.7: Growth rates in industry value added in 2018 and 2019 (Data source: StatsSA, 2020).

1.5. Sectoral profiles

1.5.1. Energy

1.5.1.1. Energy expenditure

Globally, South Africa continues to be one of the major suppliers of mineral commodities. Hence, the total energy consumption per unit of GDP is about 50% higher than the world's average. This high consumption rate is caused by industries that are energy intensive and the type of coal used in the energy supply system. The South African manufacturing industry at present depends largely on primary extraction and relatively low-grade processing, making it a heavy user of energy. In addition, South Africa's energy intensity is high (see section 3.8.2). The public sector continues to invest in infrastructure, with particular focus on new construction related to electricity generation. The public-sector capital expenditure displayed an increasing trend from 2012 to 2016. However, capital expenditure decreased from R284 billion in 2016 to R 249.6 billion in 2018 with an average decline of 17.2% per year.

Infrastructural spending also underpins some of the goals of the National Development Plan (NDP) (NPC, 2011), in particular the provision of service delivery and infrastructural development. Hence, well-maintained energy infrastructure facilitates trade, improves connectivity, attracts investment, and allows communities to access services.

More than a quarter of the South Africa's public-sector capital expenditure in 2017 was spent on electricity infrastructure (funds for power utility Eskom in Figure 1.8). Eskom has remained the single largest contributor over the last 3 years, contributing 25.7%, 28% and 25.3% to the public sector capital expenditure in 2016, 2017 and 2018 respectively. Eskom reduced spending from R73 billion in 2016 to R63 billion in 2018. This amount was mainly focused on the power generation projects at Kusile, new electricity distribution programmes, and vehicle build programmes.

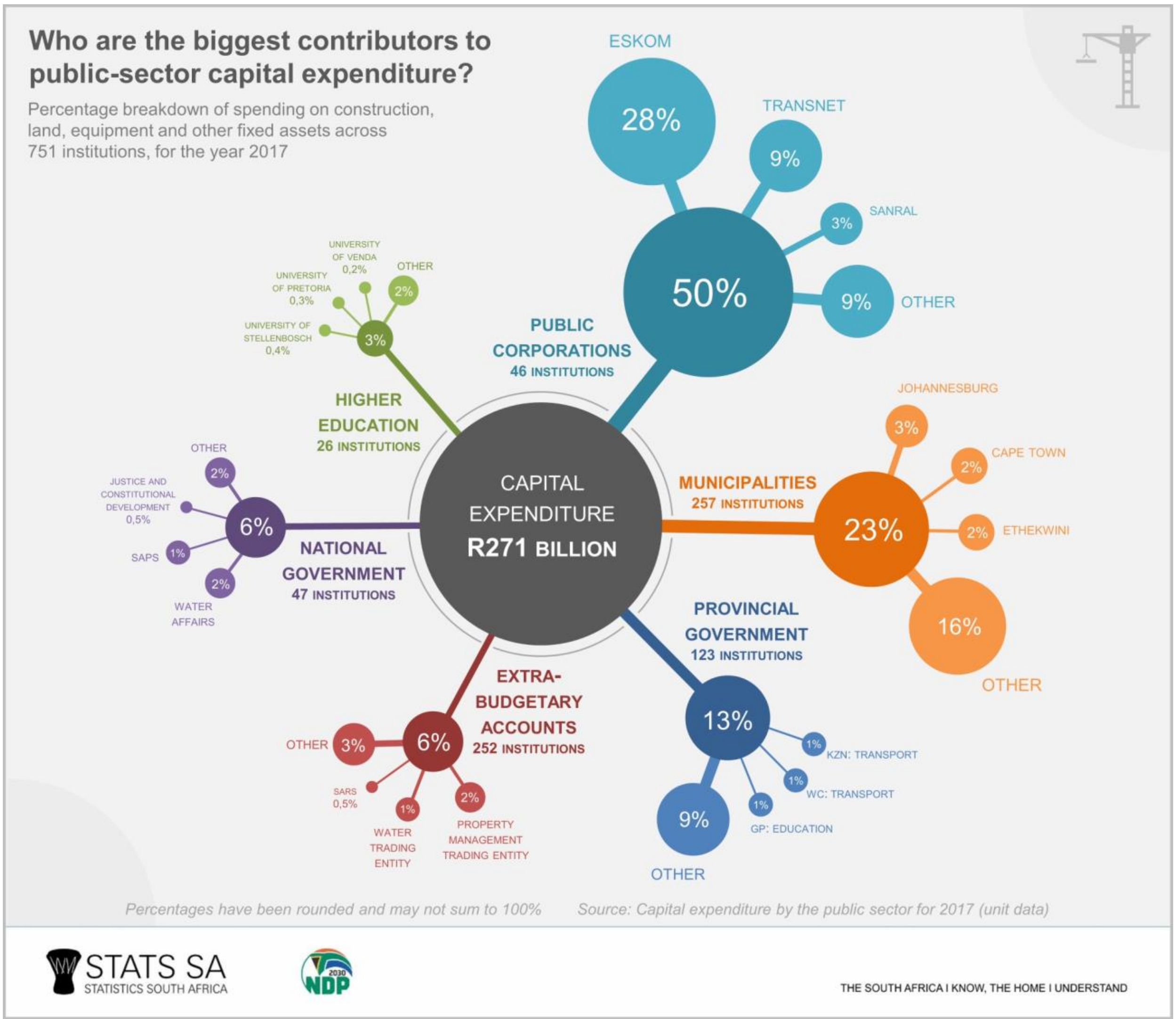

Figure 1.8: 2017 Capital expenditure budget on electricity infrastructure (StatsSA, 2018a).

1.5.1.2. Energy sources

Coal remains South Africa's dominant primary energy source (Figure 1.9), but its contribution has declined from 69% in 2016 to 61% in 2017 (DoE, 2017; DoE, 2019). Traditional fossil fuels-based energy has been experiencing ever increasing costs, and so renewable energy is growing and becoming a viable option (DoE, 2019). South Africa is presently rated as the 12th most attractive investment for renewable energy. The Renewable Energy Independent Power Producers Procurement Programme

(REIPPPP) has, to date, attracted investment (equity and debt) to the value of R209.7 billion, of which R41.8 billion (20%) is foreign investment (DoE, 2019).

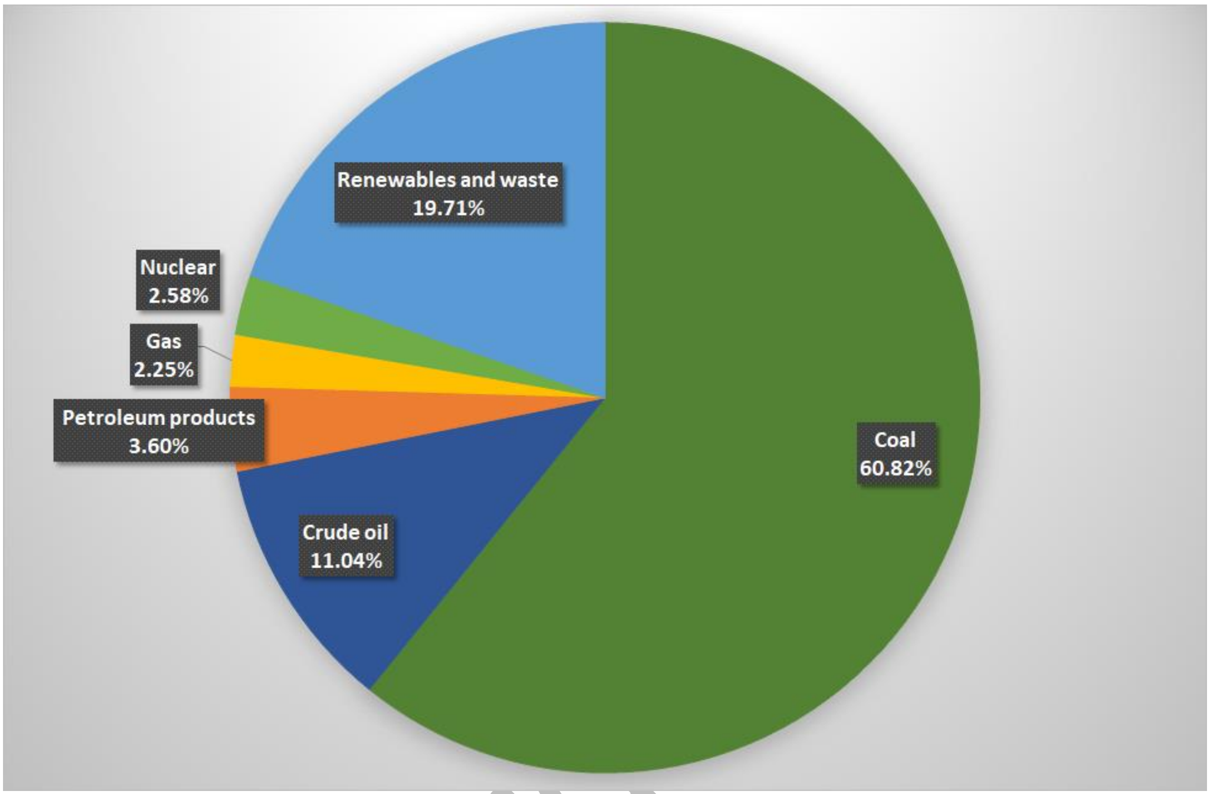

Figure 1.9: Total primary energy supply in South Africa in 2017 (Source: DoE, 2017).

1.5.1.3. Energy consumption

The largest consumer of energy is the industrial sector, consuming 47% of the total energy consumption in 2017 (Figure 1.10). This is followed by the transport sector at 27% and the residential and commercial sector consuming 16%. The agriculture sector energy consumption increased by 3% and the residential and commercial sector by 4% between 2015 and 2017. In 2018 it was reported that 84.7% of households had access to electricity, which is up from 84.2% in 2017 (StatsSA, 2019c).

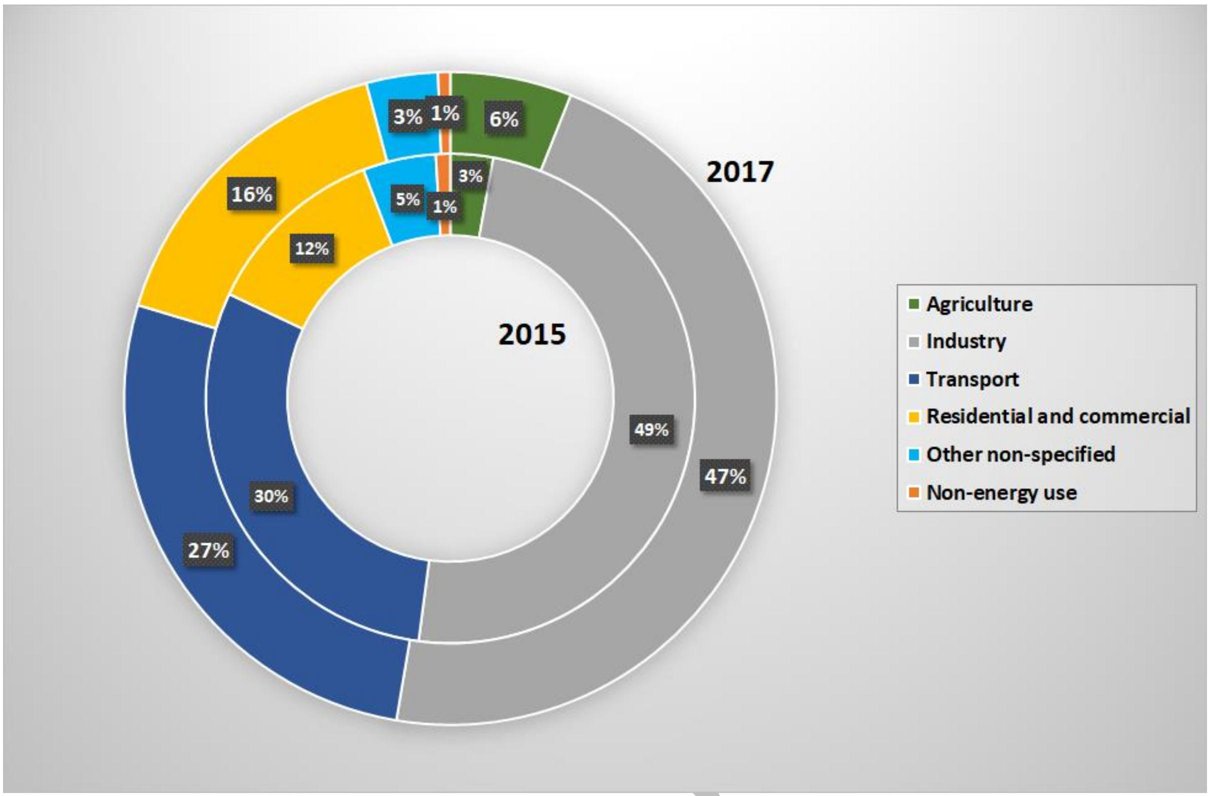

Figure 1.10: Energy consumption per sector in 2015 and 2017 (Source: DoE, 2015, 2017).

1.5.2. Transport

Travelling is an everyday life activity in South Africa. The road sub-sector accounts for more than 90% of South Africa's transport emissions (DEFF, 2020). In the 2013 National Household Travel Survey, findings revealed that 68.8% of South African households use taxi services daily, followed by commuter bus (21.1%) and commuter rail operations (9.9%) (StatsSA, 2014). The General Household Survey (StatsSA, 2019c) showed that 64.6% of learners walk to school, 9.0% travel by car and 6.8% travel by taxi. It also indicated that 33.7% of people travel to work in a private car, followed by 24.0% by taxi.

In South Africa, the public transport industry consists of three main modes of transport: (a) the commuter rail system with the new Gautrain traveling between the main cities of the Gauteng province; (b) the commuter bus industry including the two bus rapid transit (BRT) systems operative in Johannesburg and Cape Town and (c) the commonly used form of subsidized transport, the 16-seater minibus-taxi industry (Aropet, 2017). The success of the BRT system in Johannesburg has led to its implementation in other cities such as Nelson Mandela Bay, Rustenburg, Tshwane and Ekurhuleni. Tshwane is also the first African city to operate BRT buses which operate on CNG. Besides passenger vehicles, South Africa is very dependent on road transport for freight as 77.3% of freight is classified as land freight (StatsSA, 2019a).

The Department of Transport has developed the Green Transport Strategy programmes to address the adverse effects and impacts of transport on the environment, and concurrently, to address the current and future transport demands based on the principles of sustainable development (GCIS, 2019). In addition, the government is introducing a taxi recapitalization progamme which aims to replace old taxi's with newer, more efficient vehicles.

1.5.3. Agriculture

South Africa is a richly diverse country with pulsating variety in cultures, vegetation types, biodiversity, climates and soil types. The total land used for commercial agriculture is 46.4 million hectares, which represents 37.9% of the total land area of South Africa (StatsSA, 2020b). Commercial agricultural land comprised mainly grazing land (36.5 million hectares) and arable land (7.6 million hectares). The Agricultural Census for 2017 (StatsSA, 2020b) showed that 33.9% of farms are livestock farmers, 31.1% are mixed farmers and 21.3% farm with field crops. Livestock farming is the largest agricultural sector in the country generating R128.2 billion in 2017 (WWF, n.d.). There are currently 12.8 million cattle, 1.8 million sheep and goats, and 1.4 million pigs in South Africa (DAFF, 2020). In addition, in 2018 South Africa produced 454 000 eggs and over 1.7 million metric tons of white meat.

Only 12% of the country's land is suitable for rain-fed crop production, and only 3% of South African agricultural land is considered truly fertile, making it fall short of other countries (WWF, n.d.). The grain industry is one of the largest in South Africa, producing between 25% and 33% of the country's total gross agricultural produce. The largest area of farmland is planted with maize, followed by wheat and, to a lesser extent, sugarcane and sunflowers.

1.5.4. Forestry

South Africa's forest land, divided into natural forests, commercial plantations and woodlands, covers just over 21 million hectares of the country's total 122 million hectares (DEA, 2019). Forest plantations cover 1.2 million hectares (around 1%) of South Africa's land area and is an important contributor to South Africa's economy. There has been a decline in plantation area over the last 8 years due to land being converted predominantly to other agricultural crops, such as avocados and macadamias, at a rate of approximately 10 000 hectares per year (FSA, 2020). Plantations are owned by corporate timber companies (11), commercial timber farmers (1 300), small-scale timber growers (25 000) and the State. Between 16 and 17 million metric tons of timber is produced on a sustainable basis annually. In 2016, forestry contributed 10.1% of the Agricultural sector GDP, 5.1% of the Manufacturing sector GDP and 0.6% of the total GDP (FSA, 2020). Forestry also happens to be a key driver for the development of South Africa's local rural economies where poverty is compounded by lack of opportunities for employment. The industry employs approximately 62 000 people directly and a further 98 000 in the primary processing industries which rely on the forestry industry for raw materials.

1.5.5. Waste

The state of waste in South Africa is driven by numerous pressures affecting the generation of waste, such as population – size, growth and density; economy – manufacturing and industry, higher incomes and affluence; urbanization; and globalization of the recycling market. Alongside the likes of Cuba, Mexico, Namibia and Russia, South Africa is classified as an 'upper-middle income' country. Waste management challenges include lack of law enforcement (UNEP, 2018); weak governance; low public awareness and negative attitudes; insufficient financial provision; and service backlog to address issues faced by communities (DEA, 2018a). Based on a representative sample of municipalities from each of its nine provinces, South Africa recycled 38.6% of its estimated 54.2 million tonnes (Mt) of general waste generated in 2017 – a sum of municipal (4.8 Mt), commercial and industrial (3.5 Mt), organic (30.5 Mt), construction and demolition (4.5 Mt), metals (4 Mt), glass (2.5 Mt), paper (2.2 Mt), plastic (1.1 Mt), tyres (0.24 Mt), and other (0.73 Mt) wastes. 38.3% of generated waste in 2017 was recovered and/or recycled, while 61.77% was landfilled or treated (DEA, 2018a).

Despite rising waste generation tonnage and waste management challenges faced, South Africa is heading towards directing the predominant destiny of its general waste away from landfilling – 90% of waste was landfilled in 2011 to almost 40% in 2017 (DEA, 2018a). Numerous municipalities have planned to implement capacity building and campaigns to raise awareness in order to address impacts associated with the mismanagement of waste and improve waste management practices by citizens. This includes introduction of legislative and fiscal instruments, greater compliance and enforcement and identification of priority wastes (DEA, 2018a). At national level, the Department of Environmental Affairs (DEA) developed the Waste Awareness Strategy Framework in 2016 to assist provincial and local authorities in the implementation of awareness raising campaigns. The DEA also included various schools and communities around the country in its national environmental outreach and awareness campaign (DEA, 2018a).

1.6. Institutional Arrangements for Climate Change

1.6.1. Domestic institutional arrangements for climate change

1.6.1.1. National level institutional arrangements

South Africa is a constitutional democracy, with three spheres of government, namely national, provincial and local. The Constitution of the Republic of South Africa (RSA, 1996) guarantees the autonomy of each of these government spheres. Local government has a more autonomous role in terms of raising revenue and designing by-laws that are aligned to the Constitution, and national and provincial government policies. The underlying framework to such autonomy is that of cooperative governance which is also anchored through such acts as the Intergovernmental Relations Framework Act (Act 13 of 2005). With regards to climate change, the National Climate Change Response Policy (NCCRP) (DEA, 2011) provides a clear framework for the mainstreaming of climate change planning and action between the different spheres of government. Many government departments and municipalities have started mainstreaming climate change into their government strategies, policies and Integrated Development Plans (IDPs) which signals South Africa's readiness to tackle climate change whilst delivering services to the people of South Africa. Table 1.2 presents the details of the institutional arrangements that South Africa currently has in place to address climate change response actions.

Table 1.2: Domestic institutional arrangements to address climate change response actions.

Structure	Function
Parliament and Portfolio Committees	• Oversee the implementation of the NCCRP. • Review legislation to support the NCCRP. • BURs and National Communication reports are submitted to the committee for their approval.
The Inter-Ministerial Committee on Climate Change (IMCCC)	• Executive (Cabinet) level committee coordinates and aligns climate change response actions with national policies and legislation. • The IMCCC shall oversee all aspects of the implementation of the NCCRP. • The Minister of the Environment chairs the IMCCC.
Forum of South African Directors-General clusters	• South African Directors-General clusters based on their different mandates will guide the implementation of NCCRP actions.
Intergovernmental Committee on Climate Change	• Operationalise cooperative governance. • Consists of the relevant national and provincial departments and organised local government.
National Disaster Management Council	• Responsible for ensuring that the National Framework for Disaster Risk Management provides clear guidance across all spheres and sectors of government for managing climate change-related risk. • Ensure that an effective communications strategy is in place for early warnings to vulnerable communities.
MINMEC and MINTECH	• Facilitate a high level of policy and strategy coherence among the three spheres of government. • Guide climate change work across the three spheres of government.
National Committee for Climate Change	• Consult with stakeholders from key sectors that impact on or are impacted by climate change. • Advise on matters relating to national responsibilities. • Advise on the implementation of climate change-related activities.
National Economic Development and Labour Council	• Forum where government comes together with organised business, labour and community groupings on a national level. • Ensure that climate change policy implementation is balanced and meets the needs of all sectors of the economy.
City Resilience Committees	• Forums where city government come together to discuss climate change issues and how cities need to take the lead in climate action.

1.6.1.2. Provincial and Local Government institutional arrangements

At a provincial level, departments responsible for the environment are assigned to lead climate change response action in collaboration with their respective environmental departments and provincial entities. The majority of the lead departments have established provincial climate change structures to provide a platform for provincial stakeholders to jointly learn about climate change and coordinate their respective climate change responses. South African Local Government Association (SALGA) is mandated to support, represent and advise local governments on issues pertaining to governance at community level. The role of local government in South Africa is critical because it is the sphere of government closest to the people. Therefore, municipalities coordinate the implementation of service delivery within communities. The local sphere is the most appropriate level to create public awareness and assist communities to build a better and more sustainable environment and enhance resilience. Cities are taking the lead in driving climate action because they have enough capacity to do so. District and Local Municipalities are undertaking Climate Vulnerability Assessments and are mainstreaming climate action into their policies, strategies and plans under the guidance of the Department of Environment, Forestry and Fisheries (DEFF) and SALGA.

1.6.2. Institutional arrangements for the preparation of the BUR4

1.6.2.1. National Focal Point

The Department of Environmental Affairs (DEA) was renamed the Department of Environment, Forestry and Fisheries (DEFF) in June 2019, incorporating the forestry and fisheries functions from the previous Department of Agriculture, Forestry and Fisheries. The DEFF plays a central coordinating and policy making role as the designated authority for environmental conservation and protection in South Africa. It monitors national environmental information, policies, programmes and legislation related to climate change. The department is responsible for providing guidance and ensuring that there is a clear alignment of policies and international obligations when it comes to climate change. For example, there is a need to align the Sustainable Development Goals (SDG), the Sendai Framework for Disaster Risk Reduction and the Paris Agreement. All these frameworks and policies play a significant role in the current efforts required for developing countries to become low carbon and climate resilient economies.

The work of the DEFF is underpinned by the Constitution of the Republic of South Africa (Act 108 of 1996), the National Development Plan (NDP), National Environmental Management Act (NEMA) (Act 39 of 2004), NCCRP and other relevant legislation and policies applicable to government to address environmental management, including climate change. The DEFF is responsible for coordination and management of all climate change-related information such as mitigation, adaptation, monitoring and evaluation programmes.

The DEFF is responsible for the implementation of the UNFCCC, Kyoto Protocol and Paris Agreement, on behalf of the South African Government. The DEFF has been appointed as the UNFCCC National Focal Point and the Global Environment Facility Political Focal Point. The Department leads the work on the ongoing preparation of BURs under the Chief Directorate: International Climate Change Relations and Reporting (Figure 1.11). This function has been restructured as it was previously under the climate change monitoring and evaluation chief directorate. The Project Steering Committee (PSC) established by the Director General of the DEFF continues to support contributing authors and in providing technical inputs and oversight on the compilation of these reports. This includes reviewing and commenting on technical information to ensure the reports reflect the national circumstances.

1.6.2.2. Project steering committee

The PSC is chaired by the DEFF and comprises government officials from the following national departments:

- Department of Environment, Forestry and Fisheries
- Department of Agriculture, Land Reform and Rural Development
- Department of Women, Youth and Persons with Disabilities
- Department of Cooperative Governance and Traditional Affairs
- Department of Health
- Department of Higher Education and Training
- Department of Human Settlements
- Department of International Relations and Cooperation
- Department of Mineral Resources and Energy
- Department of Planning, Monitoring and Evaluation
- Department of Public Enterprises
- Department of Public Works and Infrastructure
- Department of Science and Innovation
- Department of Trade, Industry and Competition
- Department of Transport
- Department of Water and Sanitation
- National Treasury
- Statistics South Africa

The PSC meets every four months to evaluate progress of work, advise project execution, and where necessary provide overall direction and oversight to the project. The PSC informs the members of the Intergovernmental Committee on Climate Change and the National Climate Change Committee of the progress made on the BUR Project, on a regular basis (at least once a year).

The BUR and National Inventory Reports (NIRs) are endorsed by the PSC before they are submitted to Cabinet for approval. Once the reports are approved by Cabinet, they are submitted to the UNFCCC by the Chief Directorate for Climate Change International Relations and Reporting and undergo an international review process.

The Project Management Unit is in charge of project implementation activities as per the agreed Project Implementation Plan and is responsible for the day-to-day management of the project, monitoring, and evaluation. The Project Management Unit coordinates all activities and provides services to carry out activities such as procurement and delivery of project inputs, and their conversion into the project outputs. The National Project Manager serves as the Project Management Unit head and is responsible for the effective, efficient and timely implementation of project activities. The National Project Manager reports to the Steering Committee of the DEFF and UNEP and coordinates the implementation of all project activities with them.

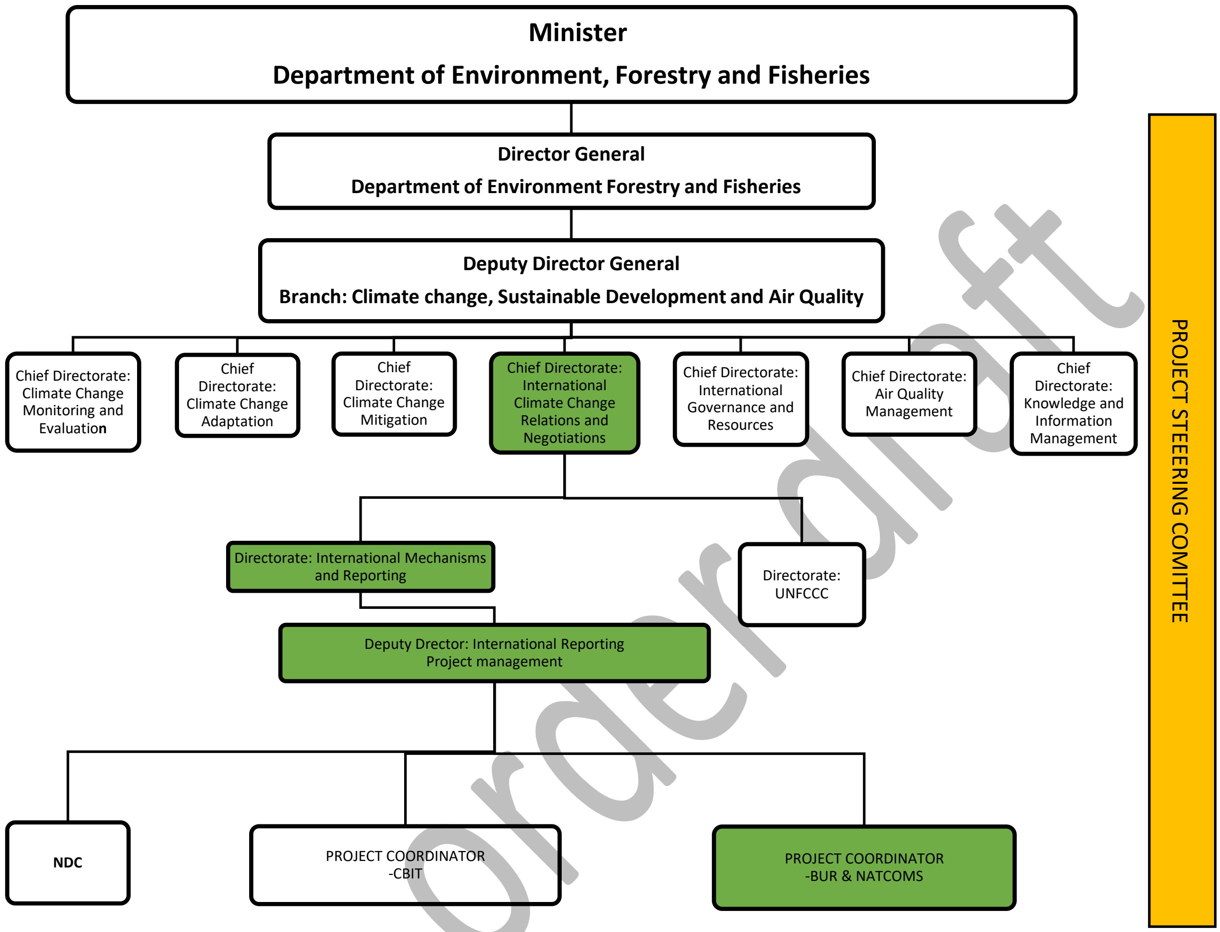

Figure 1.11: Institutional arrangements for BUR4 project implementation: (project steering committee, consultation platforms, national stakeholders and national working group.

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2. National GHG inventory

2.1. Introduction

This chapter presents a summary of the national Greenhouse Gas (GHG) inventory for South Africa for the period of 2000 to 2017. The complete national inventory was subjected to an independent review process and data was finalized and incorporated into this report. As with the previous inventory of 2015, this inventory was compiled in accordance with the International Panel on Climate Change (IPCC) 2006 guidelines for national GHG inventories and covers all four sectors, namely:

(i) Energy
(ii) Industrial process and product use (IPPU)
(iii) Agriculture, Forestry and Other Land Use (AFOLU)
(iv) Waste

The emissions for the reporting period are presented as trends by gas and sector covering carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). Sulfur hexafluoride (SF_6) emissions are not reported due to a lack of data. The DEFF are, however, in discussions with the main electricity producer (Eskom) to obtain historical SF_6 data so that it can be included in the next inventory. Furthermore, a threshold has been set for SF_6 in the new GHG reporting regulation so that companies will start reporting SF_6 data.

The trends per sector are also presented, highlighting the methods, data and quality control measures that have been implemented. This chapter concludes with a summary of the key focus areas for improving future inventories.

2.2. Summary of progress on inventory since BUR3

2.2.1. Progress since BUR3

2.2.1.1. Inventory improvements

In the *Energy* sector, the charcoal production data for *Other emissions from energy production* were updated, charcoal consumption in the *Residential* category were updated, and in *Road transport* petrol and diesel consumption was determined using vehicle kilometres travelled (VKT), and natural gas consumption was added.

The main improvements and updates in the *AFOLU* sector were:

(i) Livestock:
   a. Updated cattle herd compositions.
   b. Updated manure management.
   c. Included country specific N-excretion rates.
(ii) Land:
   a. Included 20-year default transition period.

    b. Updated burnt area data.
    c. Included annual burnt area data instead of 5-year averages.
    d. Updated biomass, dissolved organic matter (DOM) and soil organic carbon (SOC) data.
    e. Improved plantation data.
    f. Updated wood removal data.

(iii) Aggregated and non-CO_2 emissions on land:
    a. Updated biomass burning factors (burnt area, emission factors, fuel loads, etc).
    b. Updated burnt area to the MODIS collection 6 data.
    c. Applied annual burnt area data instead of 5-year averages.
    d. Improved crop residue calculations.
    e. Included N_2O losses from land use change.

Further improvements in the *AFOLU* sector are discussed in section 2.8.3.4.

In the *Waste* sector the population data was updated, and the waste per capita and percentage of waste going to solid waste disposal sites was corrected in the First Order Decay (FOD) model. Further details of improvements are provided in the sectoral analysis section of this chapter, as well as in the 2017 National Inventory Report.

In addition, this submission contains a full uncertainty analysis with all sectors being included.

2.2.1.2. Enhanced capacity of the DEFF inventory team

Since the last BUR, the DEFF has increased the capacity of the inventory team by taking on an inventory coordinator as well as a specialist in each of the sectors. The inventory coordinator will coordinate the preparation of the GHG inventory and will also be in charge of maintaining the National GHG Inventory Management System (NGHGIS). The sector specialists will take the lead in the preparation of the emission estimates for each of the sectors. The team was not fully involved in the preparation of the 2017 inventory since new team members were only brought on board in 2019 but will be involved in the 2019 inventory.

Gondwana Environmental Solutions International, the consulting company involved in developing the NGHGIS (in collaboration with Aether), compiling the AFOLU sector emission estimates and compiling the overall inventory, have provided training for the new inventory team on inventory preparation, sector compilation files, Quality Assurance (QA) and Quality Control (QC) and the NGHGIS. The capacity building will enable the DEFF to manage and complete the inventory compilation of future inventories.

2.2.1.3. National GHG Emissions Reporting Regulations

Many companies in South Africa have been reporting their GHG emissions voluntarily for a number of years, primarily through the CDP (formerly the Carbon Disclosure Project), while at the same time national government has been reporting South Africa's emissions as part of National Communications to the United Nations Framework Convention on Climate Change (UNFCCC). While corporate reporting and national reporting have developed independently of each other, they have the potential to complement each other and enable decision-makers to understand national and sector trends, as well as to inform mitigation activities (Singh et al., 2014). The South African Government, through the

National Environmental Management: Air Quality Act (Act No. 39 of 2004): National Greenhouse Gas Emission Reporting Regulations (NGER) (DEA, 2017), has introduced mandatory reporting which implies that some emitters meeting set capacity, production or usage thresholds will be required to report their emissions to the government. The purpose of the GHG Regulations is to introduce a single national reporting system for the transparent reporting of greenhouse gas emissions, which will be used (a) to update and maintain a National Greenhouse Gas Inventory; (b) for the Republic of South Africa to meet its reporting obligations under the United Framework Convention on Climate Change (UNFCCC) and instrument treaties to which it is bound; and (c) to inform the formulation and implementation of legislation and policy. Companies will submit emissions data to the South African GHG Emissions Reporting System (SAGERS) (discussed in chapter 6, section 6.3.3.1) which is a component of the National Atmospheric Emissions Inventory System (NAEIS).

2.3. Institutional context

The preparation of the national greenhouse gas inventory is a multi-organization effort led by the Department of Environment, Forestry and Fisheries (DEFF). South Africa uses a hybrid (centralised/distributed) approach to programme management for the Inventory. Management and coordination of the inventory programme, as well as compilation, publication and submission of the Inventory are carried out by the Single National Entity (being the DEFF) in a centralised manner. The DEFF, previously the DEA, is responsible for the coordination and management of all climate change-related information, including mitigation, adaptation, monitoring and evaluation, and GHG inventories. Although the DEFF takes a lead role in the compilation, implementation and reporting of the national GHG inventories, other relevant agencies and ministries play supportive roles in terms of data provision across relevant sectors. The *AFOLU* sector inventory was compiled by external consultants (Gondwana Environmental Solutions International (Gondwana)) who were appointed formally through a contract. All other sector estimates were compiled by the DEFF.

Figure 2.1 gives an overview of the institutional arrangements for the compilation of the GHG emissions inventory in South Africa.

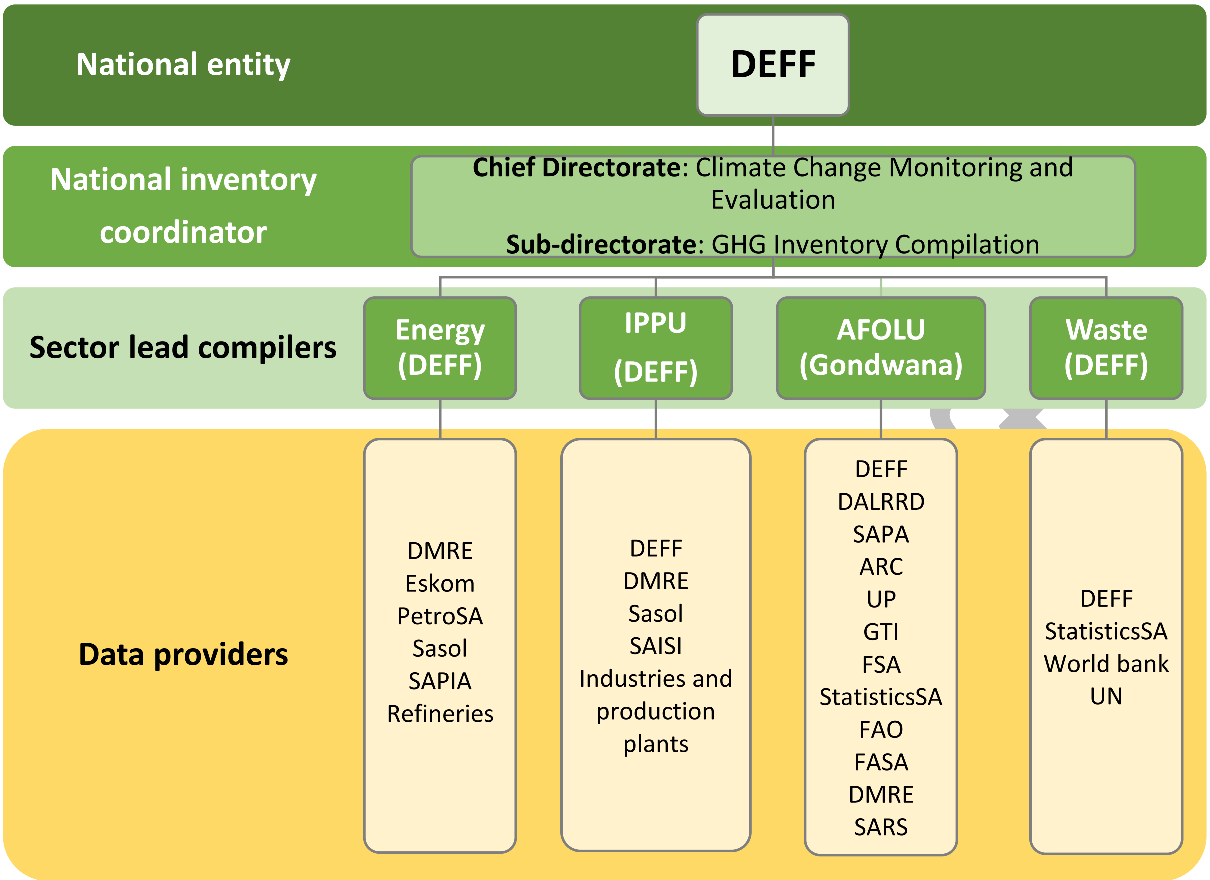


Figure 2.1: Overview of the institutional arrangements for the compilation of the GHG emissions inventory.

2.4. Global warming potentials

In this inventory, the Second Assessment Report (SAR) (IPCC, 1996) global warming potentials (GWPs) were applied. This is consistent with the previous inventory for 2015 (DEA, 2019b) and is compliant with UNFCCC reporting requirements.

2.5. Quality control and assurance procedures

A quality control and assurance plan was developed for the GHG inventory (DEA, 2019b) and the procedures are shown in Figure 2.2.

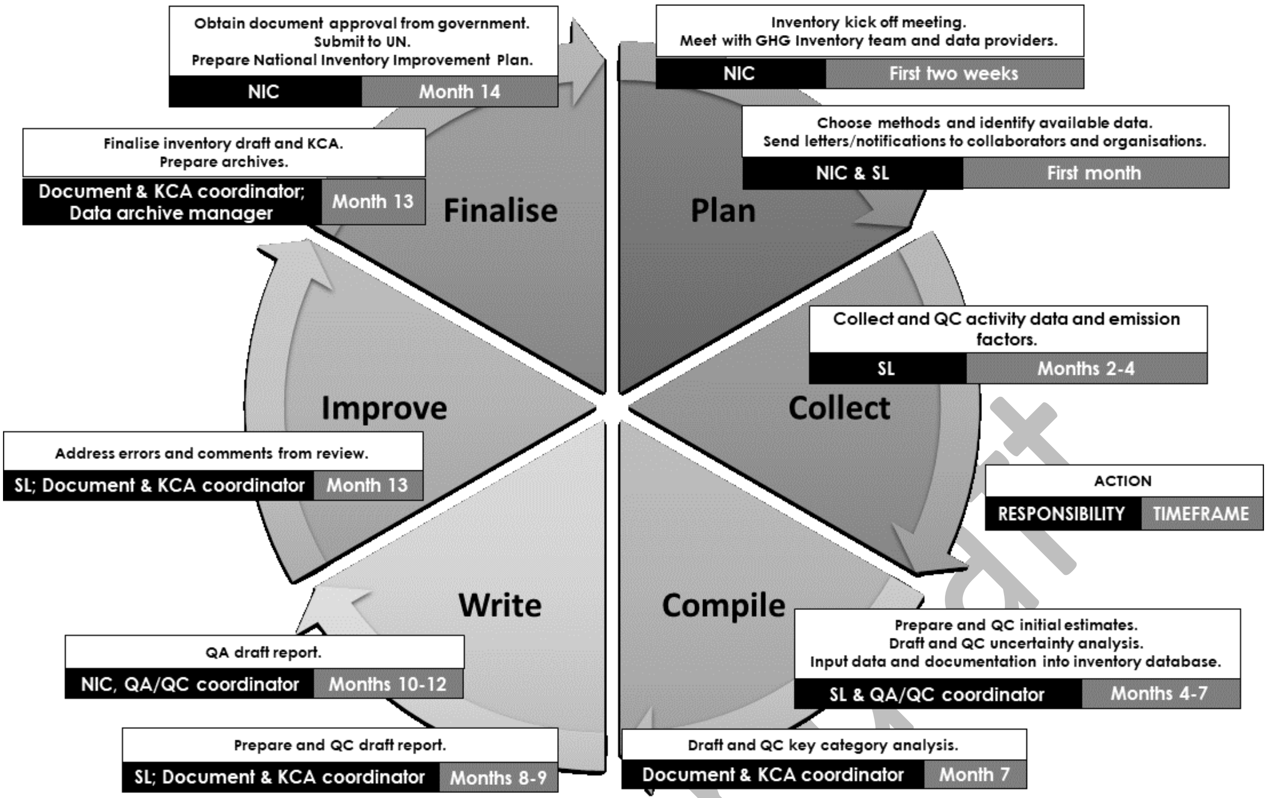


Figure 2.2: Quality control and assurance procedures, relative to inventory cycle, for South Africa's GHG inventory (NIC = National Inventory Co-ordinator; SL = Sector Lead; KCA = Key Category Analysis).

2.5.1. Quality control

The QC procedures are performed by the experts during inventory calculation and compilation. QC measures are aimed at the attainment of the quality objectives. The QC procedures comply with the IPCC good practice guidance and the 2006 IPCC Guidelines. General inventory QC checks include routine checks of the integrity, correctness and completeness of data, identification of errors and deficiencies, and documentation and archiving of inventory data and quality control actions.

In addition to general QC checks, category-specific QC checks including technical reviews of the source categories, activity data, emission factors and methods are applied on a case-by-case basis focusing on key categories and on categories where significant methodological and data revisions have taken place.

The general quality checks are used routinely throughout the inventory compilation process. Although general QC procedures are designed to be implemented for all categories and on a routine basis, it is not always necessary or possible to check all aspects of inventory input data, parameters and calculations every year. Checks are then performed on selected sets of data and processes. A representative sample of data and calculations from every category may be subjected to general QC procedures each year.

The quality control checks performed in the 2017 inventory are provided in Appendix A1.

2.5.2. Quality assurance

Quality Assurance, as defined in the *IPCC Good Practice Guidanc*e, comprises a "planned system of review procedures conducted by personnel not directly involved in the inventory compilation and development process." The quality assurance process includes both expert review and a general public review as shown in Figure 2.3. The expert and public reviews each present opportunity to uncover technical issues related to the application of methodologies, selection of activity data, or the development and choice of emission factors. The expert and public reviews of the draft document offer a broader range of researchers and practitioners in government, industry and academia, as well as the general public, the opportunity to contribute to the final document. The comments received during these processes are reviewed and, as appropriate, incorporated into the Inventory Report or reflected in the inventory estimates.

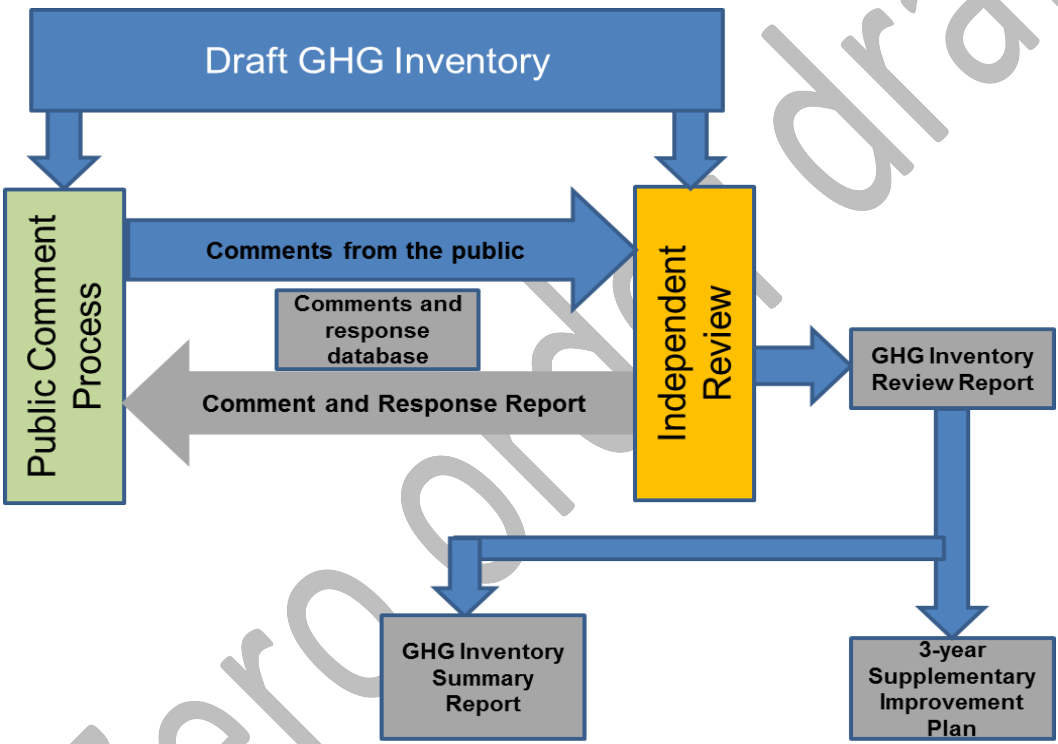


Figure 2.3: The independent review process for the 2000 – 2017 inventory.

2.5.3. Verification

Emission and activity data are verified by comparing them with other available data compiled independently of the GHG inventory system. These include measurement and research projects and programmes initiated to support the inventory system, or for other purposes, but producing information relevant to the inventory preparation. The specific verification activities are described in detail in the relevant category sections in the following chapters.

2.6. Data storage and archiving

South Africa recently developed a National GHG Inventory Management System (NGHGIS) to manage and simplify its climate change obligations to the UNFCCC process. This system aims to ensure: a) the sustainability of the inventory preparation in the country, b) consistency of reported emissions and c) the standard/quality of results. The NGHGIS ensures that the country prepares and manages data collection and analysis, as well as all relevant information related to climate change in the most consistent, transparent and accurate manner for both internal and external reporting.

The NGHGIS includes:

(i) The formalization of a National Entity (the DEFF) responsible for the preparation, planning, management, review, implementation and improvement of the inventory.
(ii) Legal and collaborative arrangements between the National Entity and the institutions that are custodians of key source data.
(iii) A process and plan for implementing quality assurance and quality control procedures.
(iv) A process to ensure that the national inventory meets the standard inventory data quality indicators of accuracy, transparency, completeness, consistency and comparability.
(v) A process for continual improvement of the national inventory.

The NGHGIS has been useful in compilation of the 2015 and the 2017 inventory respectively in keeping records of the following; stakeholders lists with their contact details, list of input datasets which are linked to the stakeholder list, QA/QC plan and checks, QA/QC logs which provide details of all QA/QC activities, all method statements, calculations and supporting files, key references, key categories and all inventory reports.

Other data collected to support the compilation of the GHG emissions inventory can be stored on the government's departmental Electronic Data Management System. South Africa also completed the South African Greenhouse Gas Emissions Reporting System (SAGERS) which will also be used in collecting and storing data.

2.7. Summary of 2017 GHG emissions inventory

The GHG inventory covers sources of greenhouse gas emissions, and removals by sinks, resulting from human (anthropogenic) activities for the major greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs). The indirect greenhouse gases, carbon monoxide (CO), and oxides of nitrogen (NO_X), are also included for biomass burning. The gases are reported under four sectors: *Energy*; *Industrial Processes and Product Use* (IPPU); *Agriculture, Forestry and Other Land Use* (AFOLU) and *Waste*. SF_6 emissions have not yet been included due to a lack of data, however the DEFF are in discussions with the main electricity producer (Eskom) to obtain historical SF_6 data so that it can be included in the next inventory. Furthermore, a threshold has been set for SF_6 in the new GHG reporting regulation so that companies will start reporting SF_6 data.

2.7.1. National inventory emissions for 2017

Emissions are to be reported using the IPCC 1996 Guideline table format, however, since SA utilises the IPCC 2006 Guidelines, methodologies populating the 1996 summary table leads to many inconsistencies and errors. The emissions are therefore reported using the similar 2006 Guideline reporting formats, and in order to be transparent about the relationship between the IPCC 1996 and 2006 categories a comparison between the two is shown in Table 2.1.

National emissions of CO_2, CH_4 and N_2O and GHG pre-cursors for 2017 are provided in Table 2.2. GWPs from the IPCC Second Assessment Report (SAR) (IPCC, 1996) GWPs were used. The AFOLU sector has emissions and removals, with the removals occurring in the *Land* and *Harvested Wood Products categories*. Together these two categories form what is termed the FOLU (Forestry and Other Land Use) component of the inventory. Net emissions (or emissions including FOLU) include emissions and sinks from all sectors, while gross emissions exclude the removals from the FOLU categories.

Table 2.1: Relationship between the IPCC 1996 and 2006 Guideline categories.

IPCC 1996 category	IPCC 2006 category
1 - Energy	**1 - Energy**
1.A - Fuel Combustion Activities	**1.A - Fuel Combustion Activities**
1.A.1 - Energy Industries	1.A.1 - Energy Industries
1.A.2 - Manufacturing Industries and Construction	1.A.2 - Manufacturing Industries and Construction
1.A.3 - Transport	1.A.3 - Transport
1.A.4 - Other Sectors	1.A.4 - Other Sectors
1.A.5 – Other	1.A.5 - Non-Specified
1.B - Fugitive emissions from fuels	**1.B - Fugitive emissions from fuels**
1.B.1 - Solid Fuels	1.B.1 - Solid Fuels
1.B.2 - Oil and Natural Gas	1.B.2 - Oil and Natural Gas
IE	1.B.3 - Other emissions from Energy Production
IE	**1.C - Carbon dioxide Transport and Storage**
IE	1.C.1 - Transport of CO_2
IE	1.C.2 - Injection and Storage
IE	1.C.3 - Other
2 - Industrial Processes and Product Use	**2 - Industrial Processes and Product Use**
2.A - Mineral Industry	**2.A - Mineral Industry**
2.B - Chemical Industry	**2.B - Chemical Industry**
2.C - Metal production	**2.C - Metal Industry**
IE - 1A, 2A5, 2A6, 3	**2.D - Non-Energy Products from Fuels and Solvent Use**
IE - 2F6	**2.E - Electronics Industry**
2.F - Consumption of Halocarbons and Sulphur Hexafluoride	**2.F - Product Uses as Substitutes for Ozone Depleting Substances**
IE - 2F6, 3D	**2.G - Other Product Manufacture and Use**
IE - 2D1, 2D2, 2G	**2.H - Other**
3 - Solvent and other product use	
	3 - Agriculture, Forestry, and Other Land Use

4 – Agriculture	**3.A - Livestock**
4.A - Enteric Fermentation	3.A.1 - Enteric Fermentation
4.B - Manure Management	3.A.2 - Manure Management
5 – LULUCF	**3.B - Land**
5.A - Changes in forest and other woody biomass stocks; 5.B - Forest and grassland conversion; 5.C - Abandonment of management soils; 5.D - CO_2 emissions and removals from soil; 5.E - Other	3.B.1 - Forest land 3.B.2 - Cropland 3.B.3 - Grassland 3.B.4 - Wetlands 3.B.5 - Settlements 3.B.6 - Other Land
	3.C - Aggregate sources and non-CO_2 emissions sources on land
4.E - Prescribed burning of savannas; 4.F - Field burning of agricultural residues	3.C.1 - Emissions from biomass burning
4.D - Agricultural soils	3.C.2 - Liming
4.D - Agricultural soils	3.C.3 - Urea application
4.D - Agricultural soils	3.C.4 - Direct N_2O Emissions from Managed Soils
4.D - Agricultural soils	3.C.5 - Indirect N_2O Emissions from Managed Soils
4.D - Agricultural soils	3.C.6 - Indirect N_2O Emissions from manure management
4.C Rice cultivation	3.C.7 - Rice cultivations
4.G – Other	3.C.8 - Other (please specify)
	3.D - Other
	3.D.1 - Harvested Wood Products 3.D.2 - Other (please specify)
6 - Waste	**4 - Waste**
6.A - Solid Waste Disposal on land	**4.A - Solid Waste Disposal**
IE - 6A3	**4.B - Biological Treatment of Solid Waste**
4.C - Waste incineration	**4.C - Incineration and Open Burning of Waste**
4.D - Wastewater Treatment and Discharge	**4.D - Wastewater Treatment and Discharge**
4.E – Other	**4.E – Other**
	5 – Other
	5.A - Indirect N_2O emissions from the atmospheric deposition of nitrogen in NOx and NH_3
	5.B – Other
	Memo items
	International bunkers
	International aviation
	International water-borne transport
	Multilateral operations

Table 2.2: National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks for 2017, including GHG precursors.

IPCC 2006 category	Emissions and removals								
	Net CO_2	CH_4	N_2O	HFCs	PFCs	NOx	CO	NMVOC	Total GHGs
	(Gg)[a]			(Gg CO_2e)[b]		(Gg)[a]			(Gg CO_2e)
Emissions (incl. FOLU)	**446 356.3**	**2 493.3**	**87.1**	**4 014.5**	**2 453.4**	**21.1**	**487.8**	**27.2**	**532 173.3**
Emissions (excl. FOLU)	**489 546.1**	**2 461.6**	**87.1**	**4 014.5**	**2 453.4**	**21.1**	**487.8**	**27.2**	**574 696.5**
1 - Energy	**451 308.2**	**206.1**	**9.6**						**458 609.7**
1.A - Fuel Combustion Activities	**424 899.2**	**26.5**	**9.6**			NE	NE	NE	**428 429.2**
1.A.1 - Energy Industries	256 724.5	2.9	3.9			NE	NE	NE	258 001.3
1.A.2 - Manufacturing Industries and Construction	37 264.4	0.5	0.5			NE	NE	NE	37 432.5
1.A.3 - Transport	76 476.1	19.3	3.7			NE	NE	NE	78 016.6
1.A.4 - Other Sectors	53 234.9	3.8	1.5			NE	NE	NE	53 775.3
1.A.5 - Non-Specified	1 199.3	0.1	0.0			NE	NE	NE	1 203.6
1.B - Fugitive emissions from fuels	**26 409.1**	**179.6**	NE			NE	NE	NE	**30 180.4**
1.B.1 - Solid Fuels	20.8	75.6	NE			NE	NE	NE	1 608.2
1.B.2 - Oil and Natural Gas	641.8	NE	NE			NE	NE	NE	641.8
1.B.3 - Other emissions from Energy Production	25 746.5	104.0	NE			NE	NE	NE	27 930.4
1.C - Carbon dioxide Transport and Storage	**NE**					**NE**	**NE**	**NE**	**0.0**
1.C.1 - Transport of CO_2	NE					NE	NE	NE	0.0
1.C.2 - Injection and Storage	NE					NE	NE	NE	0.0
1.C.3 - Other	NA					NE	NE	NE	0.0
2 - Industrial Processes and Product Use	**36 298.7**	**8.1**	**0.9**	**4 014.5**	**2 453.4**				**43 229.5**
2.A - Mineral Industry	**6 462.1**	**NE**				**NE**	**NE**	**NE**	**6 462.1**
2.B - Chemical Industry	**523.9**	**8.0**	**0.9**			**NE**	**NE**	**NE**	**983.7**
2.C - Metal Industry	**29 037.2**	**0.1**	**NE**	**NE**	**2 453.4**	**NE**	**NE**	**NE**	**31 493.6**
2.D - Non-Energy Products from Fuels and Solvent Use	**275.6**	**NE**	**NE**			**NE**	**NE**	**NE**	**275.6**
2.E - Electronics Industry	**NE**		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**0.0**
2.F - Product Uses as Substitutes for Ozone Depleting Substances	**NE**			**4 014.5**	**NE**	**NE**	**NE**	**NE**	**4 014.5**

2.G - Other Product Manufacture and Use			**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**0.0**
2.H - Other	**NA**	**NA**	**NA**			**NE**	**NE**	**NE**	**0.0**
3 - Agriculture, Forestry, and Other Land Use	**-41 288.1**	**1 309.6**	**73.8**			**21.1**	**487.8**	**27.2**	**9 085.2**
3.A - Livestock		**1 259.7**	**5.5**						**28 161.3**
3.A.1 - Enteric Fermentation		1 224.2							25 708.9
3.A.2 - Manure Management		35.5	5.5						2 452.4
3.B - Land	**-42 412.8**	**31.7**	**NE**						**-41 746.2**
3.B.1 - Forest land	-40 707.4	NE	NE						-40 707.4
3.B.2 - Cropland	528.3	NE	NE						528.3
3.B.3 - Grassland	-18 172.7	NE	NE						-18 172.7
3.B.4 - Wetlands	NE	31.7	NE						666.6
3.B.5 - Settlements	-105.8	NE	NE						-105.8
3.B.6 - Other Land	16 044.8	NE	NE						16 044.8
3.C - Aggregate sources and non-CO_2 emissions sources on land	**1 901.7**	**18.1**	**68.3**			**21.1**	**487.8**	**27.2**	**23 447.1**
3.C.1 - Emissions from biomass burning	IE	18.1	1.2			21.1	487.8	27.2	758.8
3.C.2 - Liming	1 222.1								1 222.1
3.C.3 - Urea application	679.6								679.6
3.C.4 - Direct N_2O Emissions from Managed Soils			58.3						18 081.0
3.C.5 - Indirect N_2O Emissions from managed soils			7.2						2 236.3
3.C.6 - Indirect N_2O Emissions from manure management			1.5						469.3
3.C.7 - Rice cultivations		NO	NO						0.0
3.C.8 - Other (please specify)	NO	NO	NO						0.0
3.D - Other	**-776.9**	**NA**	**NA**						**-776.9**
3.D.1 - Harvested Wood Products	-776.9								-776.9
3.D.2 - Other (please specify)	NO	NO	NO						0.0
4 - Waste	**37.5**	**969.5**	**2.7**						**21 249.0**
4.A - Solid Waste Disposal		**827.0**	**NE**			**NO/NA**	**NO/NA**	**NO/NA**	**17 366.0**
4.B - Biological Treatment of Solid Waste		**NE**	**NE**			**NO/NA**	**NO/NA**	**NO/NA**	

4.C - Incineration and Open Burning of Waste	**37.5**	**11.5**	**0.3**			**NA**	**NA**	**NA**	**360.2**
4.D - Wastewater Treatment and Discharge		**131.1**	**2.5**			**NO/NA**	**NO/NA**	**NO/NA**	**3 522.8**
4.E – Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	
5 – Other									
5.A - Indirect N_2O emissions from the atmospheric deposition of nitrogen in NOx and NH_3			**NE**			**NE**	**NE**	**NE**	
5.B – Other			**NO**			**NO**	**NO**	**NO**	
Memo items									
International bunkers	**11 494.4**	**0.9**	**0.3**	**NA**	**NA**	**NA**	**NA**	**NA**	**11 603.2**
International aviation	2 242.3	0.1	0.0	NA	NA	NA	NA	NA	2 248.2
International water-borne transport	9 252.0	0.8	0.3	NA	NA	NA	NA	NA	9 354.9
Multilateral operations	NA	NA	NA	NA	NA	NA	NA	NA	

[a] *The emissions in Gg CO_2e for CH_4 and N_2O per category are available in the Appendix of the NIR.*

[b] *The emissions of PFC and HFCs are reported in Gg in Table 2.7.*

2.7.2. Changes in emissions since BUR3

Emissions (excl. FOLU) increased by 1.1% since the last inventory submission (for 2015) (Table 2.3). The increase was due to a 1.5%, 3.2%, and 4.4% increase in the *Energy*, *IPPU*, and *Waste* sectors, respectively, over the 2015 to 2017 period. Emissions (incl. FOLU) decreased by 0.5% since the last inventory submission (Table 2.3). The reduction in the emissions relative to the growth in emissions (excl. FOLU) was due to a decline in the *AFOLU* emissions and this was due to a 26.1% increase in removals from the *Land* sector. The *Energy* sector was the largest contributor to South Africa's total emissions (incl. FOLU) in 2017, comprising 86.2% of total net emissions. This was followed by the *IPPU* sector (8.1%) and *Waste* sector (4.0%).

Table 2.3: Changes in South Africa's total emissions (including and excluding FOLU) between 2000, 2015 and 2017.

	Emissions (Gg CO_2e)			Change between 2000 and 2017		Change between 2015 and 2017	
	2000	2015	2017	Gg CO_2e	%	Gg CO_2e	%
Emissions (excl. FOLU)	449 180.8	568 578.1	574 696.5	125 515.7	27.9	6 118.4	1.1
Emissions (incl. FOLU)	428 652.9	534 846.1	532 173.3	103 520.5	24.2	-2 672.8	-0.5

2.7.3. Trends in total aggregated emissions since 2000

South Africa's GHG emissions excluding FOLU were 449 181 Gg CO_2e in 2000 and these increased by 27.9% by 2017 (Table 2.4). Emissions (excl. FOLU) in 2017 were estimated at 574 697 Gg CO_2e. Emissions increased slowly between 2000 and 2013 when emissions reached their peak, after which there was a slight decline to 2015 and a stabilisation to 2017 (Figure 2.4). There were small declines in emissions in 2005, 2008 and 2011 (Table 2.4), but these dips have usually only lasted for one year. In 2014–2015 there was a decline in two consecutive years. Between 2000 and 2017 the average annual growth was 1.5%, however the growth rate was 2.3% between 2000 and 2010 and this declined to 0.4% between 2010 and 2017. The *Energy* sector is the main contributor to the increasing emissions.

South Africa's GHG emissions (incl. FOLU) were 428 653 Gg CO_2e in 2000 and these increased by 24.2% by 2017 (Table 2.4). Emissions (incl. FOLU) in 2017 were estimated at 532 173 Gg CO_2e. The emissions (incl. FOLU) followed the same trend as the emissions (excl. FOLU) with slightly lower emissions between 2010 and 2017 (Figure 2.4). This was due to the increased *Land* sink during this period. Emissions, therefore, increased slowly between 2000 and 2013 after which there was a decline to 2017 (Table 2.4). Between 2000 and 2017 the average annual growth was 1.3%. The *Energy* sector is the main contributor to this increase.

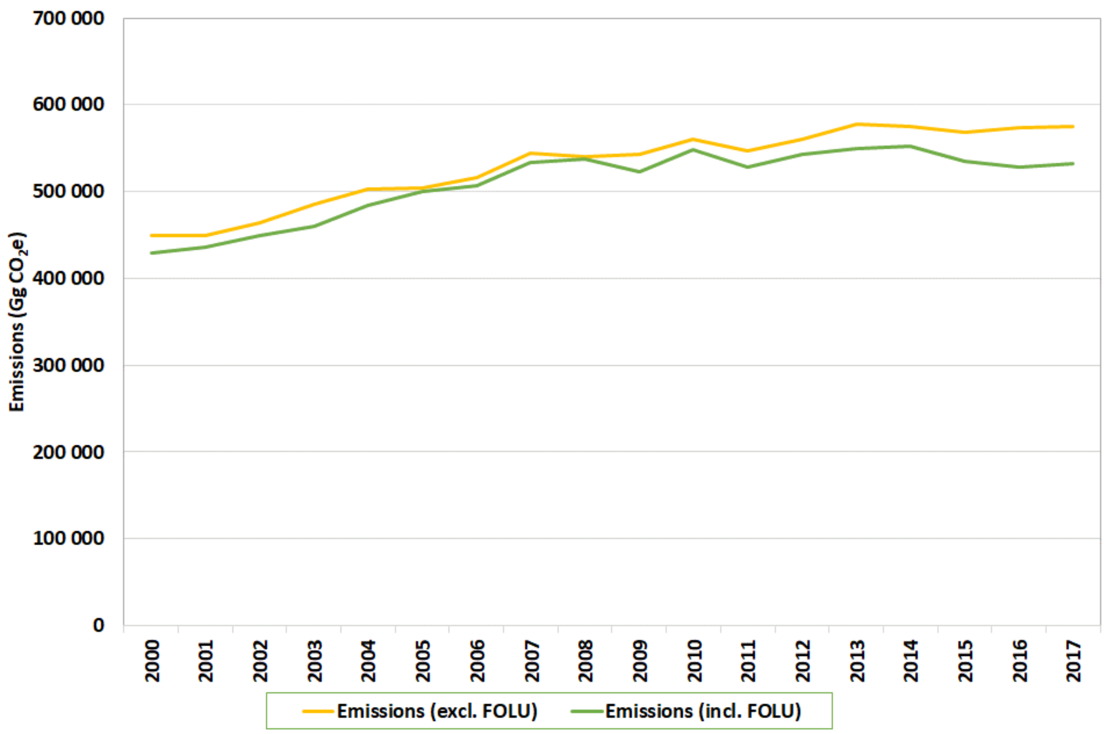


Figure 2.4: National aggregated GHG emissions (excluding and including FOLU), 2000–2017.

Table 2.4: Trends and annual change in emissions (excluding and including FOLU), 2000–2017.

	Emissions (excl. FOLU)		Emissions (incl. FOLU)	
	Gg CO_2e	Annual change (%)	Gg CO_2e	Annual change (%)
2000	449 180.8		428 652.9	
2001	448 796.9	-0.09	436 248.6	1.77
2002	464 021.1	3.39	448 800.7	2.88
2003	484 967.9	4.51	459 899.7	2.47
2004	503 189.6	3.76	484 491.3	5.35
2005	504 561.8	0.27	499 539.0	3.11
2006	515 702.9	2.21	506 393.6	1.37
2007	543 982.1	5.48	533 360.2	5.33
2008	540 463.5	-0.65	537 453.1	0.77
2009	543 008.8	0.47	523 137.2	-2.66
2010	560 530.4	3.23	547 809.6	4.72
2011	546 614.1	-2.48	527 589.1	-3.69
2012	560 322.1	2.51	542 520.3	2.83
2013	578 367.8	3.22	550 183.2	1.41
2014	575 463.6	-0.50	552 229.1	0.37
2015	568 578.1	-1.20	534 846.1	-3.15
2016	574 234.7	0.99	528 473.7	-1.19
2017	574 696.5	0.08	532 173.3	0.70

2.7.4. Emission trends by sector

Figure 2.5 and Table 2.5 show the trend in the contribution from the four sectors to the GHG emissions (excl. FOLU) in South Africa between 2000 and 2017, while Figure 2.6 shows the percentage contributed by each sector over this period.

2.7.4.1. Energy

The *Energy* sector is the largest contributor to South Africa's emissions (excl. FOLU), contributing 79.8% in 2017 (Figure 2.6). *Energy* sector emissions increased between 2000 and 2017 (Table 2.5). The main contributor to the increased *Energy* emissions is increased demand for liquid fuels in road transportation, manufacturing industries and construction, civil aviation, and the residential and commercial sectors. This increased demand for fuels is largely driven by the increase in population and economic growth.

2.7.4.2. IPPU

The *IPPU* sector contributed an average of 7.3% and 7.5% to the total emissions excluding and including FOLU, respectively, between 2000 and 2017 (Figure 2.6). In 2017 the IPPU contribution was 43 230 Gg CO_2e (Table 2.5). There has been an increasing trend in emissions from the *IPPU* sector, except for the reduced emissions during the recession. The main drivers in the *IPPU* sector are the metal industries, particularly *Iron and steel production* and *Ferroalloy production* which contributed 34.9% and 29.1% respectively to the total IPPU emissions in 2017. In addition, the HFC and PFC emissions should be monitored closely since HFC emissions have more than tripled since 2005, while PFC emissions have more than doubled since 2000. PFC emissions did increase from 2011 due to the addition of new categories (*Foam blowing agents*, *Fire protection* and *Aerosols*), but only 1.8% of the increase was accounted for by the new emissions categories.

2.7.4.3. AFOLU

The *AFOLU* sector (excl. FOLU) contributed an average of 10.3% to the total emissions (excl. FOLU) between 2000 and 2017 (Figure 2.6). The contribution has declined by 3.5% since 2000. The main driver of change in the *AFOLU* emissions (excl. FOLU) is the decrease in the livestock population. Livestock have input into the enteric fermentation, manure management, as well as direct and indirect N_2O emissions.

The *AFOLU* sector produced 51 608 Gg CO_2e (excl. FOLU) in 2017, while the emissions including FOLU were 9 085 Gg CO_2e (Table 2.5). This change is due to the increasing *Land* sink, which strengthened between 2009 and 2017. The largest contributor was the *Forest land* category. The increasing sink is due to increasing forest land area (particularly thickets and woodlands/open bush), and a decline in wood losses. There was a peak in burnt area in 2008, and then a fairly steep decline between 2014 and 2017, leading to reduction in disturbance losses. Furthermore, there was a decline is wood removals by households for lighting and cooking purposes, probably due to increased electrification, which also contributed to the reduced removals. Emissions and removals from *Grasslands* remained fairly constant, with *Land converted to grasslands* contributing the largest portion to this category. *Other lands* provide a fairly constant source of emissions as carbon is lost when land is converted to *Other lands*. The source from Other lands (16 044 Gg CO_2) is almost equal to the sink from Grasslands (18 173 Gg CO_2 in 2017).

Aggregated and non-CO_2 emissions on land contributed 45.4% to the AFOLU (excl. FOLU) emissions in 2017, and the largest contributor to this category (77.1%) is *Direct N_2O from managed soils*. Nitrogen inputs from urine and dung deposits contribute 63.3% to direct N_2O, followed by 11.9% from inorganic N inputs and 11.2% from organic N inputs.

2.7.4.4. Waste

The *Waste* sector emissions have increased from 13 558 Gg CO_2e in 2000 to 21 249 Gg CO_2e in 2017 (Table 2.5). The *Waste* sector contribution to overall emissions (excl. FOLU) has slowly increased from 3.0% in 2000 to 3.7% in 2017 (Figure 2.6). The emissions in this sector are driven mainly by population growth.

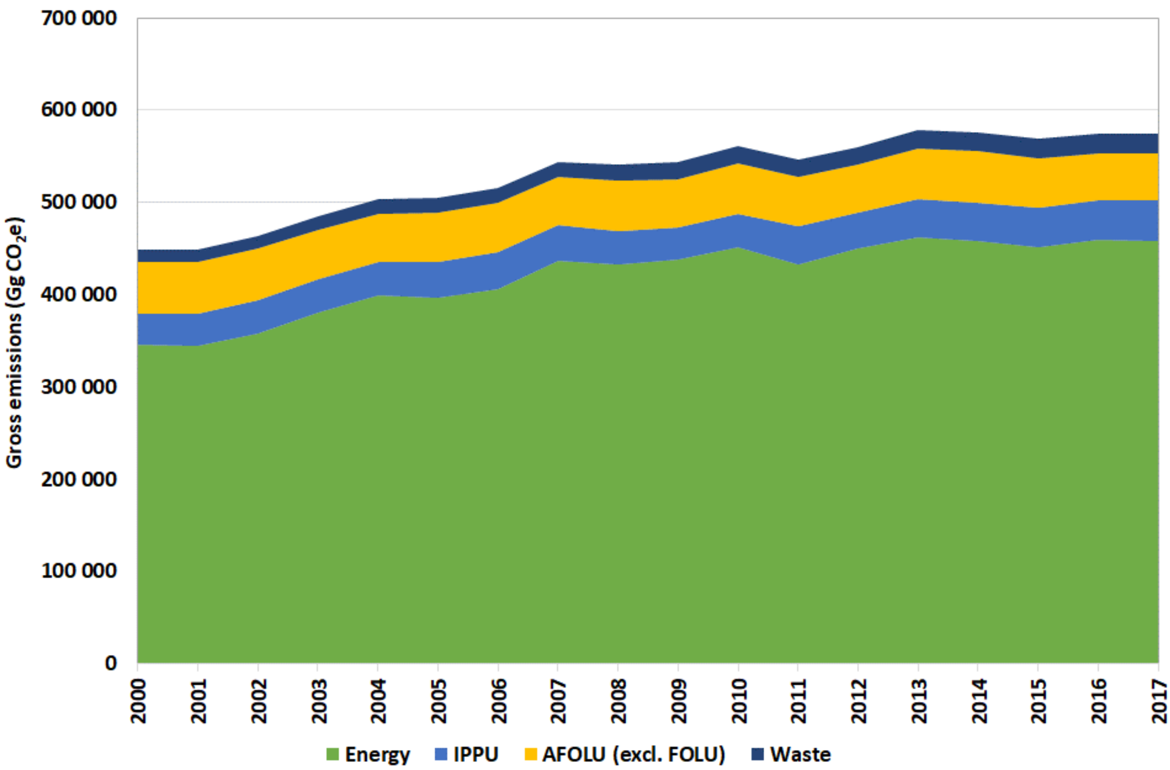


Figure 2.5: Sectoral contribution to the trend in the emissions (excl. FOLU) for South Africa, 2000–2017.

Table 2.5: Trend in sector emissions and removals by sector for 2000 to 2017.

	Energy	IPPU	AFOLU (excl. FOLU)	AFOLU (incl. FOLU)	Waste
	Emissions and removals (Gg CO_2e)				
2000	345 308.9	34 070.8	56 243.2	35 715.3	13 557.8
2001	344 564.5	34 057.4	56 123.6	43 575.3	14 051.4
2002	357 151.8	36 140.6	56 205.7	40 985.3	14 523.1
2003	380 773.1	35 606.5	53 603.5	28 535.2	14 984.9
2004	398 876.4	35 783.8	53 093.2	34 394.9	15 436.3
2005	396 353.4	39 118.2	53 211.1	48 188.3	15 879.1
2006	405 912.4	40 173.2	53 302.6	43 993.3	16 314.7
2007	436 756.9	38 222.5	52 259.4	41 637.5	16 743.3
2008	432 651.0	36 048.0	54 598.1	51 587.6	17 166.4
2009	438 078.5	34 352.0	52 996.0	33 124.4	17 582.3
2010	451 634.0	36 441.6	54 464.0	41 743.2	17 990.8
2011	433 215.0	40 227.7	54 678.2	35 653.2	18 493.2
2012	449 409.3	38 954.9	52 984.6	35 182.8	18 973.3
2013	462 066.3	41 348.8	55 559.1	27 374.5	19 393.6
2014	458 180.9	41 878.4	55 529.7	32 295.2	19 874.6
2015	451 831.5	41 882.3	54 514.1	20 782.2	20 350.2
2016	459 314.4	42 465.4	51 657.9	5 896.9	20 797.1
2017	458 609.7	43 229.5	51 608.4	9 085.2	21 249.0

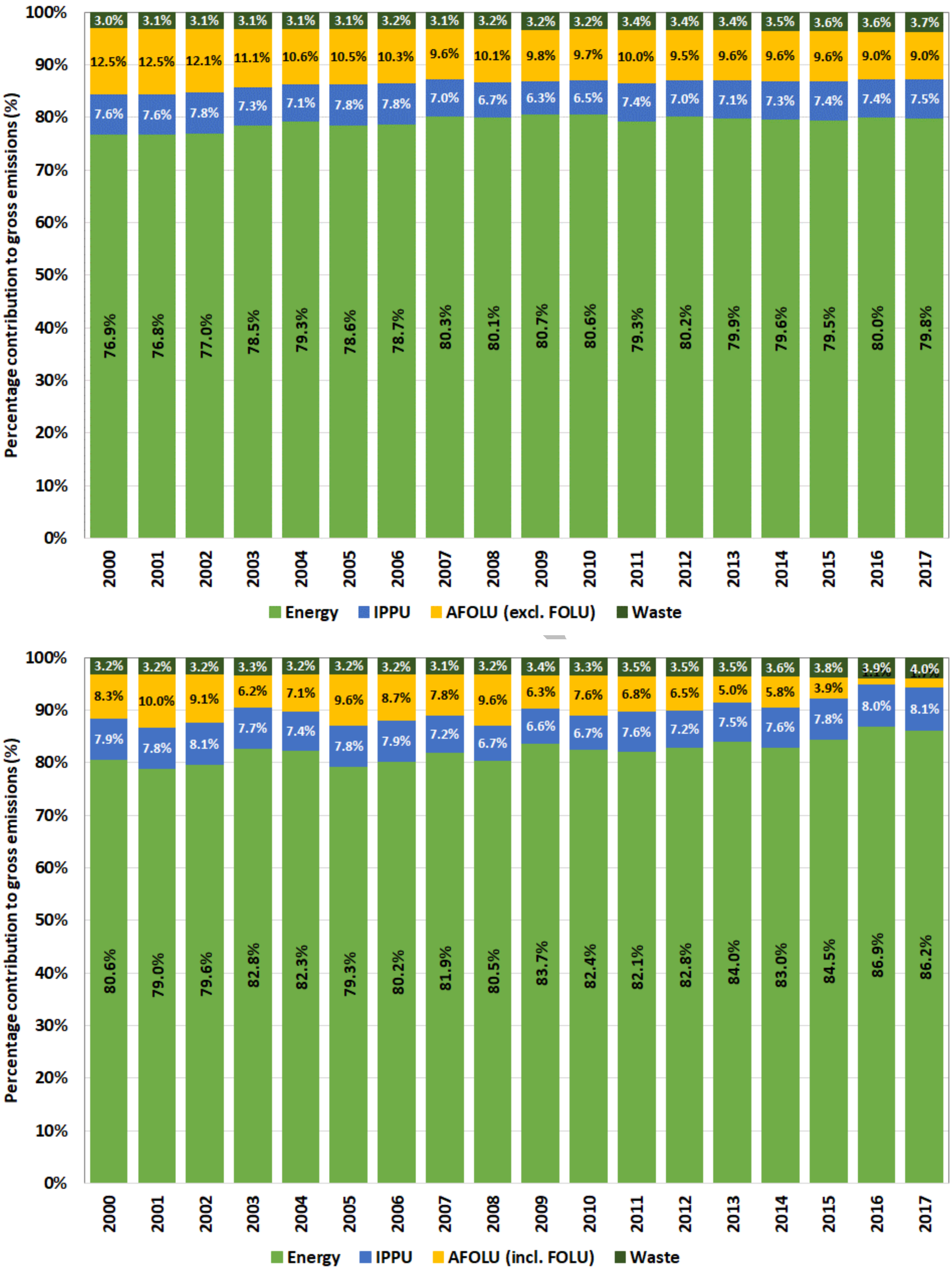
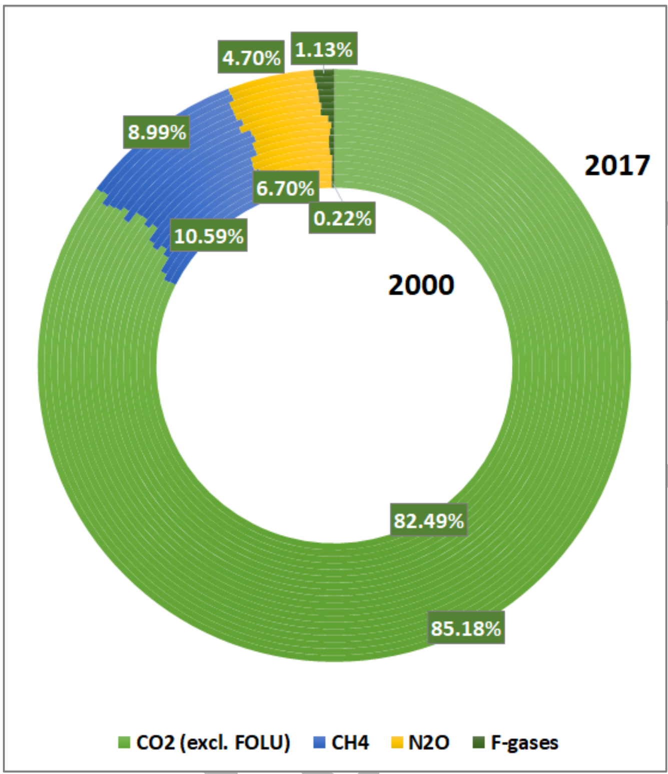


Figure 2.6: Percentage contribution of the sectors to emissions (excl. FOLU) (top) and emissions and removals (incl. FOLU) (bottom) between 2000 and 2017.

2.7.5. Emission trends by gas

CO_2 gas is the largest contributor to South Africa's emissions (Figure 2.7). This is followed by CH_4 and then N_2O. The contribution from CH_4 and N_2O generally decline from 2000 to 2017 (Table 2.6), while the contribution from CO_2 and F-gases increase. The F-gas contribution is, however, still below 1.5%.



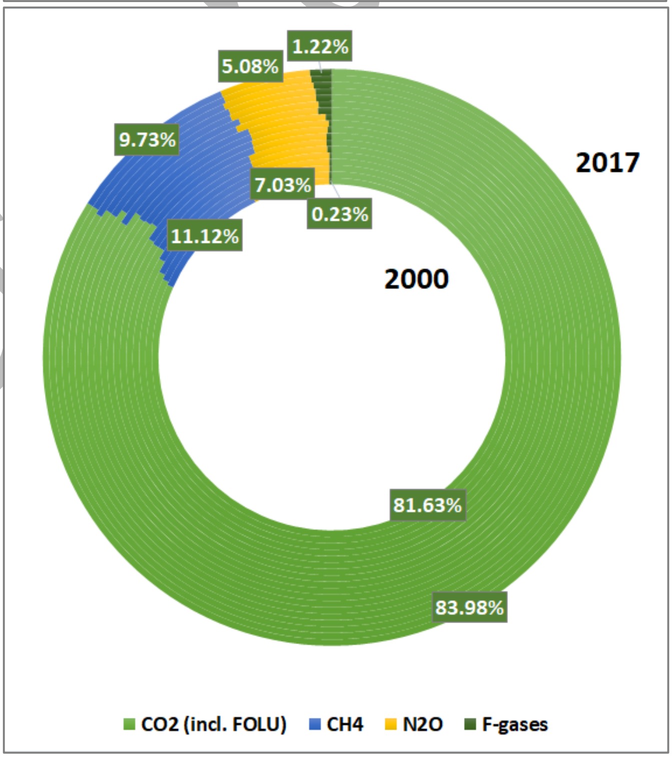


Figure 2.7: Percentage contributions from each of the gases to South Africa's emissions (excl. FOLU (top)) and incl. FOLU (bottom)) between 2000 and 2017.

Table 2.6: Trend in CO_2, CH_4, N_2O and F-gases between 2000 and 2017.

	Emissions						
	CO_2 (excl. FOLU)	CO_2 (incl. FOLU)	CH_4		N_2O		F-gases#
	Gg CO_2		Gg CO_2e	Gg CH_4	Gg CO_2e	Gg N_2O	Gg CO_2e
2000	370 550.6	349 356.1	47 573.3	2 265.4	30 073.7	97.0	983.2
2001	369 945.4	356 730.5	48 043.6	2 287.8	29 800.2	96.1	1 007.7
2002	384 809.9	368 922.9	48 050.0	2 288.1	30 264.1	97.6	897.1
2003	408 203.7	382 468.8	47 499.6	2 261.9	28 368.4	91.5	896.2
2004	425 966.4	406 601.4	47 853.3	2 278.7	28 480.6	91.9	889.4
2005	424 858.7	419 169.4	48 578.1	2 313.2	29 411.6	94.9	1 713.4
2006	435 635.5	425 659.6	48 610.3	2 314.8	29 476.2	95.1	1 980.9
2007	465 200.6	453 912.1	48 406.8	2 305.1	28 340.6	91.4	2 034.1
2008	460 288.7	456 611.6	49 834.3	2 373.1	28 767.0	92.8	1 573.6
2009	464 493.6	443 955.4	49 480.3	2 356.2	27 934.7	90.1	1 100.3
2010	479 181.8	465 794.4	50 798.1	2 419.0	28 346.7	91.4	2 203.7
2011	462 803.2	443 111.6	50 760.9	2 417.2	28 364.7	91.5	4 685.2
2012	477 710.6	459 242.1	50 535.5	2 406.5	27 569.3	88.9	4 506.8
2013	491 494.0	462 642.8	52 098.4	2 480.9	29 477.0	95.1	5 298.4
2014	488 434.1	464 533.0	52 426.0	2 496.5	29 254.4	94.4	5 349.1
2015	481 680.5	447 281.9	52 491.4	2 499.6	28 738.0	92.7	5 668.2
2016	489 656.1	443 228.5	51 493.0	2 452.0	26 934.5	86.9	6 151.1
2017	489 546.1	446 356.3	51 693.3	2 461.6	26 989.2	87.1	6 467.9

 # The equivalent Gg emissions per type of PFC and HFC are provided in Table 2.8.

2.7.5.1. Carbon dioxide

The CO_2 emissions totalled 489 946 Gg CO_2 (excl. FOLU) and 446 356 Gg CO_2 (incl. FOLU) in 2017 (Table 2.6). Figure 2.8 presents the contribution of the main sectors to the trend in national CO_2 emissions (excl. FOLU). Since CO_2 is the largest contributor to national emissions the CO_2 emission trend follows that of the overall emission trend. The *Energy* sector is by far the largest contributor to CO_2 emissions in South Africa, contributing an average of 92.0% between 2000 and 2017, and 92.2% in 2017. The categories *1A1 energy industries* (56.9%), *1A3 Transport* (16.9%) and *1A4 Other sectors* (11.8%) were the major contributors to the *Energy* CO_2 emissions in 2017. The *IPPU* sector contributed an average of 7.7% between 2000 and 2017, while the *AFOLU* sector (excl. FOLU) contributed an average of 0.3%.

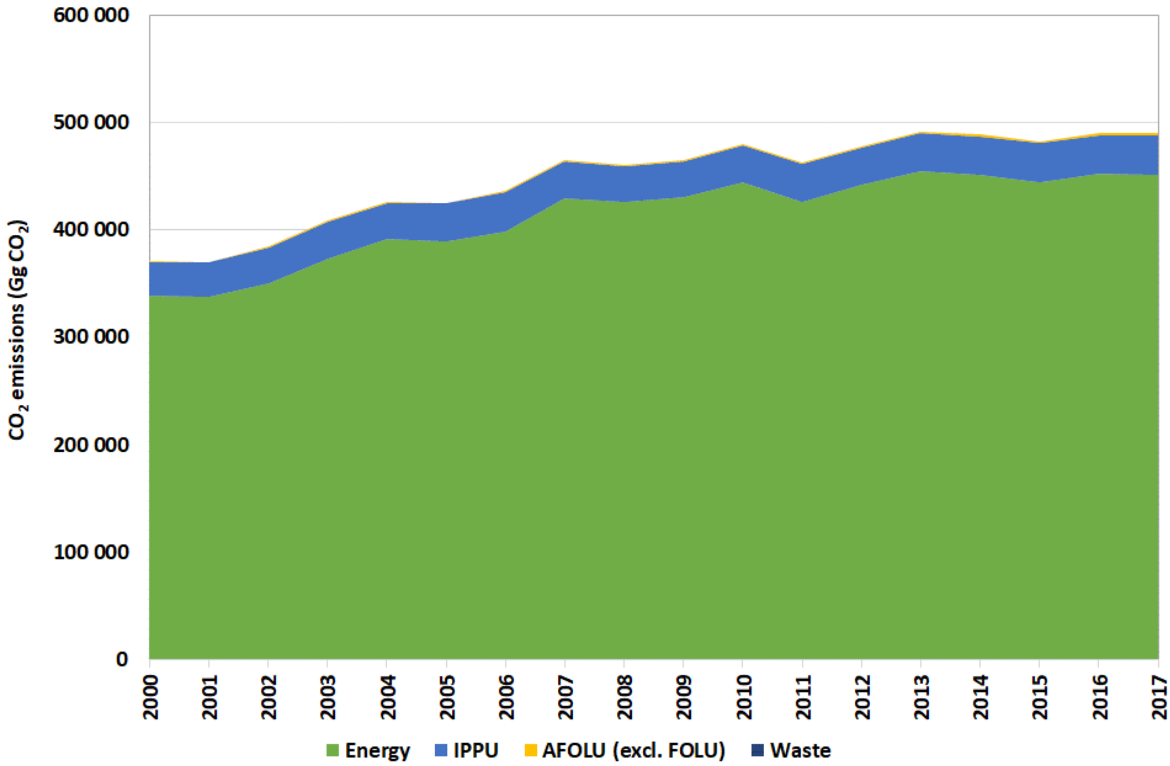


Figure 2.8: Trend and sectoral contribution to CO_2 emissions (excl. FOLU), 2000–2017.

2.7.5.2. Methane

The sector contributions to the total CH_4 emissions in South Africa are shown in Figure 2.9. National CH_4 emissions increased from 47 573 Gg CO_2e in 2000 to 51 693 Gg CO_2e in 2017 (Table 2.6). The *AFOLU livestock* category and *Waste* sectors were the major contributors, providing 51.9% and 39.4%, respectively, to the total CH_4 emissions in 2017. The contribution from *livestock* declined by 11.0% (due to a decline in livestock populations), while the contribution from the *Waste* sector increased by 12.2% over the period 2000 to 2017.

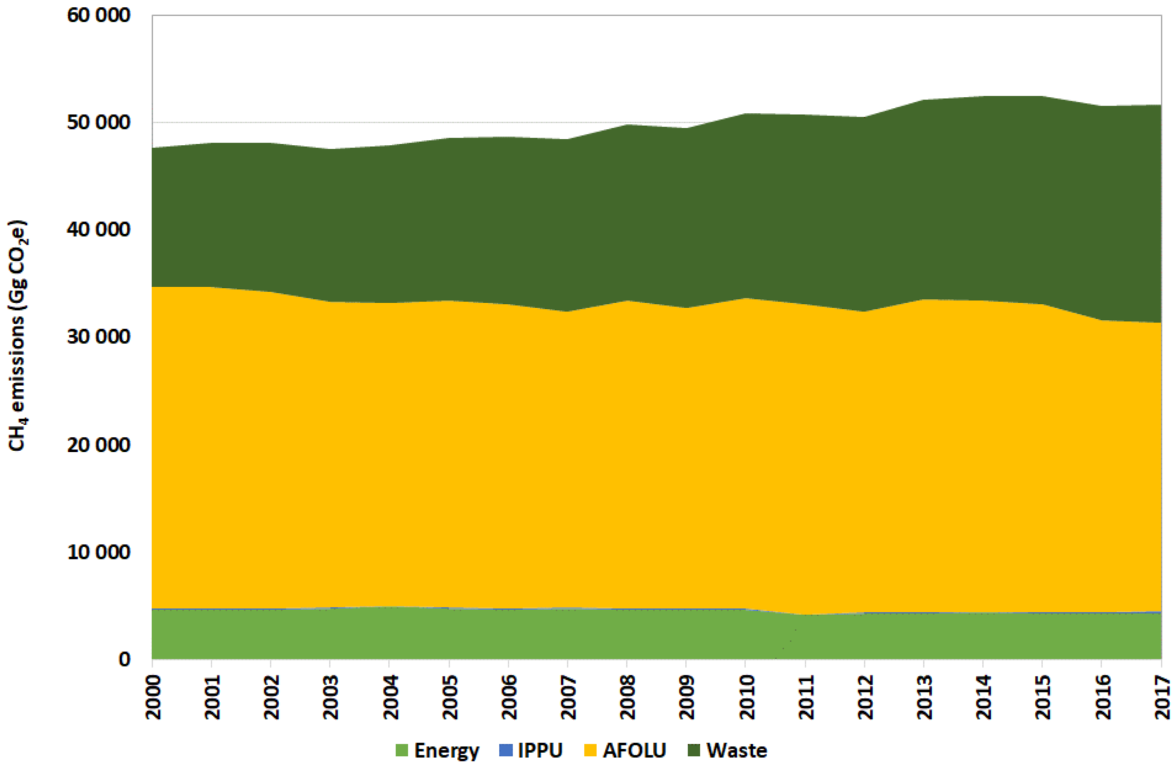


Figure 2.9: Trend and sectoral contribution to the CH_4 emissions, 2000–2017.

2.7.5.3. Nitrous oxide

Figure 2.10 shows the contribution from the major sectors to the national N_2O emissions in South Africa. The emissions declined by 10.3% over the 2000 to 2017 period from 30 074 Gg CO_2e to 26 989 Gg CO_2e (Table 2.6). The main contributors are the *AFOLU* (84.8%) and *Energy* (11.1%) sectors (Figure 2.10). The categories 3C *Aggregated and non-CO_2 sources on land* (which includes emissions from managed soils and biomass burning) and 1A *Fuel combustion activities* are the main contributors to N_2O. Livestock manure, urine and dung inputs to managed soils provided the largest N_2O contribution in the *AFOLU* sector, therefore, the trend follows a similar pattern to the livestock population. N_2O emissions from *IPPU* declined by 82.2% between 2000 and 2017. This is attributed to declines in N_2O emissions from *Nitric Acid production*. The Nitric Acid industry implemented Cleaner Development Mechanism (CDM) projects through the adoption of the latest N_2O emission reduction technologies.

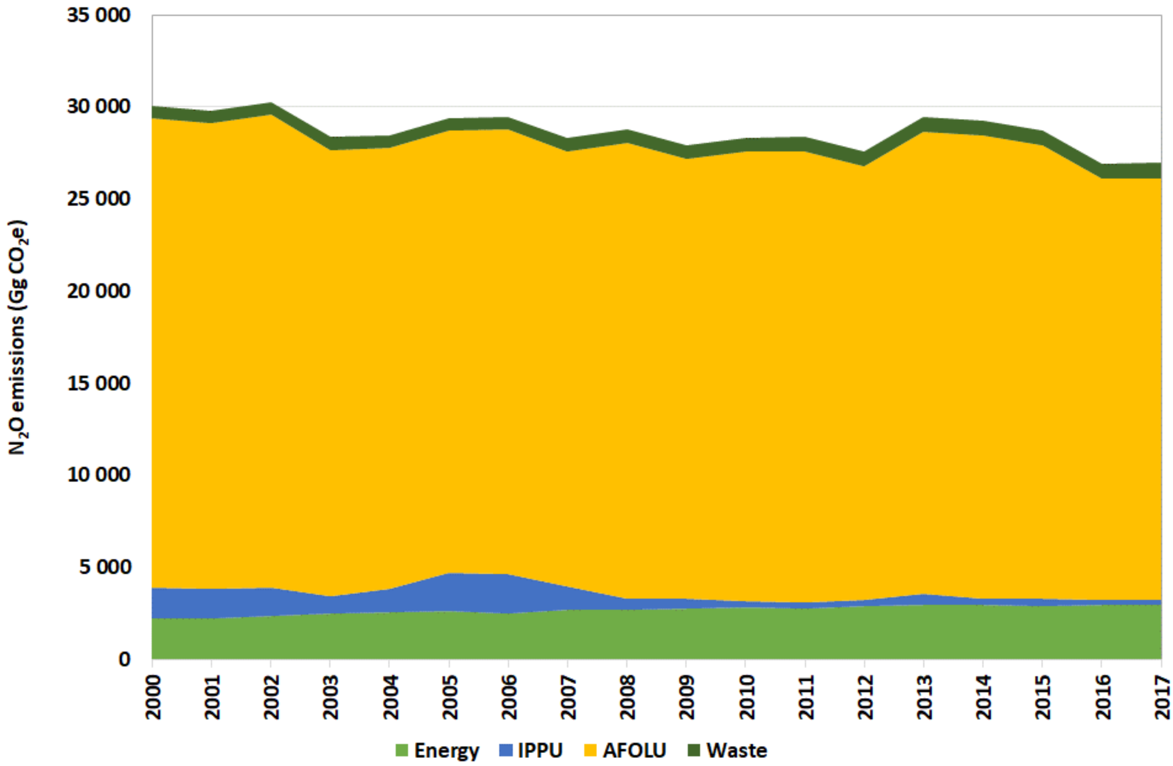


Figure 2.10: Trend and sectoral contribution to N_2O emissions in South Africa, 2000–2017.

2.7.5.4. F-gases

Estimates of hydrofluorocarbon (HFC) and perfluorocarbon (PFC) emissions were only estimated for the *IPPU* sector in South Africa. F-gas emission estimates varied annually (Table 2.6, Figure 2.11) and contributed 1.3% to overall emissions in 2017. Emissions increase from 2011 due to the addition of HFC emissions from *air conditioning*, *foam blowing agents*, *fire protection* and *aerosols* (Figure 2.11). There is no data prior to 2005 so this time-series is not consistent. The elevated F-gas emissions are, therefore, not necessarily due to an increase in emissions but rather due to the incorporation of new categories.

PFC emissions were estimated at 983 Gg CO_2e in 2000 and remained fairly constant to 2007 (971 Gg CO_2e), then declined to 108 Gg CO_2e in 2009 and increased again to 2 453 Gg CO_2e in 2017. There is a sharp decline in emissions from the *Metal industry* between 2006 and 2009 and this is attributed to reduced production caused by electricity supply challenges and decreased demand following the economic crisis that occurred during 2008/2009. Increases in 2011 and 2012 were due to increased emissions from aluminium plants due to inefficient operations. The industry was used to assist with the rotational electricity load shedding in the country at the time, which necessitated switching on and off at short notice leading to large emissions of C_2F_4 and CF_4. CF_4 emissions contribute the most to the PFC emissions (Table 2.7).

HFCs increased from 842 Gg CO_2e in 2005 to 4 015 Gg CO_2e in 2017, and the largest contributor is HFC-134a (Table 2.7).

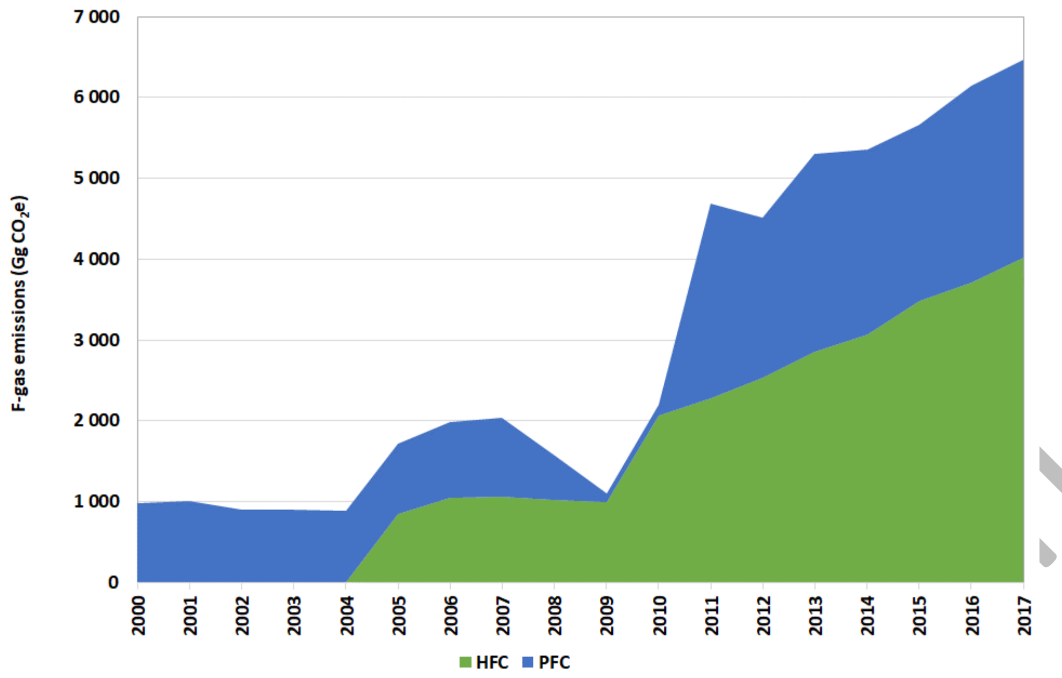


Figure 2.11: Trend in F-gas emissions in South Africa, 2000–2017.

Table 2.7: Trends in PFC and HFC emissions (Gg) by gas type.

	CF_4	C_2F_6	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-143a	HFC-227ea	HFC-365mfc
	(Mg)									
SAR GWP	**6 500**	**9200**	**11 700**	**650**	**2 800**	**1 300**	**140**	**3 800**	**2 900**	**890**
2000	133.00	12.90	NE	NE	NE	NE	NE	NE	NE	NE
2001	136.20	13.30	NE	NE	NE	NE	NE	NE	NE	NE
2002	121.60	11.60	NE	NE	NE	NE	NE	NE	NE	NE
2003	121.60	11.50	NE	NE	NE	NE	NE	NE	NE	NE
2004	120.70	11.40	NE	NE	NE	NE	NE	NE	NE	NE
2005	118.10	11.30	0.50	0.00	0.00	643.00	0.00	0.00	0.00	0.00
2006	126.80	12.10	4.00	0.00	39.20	442.00	100.00	79.00	0.00	0.00
2007	131.50	12.60	0.00	0.00	12.30	750.00	0.00	14.20	0.00	0.00
2008	74.20	7.10	2.30	0.00	3.80	696.00	0.00	22.00	0.00	0.00
2009	14.10	1.80	0.00	0.00	1.00	744.00	0.00	5.80	0.00	0.00
2010	18.10	2.20	0.80	0.00	13.10	1 423.00	0.00	44.70	0.00	0.00
2011	324.90	32.50	0.06	7.43	38.03	1 464.62	0.00	61.17	8.32	1.99
2012	266.70	26.70	0.09	9.76	49.63	1 587.60	0.00	76.10	9.12	1.91
2013	329.58	33.00	0.23	13.85	66.06	1 730.01	0.00	98.74	10.68	0.85
2014	307.70	30.80	0.37	20.47	88.07	1 786.28	0.00	116.62	12.36	0.25
2015	294.58	29.49	0.26	27.02	111.03	1 935.18	0.00	155.72	14.58	0.95
2016	328.25	32.86	0.41	30.68	126.48	2 045.52	0.00	171.19	15.88	0.95
2017	330.60	33.10	0.47	35.66	145.21	2 160.75	0.00	194.47	17.48	0.95

2.7.6. Trends in indirect GHG emissions

The trends in emissions of carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs) are shown in Table 2.8. These emissions were estimated for biomass burning only. Emissions of these indirect gases from other categories have not yet been estimated due to a lack of data but have been included on the improvement list for future inventories.

Table 2.8: Trends in indirect GHG emissions between 2000 and 2017.

	NOx	CO	NMVOC
	(Gg)		
2000	65.8	1 395.5	62.2
2001	76.3	1 579.9	71.3
2002	75.9	1 610.5	72.4
2003	56.9	1 242.5	57.7
2004	53.3	1 143.1	53.8
2005	83.4	1 774.9	77.9
2006	75.2	1 618.8	70.9
2007	69.1	1 557.5	79.1
2008	71.0	1 573.1	82.0
2009	63.1	1 346.7	61.6
2010	63.3	1 383.6	66.2
2011	62.0	1 343.1	63.8
2012	53.2	1 183.0	61.2
2013	55.7	1 196.6	58.2
2014	54.9	1 176.2	55.1
2015	39.2	841.5	41.0
2016	22.0	511.5	29.1
2017	21.1	487.8	27.2

2.7.7. Key categories

A key category is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals (IPCC, 2006). There are two approaches which can be used to determine the key categories, namely, the level approach and the trend approach. The former is used if only one year of data is available, while the latter can be used if there are two comparable years. The level assessment determines the contribution from the categories to the total national inventory. The trend assessment identifies categories that may not be large enough to be identified by the level assessment, but whose trend is significantly different from the trend of the overall inventory and should therefore receive particular attention. The trend can be an increase or a decrease in emissions. This inventory provides emissions for more than one year; therefore, both the level and trend assessments for key category analysis were performed.

The key categories have been assessed using the Approach 1 level (L1) and Approach 1 trend (T1) methodologies from the 2006 IPCC Guidelines (IPCC, 2006). The key category analysis identifies key categories of emissions and removals as those that sum to 95% of the total emissions excluding or including FOLU, i.e. the categories that together contribute to 95% of the emissions.

Identifying key categories allows resources to be allocated to the appropriate activities so as to improve those specific subcategory emissions in future submissions. The key categories identified in 2017 are summarised in Table 2.9 and Table 2.10. In accordance with the 2006 IPCC Guidelines, the key category analysis is performed once for the inventory excluding the FOLU sector and then repeated for the inventory including the FOLU sector. In this submission the emission estimates in the *Energy* sector were split by fuel type (i.e. solid, liquid or gas) as well as by gas type, as suggested by the IPCC, and these are reflected in the key category outputs. The full key category analysis is provided in Annex A2. It should be noted that HFC and PFC emissions from *Product uses as substitute ODS* are not included in the trend assessment due to the fact that there was no data for the initial year, 2000.

In the level assessment *Electricity and heat production* still remains the key category, contributing 38.1% and 33.5% to total emissions excluding and including FOLU, respectively (Table 2.9). This is similar to its contribution in the previous submission. *Road transport* was the second key category with a contribution of 10.7% to emissions (incl. FOLU), which is a 2.8% increase on the previous submission. With the trend assessment *Road transport* took the top position ahead of *Residential* and contributed 17.3% and 15.3% to the trend including and excluding FOLU, respectively (Table 2.10).

Table 2.9: Top ten key categories for South Africa for 2017 (excluding and including FOLU) determined by level (L1) assessment.

Key category number	IPCC code	IPCC category	GHG	2017 Emissions (Gg CO_2e)	% Contribution
Emissions excluding FOLU - Level assessment (2017)					
1	1A1a	Electricity and Heat Production (Solid fuel)	CO_2	218 959.2	38.10
2	1A3b	Road Transport (Liquid fuel)	CO_2	69 816.6	12.15
3	1A2	Manufacturing Industries and Construction (Solid fuel)	CO_2	31 855.1	5.54
4	1A1c	Manufacture of Solid Fuels and Other Energy Industries (Solid fuel)	CO_2	29 270.6	5.09
5	1A4b	Residential (Solid fuel)	CO_2	28 337.4	4.93
6	1B3	Other Emissions from Energy Production	CO_2	25 746.5	4.48
7	3A1a	Enteric Fermentation – Cattle	CH_4	21 589.7	3.76
8	3C4	Direct N_2O Emissions from Managed Soils	N_2O	18 081.0	3.15
9	4A	Solid Waste Disposal	CH_4	17 366.0	3.02
10	1A4a	Commercial/Institutional (Liquid fuel)	CO_2	16 176.0	2.81
Emissions including FOLU - Level assessment (2017)					
1	1A1a	Electricity and Heat Production (Solid fuel)	CO_2	218 959.2	33.54
2	1A3b	Road Transport (Liquid fuel)	CO_2	48 618.7	10.69
3	1A2	Manufacturing Industries and Construction (Solid fuel)	CO_2	31 855.1	4.88

4	1A1c	Manufacture of Solid Fuels and Other Energy Industries (Solid fuel)	CO_2	29 270.6	4.48
5	1A4b	Residential (Solid fuel)	CO_2	28 337.4	4.34
6	3B1b	Land Converted to Forest Land[a]	CO_2	-26 613.8	4.08
7	1B3	Other Emissions from Energy Production	CO_2	25 746.5	3.94
8	3A1a	Enteric Fermentation – Cattle	CH_4	21 589.7	3.31
9	3C4	Direct N_2O Emissions from Managed Soils	N_2O	18 081.0	2.77
10	3B3b	Land Converted to Grassland	CO_2	-17 662.3	2.71

[a] *For forest land it is the biomass carbon pool that is the key category.*

Table 2.10: Top ten key categories contributing to the trend in emissions in South Africa between 2000 and 2017 (excluding and including FOLU) as determined by trend (T1) assessment.

Key category number	IPCC code	IPCC category	GHG	Emissions ($Gg\ CO_2e$)		% Contribution
				2000	2017	
Emissions excluding FOLU - Trend assessment (2000 - 2015)						
1	1A3b	Road Transport (Liquid fuel)	CO_2	34 053.1	69 816.6	17.26
2	1A4b	Residential (Solid fuel)	CO_2	3 604.2	28 337.4	15.60
3	1A1a	Electricity and Heat Production (Solid fuel)	CO_2	185 027.4	218 959.2	11.69
4	1B3	Other Emissions from Energy Production	CO_2	28 146.6	25 746.5	6.75
5	1A1c	Manufacture of Solid Fuels and Other Energy Industries (Solid fuel)	CO_2	30 454.7	29 270.6	6.38
6	3A1a	Enteric Fermentation – Cattle	CH_4	23 344.7	21 589.7	5.44
7	3C4	Direct N_2O Emissions from Managed Soils	N_2O	20 072.5	18 081.0	5.00
8	1A4a	Commercial/Institutional (Liquid fuel)	CO_2	7 690.5	16 176.0	4.17
9	2C1	Iron and Steel Production	CO_2	16 410.5	15 074.3	3.89
10	1A2	Manufacturing Industries and Construction (Solid fuel)	CO_2	29 509.4	31 855.1	3.88
Emissions including FOLU - Trend assessment (2000 - 2017)						
1	1A3b	Road Transport (Liquid fuel)	CO_2	34 053.1	69 816.6	15.34
2	1A4b	Residential (Solid fuel)	CO_2	3 604.2	28 337.4	13.29
3	3B1a	Forest Land Remaining Forest Land[a]	CO_2	1 633.2	-14 093.6	8.98
4	3B1b	Land Converted to Forest Land[a]	CO_2	-20 846.1	-26 613.8	6.02
5	1A1a	Electricity and Heat Production (Solid fuel)	CO_2	185 027.4	218 959.2	5.99
6	1B3	Other Emissions from Energy Production	CO_2	28 146.6	25 746.5	5.12
7	1A1c	Manufacture of Solid Fuels and Other Energy Industries (Solid fuel)	CO_2	30 454.7	29 270.6	4.76
8	3A1a	Enteric Fermentation – Cattle	CH_4	23 344.7	21 589.7	4.12
9	3C4	Direct N_2O Emissions from Managed Soils	N_2O	20 072.5	18 081.0	3.81
10	1A4a	Commercial/Institutional (Liquid fuel)	CO_2	7 690.5	16 176.0	3.69

[a] *For forest land it is the biomass carbon pool that is the key category.*

2.7.7.1. Key category changes since BUR3

In the level assessment of emissions (excl. FOLU) there are two new key categories in this submission which are *Aluminium production* (PFCs) and *Indirect N_2O from managed soils* (N_2O). These categories are at the bottom of the key category list, just above *Petroleum refining*. These two categories are, however, included in the key categories for level assessment of emissions (incl. FOLU). Analysing the difference in contribution of each category to the current submission and the 2015 submission, *Road transport* increased its contribution by 3.5% and *Electricity and heat production* reduced its contribution by 2.5% (Figure 2.12). The increase in *Road transport* emissions could be due to the updated values based on VKT data. The *Commercial/institutional* category appears to have moved down the list slightly, however, in this submission emissions were divided by fuel type (i.e. solid, liquid or gas) which was not done in 2015 so this could be the reason. The top five key categories remain unchanged.

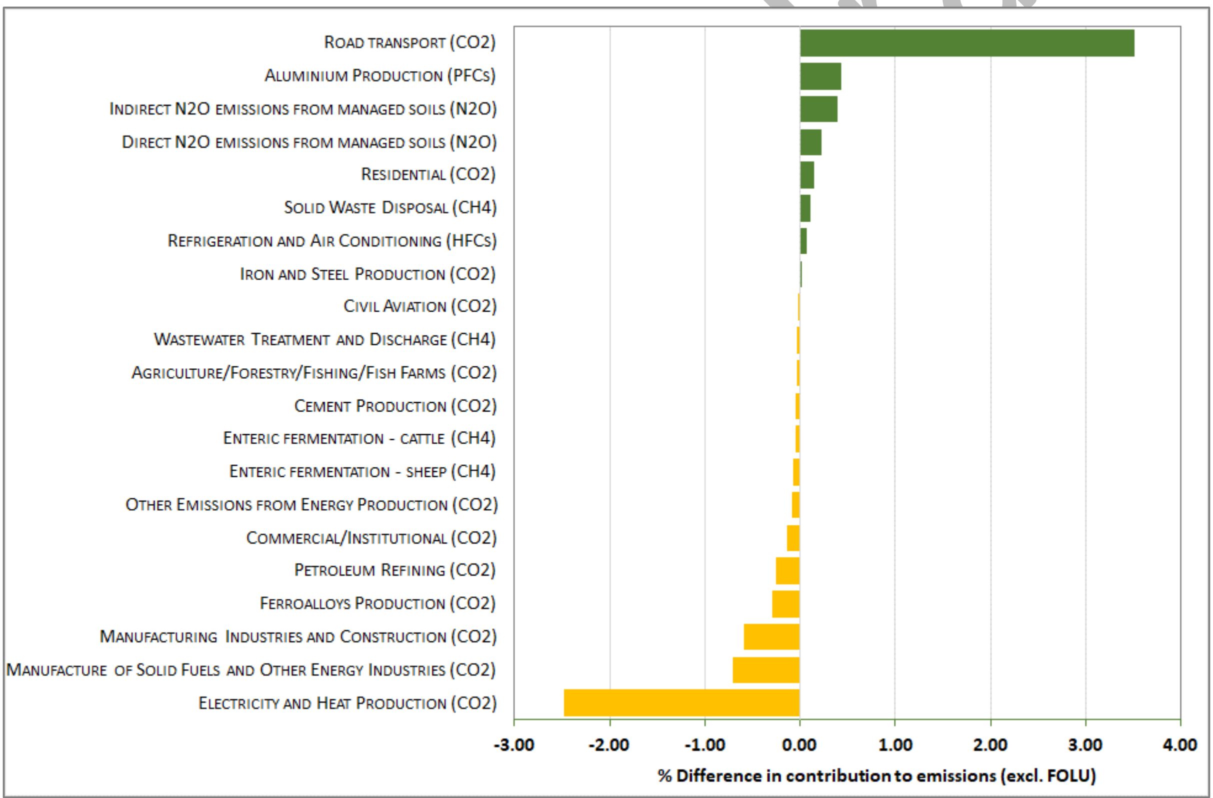


Figure 2.12: Difference in contribution to the level assessment (excl. FOLU) key category analysis between the current submission and the 2015 submission.

In the level assessment of emissions (incl. FOLU) there was one additional key category, namely *Land converted to grasslands* (CO_2) (Figure 2.13). Several updates were made to the *AFOLU* sector which has led this category to be the tenth key category in this list. Otherwise all the rest of the key categories remain, with the top five key categories maintaining the same sequence and other categories showing some movement. The main movements were *Commercial/institutional* CO_2 emissions moving down the list (as mentioned this maybe be due to splitting of fuel types), along with *Land converted to croplands* (CO_2). *Land converted to other lands* has moved up the level key category list from 25th position to 13th position. The categories *Grassland remaining grassland* and *Land converted to settlements* were identified as key categories in 2015 but these are not included in 2017.

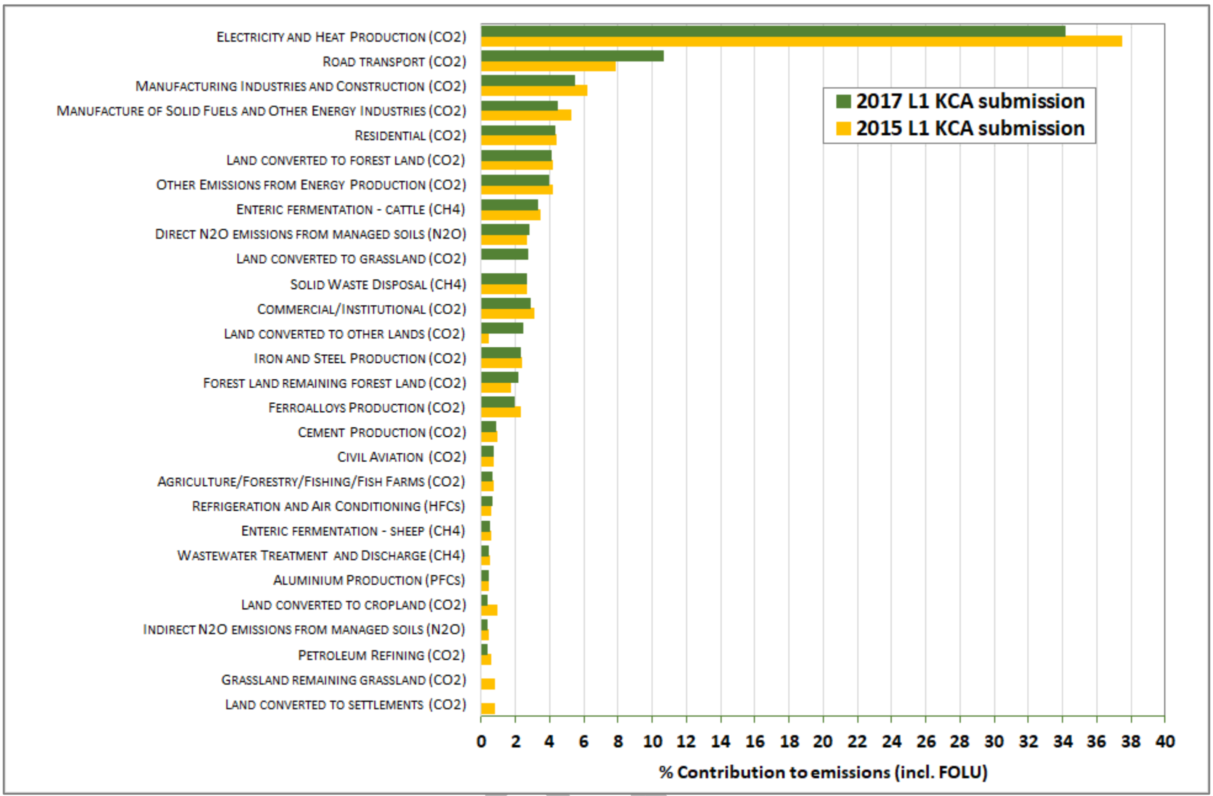


Figure 2.13: Comparison of level assessment key categories and their contribution to emissions (incl. FOLU) in the current and previous 2015 submission.

With the trend analysis on emissions (excl. FOLU) the *Cement industry* was previously identified but was no longer on the key category list in this submission. This submission identified three new key categories, namely, *Liming*, *Chemical industry* and *Biomass burning in grasslands*. Most importantly, the *Residential* category was identified as the top key category, but this has now been replaced by *Road transport*. The *Residential* contribution declined by 3.3%, while *Road transport* increased its contribution by 10.4% (Figure 2.14). *Electricity and heat production* also increased its contribution, while *Solid waste disposal* (CH_4), *Other emissions from energy production* and *Other sectors* (which includes residential and commercial/institutional) all showed a reduction in their contribution compared to the previous submission.

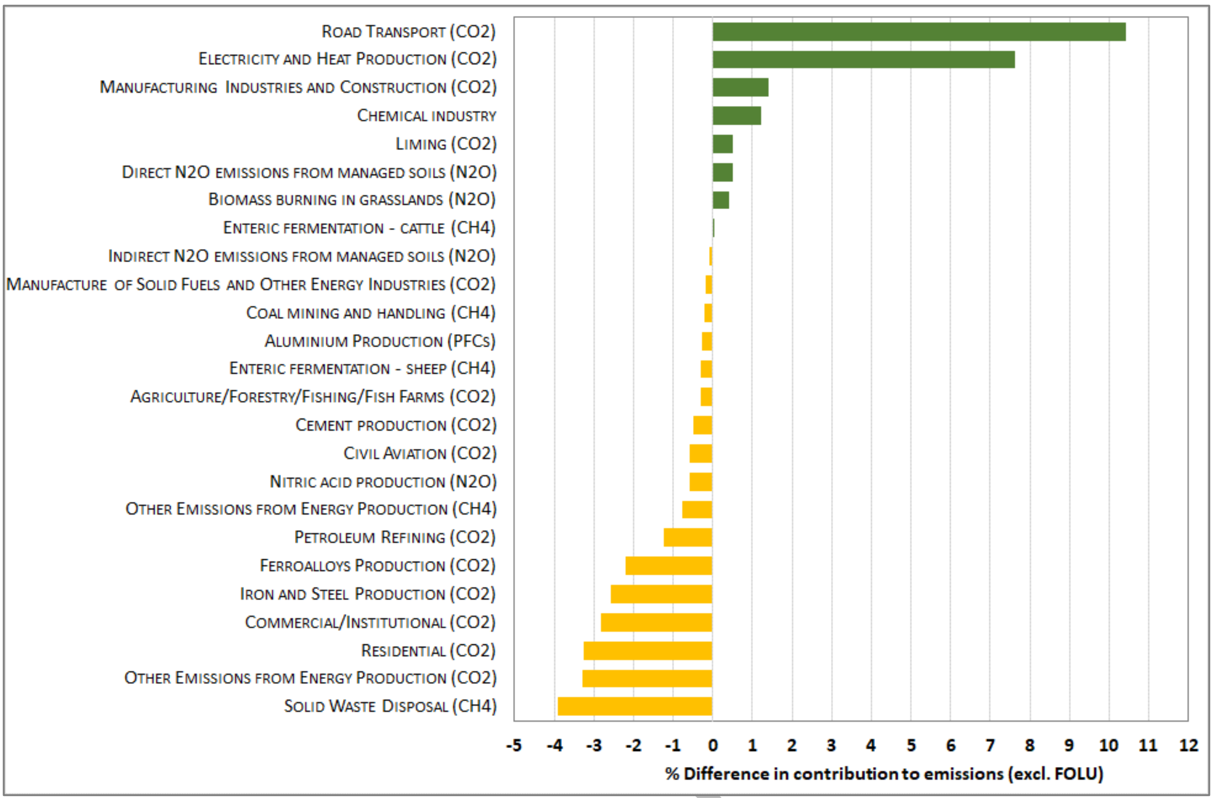


Figure 2.14: Difference in contribution to the trend assessment (excl. FOLU) key category analysis between the current submission and the 2015 submission.

Including FOLU in the trend analysis led to the removal of the categories *Grassland remaining grassland*, *Land converted to settlements*, *Nitric Acid production* and *Cement productions* from the key category list (Figure 2.15). These were replaced by *Chemical industry*, *Indirect N_2O from managed soils*, *Liming*, *Cropland remaining cropland*, *Biomass burning in grasslands* and *Harvested wood products*. In the 2015 submission *Land converted to forest land* was identified as the third key category and *Forest land remaining forest land* as the fourth, but in this submission, these have swapped around due to the 20-year transition correction. For similar reasons there are several changes in the order and contribution from the various land categories.

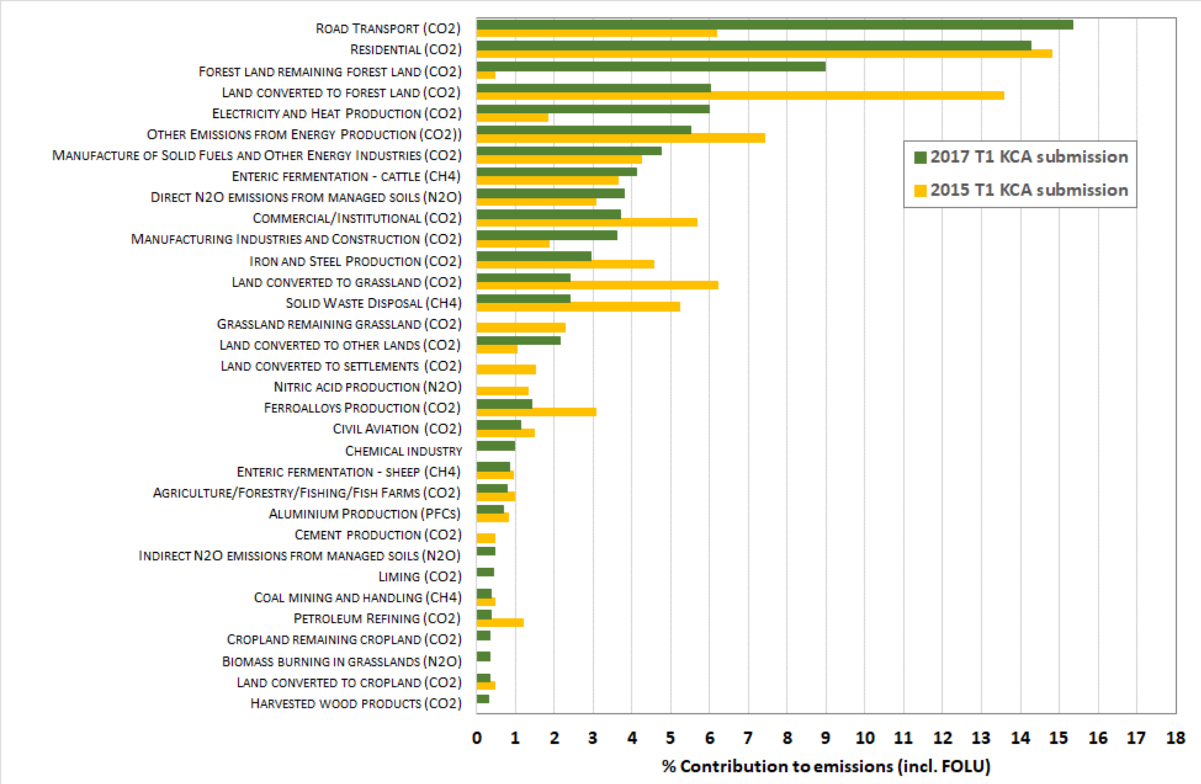


Figure 2.15: Comparison of trend assessment key categories and their contribution to emissions (incl. FOLU) in the current and previous 2015 submission.

2.7.8. Uncertainty Analysis

Uncertainty analysis is regarded by the IPPC Guidelines as an essential element of any complete inventory. Uncertainty is inherent within any kind of estimation and arises from the limitations of the measuring instruments, sampling processes and model complexities and assumptions. The reporting of uncertainties requires a complete understanding of the processes of compiling the inventory, so that potential sources of inaccuracy can be qualified and possibly quantified. Managing these uncertainties, and reducing them over time, is recognised by IPCC 2006 as an important element of inventory preparation and development.

South Africa has conducted uncertainty analysis across the sectors of *Energy*, *IPPU*, *AFOLU* and *Waste.* Progress has been made since the last submission, as previously the uncertainty was only included for the *Energy* and *IPPU* sectors.

Emission estimate uncertainties typically are low for CO_2 from energy consumption as well as from some industrial process emissions. Uncertainty surrounding estimates of emissions are higher for AFOLU and synthetic gases. Uncertainty ranges for the various sectors (Annex A3) are largely consistent with typical uncertainty ranges expected for each sector (IPCC, 2014).

The IPCC good practice tier 1 (Approach 1) method was used to determine the overall aggregated uncertainty on South Africa's inventory estimate for 2017. The analysis (Annex A3) shows that the overall uncertainty on the 2017 estimate is 9.8%, while the uncertainty in the emission trend is estimated at 8.23%. If FOLU is excluded, then the overall uncertainty is reduced to 8.76% with the uncertainty on trend being 7.61%.

2.7.9. Recalculations and their impact

Due to updates and improvements discussed in section 2.2.1.1. recalculations were undertaken. Recalculations for the entire time series lead to an increase in the emission estimates (Figure 2.16). Comparing the emission estimates for 2015, there was a 5.13% (27 724 Gg CO_2e) and a 4.38% (22 463 Gg CO_2e) increase in the emissions excluding and including FOLU, respectively (Table 2.11). This increase was due to a 5.1%, 10.1% and 4.2% increase in recalculated emissions in the *Energy*, *AFOLU* (excl. FOLU) and *Waste* sectors, respectively. There was a 21.9% increase in the *Land* sink in 2015, hence the smaller increase in emission estimates including FOLU.

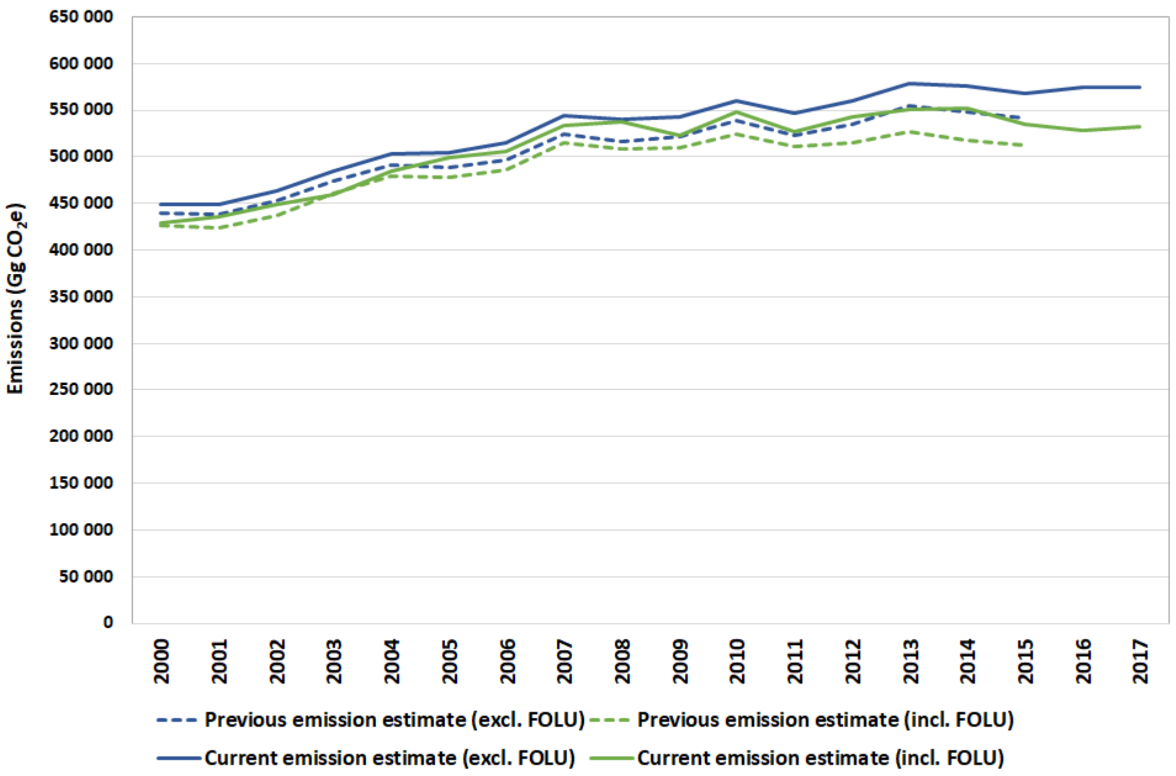


Figure 2.16: Impact of 2017 recalculations on the emission estimates.

Table 2.11: Current and previous emission estimates across the time-series and the impact of recalculations.

	Total emissions (excl. FOLU)			Total emissions (incl. FOLU)		
	Previous submission	Current submission	Difference	Previous submission	Current submission	Difference
	(Gg CO_2e)		(%)	(Gg CO_2e)		(%)
2000	439 237.9	449 180.8	2.26	426 213.9	428 652.9	0.57
2001	438 167.5	448 796.9	2.43	423 800.0	436 248.6	2.94
2002	452 260.9	464 021.1	2.60	436 968.8	448 800.7	2.71
2003	473 942.1	484 967.9	2.33	460 781.2	459 899.7	-0.19
2004	490 972.2	503 189.6	2.49	479 410.2	484 491.3	1.06
2005	488 656.5	504 561.8	3.25	477 796.6	499 539.0	4.55
2006	496 908.3	515 702.9	3.78	485 908.7	506 393.6	4.22
2007	523 801.9	543 982.1	3.85	514 472.5	533 360.2	3.67
2008	516 256.1	540 463.5	4.69	508 699.4	537 453.1	5.65
2009	521 245.7	543 008.8	4.18	510 168.2	523 137.2	2.54
2010	538 778.1	560 530.4	4.04	524 296.5	547 809.6	4.48
2011	522 861.4	546 614.1	4.54	511 376.8	527 589.1	3.17
2012	534 696.8	560 322.1	4.79	514 519.9	542 520.3	5.44
2013	554 705.3	578 367.8	4.27	527 468.1	550 183.2	4.31
2014	547 509.5	575 463.6	5.11	518 249.7	552 229.1	6.56
2015	540 853.9	568 578.1	5.13	512 382.8	534 846.1	4.38
2016		574 234.7			528 473.7	
2017		574 696.5			532 173.3	

There was a 4.7% increase in the overall CO_2 emission estimates (excl. FOLU) and a 3.7% increase in estimates for CO_2 emissions (incl. FOLU) in 2015. This was due to recalculations in the *Energy* and *AFOLU* sectors. After recalculations, the 2015 CH_4 emissions were estimated to be 3.2% higher due to changes in the *Energy, AFOLU* and *Waste* sector calculations. Recalculated N_2O emissions were 17.8% higher in this submission due to recalculated values in the *Energy* and *AFOLU* sectors.

2.7.10. Completeness

The South African GHG emission inventory for the period 2000–2017 is not complete, mainly due to a lack of data. Table 2.12 identifies the sources in the 2006 IPCC Guidelines which were not included in this inventory and the reason for their omission is discussed further in the appropriate chapters.

Table 2.12: Activities in the 2017 inventory which are not estimated (NE), included elsewhere (IE) or not occurring (NO).

NE, IE or NO	Activity	Comments
NE	CO_2 and CH_4 fugitive emissions from oil and natural gas operations.	Emissions from this source category will be included in the next inventory submission.
	CO_2, CH_4 and N_2O from spontaneous combustion of coal seams.	New research on sources of emissions from this category will be used to report emissions in the next inventory submission.
	CH_4 emissions from abandoned mines.	New research on sources of emissions from this category will be used to report emissions in the next inventory submission.
	CO_2 transport and storage.	
	CO_2, CH_4 and N_2O emissions from Combined Heat and Power (CHP) combustion systems.	
	Other process use of carbonates.	It has been highlighted in a review that this could be included based on existing data, therefore, this category will be considered for inclusion in the next inventory.
	Electronics industry.	A study needs to be undertaken to understand emissions from this source category.
	Emissions from other product manufacture and use.	
	CO_2 from organic soils.	Insufficient data on the distribution and extent of organic soils. A project has been completed by DEFF (DEA, 2019a) to identify and map organic soils. These emissions will be considered in the next inventory (see improvement list).
	CO_2 from changes in dead wood for all land categories.	Estimates are provided for litter, but not for dead wood due to insufficient data. The National Terrestrial Carbon Sinks Assessment (NTCSA) has recently been updated and this included deadwood estimates. This data will be considered in the next inventory.
	Harvested Wood Products (HWP) from solid waste.	This will be included in the next inventory.
	CH_4, N_2O emissions from biological treatment of waste.	
	CO_2, CH_4 and N_2O from waste incineration.	
	Precursor (NOx, CO, NMVOCs) emissions.	These have only been included for biomass burning.
	SO_2 emissions.	
	SF_6 emissions.	The DEFF are in discussions with the main electricity producer (Eskom) to obtain historical SF_6 data so that it can be included in the next inventory.

IE	CO_2 emissions from biomass burning.	These are not included under biomass burning, but rather under disturbance losses in the Land sector.
	CO_2, CH_4 and N_2O emissions from off-road vehicles and other machinery.	Included under Road transportation.
	Domestic wastewater treatment and discharge emissions.	Reported under the total for Wastewater treatment and discharge.
	Industrial wastewater treatment and discharge emissions.	Reported under the total for Wastewater treatment and discharge.
NO	Other product manufacture and use.	
	Rice cultivation.	
	CO_2, CH_4 and N_2O emissions from Soda Ash Production.	
	CO_2 from Carbon Capture and Storage.	
	CO_2, CH_4 and N_2O emissions from Adipic acid production.	
	CO_2, CH_4 and N_2O Caprolactam, Glyoxal and Glyoxylic acid production.	

2.7.11. Planned Improvements

The main challenges in the compilation of South Africa's GHG inventory are the availability of accurate activity data and resources. The DEFF has recently increased the number of personnel in the inventory team (see section 2.2.1.2) to assist with the resource issue. With a small inventory team there was not a lot of time to incorporate improvements on top of completing the inventory, therefore, a larger number of personnel will allow the completion of more improvement activities within an inventory cycle. In addition, the enhanced capacity will assist in improving the QA/QC process, as there are additional people to complete the checks and to follow the gaps and needs through to the improvement plan.

In terms of data, the DEFF has undertaken a project to modify the National Atmospheric Emissions Inventory System (NAEIS) to meet the requirements of the National Greenhouse Gas Reporting Regulations (DEA, 2017a). The South African GHG Emission Reporting System (SAGERS) portal is under development as part of the project, it will serve as a tool for the implementation of the online registration and reporting by industry in fulfilment of the mandatory NGERs. The system enables the country to enhance the data collection process and obtain company specific data, thereby reducing the reliance on publicly available data. This means an improvement in the quality of the national GHG inventories, consistent with the requisite principles of completeness, consistency, accuracy, comparability and transparency credentials. The key benefits of the portal to South Africa include the institutionalization of the preparation of the National GHG Inventory.

Institutionalising the GHG preparations has several additional advantages, with the most important being sustainability. Previously, data was collected on a voluntary, ad hoc basis and relied on the relationships between the inventory team member and the company individual. Institutionalising the data collection process provides a formal and more regular means of obtaining data, and this process is also independent of individual relationships. Data collection will not be hindered by loss of information due to staff turnover. In addition, institutionalising the data collection system speeds up the data collection process, as the inventory team members do not need to go to individual companies to obtain activity data, but rather go to a central point to collect all data. This will, therefore, create more time for QA/QC and improvements.

In this inventory cycle, the full-time series back to 1990 was estimated for the *AFOLU* sector, however the results of this are not shown since the other sectors still only have data from 2000. The inventory team is planning on extending the time-series for all sectors over the next few years and it is planned that in the 6th BUR, the time-series will be starting from 1990 and going to 2021.

There is still a need to include SF_6 emissions, as well as other gases such as SOx, NOx and NMVOC. The DEFF is in discussions with Eskom to obtain SF_6 data and a threshold has been set for SF_6 in the new GHG reporting regulation so companies will start reporting SF_6 data. SF_6 emissions are, therefore, expected to be included by the 2021 inventory.

Table 2.13 presents a list of activities in South Africa's GHG inventory improvement plan. Further details on sector specific improvements are discussed in the sectoral analysis section (section 2.8) below.

Table 2.13: List of improvements for South Africa's GHG inventory.

Sector	Improvement	Priority	Reason	Status	Completion timeframe	Barriers and constraints
Cross cutting	Improve uncertainty data for all sectors but incorporating more country specific uncertainty values.	Medium	Accuracy	Proposed		Lack of uncertainty data constrains this activity. As data becomes available it will be incorporated, but there are no specific planned projects for this activity at this stage.
	Improve transparency in reporting by including more detailed description of methodologies and activity data, particularly in the *Energy* and *IPPU* sectors.	High	Transparency	Planned	5th BUR (2019 inventory)	Lack of resources and time have hindered the completion of this activity. The enhanced inventory team should assist in completing this task.
	Incorporate data from SAGERS into inventory (data reported due to NGER).	High	Accuracy	Planned	5th BUR (2019 inventory)	The NGER had to be implemented and the SAGERS system for reporting had to be developed. These are now in place and reporting has started.
	Extend time-series back to 1990 for the *Energy*, *IPPU* and *Waste* sectors.	Medium	Completeness	Planned	6th BUR (2021 inventory)	Lack of data for years prior to 2000, particularly for categories where data is highly variable (such as HFCs and PFCs), have constrained the completion of this task. A study is planned to extend/extrapolate the data back to1990 for the three IPCC sectors. IPCC splicing techniques will be considered during this study.
	Investigate inconsistencies in lime activity data (for lime production in *IPPU* and lime application emission in *AFOLU*), explore alternative data sources or improve consistency through the use of IPCC splicing techniques.	Low	Consistency	Planned	5th BUR (2019 inventory)	Inconsistencies in lime data have been noted in previous reviews and have not yet been updated due to time constraints and low priority. It is planned that this issue will be addressed in the next inventory.

	Set up memorandums of understanding with key data providers, e.g. DMRE, Eskom, SAPIA.	High	Transparency	Not completed		This has proved to be difficult and is not working, therefore, regulatory processes and the National Greenhouse Gas Improvement Programme (GHGIP) are being used for data gathering instead.
	Improve QA/QC processes by addressing all issues in external review.	High	Transparency	In progress	5th BUR (2019 inventory)	Challenges in addressing external review comments have been limited by resources and process management. The DEFF inventory team has increased in size which should assist in addressing this issue. External reviewers should also use QC procedures suggested in the QA/QC plan for commenting on the calculation files so as to assist with the speed of the process.
	Improve the improvement plan by incorporating all review activities not addressed in the current inventory.	High	Transparency	In progress	5th BUR (2019 inventory)	Challenges around inclusion of further improvements into the improvement plan are limited resources and process management. The DEFF inventory team has increased in size, including an inventory co-ordinator, which should assist in addressing this issue.
	Incorporate NOx, CO, NMVOC, and SOx emissions	High	Completeness	Proposed	5th BUR (2019 inventory)	These emissions will first be implemented in the transport sector especially the road transport sector. A study which looked at vehicle kilometres travelled by vehicle technology is being concluded in April 2020 and will enable the estimation of these emissions from the Energy Sector. Data for the *Energy* sector will be included in the 2019 inventory, followed by both other sectors in the 2021 inventory.

Energy	Incorporate all updated information from the recent fuel consumption study.	High	Key category; Accuracy	In progress	5th BUR (2019 inventory)	Completion of the fuel consumption study is a barrier to completing this task, however it should be completed in 2020 (see Table 2.14 on GHGIP). The results of the study will be incorporated to produce an enhanced inventory. Sections that have been completed have already begun to be incorporated into the inventory.
	CO_2 and CH_4 fugitive emissions from oil and natural gas operations.	Medium	Completeness	Planned	5th BUR (2019 inventory)	Emissions from this source category will be added in the next inventory as information will be obtained through the GHG regulation reporting.
	CO_2, CH_4 and N_2O from spontaneous combustion of coal seams.	Low	Completeness	Planned	6th BUR (2021 inventory)	New research will allow this category to be included in the 2021 inventory.
	CH_4 emissions from abandoned mines.	Low	Completeness	Planned	6th BUR (2021 inventory)	New research outputs will enable this activity to be included in the 2021 inventory.
	Fugitive emissions from coke production to be reported separately from 2C process emissions.	Low	Transparency	Planned	5th BUR (2019 inventory)	Progress on this has been slow but reporting through the GHG regulation will allow this activity to be incorporated in the next inventory.
	Improve understanding of difference between reference and sectoral approach.	Medium	Key category; Transparency	Planned	5th BUR (2019 inventory)	The fuel consumption study that will be concluded in April 2020, will be used to estimate emissions for the sectoral approach and the data from supply side such as Eskom, Sasol and SAPIA will be used to estimate emissions using the reference approach. Inclusion of this study will assist the inventory team in understanding the

						differences between the reference and sectoral approaches.
	Incorporate emissions from biogas.	Low	Completeness	Proposed		This would require a study and so should be recommended as a project under the GHGIP.
	CO_2 transport and storage.	Low	Completeness	Proposed		
	CO_2, CH_4 and N_2O emissions from combined heat and power (CHP) combustion systems.	Medium	Completeness	Proposed		
	Develop emission factors, carbon content of fuels and net calorific values of liquid fuels.	High	Key category; Accuracy	Planned	6th BUR (2021 inventory)	Resources and funding are required to complete this study so it will be incorporated into the GHGIP (see section 2.7.11.1). This study is planned to start in 2020.
	Development of T3 methods for coal-to-liquid, gas-to-chemicals and gas-to-liquid.		Accuracy	Proposed		Resources and funding are required to complete this study so it will be incorporated into the GHGIP (see section 2.7.11.1).
	Improve explanation of large changes in trends.		Transparency	Planned	5th BUR (2019 inventory)	This aspect will be incorporated in the next inventory and BUR.
	Calculate CH_4 emissions from Iron and steel production.	High	Key category; Completeness	Planned	5th BUR (2019 inventory)	Data is available for this activity so it will be incorporated in the next inventory.
IPPU	Estimate emissions from OPUC category using currently available data.	Medium	Completeness	Planned	5th BUR (2019 inventory)	Emissions from this category can be calculated from existing data, so this will be included in the next inventory.
	Development of country specific emission factor for the ferroalloy industry.	Medium	Key category; Accuracy	Proposed	6th BUR (2021 inventory)	Resources and funding are required to complete this study so it will be incorporated into the GHGIP (see section 2.7.11.1).

	Development of Tier 3 methodologies for aluminium production.	Medium	Key category; Accuracy	Proposed		Resources and funding are required to complete this study so it will be incorporated into the GHGIP (see section 2.7.11.1).
	Include emissions from electronics industry.	Medium	Completeness	Planned	6th BUR (2021 inventory)	A study needs to be undertaken to understand emissions from this source so it should be highlighted as a project for the GHGIP (see section 2.7.11.1).
	Incorporate SF_6 emissions.	Medium	Completeness	In progress	5th BUR (2019 inventory)	Lack of data has been a challenge.
AFOLU	Incorporate all background data and equations for the tier 2 calculations of enteric fermentation.	High	Key category; Accuracy; Transparency	Planned	6th BUR (2021 inventory)	Lack of time and resources have been barriers to incorporating this information. With the increase in inventory team members this should now be possible.
	Incorporate 2018 National Land Cover map and update land use change data for 2015–2018.	High	Key category; Accuracy	Planned	5th BUR (2019 inventory)	NLC maps were not available at the time of preparing the 2017 inventory but this has now been completed (see Table 2.14)
	Incorporate organic soils study to include emissions from organic soils.	Medium	Completeness	Planned	5th BUR (2019 inventory)	Time has been the main barrier for this activity as for the 2015 inventory the soil map was not complete, and in the 2017 inventory there was insufficient time to complete all the mapping integration and land cover overlays. Some of this work has now been done as part of the NTCSA.
	Include deadwood in the DOM pool for all land categories.	Low	Completeness	Planned	6th BUR (2021 inventory)	The recently updated NTCSA included dead wood estimates, so this data will be considered in the next inventory. However, a literature search for forest lands during the current inventory revealed that there is insufficient data to support the inclusion of

						deadwood, therefore, more research may be required and deadwood would then only be included in the 2021 inventory.
	Incorporate updated NTCSA data to improve estimates, particularly for soils.	High	Key category; Accuracy	Planned	5th BUR (2019 inventory)	NTCSA update has just been completed, so data will begin to be incorporated.
	Complete an assessment of crop types and areas and investigate discrepancies between crop statistics and NLC data.	Medium	Consistency; Comparability	Planned	6th BUR (2021 inventory)	Variability in crop classifications from the various data sources have made this challenging. Funding will be required to complete a proper assessment of croplands so this project can be included in the GHGIP (see section 2.7.11.1).
	Include CO_2 estimates for wetlands.	Low	Completeness	Proposed	6th BUR (2021 inventory)	Lack of data has been the barrier to including this activity and it has been a low priority due to the small area of wetlands. Data from NTCSA will be considered, and other data explored, so that estimates can be included by the 2021 inventory.
	Update HWP with country specific data.	Low	Accuracy	Planned	5th BUR (2019 inventory)	Time constraints and priority level are the reasons for this not being completed yet.
Waste	Data collection on quantities of waste disposed of into managed and unmanaged landfills.		Key category; Accuracy	In progress	5th BUR (2019 inventory)	Project is underway so data will be included in 2019 inventory.
	Improve methane correction factor and rate constants.		Key category; Accuracy	Proposed		This would require a study so will be recommended as a project under the GHGIP.
	Include economic data for different population groups.		Key category; Accuracy	In progress	5th BUR (2019 inventory)	Study was completed in March 2020 so data will be included in next inventory.

	Include information on population distribution in rural and urban areas as a function of income.		Key category; Accuracy	In progress	5th BUR (2019 inventory)	Study was completed in March 2020 so data will be included in next inventory.
	Include HWP in solid waste.	Medium	Key category; Completeness	Proposed		Insufficient data.
	Obtain data on waste streams and the bucket system.		Accuracy	In progress	5th BUR (2019 inventory)	Study was completed in March 2020 so data will be included in next inventory.
	CH_4, N_2O emissions from biological treatment of waste.	Medium	Completeness	In progress	5th BUR (2019 inventory)	Study was completed in March 2020 so data will be included in next inventory.
	CO_2, CH_4 and N_2O from waste incineration.	High	Completeness	In progress	5th BUR (2019 inventory)	Study was completed in March 2020 so data will be included in next inventory.

2.7.11.1. GHG Improvement Programme

As part of the ongoing initiative to improve the GHG inventory, South Africa is implementing the National Greenhouse Gas Improvement Programme (GHGIP), which comprises a series of sector-specific projects that are targeting improvements in activity data, country-specific methodologies and emission factors used in the most significant sectors. Table 2.14 summarize some of the projects that are under implementation as part of the GHGIP.

The DEFF has also identified the following private sectors for engagement on the GHGIP:

(i) Ferroalloys Industry – development of country specific emission factors.
(ii) Cement industry – development of country specific emission factors.
(iii) CTL-GTCs and GTLs – development of T3 methodologies.
(iv) Aluminium production – development of T3 methodologies.
(v) Petrochemical industry – development of emission factors, carbon content of fuels, and net calorific values of liquid fuels.

Table 2.14: GHGIP projects under Implementation.

Project	Partner	Objective	Outcome	Timelines	Status
Development of a formal GHG National Inventory System	Norwegian Embassy	Helping South Africa develop its national system	SA GHG inventories are documented and managed centrally	2015-2020	Completed
Land-cover mapping	The UK Department for International Development	To develop a land-use map for one time step 2017/18	Land-use change matrix developed for 36 IPCC land-use classes to detect changes	2019-2020	Completed
Waste-sector data improvement project	GIZ	To improve waste-sector GHG emissions estimates and address data gaps	Waste-sector GHG inventory is complete, accurate and reflective of national circumstances	2019-2020	In Progress
2nd Energy Sector Fuel Consumption Study and VKT Study	GIZ	Improved energy activity data on fuel consumption for solid, liquid and gaseous fuels	Improved energy activity data on fuel consumption for solid, liquid and gaseous fuels	2019-2020	In Progress

2.8. Sectoral analysis

2.8.1. Energy

South Africa's GDP is the 30th highest in the world, but in primary energy consumption South Africa is ranked 17th in the world. South Africa's energy intensity is high mainly because the economy is dominated by large-scale, energy-intensive primary minerals beneficiation industries and mining industries. Furthermore, there is a heavy reliance on fossil fuels for the generation of electricity and for the production of a significant proportion of the liquid fuels consumed in the country. The energy sector is critical to the South African economy because it accounts for a total of 15% of the GDP.

The energy sector in South Africa is highly dependent on coal as the primary energy resource. The largest source of energy sector emissions in South Africa is the combustion of fossil fuels. Emissions from combustion include CO_2, N_2O, CH_4 and H_2O. A large quantity of liquid fuels is imported in the form of crude oil. Renewable energy sources include biomass and natural processes that can be used as energy sources. Biomass is used commercially in industry to produce process heat and in households for cooking and heating.

In terms of energy demand, South Africa is divided into six sectors: industry, agriculture, commerce, residential, transport and other. The industrial sector (which includes mining, iron and steel, chemicals, non-ferrous metals, non-metallic minerals, pulp and paper, food and tobacco, and other) is the largest user of energy in South Africa. The primary energy supply in South Africa is dominated by coal (59%), followed by crude oil (16%), renewable resources and waste (20%), natural gas (3%) and nuclear energy (2.0%) (DoE, 2017).

The energy sector includes:

(i) Exploration and exploitation of primary energy sources.
(ii) Conversion of primary energy sources into more useable energy forms in refineries and power plants.
(iii) Distribution of fuels.
(iv) Final use of fuels in stationary and mobile applications.

The categories included in the *Energy* sector for South Africa are *Fuel combustion activities* (1A), including international bunkers, and *Fugitive emissions from fuels* (1B).

2.8.1.1. Trends

Total emissions from the *Energy* sector for 2017 were estimated to be 458 600 Gg CO_2e (Table 2.15). *Fuel combustion activities (1A)* was the main contributor, accounting for 93.4% of emissions from the *Energy* sector. *Fugitive emissions from fuels (1B)* contributed the rest, since emissions from *Carbon dioxide transport and storage (1C)* were not estimated. Overall, *Energy industries* were the main contributor, accounting for 60.2% of emissions from the *Energy* sector. This was followed by *transport* (17.0%) and *manufacturing industries and construction* (8.2%). The *residential* and *commercial* sectors are both heavily reliant on electricity for meeting energy needs, contributing 30 644 Gg CO_2e and 18 851 Gg CO_2e to total *Energy* emissions in 2017, respectively.

Table 2.15: Emissions from the energy sector in 2017 by gas and sub-category.

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	Total
	Gg CO_2	Gg CH_4	Gg N_2O	Gg CO_2e
1 ENERGY	451 308.2	204.7	9.7	458 600.0
1A Fuel combustion activities	424 899.2	27.1	9.7	428 461.1
1B Fugitive emissions from fuels	26 409.1	177.6	0.0	30 138.9
1C Carbon dioxide transport and storage	NE	NE	NE	NE

Energy sector emissions increased by 32.8% (112 319 Gg CO_2e) between 2000 and 2017 (Figure 2.17, Table 2.16). It can be seen that emissions peaked in 2013, after which emissions plateau. The plateauing might be a result of increasing penetration of electricity generated from renewable energy resources (wind, solar photovoltaics (PV) and concentrated solar power (CSP)). In 2013, a penetration level of 0.03% (0.01 TWh) of wind and solar energy resources was introduced into the national electricity system[1]. By 2016 and 2017, the penetration levels of these renewable resources had increased to 3% (6.9 TWh) and 4% (10.8 TWh), respectively. When assuming that the electricity from these three renewable energy resources replaced coal generated electricity, only 0.01% of CO_2 was mitigated in 2013. By 2017, CO_2 emissions were reduced by 1.4% through directly replacing coal generated electricity with electricity from wind, solar PV and concentrated solar power.

The *Fuel combustion activities* grew by 116 203 Gg CO_2e (37.2%) over the 2000 to 2017 period, while the *Fugitive emissions from fuels* declined by 2 884 Gg CO_2e (8.7%). The main driver of the increase was the doubling of emissions in the transport sector due to increased civil aviation and road transport emissions, and the large increase (emissions increasing by more than three-fold) in residential emissions due to increased consumption of Liquefied Petroleum Gas (LPG) and coal. The emissions from the *Other sectors (1A4)* sub-category grew by an average of 6.5% per annum while emissions growth rate from other sub-categories (1A1–1A3 and 1A5) was between 1% and 2.4%.

[1] https://researchspace.csir.co.za/dspace/bitstream/handle/10204/10636/Calitz_21959_2019.pdf?sequence=1&isAllowed=y

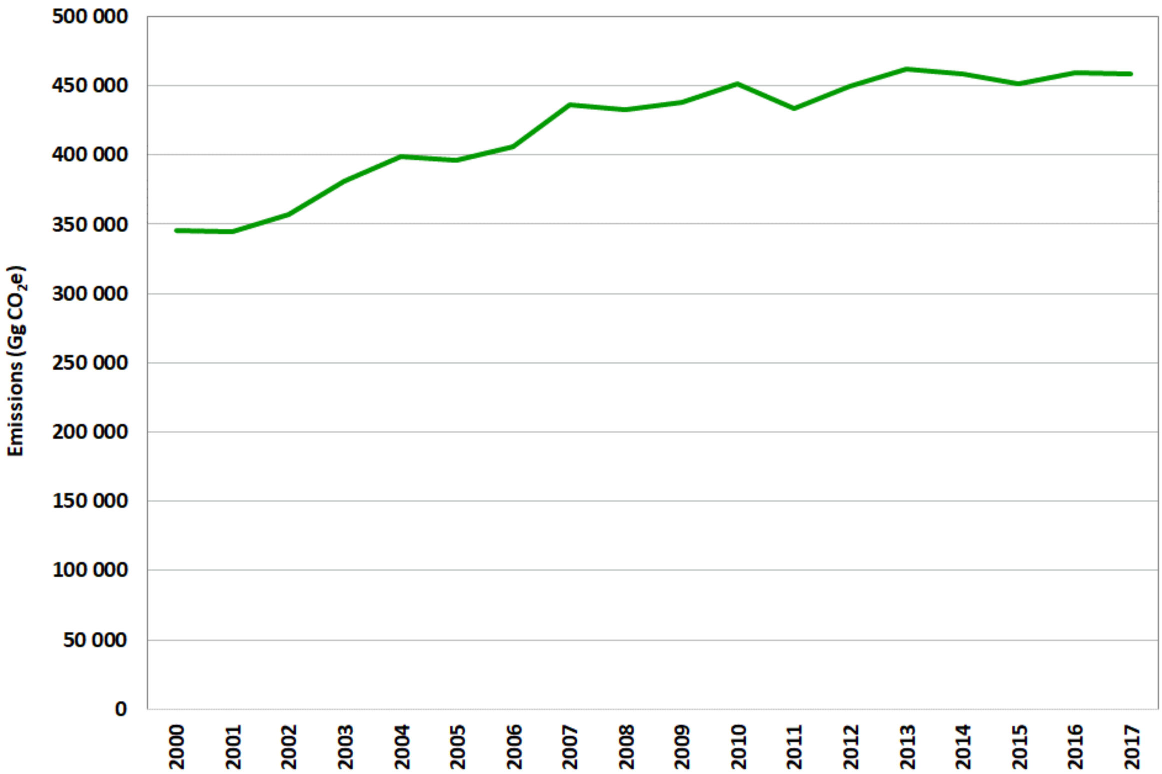


Figure 2.17: Trends in South Africa's energy sector emissions, 2000–2017.

Table 2.16: Emission trends for the sub-categories in the energy sector, 2000–2017.

	1A Fuel consumption activities						1B Fugitive emissions from fuel				1C CO_2 transport and storage	Energy sector total
	1A1 Energy Industries	1A2 Manufact-uring Industries and Construction	1A3 Transport	1A4 Other Sectors	1A5 Non-specified	1A Total	1B1 Solid Fuel	1B2 Oil and Natural Gas	1B3 Other Emissions from energy production	1B Total		
	Gg CO_2e											
2000	220 587.0	32 658.3	38 978.0	19 045.8	989.1	312 258.2	1 830.5	752.0	30 440.2	33 022.7	NE	345 280.9
2001	215 884.1	32 186.3	39 706.7	22 538.3	983.8	311 299.1	1 819.0	752.9	30 666.4	33 238.3	NE	344 537.4
2002	221 177.2	33 395.4	42 014.1	25 660.0	983.3	323 230.0	1 792.7	955.1	30 666.4	33 896.3	NE	357 126.3
2003	238 889.8	35 905.1	44 021.6	27 965.1	1 014.9	347 796.5	1 936.0	1 458.0	29 561.1	32 955.1	NE	380 751.5
2004	246 680.0	37 884.3	47 485.6	31 036.1	1 045.1	364 131.1	1 980.8	1 378.9	31 358.3	34 718.0	NE	398 849.1
2005	242 786.0	37 154.9	51 616.8	32 921.1	1 062.3	365 541.2	1 993.9	1 160.1	27 631.3	30 785.3	NE	396 326.5
2006	244 834.0	38 078.3	55 725.1	35 556.1	1 073.1	375 266.6	1 992.6	1 133.2	27 492.6	30 618.5	NE	405 885.1
2007	268 012.3	39 469.3	60 379.8	36 679.8	1 099.7	405 640.8	2 015.7	1 132.7	27 940.7	31 089.1	NE	436 729.9
2008	257 213.4	42 284.6	63 606.8	38 726.4	1 053.1	402 884.4	2 052.7	1 138.2	26 575.7	29 766.6	NE	432 650.9
2009	263 672.2	40 135.5	61 515.4	41 516.8	1 076.4	407 916.2	2 038.9	1 243.4	26 878.2	30 160.6	NE	438 076.8
2010	269 930.7	41 124.5	64 459.5	45 272.7	1 139.0	421 926.4	2 071.5	964.2	26 669.0	29 704.7	NE	451 631.1
2011	267 890.2	28 417.2	67 472.7	39 688.1	1 138.2	404 606.3	1 535.6	785.8	26 283.4	28 604.8	NE	433 211.1
2012	279 356.4	29 217.0	69 490.1	40 714.4	1 114.5	419 892.4	1 608.7	641.8	27 261.4	29 512.0	NE	449 404.4
2013	273 022.4	38 429.6	72 465.7	47 052.9	1 151.2	432 121.7	1 630.0	641.8	27 667.0	29 938.8	NE	462 060.5
2014	267 531.9	37 011.2	74 631.3	48 302.1	1 164.3	428 640.8	1 663.7	641.8	27 227.8	29 533.3	NE	458 174.1
2015	259 981.2	36 870.3	75 965.2	48 793.5	1 177.4	422 787.5	1 607.7	641.8	26 786.8	29 036.3	NE	451 823.8
2016	263 428.4	37 309.5	76 380.0	51 768.5	1 190.5	430 076.9	1 595.0	641.8	26 991.9	29 228.7	NE	459 305.6
2017	258 001.3	37 432.5	78 016.6	53 807.1	1 203.6	428 461.1	1 608.2	641.8	27 888.8	30 138.9	NE	458 600.0

2.8.1.2. Methods and data

GHG emissions from the *Energy* sector were estimated using a detailed sectoral or bottom-up approach. Most of the emission estimates in the sectoral approach for the *Energy* sector are calculated using IPCC Tier 1 and 2 methods as shown in Table 2.17.

Table 2.17: Summary of methods and emission factors for the energy sector and an assessment of the completeness of the energy sector emissions.

GHG Source and sink category		CO_2		CH_4		N_2O		Details
		Method Applied	Emission factor	Method Applied	Emission factor	Method Applied	Emission factor	
1A	**Fuel combustion activities**							
1	**Energy industries**							
	a. Main activity electricity and heat production	T1, T2	DF, CS	T1	DF	T1	DF	CS CO_2 EF for subbituminous coal (Technical Guidelines: DEA, 2017b)
	b. Petroleum refining	T1	DF	T1	DF	T1	DF	
	c. Manufacture of solid fuels and other energy industries	T3	CS	T3	CS	T3	CS	No activity data; emissions supplied by Sasol and PetroSA - based on Mass Balance Approach
2	**Manufacturing industries and construction**	T1, T2	DF, CS	T1	DF	T1	DF	CS CO_2 EF for sub-bituminous coal (Technical Guidelines: DEA, 2017b)
3	**Transport**							
	a. Civil aviation	T1	DF	T1	DF	T1	DF	
	b. Road transportation	T1	DF	T1	DF	T1	DF	
	c. Railways	T1	DF	T1, T2	DF, CS	T1	DF	CS CH_4 EF for gas/diesel oil
	d. Water-borne navigation	T1	DF	T1	DF	T1	DF	
	e. Other transportation	NO		NO		NO		
4	**Other sectors**							
	a. Commercial/ Institutional	T1, T2	DF, CS	T1	DF	T1	DF	CS CO_2 EF for sub-bituminous coal (Technical Guidelines: DEA, 2017b)
	b. Residential	T1, T3	DF, CS	T1	DF	T1	DF	CS CO_2 EF for sub-bituminous coal (Technical Guidelines: DEA, 2017b)
	c. Agriculture/Forestry/ Fishing/ Fish farms	T1, T4	DF, CS	T1	DF	T1	DF	CS CO_2 EF for sub-bituminous coal (Technical Guidelines: DEA, 2017b)
5	**Non-specified**							
	a. Stationary	T1, T2	DF, CS	T1	DF	T1	DF	CS CO_2 EF for sub-bituminous coal (Technical Guidelines: DEA, 2017b)
	b. Mobile	IE		IE		IE		The fuels associated with this category are assumed to be

								included elsewhere in the energy balance.
B	**Fugitive emissions from fuels**							
1	**Solid fuels**							
	a. Coal mining and handling	T2	CS	T2	CS	NO		
	b. Uncontrolled combustion and burning coal dumps	NE		NE		NO		
	c. Solid fuel transformation	NE		NE		NO		
2	**Oil and natural gas**							
	a. Oil	T3	CS	T3	CS	NO		Based on measurements - PetroSA
	b. Natural gas	NE		NE				
3	**Other emissions from energy production**	T3	CS	T1, T3	DF, CS	NE		Industry specific CO_2 and CH_4 emissions supplied by Sasol and PetroSA - based on Mass Balance Approach. Charcoal CH_4 used approach T1
C	**Carbon dioxide transport and storage**							
1	**Transport of CO_2**							
	a. Pipelines	NE		NE		NE		
	b. Ships	NE		NE		NE		
	c. Other	NE		NE		NE		
2	**Injection and storage**							
	a. Injection	NE		NE		NE		
	b. Storage	NE		NE		NE		
3	**Other**	NE		NE		NE		

T1-T3 = Tier method 1, 2 or 3; DF = IPCC default emission factor; CS = Country specific emission factor; NE = Not estimated; NO = Not occurring.

All activity and emission factor data sources for the *Energy* sector are listed below in Table 2.18. Data is collected through two instruments. The first process involved receiving data through direct interaction between the DEFF and stakeholders that can supply the department with the data. These key department and stakeholders are government departments such as the Department of Minerals Resources and Energy (DMRE), public entities such as Eskom (electricity production), Transnet and associations such as South African Petroleum Industry Association (SAPIA). The second process is collected data that is publicly available. The datasets from all these data collection processes is run through a data completeness checking system to check whether all the sectors within the economy are covered (Figure 2.18). Incomplete categories are then identified and highlighted for future data collection efforts.

Table 2.18: Activity and emission factor data sources for the energy sector.

Sub-category	Activity data	Activity data sources
Electricity generation	Fuel consumption for public electricity generation	Eskom
	Fuel consumption for auto electricity producers	Energy balance (DMRE)
	Net calorific values	Eskom
Petroleum refining	Fuel consumption	Energy balance (DMRE)
Manufacture of solid fuels and other energy industries	No activity data, only emission data - based on Mass Balance Approach	PetroSA
		Sasol
Manufacturing industries and construction	Other kerosene, bitumen and natural gas consumption	Energy balance (DMRE)
	Gas/Diesel consumption	SAPIA
	Residual fuel oil consumption	Energy digest
	LPG consumption	South African Minerals Industry (SAMI) report (DMRE)
Transport	Vehicle kilometres travelled for road transport	Fuel consumption study (Top Quartile, 2019)
	Domestic aviation gasoline consumption	SAPIA
	Domestic aviation jet kerosene consumption	Energy balance (DMRE)
	Road transport fuel consumption	Fuel consumption study (Top Quartile, 2019)
	Road transportation other kerosene consumption	SAPIA
	Railway fuel oil consumption	Transnet
	Railway gas/diesel oil consumption	SAPIA
	Water-borne navigation fuel consumption	
	International aviation Jet Kerosene consumption	Energy balance (DMRE), SAPIA
Commercial/institutional	Other kerosene, gas/diesel oil, gas works gas and natural gas consumption	Energy balance (DMRE)
	Sub-bituminous coal consumption	Energy digest
	Residual fuel oil consumption	SAPIA
Residential	Coal consumption	SAMI report (DMR)
	LPG consumption	SAPIA
	Sub-bituminous coal consumption	Energy digest
	Other fuel consumption	Energy balance (DMRE)
Agriculture/forestry/fishing/fish farms	Other kerosene consumption	SAPIA
	Gas/diesel oil consumption	Energy Digest
	Other fuel consumption	Energy balance (DMRE)
Stationary non-specified	Fuel consumption	SAPIA
Mining	Coal consumption	SAMI report (DMR)
Oil flaring	Emissions	PetroSA
Manufacturing of solid fuels and other industries	Emissions	Sasol; PetroSA
	Charcoal production	The Food and Agriculture Organization of the United Nations (FAO)

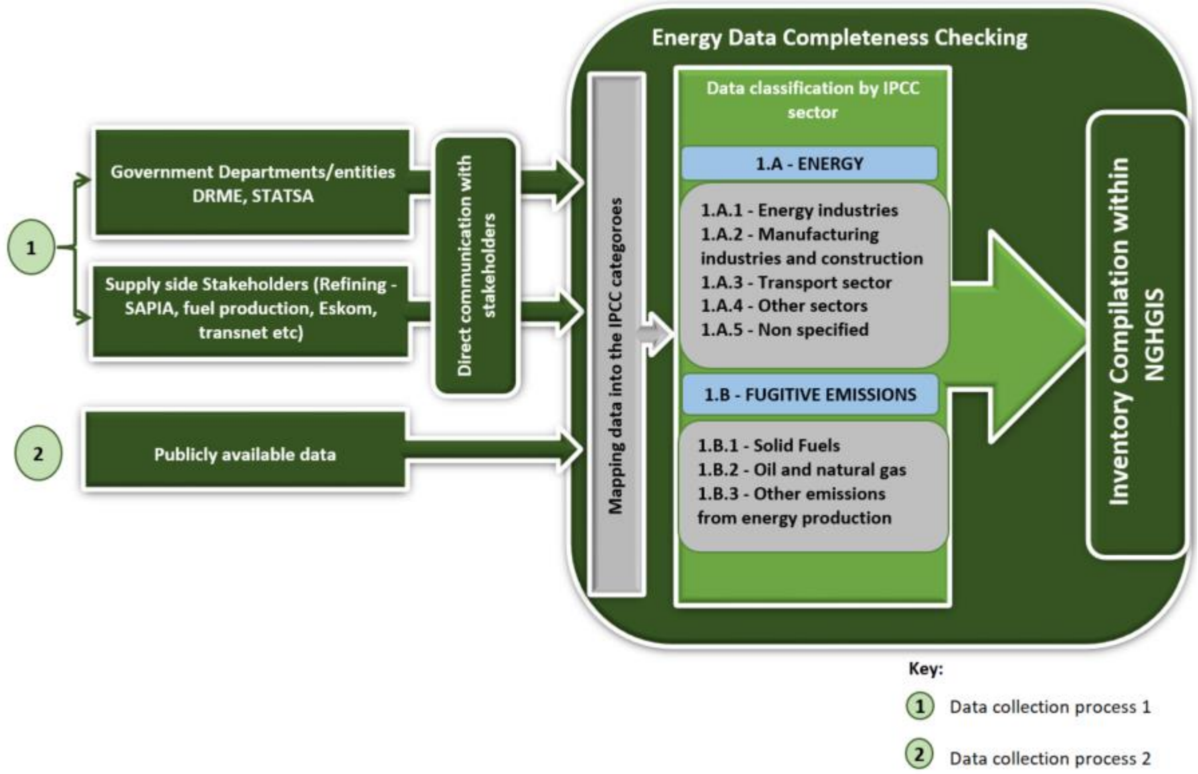


Figure 2.18: Data collection process for the 2017 GHG Energy sector inventory.

2.8.1.3. Reference and sectoral approach comparison

As a way of verifying CO_2 emissions from fuel combustion for the time series 2000–2017, South Africa also applied the top-down IPCC reference approach to the inventory. The Reference Approach was applied on the basis of relatively easily available energy supply statistics and as a way of maintaining good practice as per IPCC reporting guidelines. Significant differences between the reference and sectoral approaches may indicate possible problems with the activity data, net calorific values, carbon content, excluded carbon calculation etc. The reference approach comparison showed that over the period 2000 to 2017, the CO_2 emissions were higher using the reference approach (Figure 2.19). Fuel consumption data for solids and gases are shown to be higher for the reference approach, however, for liquids, consumption is higher when using the sectoral approach (see Energy Appendix in the NIR).

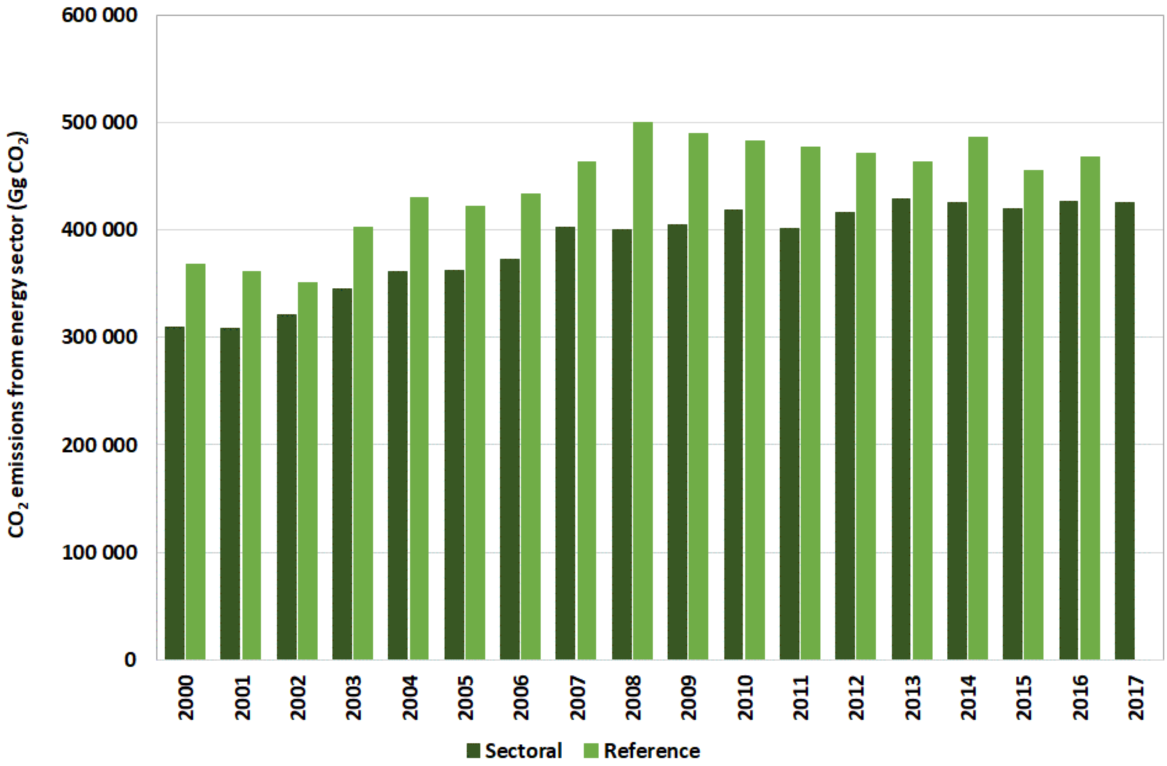


Figure 2.19: Comparison of CO_2 emissions from the Energy sector estimated by the reference and sectoral approach.

Reporting has improved over the 17-year period and, as a result, the difference between the two approaches has declined from 15.9% in 2000 to 8.7% in 2016 (2017 energy balance data was not yet available). There are a number of possible reasons for the discrepancy between the two approaches:

(i) Allocation of solid fuels between energy use, non-energy use as well as use for synthetic fuels production remains one of the key drivers of the differences observed between the two datasets.

(ii) Net calorific values used in the sectoral approach differ from those used in the reference approach. In power generation, net calorific values in the sectoral approach vary over the 2000–2017 time series based on the information provided by industry.

(iii) Activity data on liquid fuels in the sectoral approach, particularly for energy industries, is sourced directly from the companies involved and has been reconciled with other publicly available datasets.

(iv) Allocation of solid fuels between energy use, non-energy use as well as use for synthetic fuels production remains one of the key drivers of the differences observed between the two datasets.

(v) The misallocation of the quantities of fuels used for conversion into derived products (other than power or heat) or quantities combusted in the energy sector.

(vi) Inconsistencies on the sources of activity data within the time series and in some cases the application of extrapolation.

(vii) Missing information on stock changes that may occur at the final consumer level. The relevance of consumer stocks depends on the method used for the Sectoral Approach.

(viii) High distribution losses for gas will cause the Reference Approach to be higher than the Sectoral Approach.

(ix) Unrecorded consumption of gas or other fuels may lead to an underestimation of the Sectoral Approach.

(x) The treatment of transfers and reclassifications of energy products may cause a difference in the Sectoral Approach estimation since different net calorific values and emission factors may be used depending on how the fuel is classified.

2.8.1.4. Recalculations

Recalculated emission estimates for the *Energy* sector were up to 5% higher than previous estimates for the *Energy* sector (Figure 2.20). These recalculations were necessary due to an update of consumption data in the *Road transport* and *Other emissions from energy production* categories.

A recent fuel consumption study (Top Quartile, 2019) was completed for the road transport sector which provided consumption data based on vehicle kilometres travelled (VKT). In this inventory the petrol, diesel and natural gas consumption data for *Road transport* was, therefore, updated and this led to a 40% increase in the *Road transport* emission estimates in 2015. In the *Residential* category the charcoal consumption data between 2010 and 2017 was updated, as it was not available in the previous inventory and an assumed value was applied. This update had no impact on the overall emissions in this sub-category. In the *Other emissions from energy production* category the charcoal consumption data was updated, and this produced a 1% decline in emission estimates for 2008 to 2012 and a 12% reduction in the 2013 estimates.

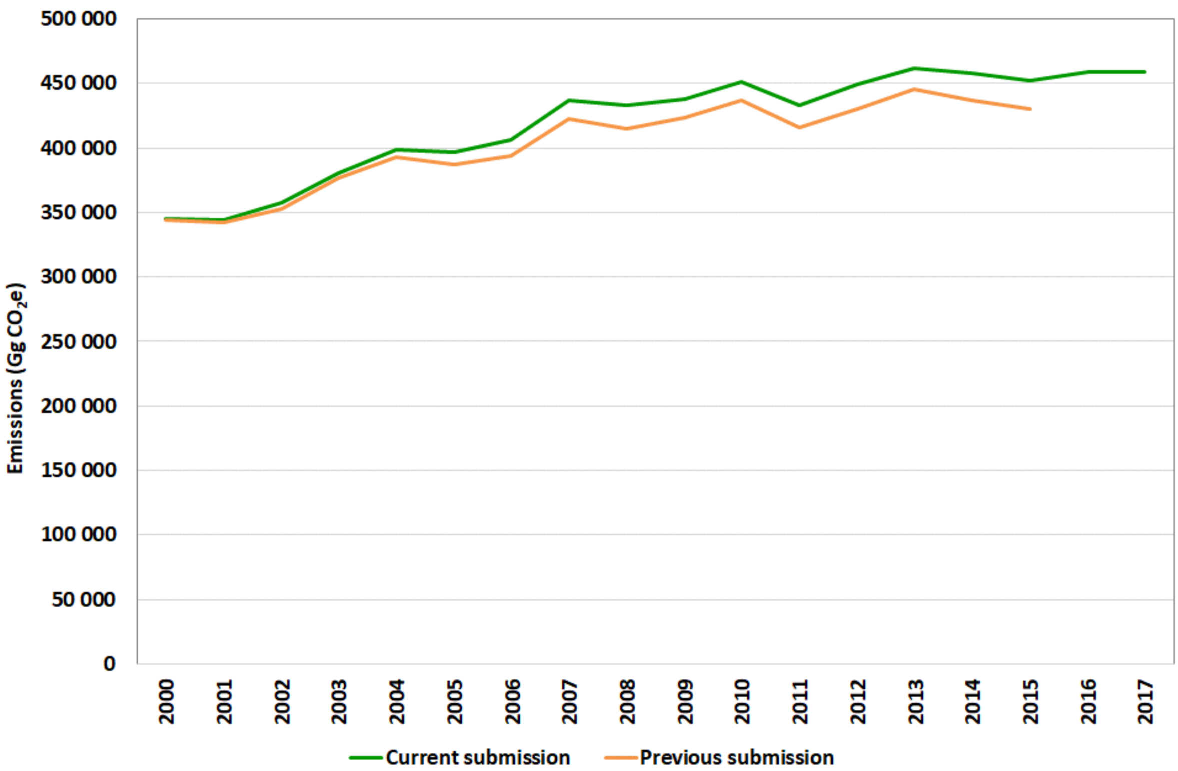


Figure 2.20: Recalculations for the Energy sector between 2000 and 2017.

2.8.1.5. Key categories

The key categories for the *Energy* sector are shown in Table 2.19.

Table 2.19: Key categories identified in the Energy sector.

IPCC Code	Category	GHG	Identification Criteria
1A1a	Electricity and heat production (solid fuels)	CO_2	L,T
1A1a	Electricity and heat production (liquid fuels)	CO_2	L
1A1b	Petroleum refining (gaseous fuels)	CO_2	L,T
1A1b	Petroleum refining (liquid fuels)	CO_2	T
1A1c	Manufacture of solid fuels and other energy industries (solid fuels)	CO_2	L,T
1A2	Manufacturing industries and construction (gaseous fuels)	CO_2	L,T
1A2	Manufacturing industries and construction (solid fuels)	CO_2	L,T
1A2	Manufacturing industries and construction (liquid fuels)	CO_2	T
1A3a	Civil aviation (liquid fuels)	CO_2	L,T
1A3b	Road transport (liquid fuels)	CO_2	L,T
1A4a	Commercial/institutional (liquid fuels)	CO_2	L,T
1A4a	Commercial/institutional (solid fuels)	CO_2	L
1A4b	Residential (solid fuels)	CO_2	L,T
1A4b	Residential (liquid fuels)	CO_2	T
1A4c	Agriculture/forestry/fishing/fish farms (liquid fuels)	CO_2	L,T
1B1a	Coal mining and handling	CH_4	T
1B3	Other emissions from energy production	CH_4	T

Note: L= level assessment, T = trend assessment

2.8.1.6. Planned improvements

Improvements planned for the next inventory are:

(i) As shown in Figure 2.21, there will be three instruments through which the data will be collected for the inventory in future. The first process will involve enhancement of the current direct communication between stakeholder and the DEFF with memorandums of understanding which are being drafted to formalise the data collection process between significant industry players and government departments. For example, memorandums of understanding will be finalised for government departments such as the DMRE, public entities such as Eskom and associations such as SAPIA.

(ii) The other improvement will be data that will be generated through SAGERS. SAGERS was developed to improve the compilation of GHG emissions inventories by assisting the DEFF and Category A[2] data providers to abide by the NGER (DEA, 2017a) (see section 6.3.3.1). SAGERS will not only improve GHG reporting for the *Energy* sector but will also improve the *IPPU*

[2] Companies conducting IPCC activities and meet reporting thresholds as per the reporting regulations

sector emission estimates which relied heavily on publicly available data. In the next inventory, data gathered through the GHG regulation and SAGERS will be incorporated.

(iii) A fuel consumption study is currently underway. This study aims primarily to disaggregate the use of combustion fuels, including liquid fuels, solid fuels, biomass-based fuels and gaseous fuel data according to the demand-side sectors and sub-sectors of the South African economy for each year in the period 2013–2018 and projections to 2035. Effectively this project will not only update the work done in the Phase I fuel disaggregation study conducted by GIZ in 2015 but will also expand on its scope. The long-term forecasting will be based on final demand figures and event scenarios that are expected (might occur) in the next 15 years. This study is generating energy consumption data from all the demand sectors in South Africa and goes further to estimating vehicle kilometres travelled in the transport sector. The inventory will be updated with information from this study as it becomes available.

(iv) Fugitive emissions from coke production is currently accounted for under category 2C as part of process emissions, however, it is planned that by the 2019 inventory these will be separated from process emissions and reported separately.

(v) Time-series will be extended back to 1990 over the next few years, but this will likely only be available in the 6th BUR.

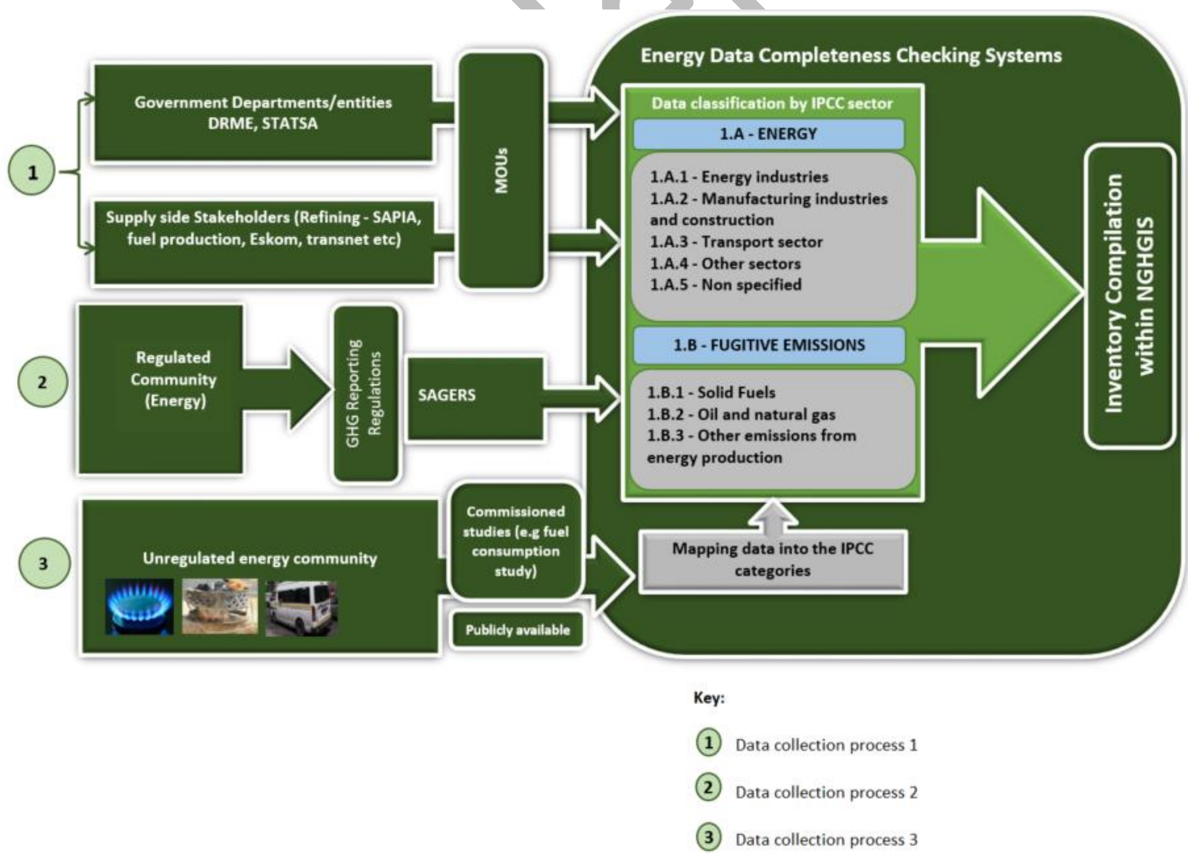


Figure 2.21: Data collection process improvements planned for the Energy sector.

2.8.2. IPPU

The *IPPU* sector includes non-energy related emissions from industrial processing plants. The main emission sources are releases from industrial processes that chemically or physically transform raw material, e.g., ammonia products manufactured from fossil fuels. GHG emissions released during these processes are CO_2, CH_4, N_2O, HFCs and PFCs. Also included in the *IPPU* sector are emissions used in products such as refrigerators, foams and aerosol cans.

Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are used in a large number of products and in refrigeration and air conditioning equipment. PFCs are also emitted as a result of anode effects in aluminium smelting. Therefore, the *IPPU* sector includes estimates of PFCs from aluminium production, and HFCs from refrigeration and air conditioning.

The estimation of GHG emissions from non-energy sources is often difficult because they are widespread and diverse. The difficulties in the allocation of GHG emissions between fuel combustion and industrial processes arise when by-product fuels or waste gases are transferred from the manufacturing site and combusted elsewhere in different activities. The largest source of emissions in the *IPPU* sector in South Africa is the production of iron and steel.

The performance of the economy is the key driver for trends in the *IPPU* sector. The South African economy is directly related to the global economy, mainly through exports and imports. South Africa officially entered an economic recession in May 2009, which was the first in 17 years. Until the global economic recession affected South Africa in late 2008, economic growth had been stable and consistent. As a result of the recession, GHG emissions during that period decreased enormously across almost all categories in the *IPPU* sector.

2.8.2.1. Trends

In 2017 the *IPPU* sector produced 43 230 Gg CO_2e (Table 2.20), which is 7.5% of South Africa's emissions (excl. FOLU). The largest source category is the *Metal industry* category, which contributes 72.9% to the total *IPPU* sector emissions. *Iron and steel production* and *Ferroalloys production* are the biggest CO_2 contributors to the *Metal industry* subsector, producing 15 074 Gg CO_2e and 12 757 Gg CO_2e, respectively. The *Mineral industry* and the *Product uses as substitute ozone depleting substances (ODS)* subsectors contribute 14.9% and 9.3%, respectively, to the *IPPU* sector emissions, with all the emissions from the *Product uses as substitute ODS* being HFCs.

Table 2.20: Emissions from the IPPU sector in 2017 by gas and sub-category.

Greenhouse gas source and sink categories	CO_2	CH_4	N_2O	HFCs	PFCs	Total
	Gg CO_2	Gg CH_4	Gg N_2O	Gg CO_2e		
2 IPPU	**36 298.7**	**8.1**	**0.9**	**4 014.6**	**2 453.4**	**43 229.5**
2A Mineral industry	6 462.1	NO	NO	NO	NO	6 462.1
2B Chemical industry	523.9	8.0	0.9	NO	NO	983.7
2C Metal industry	29 037.2	0.2	NE	NO	2 453.4	31 493.6
2D Non-energy products from fuels and solvent use	275.6	NE	NE	NO	NO	275.6
2E Electronics industry	NE	NE	NE	NO	NO	NE
2F Product uses as substitutes for ozone depleting substances	NO	NO	NO	4 014.6	NE	4 014.6
2G Other product manufacture and use	NE	NE	NE	NE	NE	NE
2H Other	NA	NA	NA	NE	NE	NE

IPPU emissions increased by 17.9% between 2000 and 2006, after which there was a 14.5% decline to 2009 due to the recession (Figure 2.22). Emissions then increased again by 25.8% by 2017. The contribution to the national emissions (excl. FOLU) increased from 7.6% to 7.8% between 2000 and 2017. Estimated emissions from the *IPPU* sector in 2017 are 26.9% higher than the emissions in 2000 (Table 2.21). This was mainly due to the 17.9% (4 778 Gg CO_2e) increase in the *Metal industry* emissions, and the 4 015 Gg CO_2e increase in *Product uses as substitutes for ODS*.

IPPU emissions showed an increase of 3.2% between 2015 and 2017. The increase was mostly due to a 547 Gg CO_2e (1.8%) increase in the *Metal industry* and a 532 Gg CO_2e (15.3%) increase in the *Product uses as substitute ODS* emissions over this period. The time-series for *Product uses as substitute ODS* is not consistent as emissions from *Mobile air conditioning*, *Foam blowing agents*, *Fire protection* and *Aerosols* were included in the inventory only since 2011 as there was no data prior to this. This led to the apparent increase in emissions from this subcategory. The *Mineral industry* emissions increased by 4.6% (284 Gg CO_2e) between 2015 and 2017, while the *Non-energy products from fuels and solvents* increased by 0.7% (70 Gg CO_2e).

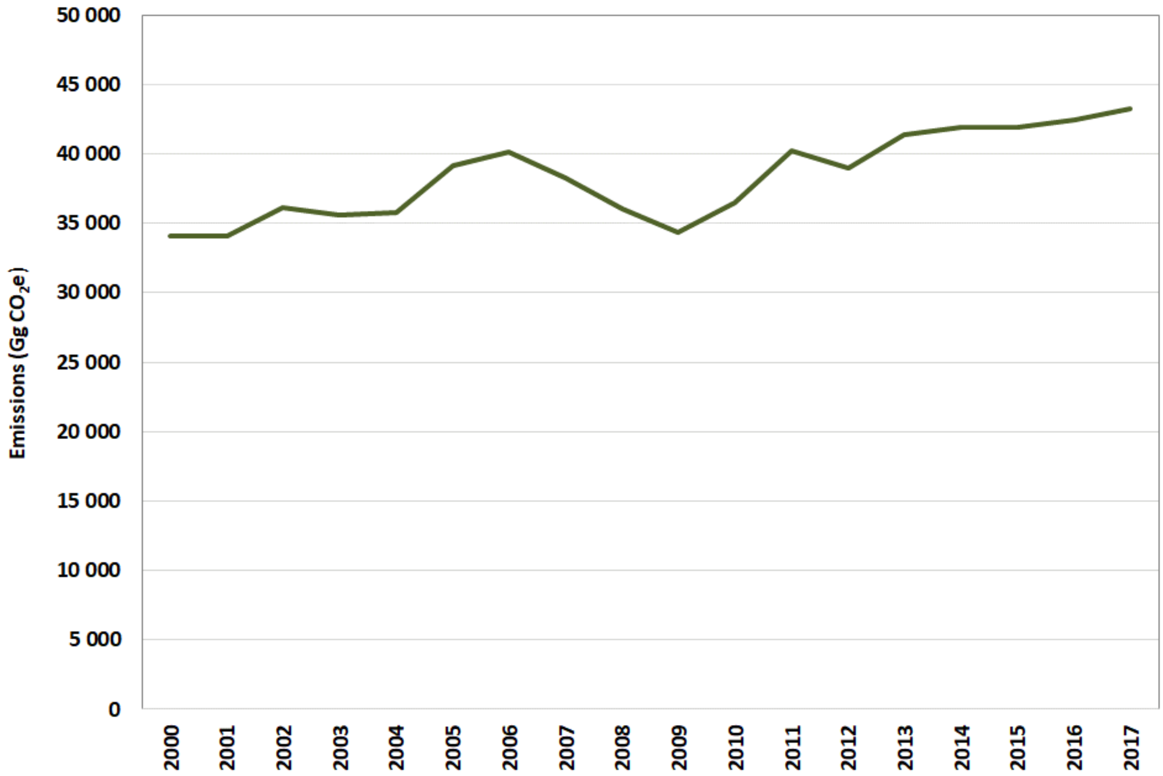


Figure 2.22: Trends in South Africa's IPPU sector emissions, 2000–2017.

Table 2.21: Trends in the IPPU sub-categories between 2000 and 2017.

	2A Mineral industry	2B Chemical industry	2C Metal industry	2D Non-energy products from fuels and solvent use	2E Electronics industry	2F Product uses as substitutes for ozone depleting substances	2G Other product manufact-ure and use	IPPU sector total
	Gg CO$_2$e							
2000	4 386.3	2 773.6	26 714.9	195.9	NE	0.0	NE	34 070.8
2001	4 303.7	2 715.1	26 812.7	226.0	NE	0.0	NE	34 057.4
2002	4 824.3	2 744.0	28 322.0	250.3	NE	0.0	NE	36 140.6
2003	5 095.6	2 169.1	28 093.2	248.6	NE	0.0	NE	35 606.5
2004	4 993.3	2 472.6	28 071.7	246.2	NE	0.0	NE	35 783.8
2005	5 736.1	2 973.6	29 098.9	467.9	NE	841.8	NE	39 118.2
2006	6 131.8	2 746.8	29 740.1	509.2	NE	1 045.4	NE	40 173.2
2007	6 064.0	1 969.0	28 892.1	234.1	NE	1 063.4	NE	38 222.5
2008	6 320.7	1 226.4	27 253.9	221.1	NE	1 026.0	NE	36 048.0
2009	6 590.8	1 068.2	25 467.2	233.8	NE	992.0	NE	34 352.0
2010	5 916.7	1 021.2	27 204.0	233.9	NE	2 065.8	NE	36 441.6
2011	5 719.8	1 070.9	30 966.2	196.4	NE	2 274.4	NE	40 227.7
2012	5 457.2	931.3	29 784.9	253.9	NE	2 527.6	NE	38 954.9

2013	5 688.4	1 152.2	31 384.1	271.7	NE	2 852.5	NE	41 348.8
2014	5 770.1	927.6	31 842.3	272.8	NE	3 065.6	NE	41 878.4
2015	6 178.5	1 001.5	30 946.4	273.8	NE	3 482.1	NE	41 882.3
2016	6 396.8	968.9	31 109.8	274.7	NE	3 715.1	NE	42 465.4
2017	6 462.1	983.7	31 493.6	275.6	NE	4 014.5	NE	43 229.5

2.8.2.2. Methods and data

Activity data in the *IPPU* sector are derived from a variety of sources (Table 2.22) with South Africa using a combination of Tier 1, Tier 2 and Tier 3 methods (Table 2.23). Many of the chemical industries determine their own emissions and provide these emission estimates to the DEFF. In most cases the activity data and emission factors used are not supplied due to confidentiality issues. In this category emissions are generally determined by a Tier 3 process balance analysis unless otherwise stated.

In Table 2.23 the methodologies applied to determine the emissions from the various chemical industries is shown, as well as the sub-categories where emissions were not estimated or not occurring. In the *IPPU* summary table (Annex A4) the emissions for the individual chemical industry sub-categories is not provided as these values are confidential (and are listed as such in the summary table). Instead the emissions are aggregated and reported at the *Chemical industries* category level.

For *Refrigeration and air conditioning* applications, the IPCC guidelines (IPCC, 2006) propose either an emissions factor approach at the sub-application level (Tier 2a) or a mass balance approach at the sub-application level (Tier 2b) to calculate emissions. In the HFC Emissions Database the emissions factor approach (Tier 2a) is primarily applied, with the mass balance approach applied for uncertainty purposes/checking. There was insufficient data to follow this approach for Commercial Refrigeration and Industrial Processes, thus a hybrid approach was applied for these sub-applications, which were combined into one application.

Table 2.22: Activity data sources for the IPPU sector.

Sub-category	Activity data	Data source
Cement production	Cement produced	SAMI Report from DMRE
	Clinker fraction	Cement industries
Lime production	Mass of lime produced	SAMI Report from DMRE
Glass production	Glass production	Glass production industries (PG Group, Consol Glass and Nampak)
Ammonia production	Emissions from ammonia production	Sasol
Nitric acid production	Emissions from nitric acid production	Sasol
		Other smaller nitric acid production plants
Carbide production	Raw material (petroleum coke) consumption	SAMI report – DMR (2018)

Titanium dioxide production	Emissions from titanium dioxide production	SAMI report – DMR (2018)
Carbon black production	Amount of carbon black produced	Orion Engineered Carbons (Pty) Ltd
Iron and steel production	Production data	South African Iron and Steel Institute (SAISI)
Ferroalloys production	Production data	South African Minerals Industry (SAMI) Report produced by DMRE
Aluminium production	Production data	Aluminium industry
Lead production	Production data	SAMI Report produced by DMR (2018)
Lubricant use	Lubricant consumption	Energy balance data from DoE
Paraffin wax use	Paraffin wax consumption	Energy balance data from DoE
Refrigeration and air conditioning	Existing, new and retired refrigerators	HFC Survey, DEA; StatsSA
	Annual data on stationary air conditioning units	HFC Survey, DEA; BSRIA
	Existing, new and retired refrigeration trucks	HFC study (GIZ, 2014); Southern African Refrigerated Distribution Association (SARDA)
	Existing. New and retired vehicles	National Traffic Information System (eNaTIS); The National Association of Automobile Manufacturers of South Africa (NAAMSA)
Foam blowing agents	Total HFC used in foam manufacturing in a year	HFC Survey DEA
Fire protection	Bank of agent in fire protection equipment in a year	HFC Survey DEA
Aerosols		HFC Survey DEA

Table 2.23: Summary of methods and emission factors for the IPPU sector.

GHG Source and Sink category		CO_2		CH_4		N_2O		HFCs		PFCs		Details
		Method Applied	Emission Factor	Method Applied	Emission Factor	Method Applied	Emission Factor	Method Applied	Emission Factor	Method Applied	Emission Factor	
A	**Mineral industry**											
1	Cement production	T1	DF	NO		NO		NO		NO		
2	Lime production	T2	DF	NO		NO		NO		NO		Lime is disaggregated into lime types.
3	Glass production	T1	DF	NO		NO		NO		NO		
4	Other process uses of carbonates	NE		NO		NO		NO		NO		
B	**Chemical industry**											
1	Ammonia production	T3	CS	T3	CS							CO_2 and CH_4 emissions calculated by industry.
2	Nitric acid production	NO		NO		T3	CS	NO		NO		N_2O emissions calculated by industry.
3	Adipic acid production	NO		NE		NE		NO		NO		
4	Caprolactam, glyoxal and glyoxylic acid production	NO		NE		NE		NO		NO		
5	Carbide production	T1	CS	NE		NE		NO		NO		
6	Titanium dioxide production	T2	CS	NE		NE		NO		NO		Emissions provided by industry.
7	Soda Ash production	NO		NE		NE		NO		NO		
8	Petrochemical and carbon black production	T1	DF	NE		NE		NO		NO		
9	Fluorochemical production			NE		NE		NO		NO		
C	**Metal industry**											
1	Iron and steel production	T1, T2	DF, CS	NE		NE		NO		NO		CS CO_2 EF for direct reduced iron and sinter.
2	Ferroalloy production	T1, T3	DF, CS	T1, T3	DF, CS	NE		NO		NO		Ferrochromium emissions provided by industry.

3	Aluminium production	T1	DF	NE		NE		NO		T3	CS	CF_4 and C_2F_6 emission data supplied by industry.
4	Magnesium production	NO		NE		NE		NO		NO		
5	Lead production	T1	DF	NE		NE		NO		NO		
6	Zinc production	T1	DF	NE		NE		NO		NO		
D	**Non-energy products from fuels and solvents**											
1	Lubricant use	T1	DF	NE		NE		NO		NO		
2	Paraffin wax use	T1	DF	NE		NE		NO		NO		
3	Solvent use	NE		NE		NE		NO		NO		
E	**Electronics industry**											
1	Integrated circuit or semiconductor	NE		NE		NE		NO		NO		
2	TFT flat panel display	NE		NE		NE		NO		NO		
3	Photovoltaics	NE		NE		NE		NO		NO		
4	Heat transfer fluid	NE		NE		NE		NO		NO		
F	**Product uses as substitute ODS**											
1	Refrigeration and air conditioning	NO		NO		NO		T2a/T2b	DF	NE		
2	Foam blowing agents	NO		NO		NO		T1	DF	NE		
3	Fire protection	NO		NO		NO		T1	DF	NE		
4	Aerosols	NO		NO		NO		T1	DF	NE		
5	Solvents	NO		NO		NO		NE		NE		
G	**Other product manufacture and use**											
1	Electrical equipment	NE		NE		NE		NO		NO		
2	SF_6 and PFCs from other product uses	NE		NA		NA		NE		NE		
3	N_2O from product uses	NO		NE		NE		NO		NO		
H	**Other product manufacture and use**											
1	Pulp and paper industry	NA		NA		NA		NE		NE		
2	Food and beverage industry	NA		NA		NA		NE		NE		

T1-T3 = Tier method 1, 2 or 3; DF = IPCC default emission factor; CS = Country specific emission factor; NE = Not estimated; NO = Not occurring; NA = Not applicable

2.8.2.3. Recalculations

No recalculations were performed for this category.

2.8.2.4. Key categories

The key categories in the IPPU sector are shown in Table 2.24.

Table 2.24: Key categories identified in the IPPU sector.

IPCC Code	Category	GHG	Identification Criteria
2A1	Cement production	CO_2	L
2B	Chemical industry	C	T
2C1	Iron and steel production	CO_2	L,T
2C2	Ferroalloys production	CO_2	L,T
2C3	Aluminium production	PFCs	L,T
2F1	Refrigeration and air conditioning	HFCs	L

Note: L= level assessment, T = trend assessment; C=confidential

2.8.2.5. Planned improvements

Due to the recent introduction of the GHG Regulations, companies will be reporting data and emissions through the SAGERS system. In the next inventory, updated and improved information from this reporting will be included. In the next few years, it is planned that by the 6th BUR the time-series will be starting from 1990 and extending to 2021.

2.8.3. AFOLU

The *AFOLU* sector includes GHG emissions and removals from agriculture as well as land use and forestry. Based on the IPCC 2006 Guidelines, the main categories that were included in the emission estimates for the *AFOLU* sector are *Livestock* (3A), *Land* (3B), *Aggregated and non-CO_2 sources on land* (3C) and *Other* (3D). Rice cultivation (3C7), Other (3C8) and Other (3D2) were not included as they do not occur in South Africa.

Emissions from fuel combustion in this sector were not included here as these fall under the *agriculture/forestry/fisheries* subsector in the energy sector. The *Land* category included land remaining in the same land use as well as land converted to another land use. This category included a Tier 1 (Formulation B) approach to the mineral soil carbon pool, while organic soils were not reported on as the area of organic soils in South Africa was estimated to be insignificant. The DEFF has recently completed a project on organic and humic soils (DEA, 2019a), but this data only became available late in the inventory preparation process, so it was not possible to be include it. This data set will be assessed in the next inventory and incorporated if found to be relevant and useable.

Emissions from ruminants in privately owned game parks was included in the previous inventory, however, due to discussions during the UNFCCC in-country review, these were excluded from this inventory as they are considered not to be managed. Similarly, for Buffalo emissions. In addition, in the previous inventory the dairy cattle included all dairy cattle (both lactating and non-lactating cattle); however, in this inventory only lactating cows and heifers are included under Dairy cattle. The emissions from non-lactating dairy cattle are included under the Other cattle sub-category. Further details are provided in the relevant sections below.

In this inventory the time-series back to 1990 was established for the AFOLU sector. Data is, however, only shown for 2000 to 2017 because the other sectors only have emission estimates for 2000 onwards. The full time-series can be used in future inventories when the time-series for other sectors is completed. The full extended time series is expected to be reported in the 6th BUR.

2.8.3.1. Trends

The *AFOLU* sector in South Africa was a sink in 2017 (Table 2.25) with the *Land* category being the main contributor to the sink. A detailed summary table for the AFOLU emissions in 2017 are provided in Appendix 5A. In 2017, CH_4 emissions contributed the most (52.0%) to the *AFOLU* (excl. FOLU) emissions, with N_2O contributing 44.3%. *Enteric fermentation* contributed 98.6% of the CH_4 emissions. *Direct N_2O emissions from managed soils* was the largest contributor (79.1%) to the N_2O emissions in this sector. Indirect emissions of NOx, CO and NMVOCs were estimated for biomass burning.

Table 2.25: Summary of the estimated emissions from South Africa's AFOLU sector in 2017.

Greenhouse gas source categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	Total*
	(Gg)						(Gg CO_2e)
3. AFOLU (incl. FOLU)	**-41 288.1**	**1 309.6**	**73.8**	**487.8**	**20.3**	**27.2**	**9 085.2**
3. AFOLU (excl. FOLU)	**1 901.7**	**1 277.8**	**73.8**	**487.8**	**20.3**	**27.2**	**51 608.4**
3A Livestock	NA	1 259.7	5.5	NA	NA	NA	28 161.3
3B Land	-42 412.8	31.7	NE	NA	NA	NA	-41 746.2
3C Aggregated and non-CO_2 sources	1 901.7	18.1	68.3	487.8	20.3	27.2	23 447.1
3D Other	-776.9	NA	NA	NA	NA	NA	-776.9

**Totals may not sum exactly due to rounding off.*

The *AFOLU* (excl. FOLU) emissions declined by 8.2% (4 635 Gg CO_2e) between 2000 and 2017, while net emissions from *AFOLU* (incl. FOLU) declined by 74.6% (26 630 Gg CO_2e) over the same period (Table 2.26). This large decline is due to a doubling of the *Land* sink over this period. There were, however, fluctuations in the *Land* sink throughout the 17-year period (Figure 2.23).

Total GHG emissions from *Livestock* declined (Table 2.26) due mainly to the decreasing cattle, sheep and goat populations. The other cattle[3] population has declined by 4.7% since 2000, leading to a decline in other cattle emissions which is the largest contributor to *Enteric fermentation*. *Livestock* contributed 54.6% to the total *AFOLU* (excl. FOLU) emissions.

The *Land* component is estimated to be an overall sink with the *Forest land* category being the main contributor to this sink (Table 2.27). The increasing sink is due to increasing forest land area (particularly thickets and woodlands/open bush), and a decline in wood losses. There was a peak in burnt area in 2008, and then a fairly steep decline between 2014 and 2017, leading to reduction in disturbance losses. Furthermore, there was a decline is wood removals by households for lighting and cooking purposes, probably due to increased electrification, which also contributed to the reduced removals.

The *Grasslands* sink remained fairly constant over the 17-year period with a reduction in the sink between 2010 and 2012. This was due to an increase in fire disturbance losses from low shrublands (which are included within the *Grassland* category) during these years. *Land converted to grasslands* contributed the largest portion (95.4%) to the *Grassland* category. *Croplands* were a small, fairly constant sink which remained below 860 Gg CO_2 over the time-series. *Croplands remaining croplands* contributed to the sink, while *Land converted to croplands* produced emissions of 2 321 Gg CO_2e in 2017, and the annual variation was not more than 60 Gg CO_2e. The majority of the emissions were from the conversion of forest land to cropland.

Other lands provide a constant source of emissions (16 045 Gg CO_2) as carbon is lost when land is converted to *Other lands*. Since it is assumed there is no vegetation on *Other lands* and no changes in soil carbon, there are no emissions or removals from the *Other lands remaining other land* category. In *Land converted to other land* only changes due to initial biomass loss and soil carbon losses are relevant. These rates of change are constant due to the constant change area.

Emissions from *Aggregated and non-CO_2 emission sources* declined by 8.9% between 2000 and 2017. The fluctuations in this category are driven mainly by changes in *Liming* and *Direct N_2O from managed soils*. *Aggregated and non-CO_2 emissions on land* contributed 45.4% to the *AFOLU* (excl. FOLU) emissions in 2017.

HWP estimates indicate that this subsector is a small sink of CO_2 and this sink increased from 290 Gg CO_2e in 2000 to 776 Gg CO_2e in 2017, however, there were annual fluctuations (Table 2.26).

[3] All cattle except dairy cows and lactating heifers.

Table 2.26: Trends in category emissions within the AFOLU sector between 2000 and 2017.

	Livestock	Land	Aggregated & non-CO_2 sources	Other	AFOLU (incl. FOLU)	AFOLU (excl. FOLU)
	Gg CO_2e					
2000	30 515.5	-20 237.4	25 727.8	-290.4	35 715.3	56 243.2
2001	30 340.1	-11 991.3	25 783.5	-557.0	43 575.3	56 123.6
2002	29 862.3	-14 484.9	26 343.3	-735.5	40 985.3	56 205.7
2003	28 988.5	-24 175.2	24 615.0	-893.1	28 535.2	53 603.5
2004	28 771.7	-17 547.3	24 321.5	-1 151.0	34 394.9	53 093.2
2005	28 806.7	-4 771.0	24 404.4	-251.7	48 188.3	53 211.1
2006	28 710.7	-8 440.2	24 591.9	-869.1	43 993.3	53 302.6
2007	27 953.8	-9 992.9	24 305.6	-629.0	41 637.5	52 259.4
2008	29 128.5	-2 218.2	25 469.6	-792.3	51 587.6	54 598.1
2009	28 566.8	-19 752.5	24 429.2	-119.1	33 124.4	52 996.0
2010	29 466.3	-12 207.7	24 997.7	-513.1	41 743.2	54 464.0
2011	29 540.4	-19 082.3	25 137.8	57.2	35 653.2	54 678.2
2012	28 765.7	-17 360.4	24 218.9	-441.4	35 182.8	52 984.6
2013	29 976.2	-27 901.6	25 583.0	-282.9	27 374.5	55 559.1
2014	29 854.3	-22 699.1	25 675.5	-535.4	32 295.2	55 529.7
2015	29 764.8	-33 123.6	24 749.3	-608.3	20 782.2	54 514.1
2016	28 493.5	-44 669.9	23 164.5	-1 091.1	5 896.9	51 657.9
2017	28 161.3	-41 746.2	23 447.1	-776.9	9 085.2	51 608.4

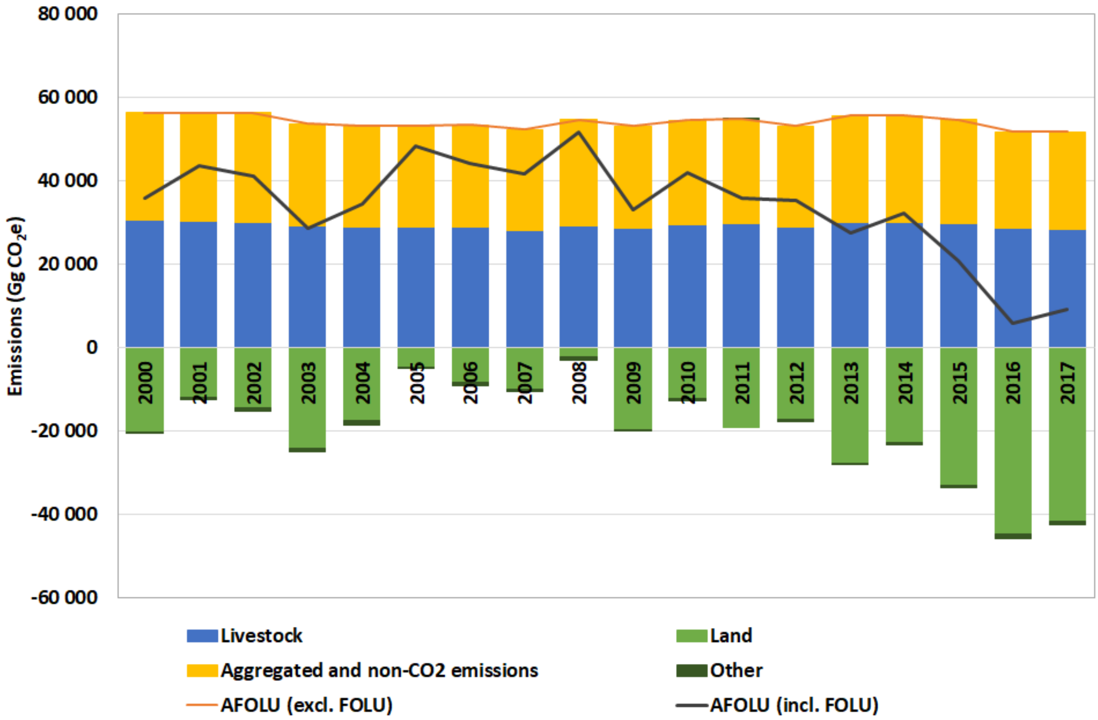


Figure 2.23: Emission trends for South Africa's AFOLU sector, 2000–2017.

Table 2.27: Trends in the emissions and removals from the sub-categories within the Land category between 2000 and 2017.

	3B1 Forest land	3B2 Cropland	3B3 Grassland	3B4 Wetlands	3B5 Settlements	3B6 Other lands
	Gg CO_2					
2000	-19 212.9	768.2	-18 903.7	666.6	399.5	16 044.8
2001	-10 984.9	852.5	-19 029.1	666.6	458.7	16 044.8
2002	-14 785.9	772.2	-17 582.7	666.6	386.6	16 044.8
2003	-23 367.5	766.5	-18 577.0	666.6	310.8	16 044.8
2004	-15 863.7	659.2	-19 247.3	666.6	205.7	16 044.8
2005	-4 515.7	770.8	-18 437.4	666.6	672.6	16 044.8
2006	-7 586.2	701.0	-18 824.0	666.6	568.3	16 044.8
2007	-9 099.2	784.3	-19 031.0	666.6	646.2	16 044.8
2008	-1 260.0	839.5	-18 841.1	666.6	333.6	16 044.8
2009	-19 149.0	632.0	-18 388.8	666.6	435.6	16 044.8
2010	-13 898.3	726.0	-16 042.5	666.6	281.4	16 044.8
2011	-20 623.0	690.2	-16 003.6	666.6	142.2	16 044.8
2012	-20 438.9	750.5	-14 523.0	666.6	132.7	16 044.8
2013	-27 595.3	641.1	-17 791.5	666.6	154.9	16 044.8
2014	-21 517.7	589.9	-18 640.8	666.6	169.1	16 044.8
2015	-32 260.0	562.7	-18 182.4	666.6	44.6	16 044.8
2016	-44 357.3	543.6	-17 466.1	666.6	-101.6	16 044.8
2017	-40 707.4	528.3	-18 155.3	666.6	-105.8	16 044.8

There was a 5.4% (2 906 Gg CO_2e) decrease in the *AFOLU* (excl. FOLU) emissions since 2015. This can be attributed to a slight decline in livestock population during this period. The *AFOLU* (incl. FOLU) emissions declined by 56.3% (11 697 Gg CO_2e) over the same period due to a large increase in the *Land* sink. *Aggregated and non-CO_2 emissions on land* decreased by 1 302 Gg CO_2e (5.3%), while the *HWP* sink increased by 169 Gg CO_2e since 2015.

2.8.3.2. Land representation

The South African National Land-Cover Dataset 1990 (GTI, 2015) and 2013-14 (GTI, 2014), developed by GeoTerraImage (GTI), were used for this study to determine long-term changes in land cover[4] and their associated impacts. Land-use changes were mapped using an Approach 2 method as described in the 2006 IPCC Guidelines. The classes used in the 2017 inventory are provided in Table 2.28. A detailed description of the methodology for determining land use change is provided in the 2017 NIR, with the annual land change matrix being provided in Table 2.29. The 20-year transition period was incorporated into the land change areas.

Table 2.28: Land classification for the 2017 inventory.

<table>
<tr><th rowspan="2">35 class categories</th><th rowspan="2">17 class categories</th><th>IPCC category</th></tr>
<tr><th>2017 submission</th></tr>
<tr><td>Indigenous forests</td><td rowspan="2">Indigenous forests</td><td rowspan="11">Forest land</td></tr>
<tr><td>Forest: Fynbos</td></tr>
<tr><td>Plantations/woodlots</td><td>Plantations/woodlots</td></tr>
<tr><td>Thicket/dense bush</td><td rowspan="4">Thicket/dense bush</td></tr>
<tr><td>Thicket: Fynbos</td></tr>
<tr><td>Thicket: Nama-Karoo</td></tr>
<tr><td>Thicket: Succulent Karoo</td></tr>
<tr><td>Woodland/open bush</td><td rowspan="4">Woodland/open bush</td></tr>
<tr><td>Open bush: Fynbos</td></tr>
<tr><td>Open bush: Nama-Karoo</td></tr>
<tr><td>Open bush: Succulent Karoo</td></tr>
<tr><td>Grasslands</td><td rowspan="4">Grasslands</td><td rowspan="9">Grassland</td></tr>
<tr><td>Grasslands: Fynbos</td></tr>
<tr><td>Grasslands: Nama-Karoo</td></tr>
<tr><td>Grasslands: Succulent Karoo</td></tr>
<tr><td>Low shrubland</td><td rowspan="4">Low shrubland</td></tr>
<tr><td>Low shrubland: Fynbos</td></tr>
<tr><td>Low shrubland: Nama-Karoo</td></tr>
<tr><td>Low shrubland: Succulent Karoo</td></tr>
<tr><td>Degraded</td><td>Degraded</td></tr>
<tr><td>Bare ground</td><td>Bare ground</td><td>Other land</td></tr>
</table>

[4] The term 'land cover' is used loosely here as the classes are a combination of land cover and land use.

Bare ground: Fynbos		
Bare ground: Nama-Karoo		
Bare ground: Succulent Karoo		
Cultivated commercial annual: non-pivot	Cultivated commercial annual: non-pivot	Cropland
Cultivated commercial annual: pivot	Cultivated commercial annual: pivot	
Cultivated commercial permanent orchards	Cultivated commercial permanent orchards	
Cultivated commercial permanent vines	Cultivated commercial permanent vines	
Cultivated subsistence crops	Cultivated subsistence crops	
Settlements	Settlements	Settlements
Mines	Mines	
Waterbodies	Waterbodies	Wetlands
Wetlands	Wetlands	

Table 2.29: Annual land conversion areas (ha) for South Africa between 1990 and 2014.

	Land categories	2014																
		Indigenous Forest	Thicket/ dense bush	Woodland/ open bush	Low s shrubland	Plantations/ woodlots	Commercial Annual crop: non-pivot	Commercial Annual crop: pivot	Permanent orchards	Permanent vines	Cultivated subsistence crops	Settlements	Wetlands	Grasslands	Mines	Waterbodies	Bare ground	Degraded
1990	Indigenous Forest		1 857	325	60	0	35	1	28	0	41	84	0	280	11	1	23	0
	Thicket/ dense bush	2 003		53 279	15 913	0	4 225	375	981	161	2 132	1 970	0	34 718	357	435	888	0
	Woodland/ open bush	420	63 139		54 184	0	4 021	1 424	484	71	2 945	3 384	0	76 698	637	481	6 666	0
	Low shrubland	206	25 088	59 216		0	9 566	2 675	575	581	397	2 367	0	172 823	324	519	104 651	0
	Plantations/ woodlots	0	0	0	0		7 169	165	1 778	206	652	0	0	0	0	0	0	0
	Commercial annual crop: non-pivot	30	3 892	9 264	16 655	0		16 223	1 322	361	717	1 158	0	33 744	1 559	91	424	0
	Commercial annual crop: pivot	0	118	241	119	0	1 037		146	39	15	39	0	222	27	2	7	0
	Permanent orchards	6	616	355	250	0	753	153		421	168	45	0	409	2	5	7	0
	Permanent vines	0	211	23	221	0	121	24	143		0	23	0	60	0	7	7	0
	Cultivated subsistence crops	11	3 474	7 520	564	0	1 879	75	116	11		362	0	3 245	59	40	239	0
	Settlements	43	2 964	1 394	793	0	747	5	30	9	1 306		0	4 143	60	25	136	0
	Wetlands	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
	Grasslands	989	69 807	127 370	161 299	9 635	26 490	2 826	452	76	9 451	8 031	0		2 170	928	9 040	0
	Mines	0	309	784	366	0	46	5	0	0	17	53	0	2 091		8	107	0
	Waterbodies	10	1 091	618	1 153	0	157	7	12	6	34	43	0	1 456	10		3 677	0
	Bare ground	11	3 338	8 747	146 389	0	122	75	9	112	14	190	0	7 931	36	1 036		0
	Degraded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

2.8.3.3. Methods and data

The *AFOLU* sector uses a mix of T1 and T2 methods as indicated in Table 2.30. For *Enteric fermentation* and *Manure management,* country specific emission factors are taken from Du Toit et al. (2013a-c) and Moeletsi et al. (2015). The National Terrestrial Carbon Sinks Assessment (DEA, 2015) provided some of the input carbon stock data for the *land* sub-category, with soil management data for *croplands* being provided by Tongwane et al. (2016). Details of sources of activity data are provided in Table 2.31 with more details available in the 2017 NIR.

Table 2.30: Summary of methods and emission factors for the AFOLU sector and an assessment of the completeness of the AFOLU sector emissions.

GHG Source and sink category		CO_2		CH_4		N_2O		Details
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	
3A LIVESTOCK	***1 Enteric fermentation***							
	a.i. Dairy cattle	NA		T2	CS	NA		CS EF for CH_4 and N_2O from Du Toit et al. (2013a - c) were applied for all indicated livestock. Buffalo and wild game are not considered to be managed, therefore, not included in the emission estimates.
	a.ii. Other cattle	NA		T2	CS	NA		
	b. Buffalo	NA		NO		NA		
	c. Sheep	NA		T2	CS	NA		
	d. Goats	NA		T2	CS	NA		
	e. Camels	NA		NO	NO	NA		
	f. Horses	NA		T1	DF	NA		
	g. Mules and asses	NA		T1	DF	NA		
	h. Swine	NA		T2	CS	NA		
	j. Other	NA		NO		NO		
	2 Manure management							
	a.i. Dairy cattle	NA		T2	CS	T2	DF	CS EF for CH_4 and N_2O from Du Toit et al. (2013a) were applied.
	a.ii. Other cattle	NA		T2	CS	T2	DF	
	b. Buffalo	NA		NO		NO		Buffalo are not considered to be managed, therefore, not included in emission estimates.
	c. Sheep	NA		T2	CS	NO		CS EF for CH_4 from Du Toit et al. (2013b) were applied.
	d. Goats	NA		T2	CS	NO		
	e. Camels	NA		NO		NO		
	f. Horses	NA		T1	DF	NO		
	g. Mules and asses	NA		T1	DF	NO		
	h. Swine	NA		T2	CS	T2	DF	CS EF for CH_4 from Du Toit et al. (2013b - c) were applied.
	i. Poultry	NA		T2	CS	T2	DF	

	j. Other	NA		NO		NO		Wild game not considered to be managed, therefore, excluded from emission estimates.
3B LAND	***1 Forest land***							
	a. Forest land remaining forest land	Biomass: T2	Biomass: CS	NE		NE		CS activity data and EF are applied (see data sources table).
		DOM: T2	DOM: CS					CS DOM stocks are utilized from NTCSA (DEA, 2014).
		Soil: T1	Soil: DF					Mineral soils (MS) only, organic soils (OS) NE.
	b. Land converted to forest land	Biomass: T2	Biomass: CS	NE		NE		CS activity data and EF are applied (see data sources table).
		DOM: T2	DOM: CS					CS DOM stocks are utilized from NTCSA (DEA, 2014).
		Soil: T1	Soil: DF					MS only, OS NE.
	2 Cropland							
	a. Cropland remaining cropland	Biomass: T2	Biomass: CS	NE		NE		CS activity data and EF are applied (see data sources table).
		DOM: T2	DOM: CS					CS DOM stocks are utilized from NTCSA (DEA, 2014).
		Soil: T1	Soil: DF					MS only, OS NE.
	b. Land converted to cropland	Biomass: T2	Biomass: CS	NE		NE		CS activity data and EF are applied (see data sources table).
		DOM: T2	DOM: CS					CS DOM stocks are utilized from NTCSA (DEA, 2014).
		Soil: T2	Soil: DF, CS					CS stock change factors were applied.
	3 Grassland							
	a. Grassland remaining grassland	Biomass: T2	Biomass: CS	NE		NE		CS activity data and EF are applied (see data sources table).
		DOM: T2	DOM: CS					CS DOM stocks are utilized from NTCSA (DEA, 2014).
		Soil: T1	Soil: DF					MS only, OS NE.
	b. Land converted to grassland	Biomass: T2	Biomass: CS	NE		NE		CS activity data and EF are applied (see data sources table).
		DOM: T2	DOM: CS					CS DOM stocks are utilized from NTCSA (DEA, 2014).
		Soil: T1	Soil: DF					MS only, OS NE.
	4 Wetland							
	a. Wetland remaining wetland	NE		T1	DF	NE		
	b. Land converted to wetland	NE		NE		NE		

	5 Settlements							
	a. Settlements remaining settlements	Biomass: T2	Biomass: CS	NE		NE		CS activity data and EF are applied (see data sources table).
		DOM: T2	DOM: CS					CS DOM stocks are utilized from NTCSA (DEA, 2014).
		Soil: T1	Soil: DF					MS only, OS NE.
	b. Land converted to settlements	Biomass: T2	Biomass: CS	NE		NE		CS activity data and EF are applied (see data sources table).
		DOM: T2	DOM: CS					CS DOM stocks are utilized from NTCSA (DEA, 2014).
		Soil: T1	Soil: DF					MS only, OS NE.
	6 Other land							
	a. Other land remaining other land	Biomass: NE		NE		NE		
		Soil: T1	Soil: DF					
	b. Land converted to other land	Biomass: T2	Biomass: CS	NE		NE		CS activity data and EF are applied (see data sources table).
		Soil: T1	Soil: DF					MS only, OS NE.
3C AGGREGATED SOURCES & NON-CO_2 EMISSIONS ON LAND	***1 Biomass burning***	T2	DF, CS	T2	DF, CS	T2	DF, CS	CS Mb, Cf and EF for savannas and croplands were applied (DEAT, 2009; DAFF, 2010).
	2 Liming	T1	DF	NA		NA		
	3 Urea application	T1	DF	NA		NA		
	4 Direct emissions from managed soils							
	Synthetic fertilizers	NA		NA		T1	DF	
	Animal waste added to soils	NA		NA		T1, T2	DF	CS manure management data was applied (Du Toit et al., 2013a - d; Moeletsi et al., 2015).
	Other organic fertilizers	NA		NA		T1	DF	
	Urine and dung deposited by grazing livestock	NA		NA		T1, T2	DF	
	Crop residues	NA		NA		T1	DF	
	5 Indirect emissions from managed soils							
	Atmospheric deposition	NA		NA		T1	DF	
	Nitrogen leaching and runoff	NA		NA		T1	DF	
	6 Indirect emissions from manure management							
	Volatilization	NA		NA		T1	DF	
	Nitrogen leaching and runoff	NA		NA		T1	DF	
	7 Rice cultivation	NO		NO		NO		
3D OTHER	***1 Harvested wood products***	T2	DF	NA		NA		
	2 Other	NO		NA		NA		

T1 –T3 =Tier method 1, 2 or 3; DF = IPCC default emission factor; CS = Country specific emission factor; NE = Not estimated; NO = Not occurring; NA = Not Applicable

Table 2.31: Activity and emission factor data sources for the AFOLU sector.

Sub-category	Activity data	Data source
Enteric fermentation	Population data	DAFF (2018)
		SA Poultry Association (SAPA)
		Du Toit et al. (2013a-c)
	Herd composition	Du Toit et al. (2013a-c)
	Livestock activity data (weights, intake, dry matter digestibility, etc)	Du Toit et al. (2013a-c)
		Moeletsi et al. (2015); Moeletsi & Tongwane (2015)
Manure Management	Manure management data	Du Toit et al. (2013a-c)
		Moeletsi et al. (2015); Moeletsi & Tongwane (2015)
	N excretion rates	IPCC 2006 Guidelines
		Du Toit et al. (2013b,c)
General Land Data	Land cover and change maps (1990–2013/14)	GTI (2014, 2015)
	Climate map	Moeletsi et al. (2015)
	Soil map	Moeletsi et al. (2015)
	Litter data	National Terrestrial Carbon Sinks Assessment (DEA, 2015)
Forest Land	Plantation data	Forestry South Africa Industry facts (FSA, 2018)
		Du Toit et al. (2016)
		Alembong (2015)
		Timber Statistics reports (DAFF, 2017)
	Natural forests and woodlands	GTI (2014)
Cropland	Planted/harvested areas	DAFF Agricultural Abstracts (DAFF, 2018);
		DAFF – Crop estimates committee
		StatsSA (2007)
		FAOStat (2018)
	Yield	DAFF Agricultural Abstracts (2018)
		Moeletsi et al. (2015)
		FAOStat (2018)
	Crop management data	Moeletsi et al. (2015)
		Tongwane et al. (2016)
	Perennial crop data	Citrus Growers Association (CGA, 2016)
Grassland	Biomass data and growth rates	Masubelele et al. (2014)
		National Terrestrial Carbon Sinks Assessment (DEA, 2015)
	Grassland management data	Fairbanks et al. (2000)
		Matsika (2007)
Settlements	Management data	Fairbanks et al. (2000)

		DEA (2016)
Other lands	Soil carbon data	IPCC (2006)
Biomass burning	Burnt area data	MODIS burnt area product – collection 5 and 6 (2019)
	Mass of fuel available	DEAT (2009), DEA (2014)
		Van Leeuwen et al. (2014)
		DAFF (2010)
Liming	Lime consumption	Fertilizer Association SA (FERTASA, 2018); SAMI Reports (DMR, 2018)
Urea application	Urea import data	SARS (2018)
Synthetic fertilizers	Total N fertilizer consumption	Fertilizer Association of SA (FERTSA, 2018)
	N content of fertilizers	Grain SA Report (Grain SA, 2011)
Organic fertilizers	Wastewater production data for sewage sludge	Waste sector
	Compost calculations	DAFF (2010)
Crop residues	Crop area planted	DAFF (2018)
		Crop Estimates Committee
		StatsSA (2007)
		FAOStat (2018)
	Crop yield data	Moeletsi et al. (2015)
		Tongwane et al. (2016)
		FAOStat (2019)
	C:N ratios	Moeletsi et al. (2015)
		Tongwane et al. (2016)
	Crop residue management	Tongwane et al. (2016)
		Moeletsi et al. (2015)
Harvested wood products	Production, import and export data for HWP	FAOStat (2019)

2.8.3.4. Recalculations

The *AFOLU* sector is under continual improvement which leads to recalculations. As in the previous 2015 inventory, significant changes have been made to this sector. The improvements and their contribution to total change in the 2015 estimates are provided in Table 2.32.

Table 2.32: AFOLU improvements and their contribution to the total change compared to the previous submission (2015).

Sub-category	Improvement/ update	Change	Change in category emissions
		(Gg CO_2e)	(%)
Enteric fermentation	Changed ratio of dairy cows to heifers; Adjusted herd composition for cattle; Removed game emissions.	1351.9 (Dairy cattle: 444.5; Other cattle: 1 943.7; Game: -1 036.0)	5.2
Manure management (CH_4)	Adjusted herd composition for cattle; Updated manure management data.	70.4 (Dairy cattle: 61.4; Other cattle: 9.4)	10.6
Manure management (N_2O)	Adjusted herd composition for cattle; Updated manure management data; Used country specific N excretion rates for poultry and swine.	654.1 (Dairy cattle: 61.4; Other cattle: -168.9; Swine: 11.5; Poultry: 602.3)	57.3
Forest land	Area adjustment for 20-year transition; Updated biomass, litter and soil ref data; Updated wood removal data; Used annual burnt area data instead of 5-year averages.	1055.0 (Land remaining: -29.1; Land converted to: 1 084.1)	-3.2
Cropland	Area adjustment for 20-year transition; Updated biomass, litter and soil ref data; Updated stock change factors; Improved disturbance data.	-3028.4 (Land remaining: -99.1; Land converted to: -2 929.3)	-84.3
Grassland	Area adjustment for 20-year transition; Degraded land class area incorporated; Updated biomass, litter and soil ref data; Improved disturbance data.	-14819.6 (Land remaining: 4 050.0; Land converted to: -18 869.5)	440.7
Wetland	Updated CH_4 emission factor.	31.6	4.5
Settlements	Area adjustment for 20-year transition; Updated biomass, litter and soil ref data; Improved disturbance data.	-2860.3 (Land remaining: 1025.9; Land converted to: -3 886.2)	-98.5
Other lands	Area adjustment for 20-year transition; Removal of degraded class area; Included Tier 1 assumption that soil carbon becomes zero after 20 years.	13674.1 (Land remaining: 0; Land converted to: 13 674.1)	576.8
Biomass burning	Updated land areas with 20-year transition; Removed assumption that forests and thickets don't burn; Improved burnt area data; Used annual burnt area instead of 5-year average; Updated fuel load and combustion factor data.	-279.2 (Forest land: 155.0; Croplands: -122.8; Grasslands: -306.7; Wetlands: 1.2; Settlements: -5.9; Other lands: 0)	17.7
Liming	Used new lime consumption data source.	323.1	69.8

Direct N_2O from managed soils	Adjusted herd composition data for cattle; Updated manure management data; Improved crop residue calculations; Updated inorganic N data; Excluded sewage sludge N input due to double counting; Included FSOM* N_2O emissions.	3 507.3 (Inorganic N: -117.9; Organic N: 1 264.9; Crop residues: 53.3; Urine & dung: 890.2; FSOM: 1 416.9)	22.2
Indirect N_2O from managed soils	Adjusted herd composition data for cattle; Updated manure management data; Improved crop residue calculations.	161.8 (Atmospheric deposition: 95.2; Leaching/runoff: 66.6)	7.3
Indirect N_2O from manure management	Adjusted herd composition for cattle; Updated manure management data; Country specific N excretion rates for poultry, swine, horses, mules and asses.	-171.4 (Volatilisation: -160.6; Leaching/runoff: -10.7)	-27.0
Harvested wood products	Updated import and export data from FAOStat.	51.8	-7.9
Total change (incl. FOLU)		**-277.7**	**-1.3**

* FSOM = amount of N in mineral soils that is mineralised, in association with loss of soil carbon from soil organic matter as a result of changes to land use or management.

The recalculations led to a 7.5% and a 16.7% increase in the 2015 estimates for *Livestock* and *Aggregated and non-CO_2 emissions on land*. The *Land* category showed a 29.5% increase in the sink in 2015, however in some years the estimates showed a decrease in the sink (Figure 2.24). Recalculations for *HWP* produced a 7.8% decrease in the sink estimate for 2015, but similar to the *Land* category, there were annual fluctuations. Overall, the recalculations for the *AFOLU* sector excluding FOLU showed a 10.1% increase in emission estimates for 2015, while the *AFOLU* sector including FOLU decreased by 1.3%.

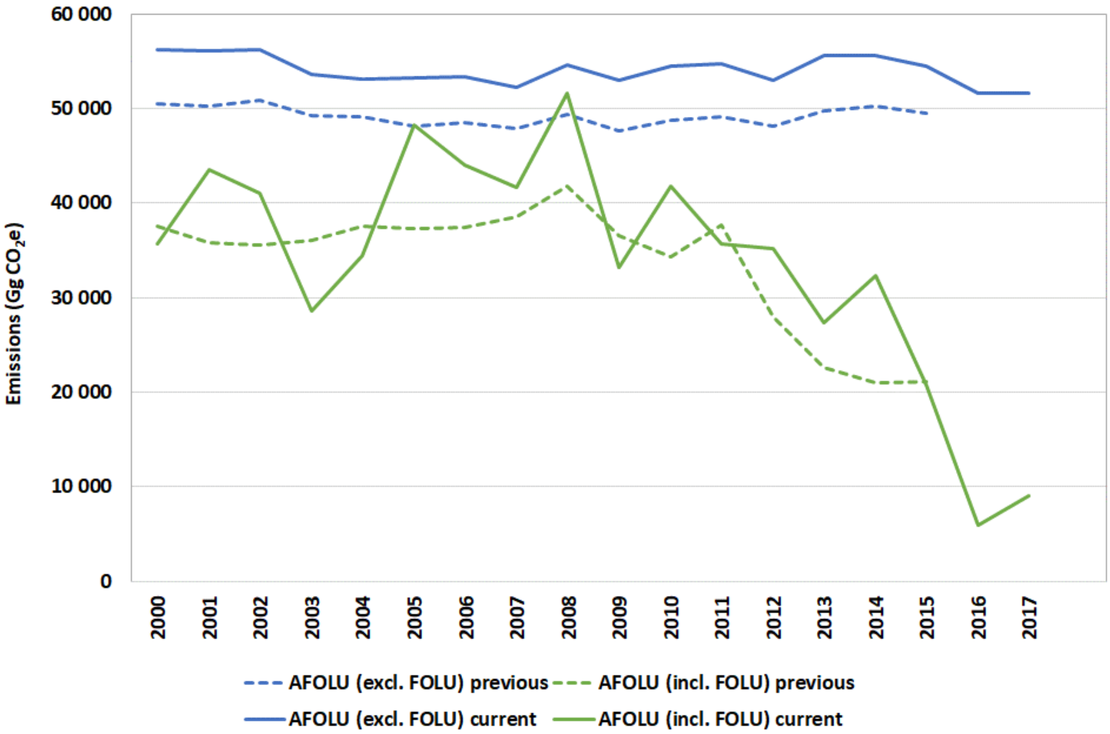


Figure 2.24: Change in AFOLU emission estimates due to recalculations since 2015 submission.

2.8.3.5. Key categories

The key categories for the *AFOLU* sector are shown in Table 2.33 with the detailed key category results presented in Annex A2.

Table 2.33: Key categories in the AFOLU sector.

IPCC Code	Category	GHG	Identification Criteria
3A1a	Enteric fermentation - cattle	CH_4	T
3A1c	Enteric fermentation - sheep	CH_4	T
3B1a	Forest land remaining forest land	CO_2	L,T
3B1b	Land converted to forest land	CO_2	L,T
3B2a	Cropland remaining cropland	CO_2	T
3B2b	Land converted to cropland	CO_2	T
3B3b	Land converted to grassland	CO_2	L,T
3B6b	Land converted to other land	CO_2	L,T
3C1c	Biomass burning - grasslands	N_2O	T
3C2	Liming	CO_2	T
3C4	Direct N_2O from managed soil	N_2O	T
3C5	Indirect N_2O from managed soils	N_2O	T
3D1	Harvested wood products	CO_2	T

Note: L= level assessment, T = trend assessment

2.8.3.6. Planned improvements

There are several needs and improvements which are required to improve the estimates in the *AFOLU* sector. For the *Livestock* category it is planned that over the next two inventory cycles the background data and calculations of the *Enteric fermentation* emission factors will be incorporated into the calculation files. Initially the cattle data will be included (since this is a key category), followed by the other livestock. This will enable adjustments to the various components of the calculations to be made as new data becomes available. For the Land category the planned improvements are:

(i) Incorporate the recently released 2018 land cover data and update land changes for 2015 to 2017. This task may be complex since technology improved since the 2014 map was produced and the land cover maps are now developed from Sentinal data. The maps are therefore more accurate and, in addition to this, a new vegetation classification was utilized to bring it into alignment with South Africa's standard classification. This makes it difficult to directly compare the 2014 data with the 2018 data. A new approach, one where the land use change matrix can be derived on the basis of all available geographically explicit datasets, will be considered for the future.

(ii) In the next inventory any relevant data for organic soils will be incorporated from the study completed by the DEFF.

(iii) Incorporate CO_2 emissions and removals from wetlands. The methodology in the new 2013 wetland supplement (IPCC, 2014) and 2006 refinement will be considered. The 2013 supplement was considered for the CH_4 emission estimates in this inventory but the emission factor of 235 kg ha^{-1} yr^{-1} for mineral soils in temperate climates is very much higher than the previous emission factor of 16.06 kg ha^{-1} yr^{-1}. This new emission factor is in line with a study done in South Africa (Otter et al., 2000), however, there was insufficient time to do a proper assessment of the new guidelines and do a validation of the higher emission outputs for wetlands for this submission.

(iv) Carbon stock data for all land types will be updated with information from the Terrestrial Carbon Sinks Assessment update that is currently underway.

(v) Undertake an assessment of crop area estimates and crop type classifications to obtain improved crop area estimates for all crop types.

(vi) Update HWP to incorporate country-specific information.

(vii) Include a more detailed uncertainty analysis for land.

(viii) Include the full time-series from 1990–2021 in the 6th BUR.

2.8.4. Waste

Among the sectors that contribute to the increasing quantities of GHGs into the atmosphere is the *Waste* sector. This section highlights the GHG emissions into the atmosphere from managed landfills, open burning of waste and wastewater treatment systems in South Africa, estimated using the IPCC 2006 Guidelines.

The waste sector in the national inventory of South Africa comprises three sources:

(i) 4A Solid waste disposal.

(ii) 4C Incineration and open burning of waste (only open burning of waste is estimated).

(iii) 4D Wastewater treatment and discharge.

For completeness in this sector, emissions from *Incineration* and *Biological treatment of organic waste* still need to be addressed.

2.8.4.1. Trends

In 2017 the *Waste* sector produced 21 249 Gg CO_2e or 3.8% of South Africa's GHG emissions (excl. FOLU). The largest source category was *Solid waste disposal* which contributed 81.7% towards the total sector emissions (Table 2.34). This was followed by *Wastewater treatment and discharge* which contributed 16.6%.

Waste sector emissions have increased by 56.7% from the 13 558 Gg CO_2e in 2000. Emissions increased steadily between 2000 and 2017 (Figure 2.25). *Solid waste disposal* was the main contributor (average of 80.2%) to these emissions. Emissions from *Solid waste disposal* increased by 64.8% (6 832 Gg CO_2e) since 2000 (10 534 Gg CO_2e), while emissions from *Incineration and open burning of waste* and *Wastewater treatment and discharge* each increased by 28.4% over this period (Table 2.35).

The contribution from the *Waste* sector to the national emissions (excl. FOLU) increased from 3.0% in 2000 to 3.8% in 2017.

Table 2.34: Summary of the estimated emissions from the Waste sector in 2017.

Greenhouse gas source categories	CO_2	CH_4	N_2O	Total waste sector
	Gg CO_2	Gg CH_4	Gg N_2O	Gg CO_2e
4 WASTE	**37.5**	**969.5**	**2.8**	**21 249.0**
4A Solid waste disposal	NA	827.0	NA	17 366.0
4B Biological treatment of solid waste	NE	NE	NE	NE
4C Incineration and open burning of waste	37.5	11.5	0.3	360.2
4D Wastewater treatment and discharge	NA	131.1	2.5	3 522.8

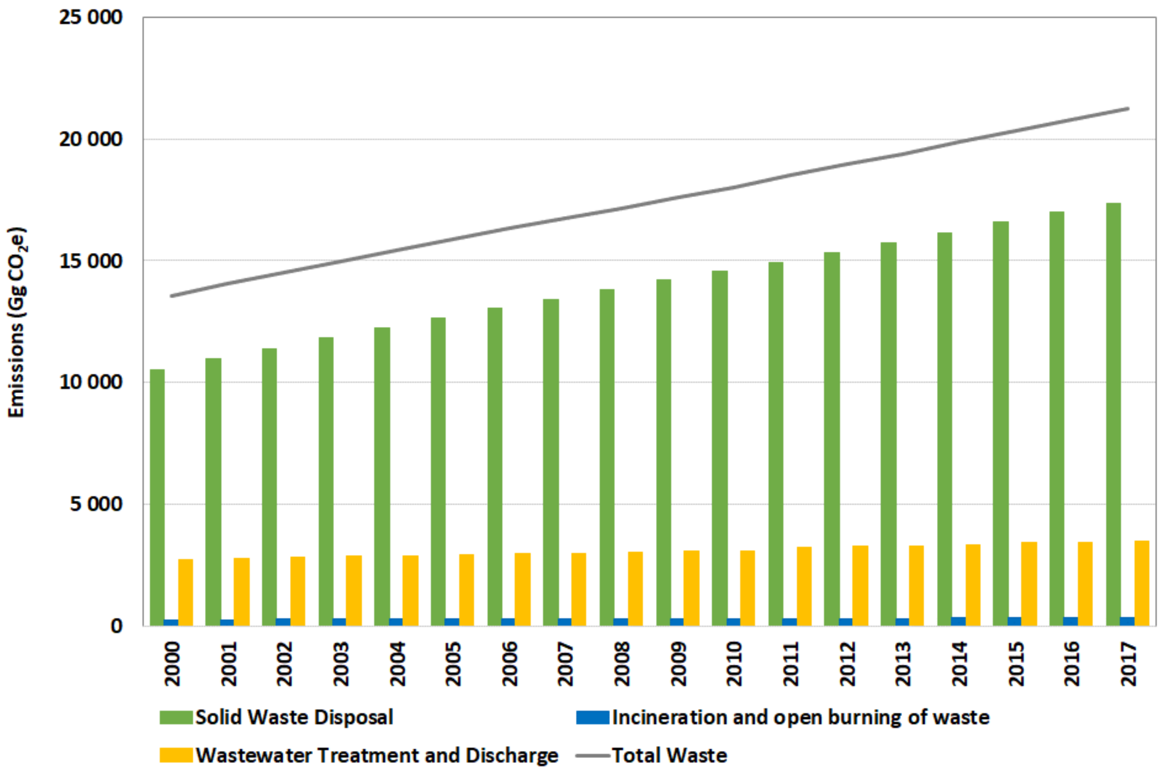


Figure 2.25: Trend in emissions from Waste sector, 2000–2017.

Table 2.35: Trends in category emission within the Waste sector between 2000 and 2017.

	4A Solid Waste Disposal	4B Biological treatment of solid waste	4C Incineration and open burning of waste		4D Wastewater Treatment and Discharge	Total Waste sector
			4C1 Waste incineration	4C2 Open burning of waste		
	Gg CO_2e					
2000	10 533.9	NE	280.5	2 743.4	13 557.8	10 533.9
2001	10 964.9	NE	286.3	2 800.2	14 051.4	10 964.9
2002	11 393.8	NE	290.3	2 839.0	14 523.1	11 393.8
2003	11 815.5	NE	294.0	2 875.4	14 984.9	11 815.5
2004	12 229.2	NE	297.5	2 909.6	15 436.3	12 229.2
2005	12 635.4	NE	300.9	2 942.8	15 879.1	12 635.4
2006	13 034.4	NE	304.3	2 976.1	16 314.7	13 034.4
2007	13 426.8	NE	307.6	3 008.9	16 743.3	13 426.8
2008	13 813.0	NE	311.1	3 042.3	17 166.4	13 813.0
2009	14 192.8	NE	314.4	3 075.1	17 582.3	14 192.8
2010	14 563.5	NE	317.9	3 109.4	17 990.8	14 563.5
2011	14 935.2	NE	330.0	3 228.0	18 493.2	14 935.2

2012	15 332.1	NE	337.8	3 303.5	18 973.3	15 332.1
2013	15 738.0	NE	339.1	3 316.6	19 393.6	15 738.0
2014	16 159.4	NE	344.6	3 370.6	19 874.6	16 159.4
2015	16 573.3	NE	350.3	3 426.5	20 350.2	16 573.3
2016	16 975.9	NE	354.4	3 466.7	20 797.1	16 975.9
2017	17 366.0	NE	360.2	3 522.8	21 249.0	17 366.0

2.8.4.2. Methods and data

The IPCC Tier 1 first order decay model has been used to estimate *Solid waste* emissions. Tier 1 methods were used to estimate all other emissions in the *Waste* sector (Table 2.36). Country-specific parameters for municipal waste and for treatment of some types of industrial wastewater (Cardno, 2015) were utilised. A Tier 1 approach, with default IPCC 2006 emission factors, was applied in the calculation of CO_2, CH_4 and N_2O emissions from open burning.

The emissions for the *Waste* sector were derived by either using available data or estimates based on accessible surrogate data sourced from the scientific literature. The main limitation to quantifying the GHG emissions from different waste streams was the lack of a periodically updated national inventory on: the quantities of organic waste deposited in well-managed landfills; the annual recovery of methane from landfills; quantities generated from anaerobically decomposed organic matter from wastewater treated; and per capita annual protein consumption in South Africa.

The main sources of data were Statistics South Africa, with the same population data being used in both the *Solid waste* and *Wastewater treatment* calculations. The emissions factors for different wastewater treatment and discharge systems were taken from the IPCC 2006 Guidelines as was the data on distribution and utilization of different treatment and discharge systems. Data sources are shown in Table 2.37.

Table 2.36: Summary of methods and emission factors for the Waste sector.

GHG Source and sink category		CO_2		CH_4		N_2O		Details
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	
A	**Solid waste disposal**			**T1**	**DF**			**Tier 1 FOD model was used.**
1	Managed waste disposal sites	NA		IE		NA		Included in aggregated Solid waste disposal estimates
2	Unmanaged waste disposal sites	NA		IE		NA		
3	Uncategorised waste disposal sites	NA		IE		NA		
B	**Biological treatment of solid waste**	**NE**		**NE**		**NE**		
C	**Incineration and open burning of waste**							
1	Waste incineration	NE		NE		NE		
2	Open burning of waste	T1	DF	T1	DF	T1	DF	
D	**Wastewater treatment and discharge**	**NA**		**T1**	**DF**	**T1**	**DF**	

1	Domestic wastewater treatment and discharge			IE		IE		Included in aggregated Wastewater treatment and discharge estimates
2	Industrial wastewater treatment and discharge			IE		IE		
E	**Other**	**NO**		**NO**		**NO**		

Table 2.37: Activity data sources for the waste sector.

Sub-category	Activity data	Data source
Solid waste disposal	Population data	StatsSA (2017). UN (2012).
	Waste composition	IPCC 2006.
	Waste generation rate for each component	DEA (2012).
	GDP	World bank
Open burning of waste	Population data	StatsSA (2017). UN (2012).
	Fraction of population burning waste	
Wastewater treatment and discharge	Population data	StatsSA (2017). UN (2012).
	Split of population by income group	StatsSA (2017).
	Biochemical oxygen demand generation rates per treatment type	IPCC 2006.
	Per capita nitrogen generation rate	IPCC 2006.

2.8.4.3. Recalculations

Recalculations were performed for the category *Solid waste disposal* for all years between 2000 and 2017 due to the following changes:

(i) The population, waste per capita and the percentage of waste going to solid waste disposal sites was corrected in the FOD model for the years 1950 to 2000. In the previous submission these numbers were only input for the years from 2000 onwards, while default values were left for the years prior to this.

(ii) The fraction of methane in developed gas was previously indicated to be 0.52 and this was corrected to the IPCC default value of 0.5.

The recalculation of the *Solid waste disposal* emissions produced outputs that were 34.8% higher than the previous submission for 2000, and this declined to a 5.2% increase in the recalculated 2015 estimate. Overall, the current recalculated estimates for *Waste* were 25.1% higher for 2000 and 4.2% higher 2015 (Figure 2.26).

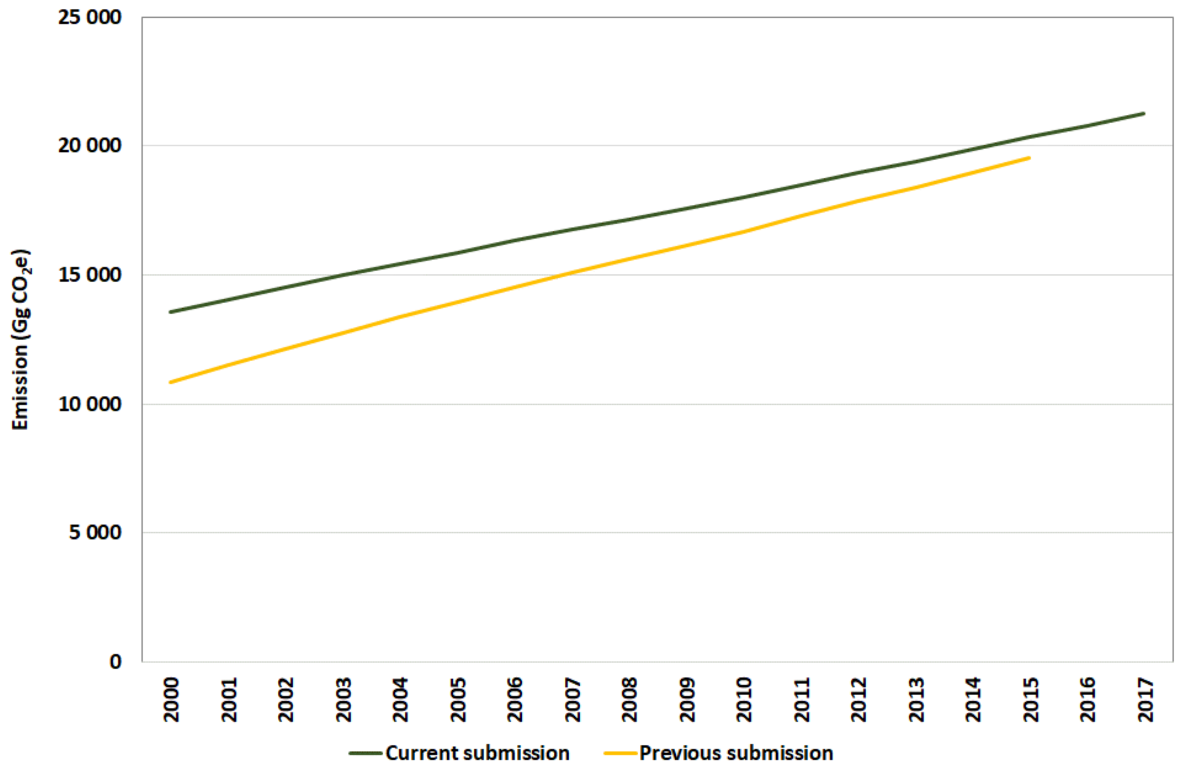


Figure 2.26: Impact of recalculations in the Waste sector.

2.8.4.4. Key categories

The key categories for the *Waste* sector are shown in Table 2.38 with the detailed key category results presented in Annex A2.

Table 2.38: Key categories in the Waste sector.

IPCC Code	Category	GHG	Identification Criteria
4A	Solid waste disposal	CH_4	L,T
4D1	Wastewater treatment and discharge	CH_4	L

Note: L= level assessment, T = trend assessment

2.8.4.5. Planned improvements

There is a lack of country specific activity and emissions factor data and as a result estimation of GHG emissions from both solid waste and wastewater sources were largely computed using default values suggested in IPCC 2006 Guidelines. This can lead to large margins of error. South Africa has identified the following areas to be considered in the improvement plan for the future:

(i) Obtain data on the quantities of waste disposed of into managed and unmanaged landfills.
(ii) Improve the methane correction factor and rate constants.
(iii) Improve the reporting of economic data (e.g. annual growth) to include different population groups. The assumption that GDP growth is evenly distributed (using a computed mean) across all the population groups is highly misleading, and leads to exacerbated margins of error.
(iv) Obtain information on population distribution trends between rural and urban settlements as a function of income.
(v) Conduct a study to trace waste streams and obtain more information on the bucket system which is still widely used in South Africa.
(vi) It is planned that by the 6th BUR the time-series will be starting from 1990 and extending to 2021.

The DEFF undertook a study to collect actual activity data for this category for the period 2000–2017. This involved the collection of activity data for all four waste categories (i.e. Solid waste, Wastewater treatment, Waste incineration and open burning of waste, and Biological treatment of solid waste). The study was completed in March 2020 so the data will be included in the next inventory.

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3. Mitigation Actions and Their Effects

3.1. Introduction

South Africa has committed to a low carbon trajectory that encompasses both its contribution to the international effort to reduce global Greenhouse Gas (GHG) emissions; and its ambitions toward development and poverty eradication (DEA, 2011a). This vision is articulated within the country's first Nationally Determined Contribution (NDC) that was submitted in September 2015 (DEA, 2015). The mitigation component of the NDC provides a commitment from the country to "deviate from business as usual", through the "peak, plateau and decline" in GHG emissions. It commits to reduce emissions below business-as-usual emission levels by 34% by 2020 and 42% by 2025, plateau for a ten-year period from 2025 to 2035 and decline from 2036 onwards.

3.2. Mitigation policy context and implementation framework

South Africa has expressed its commitment to limit the average global temperature increase to below a maximum of 2°C above pre-industrial levels, recognising the need to ensure that such agreements are inclusive, fair and effective. The DEFF is responsible for the development and implementation of South Africa's climate change mitigation response, directed by the National Development Plan (NDP) (NPC, 2011), National Climate Change Response Policy (DEA, 2011a), and the Climate Change Bill (DEA, 2018b).

3.2.1. Driving policies for climate change

3.2.1.1. National Development Plan, 2030

The overall objective of the NDP Vision 2030 is to eliminate poverty and reduce inequality by 2030 (NCP, 2011). Chapter 5 of the NDP aims to ensure that by 2030 South Africa is an environmentally sustainable society, with an expanded low-carbon economy and reduced emissions while at the same time reducing poverty, unemployment and social inequities. This chapter provides various mitigation objectives and outlines actions for achieving these goals by 2030, such as:

- Achieving the peak, plateau and decline GHG emission trajectory.
- Entrenching an economy-wide carbon price.
- Developing zero-emission building standards.
- Reducing the total volume of waste disposal to landfill each year.

3.2.1.2. National Climate Change Response Policy

The overall climate change vision and policy framework was set out in the National Climate Change Response White Paper which was then approved by Cabinet in 2011 to become the National Climate Change Response Policy (NCCRP) (DEA, 2011a). This framework arose from an extended participatory policy development process based on the country's recent history of democratic engagement. It involved modelling, research activities, stakeholder engagements, reviews and parliamentary hearings. The objectives and goals of the NCCRP were informed by other national and international commitments, including the South African Constitution (Act No. 108 of 1996), the Bill of Rights, the National Environmental Management Act (Act No. 107 of 1998), the Millennium Declaration (UN Millennium Summit, 2000) and commitments made under the UNFCCC.

The NCCRP presents the government's vision for an effective climate change response and the long-term, just transition to a climate-resilient and lower-carbon economy and society. The objectives of the policy are to (a) effectively manage inevitable climate change impacts through interventions that build and sustain South Africa's social, economic and environmental resilience and emergency response capacity, and (b) make a fair contribution to the global effort to stabilise GHG concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner (DEA, 2011a).

3.2.1.3. Climate Change Bill

In June 2018, South Africa launched public consultations on a draft National Climate Change Bill (DEA, 2018b) and these are now in the advanced stages. This bill will provide a regulatory framework for managing climate change impacts by enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change. In doing so, it also aims to make a fair contribution to the global effort to stabilise GHG concentrations in the atmosphere. The Climate Change Bill addresses issues related to institutional and coordination arrangements across the three spheres of government, namely national, provincial and local. The bill makes provision for development and review of national GHG emission trajectories, sectoral emission targets for emitting sectors and sub-sectors, and carbon budget thresholds for emitting companies.

3.2.2. Tracking mitigation impacts

3.2.2.1. National emissions trajectory

The national emissions trajectory (DEA, 2011b) serves as the benchmark against which South Africa's GHG emission reduction performance will be measured. It also informs South Africa's international obligations in the form of an NDC or variant thereof. The national emissions trajectory is informed by all necessary measures – existing and additional. In order to set the country on track to achieving its national GHG emissions goal, a range of pathways should be developed to consider different ways in which South Africa could reduce its GHG emissions. These pathways must be linked to the Vision referred to above.

In the absence of quantitative articulation of the vision, the Peak, Plateau, Decline Emissions Trajectory Range, as reflected in the NCCRP and NDP, is being used as the benchmark against which the emission reduction performance will be measured. Thus, South Africa's GHG emissions will:

- Peak in the period 2020 to 2025 in a range with a lower limit of 398 Mt CO_2e and upper limits of 583 Mt CO_2e and 614 Mt CO_2e for 2020 and 2025, respectively.
- Plateau for up to ten years after the peak within the range with a lower limit of 398 Mt CO_2e and upper limit of 614 Mt CO_2e.

- Decline in absolute terms, from 2036 onwards, to a range with lower limit of 212 Mt CO_2e and upper limit of 428 Mt CO_2e by 2050.

The Peak, Plateau, Decline Emissions Trajectory Range will need to be reviewed to respond to the vision referred above. This will involve quantitative articulation of the vision and creating the long-term desired state for the country. A broad range of structural changes will be necessary in order to ensure that the South African economy achieves this vision. This requires assessing the current situation of the country, and aligning development with climate goals through reliable data and analysis, for which collaboration with experts is necessary. The Climate Change Act will empower the Minister to develop the national GHG emissions trajectory (target) with a review every 5 years.

3.2.2.2. Nationally Determined Contribution

In the Paris Agreement, Parties collectively agree to limit "the increase in the global average temperature to well below 2°C above pre-industrial levels, and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels". Article 4 of the Agreement sets out Nationally Determined Contributions (NDCs) as the instrument countries must develop to present their part of the global effort to reach global peaking of GHG emissions as soon as possible, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of this century (UNFCCC, 2015). South Africa submitted its Intended Nationally Determined Contribution in 2015 (DEA, 2015), which became its NDC in 2016. South Africa's NDC has both adaptation and mitigation objectives. The mitigation component of the NDC moves from a 'deviation from business-as-usual' form of commitment and takes the form of a peak, plateau and decline GHG emissions trajectory range. South Africa has committed to hold GHG emissions between 398 and 614 Mt CO_2e up to 2035. This is the benchmark against which the efficacy of mitigation actions will be measured. South Africa is currently in the process of updating its NDC.

The decision accompanying the Paris Agreement in 2015, UNFCCC decision 1/CP.21, paragraphs 23 and 25, requests countries to update their NDCs in 2020. South Africa is, therefore, currently in the process of updating its NDC. The UNFCCC Secretariat's synthesis report of NDCs, and the IPCC's Special Report on 1.5 degrees indicate that the global effort is inadequate to meet the global GHG emission reduction targets to slow global warming. The UN Secretary General, ahead of the 2019 UN Climate Action Summit, therefore, urged countries to enhance their mitigation ambition. South Africa's NDC updating process will not deviate from the form which the emissions target in the NDC currently takes, but will be more ambitious and will lead to an adjustment of the peak, plateau and decline levels.

3.2.3. Implementation plan for Nationally Determined Contribution objectives

3.2.3.1. Low Emissions Development Strategy

Article 4.19 of the Paris Agreement calls on signatories to formulate and communicate long-term low GHG emission development strategies (LEDS), and the Conference of Parties Decision 1/CP.21, paragraph 35, invites parties to communicate the LEDS by 2020. The DEFF has produced a draft LEDS (DEFF, 2018a) and is working on finalizing the strategy. The document presents South Africa's first LEDS generated after the adoption of the Paris Agreement. The South African LEDS would serve as an implementation plan for the fulfilment of the NDP objectives and its timeframes will, therefore, be aligned with that of the NDC. The objectives of the LEDS is to:

- Mitigate the threats posed by climate change.
- Support the implementation of policies and measures to reduce GHG emissions across sectors of the economy and sustainable development goals in an integrated manner.
- Provide strategic guidance as to which measures will be implemented to reduce GHG emissions in the short, medium and long term.
- Provide a high-level plan on how South Africa would transition to a lower carbon development economy in a 'just transition' manner.
- Build a low carbon development culture.
- Mobilise finance for the funding of programmes to help South Africa achieve low carbon development.

Table 3.1 presents the sectoral measures provided in the LEDS to drive low carbon development.

Table 3.1: Sector measures highlighted in the LEDS.

Sector	Interventions
Energy	• Implement 2500 MW hydro by 2030. • Implement 1000 MW for PV and 1600 MW for wind annually for the period up to 2030. • Implement 200 MW embedded generation annually. • Undertake feasibility studies on the biofuels pricing framework that will inform incentives for production of biofuels. • Full implementation of post-2015 National Energy Efficiency Strategy measures. • Installation of 5 million solar water heaters by 2030. • Tightening of the building standards up to 2030. • Introduction of energy endorsement label. • Feasibility study on scrappage scheme for appliances. • Transform the market for household appliances in favour of more energy efficiency models. • Incentivise the manufacturing of electric vehicles in South Africa – for both the local and export markets. • Draft regulations providing a conducive environment for public and quasi-public transportation to be converted to cleaner dual-fuel vehicles. • Draft regulations requiring refineries to meet new standards and norms for cleaner fuels. • Develop guidelines for the procurement of vehicles throughout government to procure efficient vehicles, using clean technologies. • Finalise the feasibility of a local manufacturer of electric vehicle batteries / fuel cell batteries at a reduced cost. • Expand electric charging stations powered by photo-voltaic panels by 40 per annum: accessible to general public. • Draft regulations requiring 10% of Municipal bus fleets converted to cleaner technologies or cleaner fuel. • Develop regulatory regime for annual taxing of vehicles based on their emissions through car licensing renewal system and new car sales. • Develop a regulatory policy on congestion charges. • Re-introduce road freight permits reflecting load capacity of freight vehicles. • Develop green standards and guidelines for construction of low-carbon climate resilient road infrastructure, including bus lanes, electric vehicle charger points, Biogas/Non-condensable gas/Liquefied natural gas stations.

IPPU	• Implementation of Phase 2 carbon budget. • Implementation of carbon tax. • Continue to incentivise energy efficiency measures.
AFOLU	• Promote conservation agriculture farming methods. • Restoration of subtropical thicket, forests and woodlands.
Waste	• Promote and encourage waste avoidance and reduction, re-use, recycling and recovery. • Promote development of waste to energy solutions.

3.3. Mitigation system and its pillars

There are several elements to South Africa's developing Mitigation System and these are shown in Figure 3.1. The implementation of the system will take place in phases. The duration of Phase 1 is five years, extending from 1 January 2016 to 31 December 2020 (this may be extended until the promulgation of the Climate Change Act), and the second and subsequent phases will commence after the promulgation of the Climate Change Act.

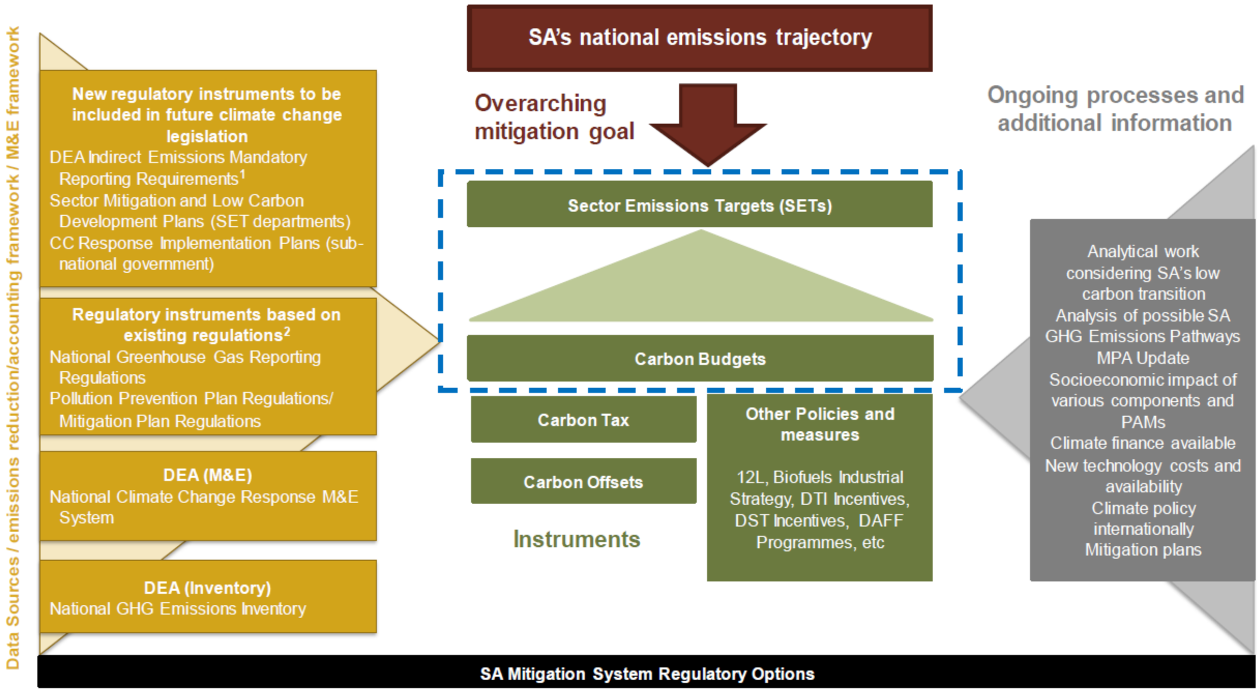


Figure 3.1: A schematic summary of the key elements of Phase 2 of South Africa's mitigation system.

3.3.1. GHG Inventory

South Africa is required, by international obligations, to provide a national GHG on a gas-by-gas basis (including anthropogenic emissions of CO_2, CH_4 and N_2O) by sources and removals by sinks. Countries are also encouraged to provide information on anthropogenic emissions by sources of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The South African GHG inventory is being compiled every two years and the latest inventory for 2017 is discussed in detail in chapter 2.

Accurate GHG emissions inventories are essential for the following reasons:

- To fulfil the United Nations Framework Convention on Climate Change (UNFCCC) reporting requirements and also support the development of the National Communications and Biennial Update Reports.
- Mitigation Potential Analysis
  - To evaluate mitigation options and to provide for GHG emissions reductions.
  - To develop long term emissions projections.
- To assess the effectiveness of policies and mitigation measures to reduce emissions.
- To monitor and evaluate the performance of South Africa's GHG emissions profile.
- Used as a basis for allocation of carbon budgets, etc.

The National Greenhouse Gas Emission Reporting Regulations (NGER) (DEA, 2017b) were promulgated to introduce a single national reporting framework for the reporting and dissemination of information related to GHG emissions. The Regulations compel GHG data providers to submit data to the department on an annual basis.

3.3.2. Mitigation Potential Analysis

The first GHG Emission Mitigation Potential Analysis (MPA) was published in 2014 (DEA, 2014). The overall objective was to conduct an updated, bottom-up assessment of mitigation potential in key economic sectors in order to identify a set of viable options for reducing GHGs. Marginal abatement cost curves for key sectors and subsectors were constructed which provide estimates of mitigation potential and marginal abatement costs for broad mitigation measures. Estimates of national mitigation potential have been derived from the sectoral marginal abatement cost curves and ranked in terms of level of implementability at national level for each of the technologies.

The MPA entails:

- Setting baselines and projecting GHG emissions into the future.
- Conducting an in-depth assessment of the mitigation potential for key sectors and sub-sectors of the economy.
- Identifying best available mitigation options for key sectors and sub-sectors which is formed by amongst others:
  - Multi-Criteria Analysis (economic, social, environmental, readiness, institutional arrangements, policy landscape, technology needs) to assess implementability of identified options.
  - Costs and benefits of achieving emission reduction outcomes for key sectors and sub-sectors (Marginal Abatement Cost Curves).

The MPA is currently being reviewed and updated.

3.3.3. Sectoral Emissions Targets

The National Planning Commission is in a process of developing a national vision of a Just Transition to low carbon economy and climate-resilient society to 2050 taking into account the developmental goals and the Paris goals. Sectoral Emission Targets (SETs) is the mitigation part of the NDC and this will be established through the Low Emission Development Strategy (DEA, 2018a). SETs are quantitative or qualitative GHG emission targets, assigned to sector departments over a period of time, which will be defined under the climate change bill when made into a law. These will be determined for three rolling 5-year periods and will be reviewed every 5 years.

Policies and Measures (PAMs) are policy instruments, which include regulatory measures, economic measures, and support measures, adopted by government and applied across the economy over a wide range of sectors in order to meet its emission reduction goals. DEFF will be engaging with line departments and support them in identifying PAMs that are sufficient to achieve the allocated SETs. DEFF aims to support the line departments in the development of identified PAMs. To implement the PAMs there would be a need to enhance opportunities and address barriers associated with their implementation (in a form of finance, technology and capacity building). A set of criteria for determining PAMs to be considered for SETs has been developed, and these criteria include:

- The Government strategic importance of the PAMs.
- PAMs have specific goals with measurable impact on GHG emissions.
- The importance of the sector targeted by the PAMs on the GHG profile of the country.
- The certainty of being able to implement the PAMs.

The alignment and coordination of emission reduction activities at all spheres of government will be guided by the multi-governance Framework for Mitigation which is established under the Sector Implementation directorate.

Before line departments are engaged on PAMs, initial research and analysis will be completed to guide discussions, and this will take the form of three scenarios:

- SET Scenario 1: Undertake a quantification of the current emission reduction resulting from the implementation of each individual and collection of PAMs. This will provide information on the contribution the PAM or PAMs in the line department are making towards emission reductions.
- SET Scenario 2: The same as for SET Scenario 1 but with added ambition. In this approach existing PAMs will be modelled and projected to determine their potential if implemented fully (optimal and sustainable at 100%). Sub-scenarios with different percentage targets can be discussed with departments.
- SET Scenario 3: A scenario where the current PAMs are not sufficient for South Africa to reach its Paris goal and would require additional PAMs to be promulgated to improve the enabling environment.

In addition, for all these SET scenarios the GHG emission reduction contributions of PAMs will be assessed both individually and collectively. Socio-economic impacts of each PAMs will also be determined. Three SETs scenarios will be constructed and the outcomes of these will be used as inputs towards engagements with the line departments.

A Presidential Climate Change Coordinating Commission, with representation from government departments, social partners, academic experts, civil society, research institutes and traditional leaders, will be established to coordinate and oversee the Just Transition to a low carbon, climate resilient economy. The Minister of Environment, Forestry and Fisheries with the support of the Inter-Ministerial Committee on Climate Change (IMCCC) will report annually to the cabinet on the developed SETs. The SETS will be included in the government planning cycles and their implementation must be monitored and reported on by the Presidency.

3.4. Overarching mitigation policies

3.4.1. Carbon budgets

A series of carbon budgets, designed by the DEFF, are envisaged to provide a GHG emissions allowance against which physical emissions arising from the operations of a company during a defined time period will be tracked (DEA, 2017a). The Carbon Budget process was discussed in detail in the BUR3. In the first phase (up to 2020), the carbon budgets are voluntary, and the information will be used to increase understanding of the emissions profile of participating companies, and to establish measurement, reporting, and verification (MRV) processes. Beyond 2020, the carbon budgets are intended to become compulsory. The lessons learned from being implemented during Phase 1 will be used in designing the subsequent phases.

3.4.2. GHG Reporting Regulation and Pollution Prevention Plans

In the previous BUR (DEA, 2019a), the gazetted GHG Regulations and how these pertain to the declaration of GHGs as priority air pollutants (DEA, 2016) were discussed. Paragraph 3 (1) of the Notice, declaring GHGs as priority air pollutants, requires the submission of Pollution Prevention Plans (PPPs) by persons conducting a production process set out in Annexure A to the Notice, which involves emission of GHGs in excess of 0.1 Megatonnes (Mt) annually, reported as carbon dioxide equivalents (CO_2e). A PPP is also required of persons undertaking a production process listed in Annexure A as a primary activity. Regulation 4(1) of the National Pollution Prevention Plans Regulations (DEA, 2017c) states that a person must submit a first PPP to the Minister within five months from the date of promulgation of the regulations, and a subsequent PPP must be submitted within five months of the existing plans being reconciled (DEA, 2018c). Due to business requests to extend the submission date of PPPs, the Minister published the extension for the submission of PPPs to 21 June 2018.

Guidelines for the development of pollution prevention plans in respect of GHG's have been developed (DEA, 2018c). These guidelines assist a person submitting a pollution prevention plan to understand the process for submission and approval of the pollution prevention plans and annual progress reports. These annual reports, importantly, also require the description of any deviation from the approved PPP and any remedial actions that were taken. The implementation of these approved plans must be monitored and evaluated, with annual progress reports for the preceding calendar year submitted to the Minister by 31 March each year. The first PPP cycle ends 31 December 2020 and the subsequent submission will be from 2021 to 2025.

3.4.3. Carbon Tax Act

The BUR3 reported on the impending implementation of the draft Carbon Tax Bill that was released for public comment in 2015 (National Treasury, 2015) and that was under a process of stakeholder consultation. Two iterations of the Bill were published for public comment, and the final Draft Bill was debated in the house of parliament and submitted to the President for assent on 29 March 2019. On 1 June 2019, the Carbon Tax Act came into effect (Act No. 15 of 2019).

The carbon tax will be implemented in phases with the first phase being 1 June 2019 to December 2022. Carbon tax will be levied at a rate of R120 per ton of CO_2e of GHG emitted by a taxpayer. During the first phase the rate of R120 per ton will be adjusted each year by the consumer price index (CPI) plus 2%. Thereafter, it will increase annually by CPI. A taxpayer is liable to pay tax should they undertake activities listed in Schedule 2 of the Act and if their emissions exceed the threshold set in the Act. Tax can be reduced by using the various allowances provided in respect of each activity (such as trade exposure allowances, carbon offset allowances, performance allowances and carbon budget allowances) which are provided in Schedule 2 of the Act.

Some amendments were made to the Bill, which include:

- The percentages of allowances in respect of some activities were emended.
- Section 14 now provides for a maximum of 100% allowance where stipulated in Schedule 2, and where a 100% allowance is not available, the maximum sum of allowances applied is 95%.

The carbon tax will be levied in terms of Section 54 A of the Customs and Excise Act (Act No. 91 of 1964) as an environmental levy. The carbon tax will be paid to, and administered by, the South African Revenue Service (SARS).

3.4.3.1. Carbon Offset Regulation

In terms of section 19(c) of the Carbon Tax Act there is a provision for the development of the Carbon Offsets Regulations, which were gazetted on 29 November 2019 (National Treasury, 2019c). The Carbon Offset Regulations were gazetted after extensive consultations on the Carbon Offsets Paper of 2014, 1st Draft Carbon Offsets Regulations which were published in June 2016, and 2nd Draft Regulations published in November 2018, followed by a stakeholder workshop held in March 2019 for clarification of comments and finalisation of the regulations. The regulations outline the eligibility criteria for offset projects and set out the procedure for claiming the offset allowance. The following main amendments were made to the gazetted regulations:

- Inclusion of renewable energy:
    - Small-scale renewable energy projects up to 15MW for both Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) and non-REIPPPP projects are eligible as carbon offsets.

    - Projects greater than 15MW, REIPPPP projects from the third bidding window and non-REIPPPP projects, except for technologies with a cost less than R1.09/kWh, will be eligible as carbon offsets.
- Eligibility of energy efficiency projects:
    - Stakeholders were of the view that some electrical efficiency and on-site co-generation projects should be eligible as offsets as they reduce indirect (scope 2) and not direct (scope 1) emissions covered by the tax, thereby improving efficiency. The regulation was amended to only allow electrical efficiency and co-generation projects which "do not co- produce useful thermal energy implemented on activities that are covered by the carbon tax resulting in reduced fuel consumption" as eligible offsets..
- Clarification of eligible projects and the use of credits generated prior to the implementation of the carbon tax:
    - projects and offsets issued for a specific monitoring period up to 31 May 2019 will be eligible for offsets.
    - Project activities that are covered under the carbon tax, these offsets must be used within the first phase of the carbon tax (up to Dec 2022), except for qualifying renewable energy projects.
    - For project activities not covered by the carbon tax in the first phase, these offsets can be used until the end of the crediting period as stipulated under the relevant carbon standard.

The carbon offset system seeks to encourage GHG emission reductions in sectors or activities not directly covered by the tax and provide flexibility for taxable entities to access GHG mitigation options at a lower cost than investment in their current operations. Investments in public transport, agriculture, forestry and other land use (AFOLU) and waste sectors are likely to qualify. Carbon offsets involve specific projects or activities that reduce, avoid, or sequester emissions, and are developed and evaluated under specific methodologies and standards, which enable the issuance of carbon credits.

During the first phase of the carbon tax, carbon offset projects developed under existing international standards, such as the Cleaner Development Mechanism (CDM), Verified Carbon Standard (VCS) and the Gold Standard (GS), will be eligible for use by companies to reduce their carbon tax liability. Scope is also given for approved domestic South African standards, subject to the necessary approval, to be utilised in subsequent phases of the carbon tax. The Designated National Authority, residing within the Clean Energy Branch of the Department of Mineral Resources and Energy (DMRE), which was established to support the development and implementation of CDM projects under the Kyoto Protocol of the UNFCCC, will be responsible for administering the carbon offset scheme.

Carbon offset projects will also generate sustainable development benefits and employment opportunities in South Africa by encouraging investments in energy efficiency and renewable energy, rural development projects, and initiatives aimed at restoring landscapes, reducing land degradation and biodiversity protection. Because carbon offset projects are localised, e.g., municipal waste to energy projects, transport energy efficiency, public transport etc., the potential employment and development benefits accrue to local communities. The carbon offset mechanism can, therefore, be a means to facilitate creation of decentralised and sustainable urban and rural economies.

The DMRE is in the process of developing a carbon offset administrative system and this is discussed in the MRV chapter (section 6.3.3.2).

3.4.3.2. Carbon sequestration in the Carbon Tax Act

The Carbon Tax Act provides information on the quantification of the various components of the tax equation, however, the sequestration component (‘S’ in the equation) is more complex and is not fully defined in the Carbon Tax Act. Carbon sequestration allows companies to reduce their tax liability through carbon storage. Effective rules and modalities for the quantification of sequestration are being developed by the DEFF. A project, currently being finalised by the DEFF, provides a Rulebook for accounting of forest plantations and the timber processing industry GHG emissions and removals (Sequestration) under the Carbon Tax Act. These rules cover the activities of afforestation, deforestation and forest management, and include rules for the inclusion of harvested wood products using a mass-balance approach. In addition to the Rulebook, a Methodological Guideline and reporting templates are being finalised.

3.4.3.3. Trade Exposure Allowance Regulations

In December 2019, Draft Regulations for Trade Exposure Allowance were proposed in terms of section 10 of the Carbon Tax Act and were published for public comment (National Treasury, 2019a). On Friday, 19 June 2020, the regulations in terms of Section 19(b) for purposes of Section 10 for the Trade Exposure Allowance was gazetted (National Treasury, 2020a). These regulations provide a list of sectors and sub-sectors and their respective trade exposure allowances. It also provides an alternative approach for the determination of the allowance for all affected companies.

3.4.3.4. GHG Emission Intensity Benchmark Regulations

Benchmark proposals for the liquid fuels, gas and coal to liquid fuels, mining, cement, iron and steel, paper and pulp, ferroalloys, titanium, chemicals, sugar and clay brick sectors were developed between 2016 and 2019. This information was incorporated into the Draft GHG Emissions Intensity Benchmark Regulations (National Treasury, 2019b). These regulations, which support the Carbon Tax Act, were published for public comment in December 2019 and gazetted in June 2020 (National Treasury, 2020b). These regulations provide for the determination of the emissions intensity benchmark a taxpayer must use based on the sector/subsector and the related benchmark value.

3.4.3.5. Renewable Energy Premium

In terms of Section 6(2)(c) of the Carbon Tax Act, taxpayers whose main activity is electricity generation from fossil fuels can offset the costs of purchasing renewable energy (the renewable energy premium), either under the REIPPPP or from non-REIPPPP projects, against their carbon tax liability. The Notice for the Renewable Energy Premium gazetted in June 2020 (National Treasury, 2020c) provides the quantity of the offset.

3.5. Sectoral mitigation policies and measures

The sectoral policies and measures (PAMs) are here defined as policy instruments implemented by government and applied across the economy, over a wide range of sectors, in order to help South Africa achieve its emission reduction goals. The PAMs may include regulatory instruments (specifically legislation, regulations and standards), economic instruments (for example, incentives and taxes), government procurement programmes or direct investment by government. These may be cross-cutting (across more than one sector) or specific to individual sectors or subsectors, and may achieve abatement through action by government or induce action by others. Many government departments and agencies, cities and provinces, are already implementing measures which have mitigation as a goal (for instance the emissions constraint in the Integrated Resource Plan (DoE, 2019), or have significant mitigation benefits (for instance energy efficiency measures and the extension of efficient public transport, such as bus rapid transit systems).

3.5.1. Energy

Table 3.2 presents a list of PAMs for the energy sector. The main policies in this sector are the Integrated Resource Plan, the National Energy Efficiency Strategy, the Green Transport Strategy and the National Land Transport Act. The Carbon Tax, Carbon Budgets and Pollution Prevention Plans also impact this sector, but these policies are discussed under the Overarching Policy Section (section 3.4).

Table 3.2: PAMs for the energy sector.

Measures	Supporting policies and legislation
12L tax incentive programme	National Climate Change Response Policy (DEA, 2011a). Income Tax Act (Act No. 58 of 1962). 12L Regulations (National Treasury, 2013).
Energy Efficiency Standards and Appliance Labelling project	SANS 941 for Energy Efficiency of Electrical and Electronic Equipment, (SABS, 2014). National Energy Act (Act No. 34 of 2008).
Eskom IDM programme	White Paper on Energy Policy (DME, 1998). Post-2015 National Energy Efficiency Strategy (DoE, 2016b). Integrated Energy Plan (DoE, 2016a).
Municipal Energy Efficiency and Demand-side Management programme	White Paper on Energy Policy (DME, 1998). Post-2015 National Energy Efficiency Strategy (DoE, 2016b). Integrated Energy Plan (DoE, 2016a).
The National Cleaner Production Centre South Africa (NCPC) Industrial Energy Efficiency programme	National Climate Change Response Policy (DEA, 2011a). Industrial Policy Action Plan (DTI, 2018).
Private Sector Energy Efficiency (PSEE) programme	National Climate Change Response Policy (DEA, 2011a). Industrial Policy Action Plan (DTI, 2018).
Landfill Gas to Energy Activities	Regulations Regarding the Exclusion of a Waste Stream for a Portion of a Waste Stream from the Definition of Waste (DEA, 2018e). National Environmental Management: Waste Act (Act No. 59 of 2008).

Renewable Energy Independent Power Producer Procurement programme	Integrated Resource Plan (DoE, 2019). Electricity Regulation Act (Act No. 4 of 2006). National Energy Act (Act No. 34 of 2008). National Climate Change Response Policy (DEA, 2011a).
Bus Rapid Transport System	Green Transport Strategy (DoT, 2018). National Land Transport Act (Act No. 5 of 2009).
Electric vehicles	Green Transport Strategy (DoT, 2018). National Land Transport Act (Act No. 5 of 2009).
Transnet Road-to-Rail programme	Green Transport Strategy (DoT, 2018). National Land Transport Act (Act No. 5 of 2009). Transnet Long-term Planning Framework (Transnet, 2017).

The Integrated Resource Plan (DoE, 2019) provides an update on South Africa's efforts to diversify its energy mix and reduce the reliance on coal (Table 3.3). The technology mix for electricity production took into consideration the roles different technologies played in providing base-load and peaking power. The plan also expanded on the future scale and role of nuclear energy and renewable energy technologies. The Integrated Resource Plan continues to reiterate that coal will continue to play a role in providing energy in the future, but it is to be limited to electricity generation. Coal will provide base-load power in the foreseeable future, although coal will be replaced substantially over time by improvements in solar, wind, nuclear and gas energy sources. These alternative options reduce GHG emissions and other pollutants, and help to improve security of supply. In most cases, they also lower the cost of providing energy when external costs are accounted for.

Table 3.3: The key actions and decisions of the 2019 Integrated Resource Plan (DoE, 2019).

Consideration	Action
Immediate term security supply	• Undertake a power purchase programme to supplement Eskoms' declining plant performance. • Reduce the extensive utilisation of diesel peaking generators in the immediate to medium term. • Extend Koeberg power plant design life by another 20 years. • Support Eskom to comply with Minimum Emissions Standards (MES) over time.
Energy mix and Just transition	• Decommission approximately 24 100 MW of coal power plants between 2030 and 2050. • Coherent policy development in support of a just transition plan.
Wind and PV	• Retain current annual build limits on renewables (wind and PV) pending the finalisation of a just transition plan.
Coal	• New coal power projects must be based on high efficiency, low emission technologies and other cleaner coal technologies.
Gas to power	• Development of gas infrastructure is supported by the Integrated Resource Plan, 2019, in addition to new gas to power capacity that has been made available and converting existing diesel-fired power plants to gas.
Nuclear	• Commence preparations for a nuclear build programme to the extent of 2 500 MW at a pace and scale the country can afford.

Regional power projects	• South Africa will participate in strategic power projects that enable the development of cross-border infrastructure needed for regional energy trading.

The National Energy Efficiency Strategy of 2005 set an overall reduction target in energy intensity of 12% by 2015, and sectoral energy intensity improvements as follows: industry and mining (15%), power generation (10%), transport (9%), commercial and public building sector (15%), and residential (15%). The Post-2015 National Energy Efficiency Strategy aims to build on these achievements and provides new targets for 2030 for the following sectors:

- Public sector:
  - Public buildings: a 50% reduction in the energy consumption by 2030 relative to a 2015 baseline;
  - Municipal services: a 20% reduction in the energy intensity of municipal service provision. The specific services included are streetlighting, traffic lights, water supply and wastewater treatment;
  - Municipal services: a 30% reduction in the fossil fuel intensity of municipality vehicle fleets;
- Residential sector:
  - A 33% reduction in te average specific energy consumption of new household appliances purchased in South Africa by 2030 relative to a 2015 baseline;
  - A 30% improvement in the average performance of the residential buildinfstock by 2030 relative to a 2015 baseline;
- Commercial sector:
  - A 37% reduction in the specific energy consumption by 2030 relative to a 2015 baseline;
- Industry and mining sector:
  - A 10% reduction in weighted mean specific energy consumption in manufacturing by 2030 relative to a 2015 baseline;
  - A cumulative total energy saving of 40 PJ arising from specific energy saving interventions undertaken by the mining sector;
- Agriculture sector:
  - A total electricity saving of 1 PJ through officially supported projects by 2030;
- Transport sector:
  - A 20% reduction in the average vehicle energy intensity of the South African road vehicle fleet relative to a 2015 baseline; and
- Production and distribution:
  - A total of 10 PJ of electricity derived from grid-connected co-generation plant by 2030;
  - Average total electricity distribution losses below 8% by 2030, and average non-technical losses below 0.5%.

The policy driver for implementing mitigation actions in the transport sector is the Green Transport Strategy (DoT, 2017), including Bus Rapid Transit (BRT) Systems, road to rail shift for freight transport, and electric vehicles as is framed by the National Land Transport Act (NLTA). The Green Transport Strategy replaced The Public Transport Strategy and Action Plan. The objective of the Green Transport

Strategy is a reduction in transport emissions of 5% by 2050. Various measures are provided, and these include a 30% shift of freight transport from road to rail; a 20% shift of passenger transport from private cars to public transport and eco-mobility transport; the promotion of alternative fuels such as compressed natural gas (CNG) or biogas and liquid biofuels as transport fuels, and the promotion of electric and hybrid-electric vehicles.

The purpose of the NLTA is to further the process of transformation and restructuring of the national land transportation system initiated by the repealed National Land Transportation Transition Act (NLTTA). The NLTTA provided a set of principles, which prioritized public over private transport while stressing the need for coherent planning which integrated transport planning with land use planning. The shift in transport planning from the NLTTA to NLTA was the devolution of the operating licence function from provinces to municipalities with regards to the planning, implementation and management of modally integrated public transport networks and travel corridors for transport within the municipal area.

3.5.1.1. Challenges, gaps and constraints

The Department of Transport reports on the progress of the implementation of public transport and freight transport actions in the country in their annual performance plans and annual reports. The Department was set to approach and appeal to National Treasury for more funding; consolidate fragmented funding streams; and identify alternative funding sources. Further inherent dependencies on other spheres of government, departments and agencies called for more coordinated intergovernmental relations; building capacity at implementing spheres and agencies; and more focused oversight capabilities (National Committee on Transport, 2019a).

Key implementation constraints for the Green Transport Strategy to increase the uptake of electric vehicles included issues of government procurement policy and infrastructure needs for such vehicles. The Department is currently busy with its Integrated Transport Plan to review the international trends on these issues, as well as looking at the long-term development of automotive parts in collaboration with the Department of Science and Technology (National Committee on Transport, 2019b). Relationships between local government and mini-bus taxi operators were a challenge to improving BRT services in the Cape Town, George and eThekwini Municipalities. Ongoing consultations with the taxi industry by the departments indicates that progress is being made to find a solution.

3.5.2. IPPU

The PAMs implemented in the IPPU sector are show in Table 3.4. These main influencing policies are the Carbon Budgets, Pollution Prevention Plans and the Carbon Tax. These were discussed in the previous BUR, with updates provided in section 3.4.

Table 3.4: PAMs for the IPPU sector.

Measures	Supporting policies and legislation
Nitrous oxide reduction projects	
Carbon budgets and pollution prevention plans (only process emissions)	National Pollution Prevention Plans (PPP) Regulations (DEA, 2017c). National Climate Change Response Policy (DEA, 2011a). Draft Climate Change Bill (DEA, 2018b).

3.5.3. AFOLU

Table 3.5 presents the PAMs for the AFOLU sector. Policies in the AFOLU sector do not often have emission reduction targets, as the policies are not focussed on mitigation but rather biodiversity and sustainability. There are, however, a few policies which mention afforestation, grassland rehabilitation and conservation agriculture which could lead to an enhancement of the land carbon sink.

Table 3.5: PAMs for the AFOLU sector.

Measures	Supporting policies and legislation
Afforestation	National Climate Change Response Policy (DEA, 2011a). National Environmental Management: Biodiversity Act (Act No. 10 of 2004). DFFE Strategic Plan 2019/20 – 2023/24 (DFFE, 2020).
Forest Rehabilitation	DFFE Strategic Plan 2019/20 – 2023/24 (DFFE, 2020). Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries (DAFF, 2015b).
Thicket restoration	DFFE Strategic Plan 2019/20 – 2023/24 (DFFE, 2020). Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries (DAFF, 2015b).
Grassland rehabilitation	National Climate Change Response Policy (DEA, 2011a). National Environmental Management: Biodiversity Act (Act No. 10 of 2004). Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries (DAFF, 2015b). DFFE Strategic Plan 2019/20 – 2023/24 (DFFE, 2020). Land Degradation Neutrality Targets (DEA, 2018d).
Conservation agriculture	Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries (DAFF, 2015b). Draft Conservation Agriculture Policy (DAFF, 2018). Draft Climate Smart Agriculture Strategic Framework (DAFF, 2018a). DAFF 2015/16 to 2019/20 Strategic Plan (DAFF, 2015a). Integrated Growth and Development Plan (DAFF, 2012).

The DAFF Strategic Plan for 2015/16 to 2018/19 mentions the rehabilitation of 1 500 ha of state-owned forests, as well as the replanting of 11 500 ha of temporarily unplanted plantation land. It identifies the activities of grassland restoration, however, does not provide any specific targets. The more recent DEFF Strategic Plan for 2017/2018 to 2023/24 provides for the afforestation of 15 000 ha, rehabilitation of 1 500 ha of state-owned forest, rehabilitation of grasslands and wetlands, and also includes the reduction in land degradation (40 452 ha). The Draft Climate Change Sector Plan for the DAFF makes provision for the afforestation of 100 000 ha of plantation area and identifies woodland and thicket restoration as activities. The rehabilitation of woodlands, thickets and natural forests contribute significantly to the mitigation of climate change and also achieve the combined aims of improving rural livelihoods, restoring biodiversity, and replenishing natural capital/ecosystem services.

In relation to the mitigation actions reported, South Africa undertook a national Land Degradation Neutrality target setting process during 2017/18 in response to the United Nations Convention to Combatting Desertification's call for signatory countries to voluntarily commit to Land Degradation Neutrality as also requested under the Sustainability Development Goal 15.3 (Von Maltitz et al., 2019). The process was supported by the Global Mechanism and followed their guidelines. This resulted in an ambitious set of targets being set for 2030. Amongst these targets were those related to agriculture, grasslands and forests (DEA, 2018d):

- Improve productivity and Soil Organic Carbon stocks in 6 000 000 ha of cropland by 2030.
- Rehabilitate and sustainably manage 1 809 767 ha of 'forest'[3] by 2030.
- Rehabilitate and sustainably manage 2 436 170 ha of grassland by 2030.
- Rehabilitate and sustainably manage 2 646 069 ha of savanna (< 5m) by 2030.
- Clear 1 063 897 ha of alien invasive species by 2030.
- Clear 633 702 ha of bush encroached land by 2030.

Several South African policy documents mention and promote Climate Smart Agriculture (CSA) or Conservation Agriculture (CA) specifically. The Agricultural Policy Action Plan mentions that CSA includes numerous well-developed approaches to agriculture and the Draft Climate Change Sector Plan for Agriculture, Forestry and Fisheries recommends a number of CSA measures for implementation (DAFF, 2015b). In the Department's Integrated Growth and Development Plan (DAFF, 2012) a section is devoted to ecological sustainability, where the importance of protecting natural resources is highlighted. The Draft Conservation Agriculture Policy highlights conservation agriculture and rangeland restoration as important activities for sustainable agriculture, however, these activities will also have implications for GHG mitigation. No targets are provided in these documents.

Overgrazing and overutilization of plant resources result in a loss of vegetative cover leading to soil erosion. Soil erosion has been found to be a pervasive problem on rangelands and grasslands, and is particularly of concern in areas of communal land tenure (Shackleton, 1993). Degradation relating to rangeland management was the most common theme emerging from the NBI-2000 and follow up Land Degradation Assessment studies. Both assessments found that communal areas had some of the worst rangeland degradation in the country. Sustainable land management initiatives and soil erosion control as part of the Landcare program are almost exclusively implemented on areas of communal land tenure (Von Maltitz et al. 2019). Because of its high and ongoing transformation and low degree of protection (only 3%), the grassland biome has long been considered one of the most threatened biomes in South Africa.

3.5.3.1. Challenges, gaps and constraints

The implementation of mitigation actions related to agriculture and forestry has been weakened due to poor institutional relations between government departments and inadequate monitoring and evaluation support by the Department of Agriculture, Land Reform and Rural Development (DALRRD). Weak intergovernmental relations, poor coordination and alignment of activities between DALRRD, the provincial departments and its entities; and between the Department of Agriculture and the Department of Rural Development and Land Reform were identified as areas that need attention, as they compromised service delivery and sector development due to silo approaches or duplicating each other particularly in terms of farmer support and training activities (National Committee on Agriculture, Land Reform and Rural Development, 2019). In the new administration the Department of Agriculture now sits with Rural Development and Land Reform which may assist in addressing some of these issues.

There is also the challenge that the AFOLU sector does not have PAMs that are specific for GHG mitigation and the actions currently mentioned in strategies are not detailed enough. For example, in rehabilitation of land the type of actions to be undertaken and on land types these are to occur on need to be specified. The lack of specific targets makes tracking emission reductions very challenging and also makes it difficult to hold departments accountable.

3.5.4. Waste

The National Waste Management Strategy (NWMS) (DEA, 2019b) is the main driving policy in the waste sector (Table 3.6).

Table 3.6: PAMs for the Waste sector.

Measures	Supporting policies and legislation
Waste Management Flagship programme	Regulations Regarding the Exclusion of a Waste Stream for a Portion of a Waste Stream from the Definition of Waste (DEA, 2018e). National Environmental Management: Waste Act (Act No. 59 of 2008).
National Waste Management Strategy	National Waste Management Strategy (DEA, 2019b)

The National Environmental Management: Waste Act (Act No. 59 of 2008) establishes the requirement for a NWMS to be implemented, and to be revised and updated. The NWMS is a government-wide strategy that applies to all organs of state that have a responsibility for waste management, the private sector, and civil society. The DEFF is responsible for developing the strategy in consultation with other spheres of government and all stakeholders. The approach of structuring strategic goals, adopted in the revised NWMS, differs significantly from the previous NWMS. It seeks to provide a simpler conceptual structure based on three main implementation themes framed as overarching goals, and is informed by global emerging trends in the management of the central implementation themes:

- Waste Minimisation: prevention and resource economy.
- Effective and Sustainable Waste Services: collection and integrated waste management planning.
- Waste Awareness and Compliance: waste management norms and standards.

The quantitative goals are associated with waste minimisation, and compliance to waste norms and standards including:

- Divert 50% of waste from landfill within 5 years; 65% within 10 years; and at least 80% of waste within 15 years through reuse, recycling and recovery, and alternative waste treatment.

- All local authorities to include provisions for recycling drop-off/buyback/storage centres in their Integrated Waste Management Plans by 2020.

The near-term priority waste management flagship programme is directly aligned with the NWMS.

3.5.4.1. Challenges, gaps and constraints

Constraints to the implementation of waste management actions are most prevalent at the level of local government. There is inadequate processing and recycling capacity in the country to improve recycling and re-use programmes (National Committee on Environment, Forestry and Fisheries, 2019a). Stakeholder consultation processes related to climate change projects were delayed due to timelines to finalise national legislation such as the Climate Change Bill. Progress to reboot the waste tyre recycling programme was constrained. Two major tyre processors' contracts had been suspended over non-compliance on exports and new companies were being appointed (National Committee on Environment, Forestry and Fisheries, 2019b). The Waste Bureau had to pick up existing gaps that were supposed to be handled by the Recycling and Economic Development Initiative of SA (National Committee on Environment, Forestry and Fisheries, 2019c). The Bureau was given this responsibility, which was beyond their normal scope, and had to engage in a process of shortlisting for the supply chain management of the waste tyre industry.

3.6. Analysis of policy impacts on emission reductions

Emission reductions can be tracked in two ways, namely through the GHG inventory emission estimates and by tracking and monitoring the impacts of individual actions. Tracking individual actions is important for understanding the impact of a particular action and whether policies associate with these actions are achieving the desired effect. Some policies are, however, overarching and have far reaching impacts across all sectors. For these policies the emission reduction impacts can be seen through reductions in the overall GHG emissions.

3.6.1. Overarching emission indicators

Chapter 2 discusses the GHG emissions from South Africa in detail, but in summary the emissions increased from 2000 to about 2013, after which emissions appear to be stabilising (Figure 2.4). In this section the overarching indicators for monitoring emissions are discussed.

3.6.1.1. Total emission indicators

South Africa's carbon and energy intensity trends were determined from the national GHG emissions, GDP data from Statistics SA, total primary energy supply data (DMRE annual energy balance data (http://www.energy.gov.za/files/energyStats_frame.html)) and population data from Statistics SA.

South Africa's per capita carbon[5] intensity was 9.74 t CO_2e in 2000 and this increased to a maximum of 11.05 t CO_2e between 2007 and 2010, after which it declined again to 9.42 by 2017 (Figure 3.2). The carbon intensity of the economy (i.e. emissions per million Rand of GDP) has declined by 22.7% since 2000. This is largely due to growth in the services and financial sectors, a decline in the manufacturing sector and stagnation in the mining sector.

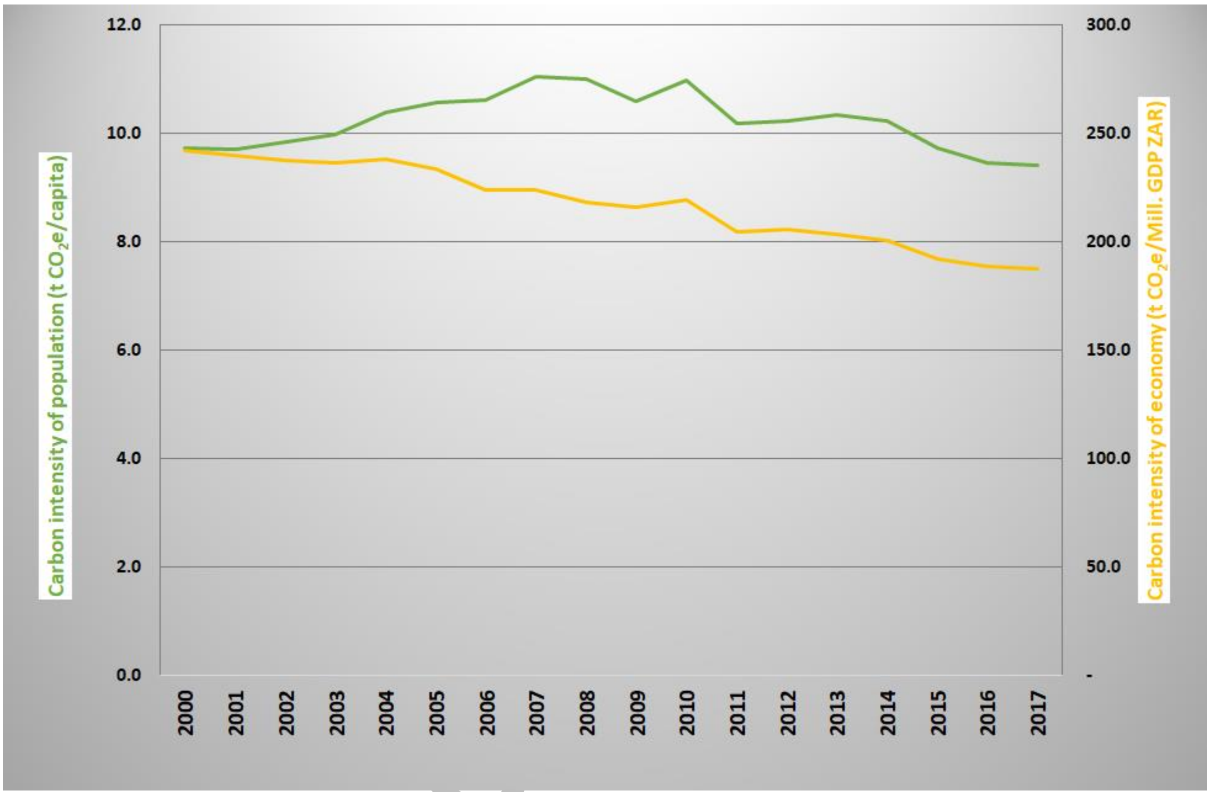


Figure 3.2: Trends in overall carbon intensity of the population and of the economy of South Africa between 2000 and 2017.

3.6.1.2. Energy indicators

The energy sector is a material source of greenhouse gas emissions in South Africa. Energy is also closely linked to developmental priorities in the country, where increasing levels of energy may be linked to socio-economic growth. Socio-economic growth requires resources which typically have associated emissions. Tracking the relationship between the electricity generated in the country, the associated greenhouse gases and national GDP, therefore, provides useful perspectives from which to understand the country's low-carbon transition.

The energy carbon intensity of the economy (energy sector emissions per GDP) shows a similar trend to the overall carbon intensity, showing the strong relationship between energy consumption and GDP. The energy carbon intensity of the population (i.e. energy sector emissions per capita) increased significantly (15.3%) between 2001 and 2007, stabilised until 2010 and then showed a decline (10.4%)

[5] Carbon in this case refers to the total net emissions (i.e. emissions including FOLU).

between 2010 and 2017 (Figure 3.3**Error! Reference source not found.**). Energy emissions per capita accounted for 80.6% of the total emissions (incl. FOLU) per capita in 2000 and this increased to 86.2% by 2017. The energy carbon intensity per capita trend is similar to that of the total carbon intensity of the population. This shows the large contribution to emissions from the energy sector.

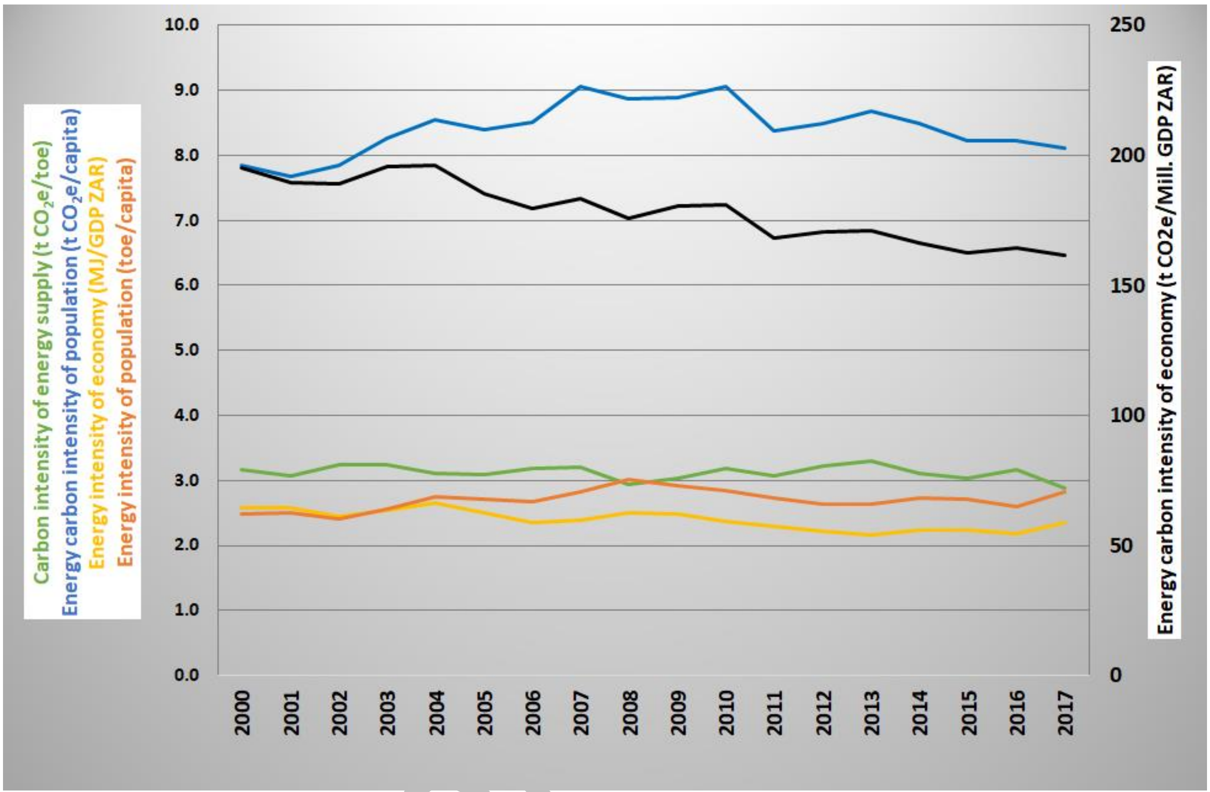


Figure 3.3: Trends in energy intensity indicators for South Africa between 2000 and 2017.

In terms of energy supply the Total Primary Energy Supply (TPES) data from South Africa's annual Energy Balances are applied. The carbon intensity of the energy supply, which is the amount of GHG emissions produced by the energy sector per unit of TPES (toe), remained fairly constant over the 17-year period with a small decline between 2016 and 2017 (Figure 3.3). The energy intensity of the population (TPES (toe) per person) has increased by 13.9% between 2000 and 2017, which is why the emissions per energy supply have remained fairly constant.

The energy intensity of the economy, which is TPES MJ per unit GDP, has declined between 2000 and 2017 (-8.9%), although there was a slight increase in 2017. There are various drivers behind this trend. The country's primary sectors (agriculture, forestry and fishing, and mining and quarrying) are recognised as energy intensive sectors. Statistics SA GDP data shows a decreasing trend in the primary sectors over time, which is likely to be a contributing factor to the reducing the energy intensity (Promethium Carbon, 2020). Additionally, the economy is becoming more diversified, with increasing contributions from the secondary and tertiary sectors, which contributes to the decreasing intensity values.

3.6.1.3. Overarching indicators for other sectors

Energy is used throughout the sectors and is also South Africa's key emitting sector, hence the focus of indicators for this sector. It is, however, important to develop indicators for the other sectors to monitor emission reduction progress. Indicators for all sectors are being discussed and identified as part of the updated NDC process, therefore additional sector indicators will be discussed in the next BUR.

3.6.2. Analysis of impact of sectoral PAMs

In the BUR3 (DEA, 2019a) numerous actions and activities in each sector were identified and reported on. There was, however, a lack of data for determining emission reductions on many of the activities. In this BUR a more limited list of actions has been identified by DEFF so as to focus monitoring and tracking efforts going forward. The aim is to track these actions and follow them through to wider impacts and support. The actions are focussed around the PAMs that are developing within each sector and which will also be impacted by the overarching policies.

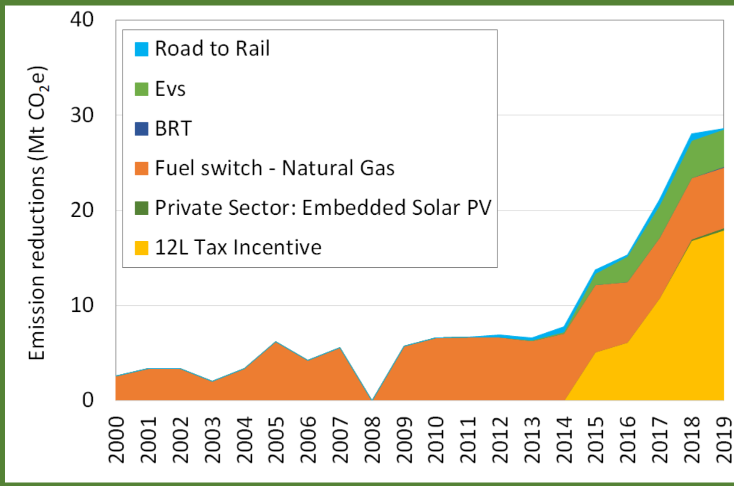
Annual emission reduction savings, related to the selected mitigation actions, were calculated and the results are reported in this section. Different calculation methodologies were applied to different actions (see methodology in Annex B1), but typically, the calculations involve the multiplication of the activity data by a relevant emission factor. For example, many of the energy-related mitigation actions were quantified using a South African grid emission factor (in t CO_2e/MWh), for specific years (which reflects the increasing trend related to the inclusion of renewable energy on the national grid). Details of each mitigation action (objectives, methods, assumptions, coverage, quantitative goals, progress of implementation, and steps taken to envisage goals) are provided in Annex B1.

3.6.2.1. Energy

The energy sector mitigation actions include energy efficiency, renewable energy and various transport related actions (Table 3.7). The total energy sector emission reductions were estimated at 21.1 Mt CO_2e in 2017 and 28.57 Mt CO_2e in 2019, which is up from the 13.72 Mt CO_2e estimated for 2015. The largest contributor was the 12 L tax incentive programme, which showed an increase of 12.85 Mt CO_2e between 2015 and 2019. The BRT system had the lowest contribution, and the road-to-rail programme showed an increase in 2017 and a decline in 2019.

In addition to these actions, there were energy savings from the Energy Efficiency Standards and Appliance Labelling project. However, these were stated as low and high ambition estimates (between 7.6 Mt CO_2e and 22.7 Mt CO_2e (Green House, 2016)) so specific annual savings couldn't be determined. Emission savings from this project were, therefore, not included in the total energy emissions savings. Additionally, there were several energy efficiency programmes (Table 3.8) where the emission reductions were determined, however, it is possible that some of the underlying projects quantified in these programmes are registered with international market-based mechanisms (IMM). It was not possible to separate out these CDM and VCS projects because the activity data sets were provided in an aggregated format. In the interest of transparency, these emission reductions were, therefore, excluded from the total energy sector savings and reported separately. International carbon credit projects will be discussed separately in section 3.7. Considering these actions, the Eskom Integrated Demand Management (IDM) programme is by far the largest contributor to emission reductions in the energy sector.

ANNUAL TRENDS AND ACCUMULATED SAVINGS: ENERGY



- ✓ 12 L tax incentive programme: 56.7 Mt CO_2e (2015–2019)
- ✓ Embedded solar generation: 0.36 Mt CO_2e (2018–2019)
- ✓ Natural gas fuel switch: 102.8 Mt CO_2e (2000–2019)
- ✓ BRT: 0.01 Mt CO_2e (2011–2019)
- ✓ Electric vehicles: 15.3 Mt CO_2e (2013–2019)
- ✓ Road-to-rail: 2.9 Mt CO_2e (2012–2019)

- ✓ Additional projects which have overlap with international carbon credits: 314.7 Mt CO2e (2005–2019)

Table 3.7: Emission reductions in the energy sector.

Name of Action	Focus area	Description	Indicator	Actual emission reductions ($MtCO_2e$)		
				2015	2017	2019
12L tax incentive programme	Energy efficiency	12L provides for a 95c per verified kWh (or kWh equivalent) of energy efficiency savings, that has been signed off by the monitoring and verification body and has been approved by the South African National Energy Development Institute (SANEDI) 12 L evaluation panel for the assessment year in	kWh savings; t CO_2e savings	5.07	10.76	17.92

		question. The tax incentive is applicable for a period of 12 months of savings.				
Private sector embedded solar generation	Renewable energy generation	Installation of embedded solar PV for electricity generation.	kWh generated; MW installed capacity			0.2
Natural gas fuel switch programme	Fuel switch	Switch to natural gas from emission intensive fuels.	t CO_2e savings	7.12	6.42	6.42
Bus Rapid Transport System (BRT)	Lower emission public transport activity	Provision of quick and safe public transport by bus. Implemented in Tshwane, Johannesburg, Durban and Cape Town.	kWh savings	0.002	0.002	0.002
Electric vehicles	Modal shift in transport sector	Shift to electric vehicle use from internal combustion engine vehicles.	t CO_2e avoided	1.17	3.35	3.94
Transnet Road-to-Rail programme	Modal shift in transport sector	Promotes the efficient use of energy resources and the limitation of adverse environmental impacts in relation to land transport.	MJ savings	0.36	0.59	0.09
Total emission reductions for the Energy sector				**13.72**	**21.12**	**28.57**

Table 3.8: Additional energy sector actions and emission reductions from projects that include registered carbon credit offset projects.

Name of Action	Focus area	Description	Indicator	Actual emission reductions ($MtCO_2e$)		
				2015	2017	2019
Energy Efficiency Standards and Appliance Labelling project	Energy efficiency	Implementation of energy efficient appliances in South Africa via the Standards and Labelling project.	kWh savings	Estimated to be between 7.6 and 22.7 Mt CO_2e		
Eskom IDM programme	Energy efficiency	Promotes energy efficiency and load management. The programme has promoted the implementation of energy efficiency technologies by providing various rebates for energy efficiency; management and conservation measures, as well as solar water heater installations.	kWh savings	45.81	56.26	61.48
Municipal Energy Efficiency and Demand-side Management programme	Energy efficiency	Disbursement of grant funding to municipalities to implement energy efficient retrofits within the municipal infrastructure.	kWh savings	0.93	3.70	14.4

NCPC programme	Energy efficiency	Implement projects in the private sector that achieve energy savings and improved economic competitiveness in South African businesses through resource and process efficiency.	kWh savings	0.50	0.50	0.49
PSEE programme	Energy efficiency	Implement projects in the private sector that achieve energy savings and improved economic competitiveness in South African businesses through resource and process efficiency.	kWh savings	0.13	0.12	0.12
Renewable Energy Independent Power Producer Procurement programme	Renewable energy	Competitive procurement programme, where prospective power producers submit bids to supply Eskom with renewable energy. The Department of Mineral Resources and Energy adjudicates the bids according to various criteria, price being the most critical.	kWh renewable energy	2.09	4.00	3.94
Total additional emission reductions in the Energy sector				**49.46**	**64.58**	**80.43**

3.6.2.2. IPPU

The IPPU sector produced emission reductions of 0.95 Mt CO_2e in 2019, which is lower than the 1.59 Mt CO_2e emission reductions in 2015 (Table 3.9). The nitrous oxide reduction projects have been running since 2006, and between 2006 and 2019 an accumulated 17.8 Mt CO_2e emissions have been saved. Carbon budgets for process emissions and the Pollution Prevention Plans Regulations have only recently been introduced so the full impact of these policies on emissions has not yet been assessed. Emission reductions for these policies will be reported in the next BUR.

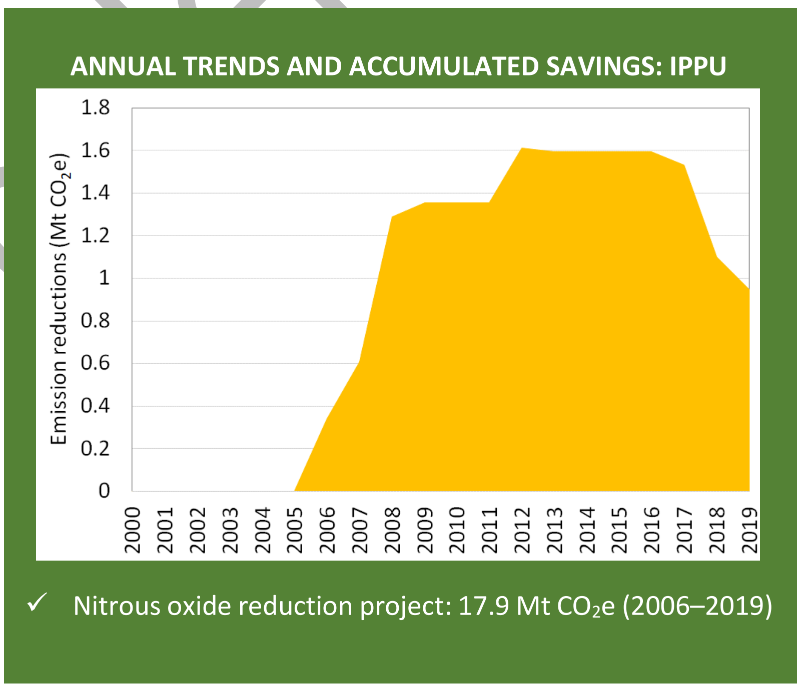


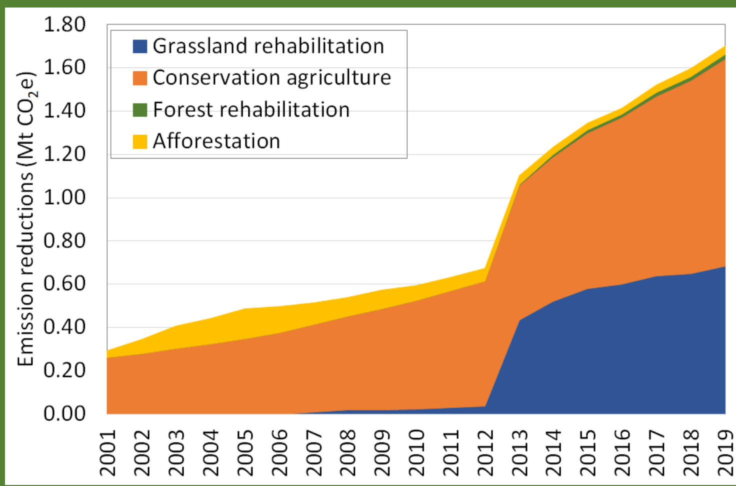
Table 3.9: Emission reductions in the IPPU sector.

Name of Action	Focus area	Description	Indicator	Actual emission reductions (Mt CO_2e)		
				2015	2017	2019
Nitrous oxide reduction projects	Process emissions	Reduction of nitrous oxide emissions in nitric acid production	Nitrous oxide reduction	1.59	1.53	0.95
Carbon budgets (only process emissions)	Process emissions	The aim of the carbon budgets is to reduce process related emissions in the industrial sectors and incentivise the uptake of cleaner technologies.	t CO_2e savings	Could not be determined at this stage as there has only been one reporting cycle and the data is still aggregate which could lead to double counting with the energy sector.		
Total emission reductions for the IPPU sector				**1.59**	**1.53**	**0.95**

3.6.2.3. AFOLU

In the AFOLU sector the actions are aimed at enhancing the carbon sinks in forest lands, croplands and grasslands. The total amount of CO_2 sequestered in this sector amounted to 1.7 Mt CO_2e in 2019 (Table 3.10). Conservation agriculture has the largest contribution to the sink, while forest rehabilitation has the smallest. Forest rehabilitation estimates are likely to be underestimated since only the reforestation of indigenous forest was included. Estimates for thicket restoration have not yet been determined.

ANNUAL TRENDS AND ACCUMULATED SAVINS: AFOLU



- ✓ Afforestation: 1.29 Mt CO_2 (2000–2019)
- ✓ Conservation agriculture: 10.27 Mt CO_2 (2000–2019)
- ✓ Forest rehabilitation: 0.1 Mt CO_2 (2013–2019)
- ✓ Grassland rehabilitation: 4.25 Mt CO_2 (2006–2019)

These reductions are estimated to be what has been achieved to date, based on the limited mitigation PAMs in this sector. DEFF is currently developing an AFOLU strategy (DEFF, 2020) which will define the way forward for this sector. As part of this strategy the mitigation potential of these activities was determined. Afforestation is estimated to have the potential to produce 2.2 Mt CO_2 over the next 20 years, while forest and woodland rehabilitation have the potential to produce 22 Mt CO_2 in the same period. Grassland rehabilitation and conservation agriculture are estimated to be able to produce 40 Mt CO_2 and 75 Mt CO_2, respectively, over the next

20 years. It is also estimated that government programmes could contribute 44 Mt CO_2 to this total, while the rest would come from private investment.

Lastly, the DEFF is developing a REDD+ strategy, but the impacts of this have not yet been quantified.

Table 3.10: Emission reductions in the AFOLU sector.

Name of Action	Focus area	Description	Indicator	Actual emission reductions (Mt CO_2e)		
				2015	2017	2019
Afforestation	Forest land sink	Department of Environment, Forestry and Fisheries afforestation programmes, including the Working for Land and Working for Ecosystems afforestation programmes.	t CO_2e sequestered	0.03	0.03	0.04
Conservation Agriculture (LandCare Programme)	Cropland sink	Reduction of the carbon footprint in Agriculture. Increase the absorption of CA into farming of cereal crops.	t CO_2e sequestered	0.72	0.83	0.96
Forest rehabilitation	Forest land sink	Restoring state forests and woodlands stems from the Draft Climate Change Sector Plan for DAFF (2015b) and the DAFF Strategic Plan 2015/2016 to 2019/2020 (DAFF, 2015a).	t CO_2e sequestered	0.01	0.02	0.02
Thicket restoration	Forest land sink	Restoring thickets is supported by the Draft Climate Change Sector Plan for DAFF (2015b) and the DAFF Strategic Plan 2015/2016 to 2019/2020 (DAFF, 2015a).	t CO_2e sequestered	Not yet quantified.		
Grassland rehabilitation (VeldCare - LandCare Programme)	Grasslands sink	Grassland rehabilitation programme.	t CO_2e sequestered	0.58	0.64	0.68
Total emission reductions for the AFOLU sector				**1.34**	**1.52**	**1.7**

3.6.2.4. *Waste*

Projects to reduce emissions in the waste sector are supported by the National Waste Management Strategy. Projects under this strategy have led to a 0.1 Mt CO_2e reduction in emissions in 2019 (Table 3.11) and an accumulated savings of 3.7 Mt CO_2e. There has been a slow reduction in emission savings since 2005.

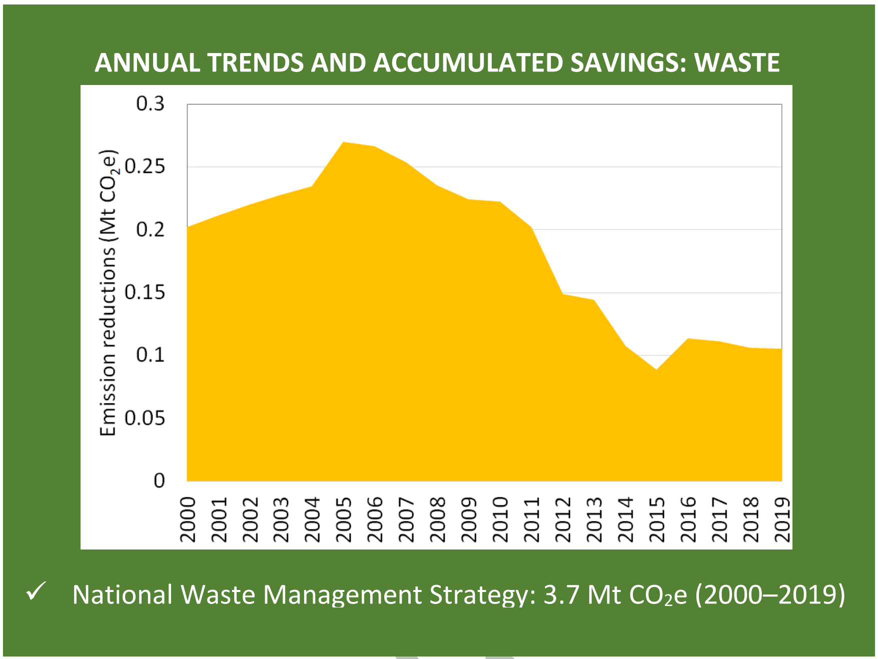


Table 3.11: Emission reductions in the Waste sector.

Name of Action	Focus area	Description	Indicator	Actual emission reductions ($Mt\ CO_2e$)		
				2015	2017	2019
National Waste Management Strategy	Waste management	Provides the overall approach to national waste management during the lifecycle of waste, including waste avoidance and reduction, re-use and recycling, recovery, and treatment and disposal.	t CO_2e mitigated	0.09	0.11	0.11

3.6.2.5. *Challenges, gaps and constraints*

There are several challenges in quantifying the emission reductions of the various actions:

- Aggregated activity data:
  - in the energy sector, the activity data is obtained as aggregated data making it difficult to separate out the CDM project reductions from the reductions due to government policies. This means that the total emission reductions reported for the energy sector are underestimated as programmes with possible CDM projects are excluded.
- Lack of Global Warming Potentials (GWPs):
  - in some cases, the emission reductions are provided in t CO_2e, yet the information regarding which GWPs were applied in the calculations is not provided. This may lead to some inconsistencies. A more structured reporting process, such as that being developed for the GHG Regulation Reporting will assist in improving the reporting. For

the NGER, activity data and emission factor data need to be reported, and this will allow for the improvement of the emission calculations.

- Lack of activity data:
    - In the AFOLU sector it is challenging to set up a baseline and project scenarios for actions due to the inadequate reporting of activity data, such as plant and tree species composition, and individual responses implemented. The main reason being that most projects and policies in this sector are not designed for mitigation. As the sector becomes more aware of the data needs, this should improve. Also, climate change is starting to be included in sector strategies, which will highlight the need for appropriate activity data.
    - Similar issues are seen in the waste sector.

3.6.2.6. Overall emission reduction impacts of sectoral PAMs

The total accumulated emission reductions between 2000 and 2019 are 216 Mt CO_2e. Eighty-three percent of these emission reductions can be attributed to mitigation actions in the energy sector. Energy sector emission reduction contributions have increased since 2015, while the contribution has declined from all other sectors.

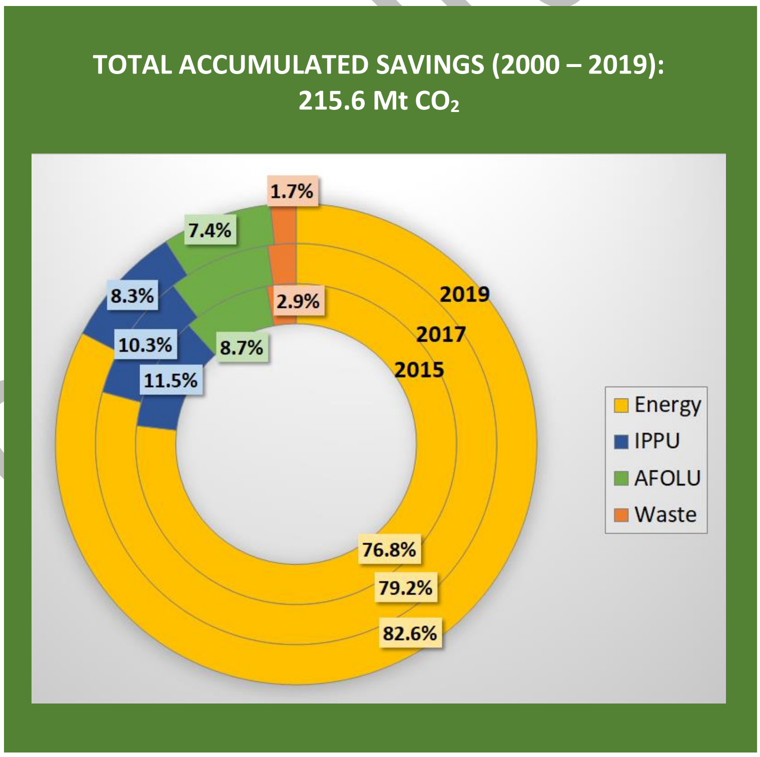


Figure 3.4 shows the annual emission reductions relative to the national GHG emission inventory. Annual savings are estimated at 16.8 Mt CO_2e, 18.5 Mt CO_2e and 24.3 Mt CO_2e in 2015, 2016 and 2017, respectively. As previously discussed, these estimates do not include any projects that have IMM project overlap. Since not all the excluded projects are IMM projects the emission reduction estimates provided here are likely to be underestimates.

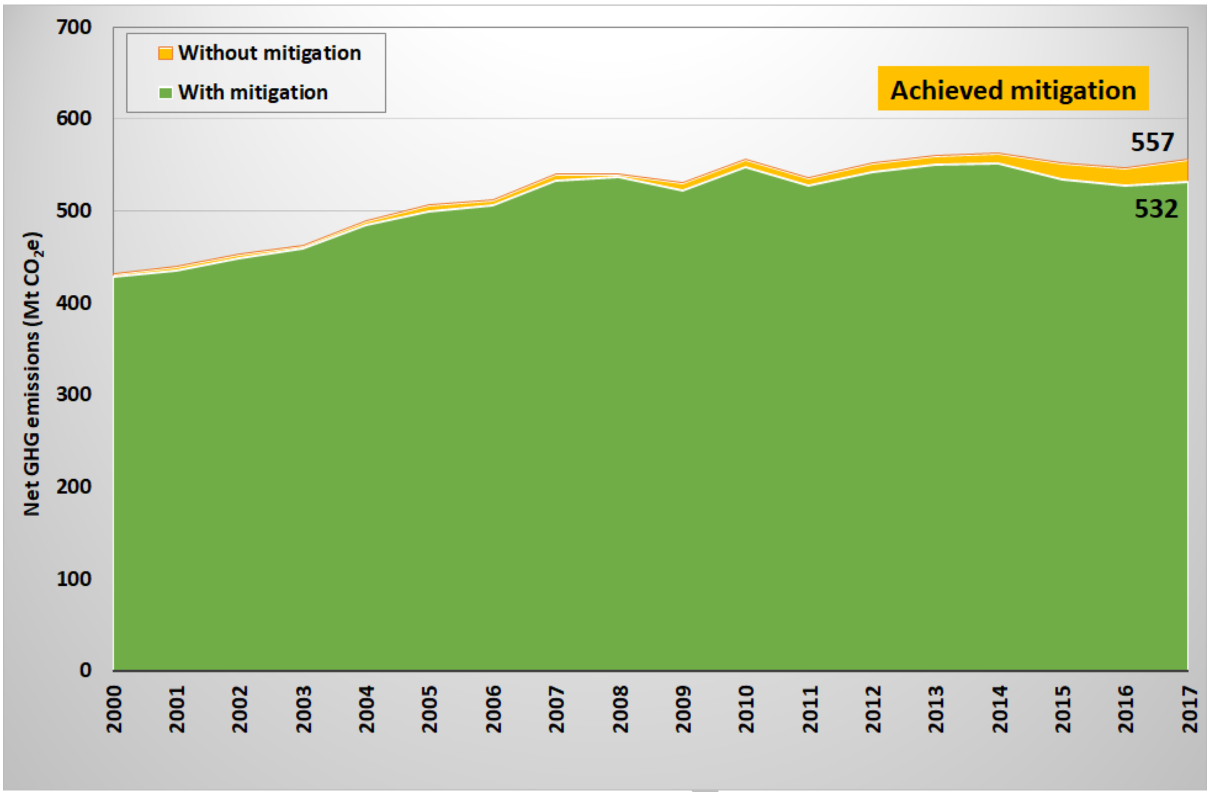


Figure 3.4: Achieved mitigation relative to GHG emissions inventory.

3.6.2.7. Co-benefits of actions

South Africa has started to identify the co-benefits of the mitigation actions and these are shown in Table 3.12.

Table 3.12: Identified co-benefits of the PAMS.

<table>
<tr><th rowspan="2">Sector</th><th rowspan="2">Action</th><th colspan="3">Co-benefits</th></tr>
<tr><th>Environmental</th><th>Social</th><th>Economic</th></tr>
<tr><td rowspan="8">Energy</td><td>12L tax incentive programme</td><td rowspan="8">Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purposes.</td><td rowspan="8">Increase in jobs due to uptake of energy efficient technologies.</td><td rowspan="8">Increase in green economy due to uptake of energy efficient technologies.</td></tr>
<tr><td>Energy Efficiency Standards and Appliance Labelling project</td></tr>
<tr><td>Eskom IDM programme</td></tr>
<tr><td>Municipal Energy Efficiency and Demand-side Management programme</td></tr>
<tr><td>NCPC programme</td></tr>
<tr><td>PSEE programme</td></tr>
<tr><td>Natural gas fuel switch programme</td></tr>
<tr><td>Bus Rapid Transport System (BRT)</td></tr>
</table>

	Transnet Road-to-Rail programme			
	Private sector embedded solar generation	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purposes.	Increase in jobs due to uptake of renewable energy technologies.	Increase in green economy due to uptake of renewable energy technologies.
	Renewable Energy Independent Power Producer Procurement programme			
IPPU	Carbon budgets and pollution prevention plans	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purposes.	Increase in jobs due to uptake of energy efficient technologies.	Increase in green economy due to uptake of energy efficient technologies.
AFOLU	Afforestation	Sustainable, performing ecosystems and increased land productivity.	Increased biodiversity and soil quality can improve subsistence farming which can positively impact human health.	Improvements in subsistence farming can increase economic livelihoods and, therefore, resilience to negative climate impacts.
	Forest rehabilitation			
	Thicket restoration			
	Grassland rehabilitation			
	Conservation agriculture	Sustainable, performing ecosystems and increased land productivity.	Increased biodiversity, catchment management, water quality and soil quality can improve subsistence farming which can positively impact human health.	Improvements in subsistence farming can increase economic livelihoods and, therefore, resilience to negative climate impacts
Waste	National waste management strategy	Prevents pollution of water, soil and air.	Reduces waste to landfill which has positive health impacts on society.	Stimulates job creation in the green economy through waste reduction, reuse and recycling.

Quantification of these co-benefits is complex. At this stage, the number of jobs in the green economy is being monitored (Table 3.13). There is a challenge to the collation of information related to the green jobs, since this is not a performance indicator required for reporting purposes to National Treasury for national mitigation activities that are subsidised. Key sources of employment in the green economy include the REIPPPP, LandCare programme and the Extended Public Works Programme.

Table 3.13: Number of green jobs in sectoral programmes.

Year	Renewable Energy Independent Power Producer Procurement programme (Full Time Equivalents)	LandCare work opportunities	Extended Public Works Programme (Full Time Equivalents)
2014	-	2 836	33 138
2015	24 964	2 043	28 141
2016	31 207	2 483	28 633
2017	35 607	2 012	40 368
2018	40 134	4 689	41 390
2019	48 334		

3.7. Assessing the impact of international market-based mechanisms

There are a number of South African projects registered with the three main IMM standards: Clean Development Mechanism (CDM), Gold Standard and Verified Carbon Standard (VCS). Many of these projects have issued respective carbon credits, which have been verified by independent auditors. Certified emission reductions (CERs) are issued under the CDM; verified emissions reductions (VERs) under the Gold Standard; and verified carbon units (VCUs) under the VCS. The majority of carbon credits are generated under the CDM. Information on CDM projects can be found on the DMRE website (http://www.energy.gov.za/files/esources/kyoto/kyoto_frame.html). To date there are 360 CDM projects submitted to the DMRE. Of the 140 Project Design Documents, 90 have been registered by CDM and 15 issued with certified emission reductions. Projects cover all sectors and include projects on biofuels, energy efficiency, waste management, cogeneration, fuel switching, hydro-power and other projects under the agriculture, mining, housing, transport and residential sectors. The VCS project details are obtained from the VCS database, while the Gold Standard projects need to be requested directly from Gold Standard.

The total carbon credits under these verified standards totalled 25.7 Mt CO_2e in 2017 and 2019, with the energy sector contributing 79.4% to the total (Table 3.14). A detailed list of projects is provided in Annex B2. Combining the reductions from the PAMs with the IMM project reductions, the total savings in 2017 and 2019 are 49.93 Mt CO_2e and 57.02 Mt CO_2e respectively (Figure 3.5).

Table 3.14: Summary of the South African IMM project emission reductions.

Year	Savings (Mt CO_2e)				
	Energy	IPPU	AFOLU	Waste	Total
2004	0.06	0.00	0.00	0.00	**0.06**
2005	0.55	0.00	0.00	0.00	**0.55**
2006	0.55	0.00	0.07	0.00	**0.62**
2007	0.65	1.17	0.10	0.00	**1.92**
2008	0.74	2.18	0.37	0.00	**3.28**
2009	1.93	2.18	1.51	0.00	**5.62**
2010	3.25	2.18	1.87	0.00	**7.30**
2011	3.90	2.18	1.87	0.02	**7.97**
2012	9.61	2.53	2.88	0.02	**15.03**
2013	12.13	2.53	2.95	0.02	**17.62**
2014	15.65	2.53	2.98	0.06	**21.22**
2015	18.47	2.53	2.98	0.06	**24.03**
2016	19.30	2.53	3.02	0.06	**24.91**
2017	20.02	2.53	3.05	0.06	**25.66**
2018	20.04	2.53	3.05	0.06	**25.68**
2019	20.04	2.53	3.05	0.06	**25.68**
Total	**146.88**	**30.10**	**29.75**	**0.41**	**207.15**

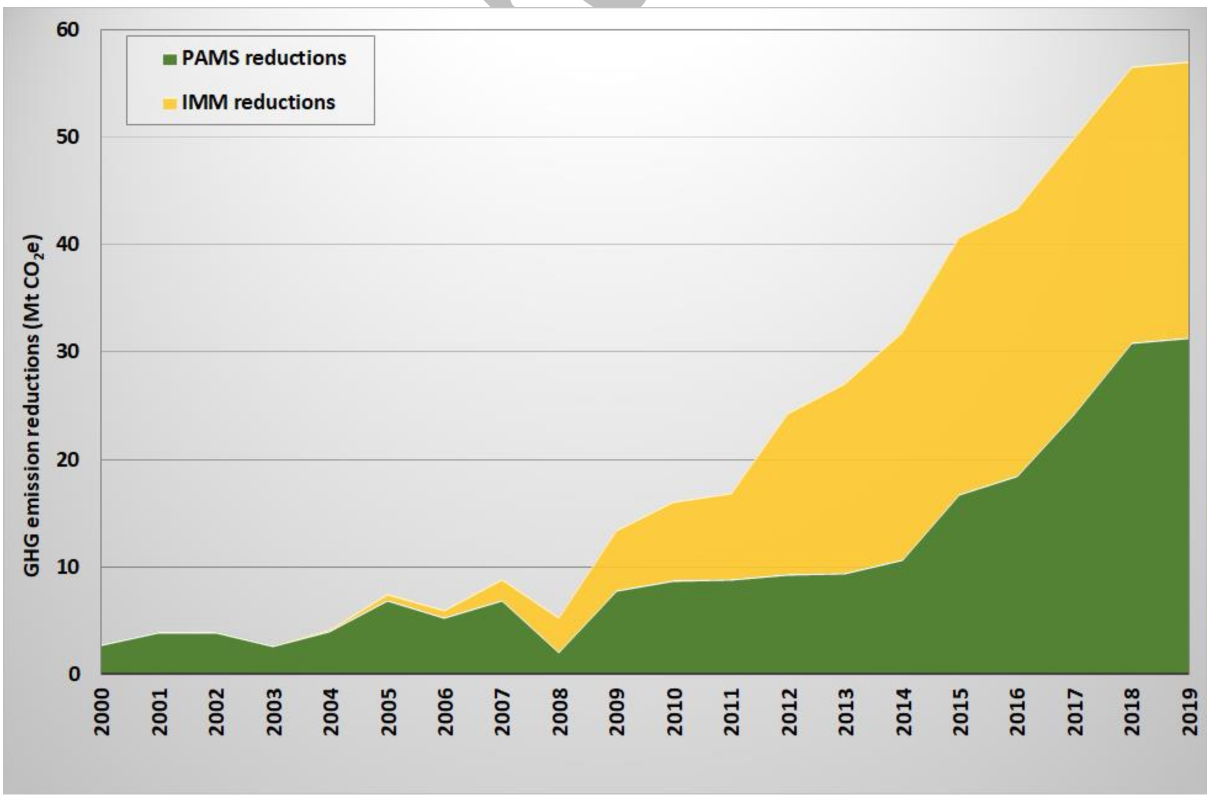


Figure 3.5: Emission reductions from PAMs actions and IMM projects.

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4. Financial resources, technology transfer, capacity building and technical support received and needs

4.1. Introduction

The chapter provides an update from the previous BUR3 report on financial, capacity and technical support received and needed by South Africa that supports the country's climate action which includes financial outflows that benefit global climate action provided by South Africa as an in-kind contribution to regional and international organizations.

South Africa's Nationally Determined Contribution (NDC) (DEA, 2015) reiterates the country's need to pursue development in response to the triple challenge of poverty, inequality and unemployment, albeit with a focus on sustainable development. The South African NDC has committed the country to implement mitigation measures to bend the curve of South Africa's GHG emissions towards a peak, plateau and decline trajectory. The NDC states that South Africa's emissions by 2025 and 2030 will be in a range between 398 and 614 Mt CO_2e, as defined in national policy. The South African Government has reiterated that the envisioned GHG emissions reductions can only be achieved if adequate financial, technological and capacity-building support is provided. South Africa's National Adaptation Strategy acknowledges that substantial finance is required to achieve meaningful adaptation in South Africa. The current update, therefore, provides overall progress on climate finance flows that are crucial to support South Africa's climate action.

The current update covers the period from 2018 to 2019. The report presents an analysis of international and domestic climate-related finance flows, as well as non-monetised support, received within the reporting period. The report also includes financial support needed (or requested) by South Africa to develop its response to climate change by sector, as well a description of non-monetised technical and capacity-building needed. The report also entails a summary of South Africa's contribution to regional and international organizations which have climate benefits.

4.2. Climate Finance

According to the National Climate Change Response Policy (NCCRP) White Paper, "*Climate finance is defined as all resources that finance the cost of South Africa's transition to a lower-carbon and climate resilient economy and society. This covers both climate-specific and climate-relevant financial resources, public and private, domestic and international. This includes financial resources that go towards reducing emissions and enhancing sinks of greenhouse gases; reducing vulnerability, maintaining and increasing the resilience of human and ecological systems to negative climate change impacts; climate-resilient and low-emission strategies, plans and policies; climate research and climate monitoring systems; as well as climate change capacity-building and technology*" (DEA, 2011).

Since reporting in the previous BURs, South Africa has been devoting efforts to enhance its reporting on climate finance to inform domestic decision making as well meeting its reporting requirements under the UNFCCC. The Department of Environment, Forestry and Fisheries (DEFF), in partnership with National Treasury and other key role-players, have initiated the development of the National Climate Finance Strategy to inform South Africa's efforts to mobilise, direct and coordinate flows of finance to address South Africa's climate change imperatives and address the national triple challenge of poverty, unemployment and inequality. The strategy will be informed by, respond to, and be implemented in collaboration with key stakeholders, to enhance the national climate change response and key implementation systems and actions. The National Climate Finance Strategy for South Africa is built on a shared vision and common understanding of South Africa's finance mobilisation approach and will enable a coordinated, long-term, inclusive and participatory national approach to resource mobilisation across the entire value chain of South Africa's climate change response. The strategy will provide the impetus for collaborative action by government, the private sector and civil society, to respond to the South Africa's climate change priorities and realise sustainable development goals, while addressing the national social and economic challenges and will thus give effect to South Africa's commitment to mobilising the resources that are necessary for both mitigation and adaptation.

Another achievement related to the reporting on climate finance flows is the institutionalisation of the Tracking and Evaluation Portal that tracks financial support provided, including supporters, responsible organizations, status, support channels and values. The portal presents a shared information portal on climate finance and ensures that monitoring, reporting and verification of climate finance are carried out in South Africa. By reporting, tracking and monitoring climate flows, policy makers, among others, can assess the scale of finance, identify the main actors (public and private) in the market, understand investment gaps, highlight opportunities and address barriers to mobilise finance in support of low-carbon, climate-resilient development.

4.2.1. Climate finance landscape

A high-level framework for understanding the actors and financial flows, in terms of the sources, intermediaries and facilitators, instruments and implementers of climate finance, is shown in Table 4.1. In addition to the entities involved with the flow of funds, there is a complex landscape of entities that form the enabling environment for climate finance. These entities include, among others, policy makers, regulatory agencies, rating agencies, buy- and sell-side research analysts, academia, the credit bureau, data providers, accountants, technical assistance providers, risk consultants and asset consultants.

Table 4.1: The flow of funds through the financial landscape (Source: DEA, 2019b).

Flow of funds ↓

Sources of Funds	**Public: national, international** **Private: individuals, companies, organisations**	
Intermediaries and Facilitators	**Beneficial Owners** Foundations, Endowments Banks Insurance companies Pension funds Venture funds Private equity funds	Development Finance Institutions Multilateral agencies (UN) Sovereign wealth funds Microfinance Institutions Savings and Credit Cooperative Societies Export Credit agencies
	Dedicated Climate Funds **Local** Green Fund	**International** Green Climate Fund Adaptation Fund Climate Investment Funds Multilateral Funds Bilateral Funds
	Managers Asset managers Fund managers	
	Investment platforms and mechanisms Bond, equity and commodity exchanges Kyoto-related: Emissions Trading System, Climate Development Mechanism, Joint Implementation UN REDD Risk pooling mechanisms Crowdfunding, peer-to-peer and other fintech-based mechanisms	
Instruments	Grants e.g. technical assistance grant from the Rockefeller Foundation to fund the position of a Chief Resilience Officer at the City of eThekwini. Guarantees e.g. Government guarantees on Power Purchase Agreements signed with Independent Power Producers under the Renewable Energy Independent Power Producers Procurement Programme. Non-concessionary and concessionary loans, debt and equity e.g. Industrial Development Corporation green bond. Insurance e.g. weather-index insurance for agriculture. Carbon credits. Operations of private sector companies. Transfers – these are inter-governmental transfers e.g. transfers to the DEFF for the implementation of the Working for Water programme.	
Implementers	Government (National, Local, Provincial), Communities, Companies, Non-profit organisations.	
Projects, Programmes, Beneficiaries	Examples: Renewable Energy Independent Power Producers Disaster Risk Management programme Working for Water programme REDD+ Gauging stations and Early flood warning systems Bus Rapid Transport System Drip irrigation system manufacturer	

4.2.2. Climate finance sources

Climate finance sources for South Africa can be classified into four different categories: bilateral finance, multilateral finance, domestic public finance and private sector finance. Support is classified as 'bilateral' if it comes from one donor country and as 'multilateral' if more than one country/entity provides the support and it is channelled through one donor agency. Bilateral assistance for climate change comes in different forms: through individual donors, through donor agencies, directly in the form of Official Development Assistance and through bilateral finance institutions.

4.3. Support Received

4.3.1. International financial support received

Support received during the reporting period, 1 Jan 2015 – 31 Dec 2017 was reported in BUR3 (DEA, 2019a). The current biennial update provides information on additional climate finance flows recorded for the period 2018 to 2019 (Tables 4.1 and 4.2).

Over the reporting period from 2018 to 2019, South Africa has received in excess of USD 4 billion in financial support from bilateral and multilateral sources that support or benefit climate change action in the country (Figure 4.1). Approximately 88.9% of the funds were in the form of loans (USD 4 343 million), and the rest being grants (USD 542 million).

The commitment levels of climate grants and loans provided by bilateral and multilateral partners has increased from the previous reporting period (3rd BUR report). The share of loans has increased, and ths reflects the overall preference of loan commitments as opposed to grants for South Africa by most bilateral cooperating partners.

The majority of the funds support mitigation projects (Figure 4.2).

Additional information on bilateral and multilateral financial support committed between 2018 and 2019 is provided in Annexure C. The funding received from the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMUB) (under the Climate Support Programme) for the preparation of this BUR is included in the bilateral funds provided here.

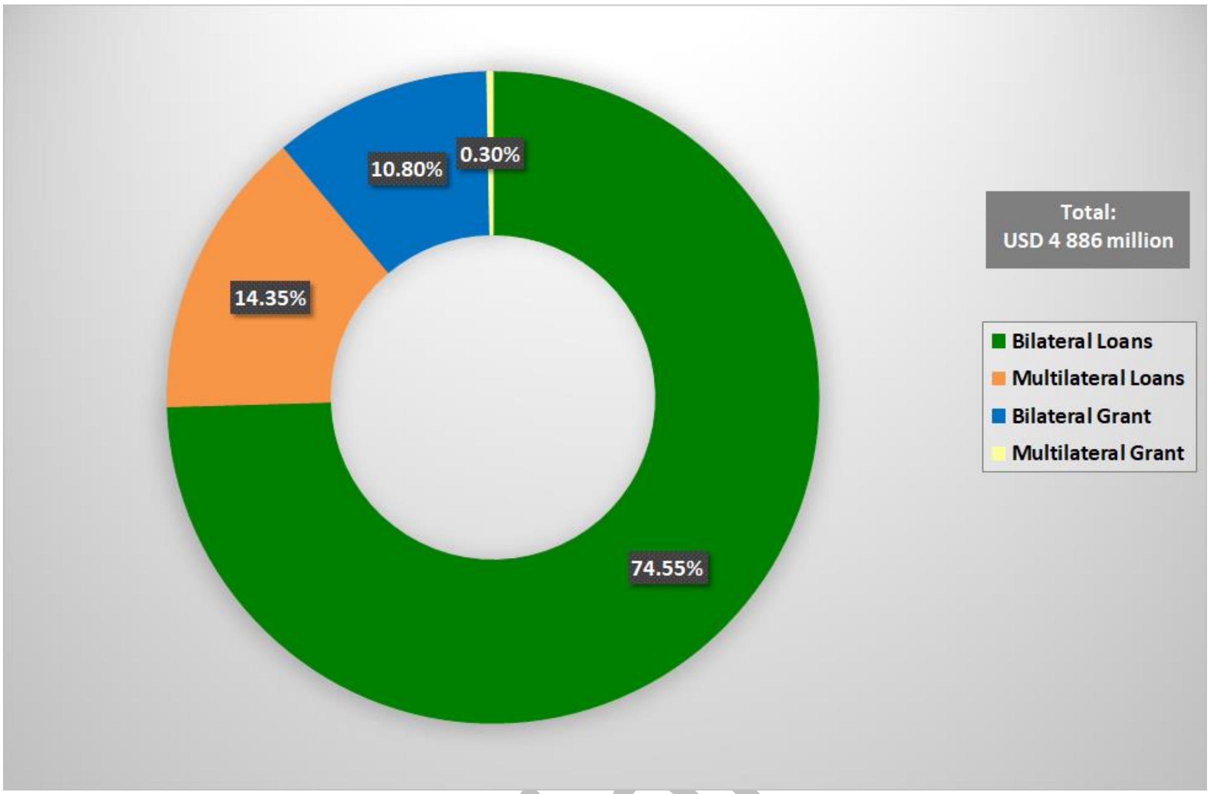

Figure 4.1: Loans and grants received for climate change in South Africa (2018 and 2019).

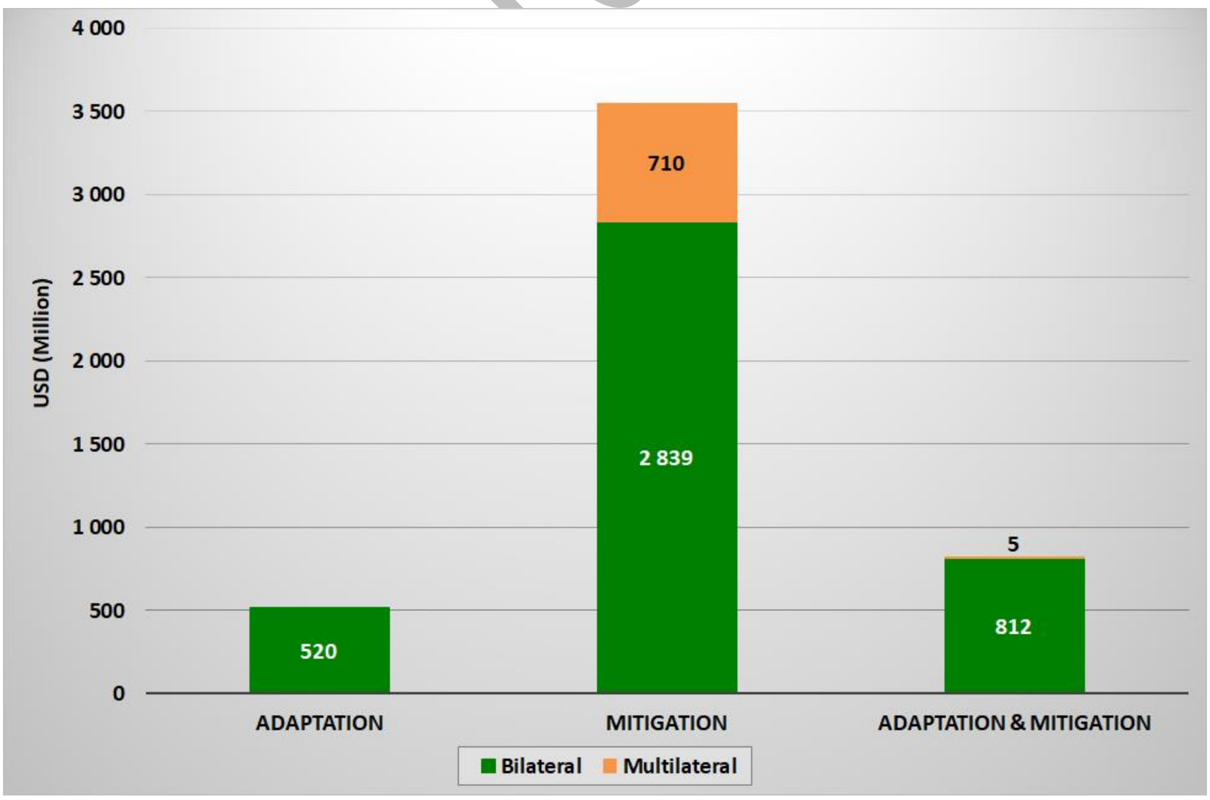

Figure 4.2: Types pf projects funded by loans and grants in South Africa (2018 to 2019).

4.3.1.1. Bilateral support received/committed (2018–2019)

In terms of bilateral support, Germany contributed 48.4% (USD 2 019 million) of the funding and 94.0% of this was in the form of loans (Figure 4.3). The largest loan was to the Green Energy Efficiency Fund with the aim to encourage investments in energy efficiency and renewable energy projects to support SA's transition towards a low-carbon economy (PSEE, 2015). Funding is in the form of a loan for the capital required for an energy-efficiency project. Italy contributed 34.1% of the bilateral funds and these were in the form of loans from Enel Green Power who supports the development of renewable energy in South Africa. Belgium contributed the most (8.0%) in terms of grants, followed by Germany (2.9%). The Belgian grants are mostly for adaptation and resilience projects and projects supporting a Green Economy. Most of Germany's bilateral support is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), through the German Climate Support Programme, which supports South Africa in achieving ambitious climate action through strengthening South Africa's institutional support at national and sub-national levels.

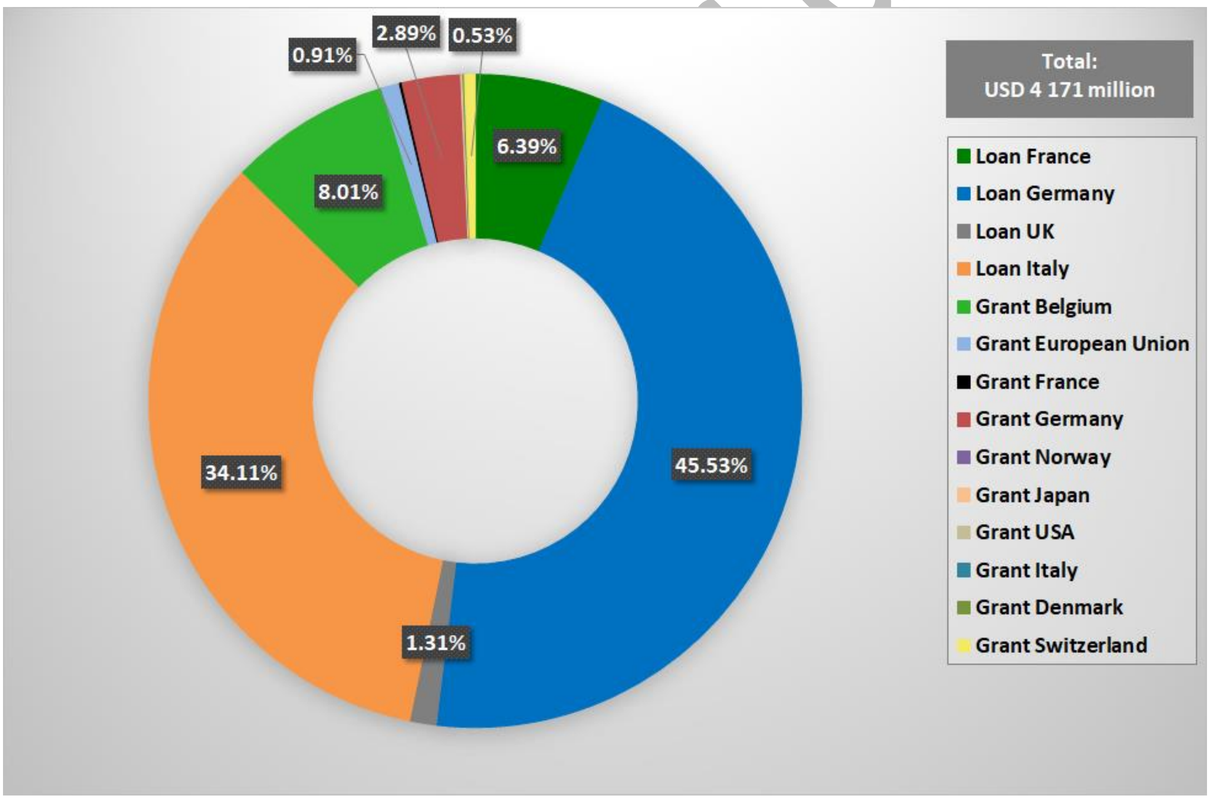

Figure 4.3: Breakdown of bilateral funding to South Africa (2018 to 2019).

4.3.1.2. Multilateral support committed/received (2018–2019)

An analysis of multilateral support to South Africa is shown in Figure 4.4. The largest loan (USD 543 million) received during the reporting period was from the Green Climate Fund (administered by the Development Bank of Southern Africa (DBSA) and the South African National Biodiversity Institute (SANBI)). These funds were used for energy efficiency projects (renewable energy and private and public sector energy efficiency programmes), as well was the Waste Management Flagship Programme (implementation of organic waste treatment solutions). In addition, some of the funds were allocated to SANBI as a Readiness Grant aimed at developing Concept Notes and Funding Proposals for submission to the Green Climate Fund (GCF) amongst other technical activities.

The second largest contribution was from the consortium consisting of the Agence Française de Développement, African Development Bank, Clean Technology Fund and the World Bank International Finance Corporation. These funds were used for the development of 100 MW wind farms to enhance Eskom's renewable energy sources. The contribution committed as grants made up 21% of the multilateral funds received, and these were from the Global Environment Facility (GEF), World Wildlife Fund (WWF) and the Adaptation Fund. The GEF support was for implementing an Energy Management System in South Africa, while the WWF funds were utilised to improve global climate change mitigation outcomes through domestic action, focusing on cities and local businesses.

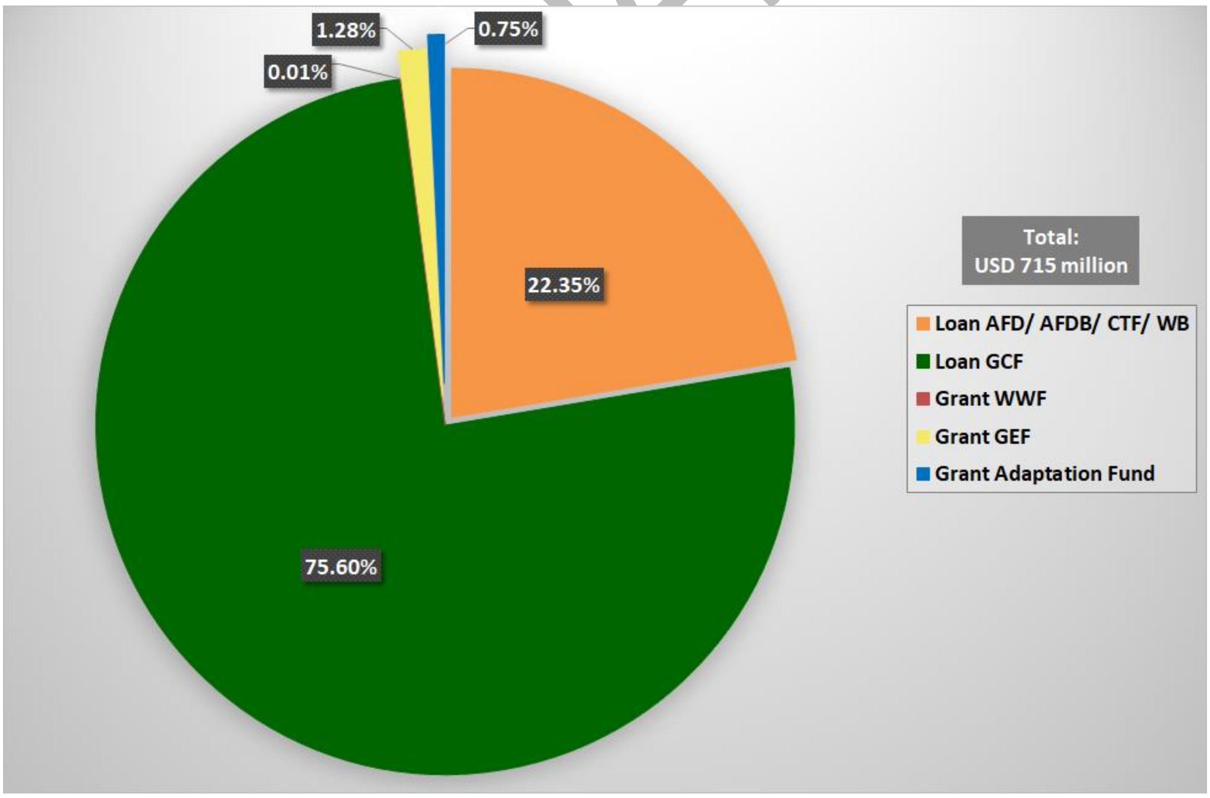

Figure 4.4: Breakdown of multilateral funding received for the period (2018–2019).

4.3.2. Domestic financial flow for climate change response actions

The South Africa Government continues to play a vital role in creating the conditions for inclusive economic growth and development and in establishing the appropriate economic framework to encourage and facilitate the shift to environmentally cleaner technologies and low carbon activities in the country. At national level there are a number of government departments that are integrating and mainstreaming climate change into sector plans. One of the primary strategic objectives set out by the South African Climate Change Policy (DEA, 2011) is to spearhead the "development of comprehensive resource and investment mobilisation strategies, capacities, mechanisms or instruments that support and enable implementation of climate change responses at the scale required; including, but not limited to, public and private financial resources, incentives, non-market and market-based instruments, technical cooperation and partnership agreements, and technology transfers at domestic, sub-regional, regional, and international levels". As a response to this calling, various national government departments are pursuing strategies to integrate and mainstream climate change into their respective sector plans.

The South African government has invested approximately USD 238 million to support climate action at the national level (Figure 4.5). The largest portion of these funds was allocated to DAFF[6] for forest resource management projects, particularly to provide an enabling framework for the sustainable management of woodlands and indigenous forests, and the efficient development and revitalisation of irrigation schemes and water use.

There are a number of domestic funding sources available in South Africa for climate change projects, and these are discussed in more detail below. Annex C3 provides a detailed list of domestic climate finance flows and projects that aim to enhance support for mitigation and adaption efforts in the country.

[6] Note that in this section the government departments are referred to by the name they had before the President Ramaphosa administration, to be consistent with the actual departments that received the funds.

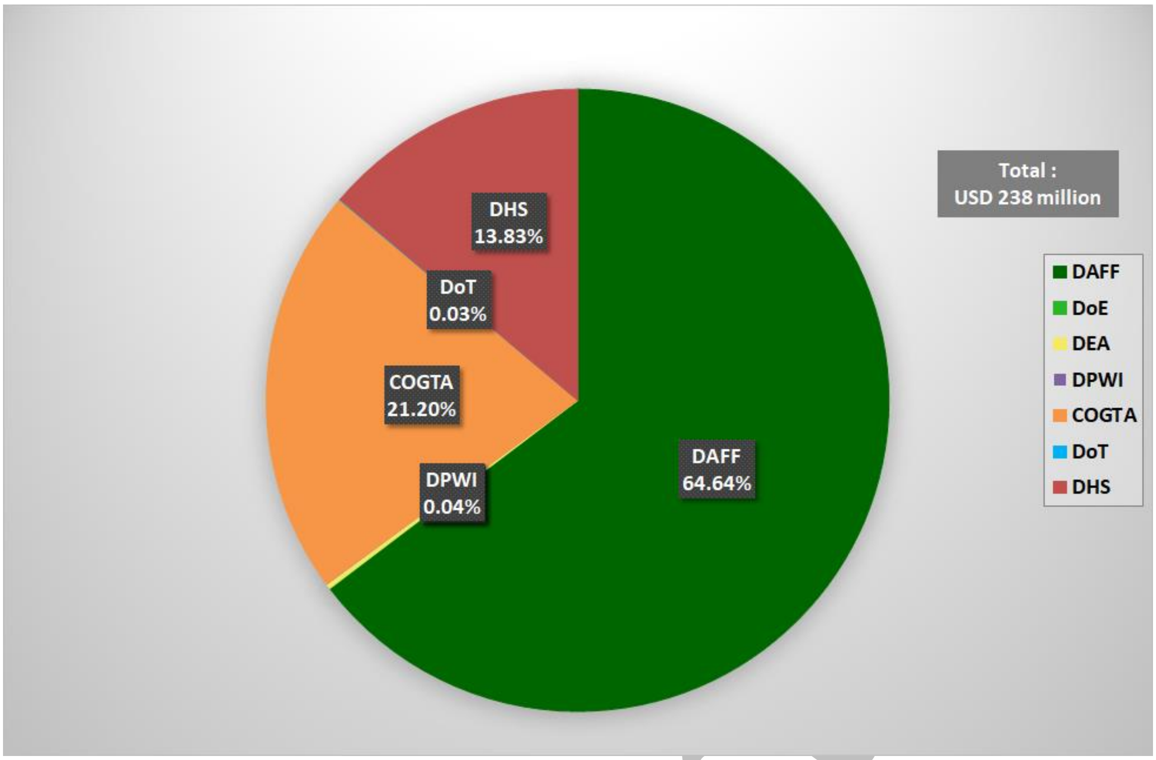

Figure 4.5: Summary of domestic funds that impact climate change responses (2018–2019)[6].

4.3.2.1. National Treasury's Cities Support Programme

This programme works across national departments to facilitate policy shifts that enable sustainable and inclusive urban growth and management in the country's eight large 'metropolitan municipalities' (or 'metros' for short). They also work directly with metro governments (at their request) on a number of topical issues. In 2017 the Programme incorporated 'climate resilience' as a core component and focused on environmental planning, air quality control and mainstreaming climate change actions across urban management sectors. Significantly, a priority has been assisting cities in climate proofing their Integrated Development Plan and Built Environment Performance Plan. A total sum of USD 30 million was disbursed to municipalities as a grant to support sustainable development at sub-national level.

4.3.2.2. Infrastructure Investment Programme for South Africa

The Infrastructure Investment Programme is a 100 million euro fund, jointly established by the Government of South Africa and the European Union. This fund aims to encourage large infrastructure projects by leveraging grants to attract additional loans from participating investment banks. The Development Bank of Southern Africa is the appointed fund manager and solicits proposals from various government levels.

4.3.2.3. The Green Fund

The national government, through the DEFF and managed by the DBSA, established the Green Fund in 2012 with an initial USD 60 million. The fund's objective is to lay the groundwork for the country's transition to a low-carbon, resource efficient and climate resilient development path. The fund responds to market weaknesses, and finances projects that would otherwise not be implemented through thematic calls for proposals and tenders. While 'Green Cities and Towns' is a stated funding priority, relatively little money has flowed to municipalities. Rather, the Fund appears to favour private sector partnerships with civil society to expand investment in a national green economy. The initial (2018) call for proposals focused on waste-water treatment and energy capture.

4.3.2.4. The Expanded Public Works Programme

In response to high unemployment, The Department of Public Works administers grants that create temporary jobs in four priority areas: infrastructure, non-state (non-profit civil society), environment, and culture and social (education and care work). Notably, the programme has created 997 000 jobs in the financial year 2018/19 through rehabilitating ecosystems. Thus, the Programme has great potential to co-finance sustainable infrastructure and highlight the co-benefits of green investment. For the financial year 2018/19, an amount of USD 17 million was spent by government on the programme.

4.3.2.5. Climate Finance Facility

In 2018 the UNFCCC Green Climate Fund awarded USD 55.6 million to the DBSA to establish the Climate Finance Facility for Southern Africa. The DBSA Climate Finance Facility Programme is a lending facility that aims to address market constraints and catalyse private sector funding for climate-related investments in the Southern African region. The lending facility proposes the use of a blended finance approach and will consist of credit enhancements focused on first loss or subordinated debt and tenor extensions to catalyse private sector climate investments. The Facility will 'crowd in capital'[7] in order to scale up climate finance for sustainable infrastructure and private sector mitigation and adaptation efforts (DEA, 2019b).

4.3.2.6. Green bonds

The Johannesburg Stock Exchange (JSE) launched its Green Bond Segment in late 2017. Its Green Bond platform seeks to unlock the investment potential of green infrastructure, technologies and services and to build trust and assurance around the environmental credentials of the bonds, by developing clear green bond qualification criteria. The proceeds of Green Bonds are exclusively used for the financing or re-financing of new or existing eligible green projects that have a positive environmental and/or climate benefit (JSE, 2017).

The JSE's green bond platform is built on the following framework:

[7] Crowdfunding is the use of small amounts of capital from a large number of individuals to finance a new business venture. Crowdfunding makes use of the easy accessibility of vast networks of people through social media and crowdfunding websites to bring investors and entrepreneurs together, with the potential to increase entrepreneurship by expanding the pool of investors beyond the traditional circle of owners, relatives and venture capitalists.

- Research into international best practice.
- Considering local needs and possible pros and cons of various frameworks.
- Stakeholder engagement (issuers, investors, government, auditors, etc.).
- Non-negotiables:
    - Credibility in terms of “green credentials”.
    - Clarity in respect of practical application of Green Bond principles.
    - Monitoring and reporting requirements (disclosure).

While green bonds in South Africa is relatively small in relation to other countries, such as the USA, China and France, green bonds offer a significant opportunity (especially at provincial and municipal level) to mobilise large amounts of private capital earmarked for low-carbon, climate resilient investments. As market actors continue to innovate in this area, the review of green bond regulations and incentives and the harmonization of standards become critical.

The first local municipality to list a green bond was the City of Johannesburg, which listed in 2014 (Table 4.2). The City of Cape Town launched its green bond in July 2017, while Growthpoint Properties became the first South African company to issue a green bond during March 2018.

Table 4.2: South Africa’s Green Bond Issuances (Source: DEA. 2019b).

Name of Issuer	Size (Rbn)	Year	Purpose
The Industrial Development Corporation	5	2012	To finance clean energy infrastructure.
The City of Johannesburg	1.5	2014	To finance biogas to energy and the Solar Geyser Initiative.
The City of Cape Town	1	2017	To fund projects aligned to the City’s Climate Change strategy, including electric buses, energy efficiency in buildings and measures to address water resource management and long-term water security.
Growthpoint Properties	1.1	2018	To fund green buildings and green initiatives of South Africa's leading Real Estate Investment Trust.

4.3.3. Non-monetised support received

Technical and capacity building support received from developed countries for the period between 2018 and 2019 is summarised in Table 4.3 below and is additional to the support that was reported in Table 37 of BUR2 (DEA, 2017) and Table 4.5 of BUR3 (DEA, 2019a) which included support within the 2015 and 2017 reporting periods.

Table 4.3: Technical support and capacity building support received from developed countries for the period 2018-2019.

Type of support	Activity	Focus	Timeframe	Donor
Capacity building	Training on the use of the IPPC guidelines to compile national GHG inventories for the AFOLU sector.	Inventory and mitigation	March to October 2018 in Zimbabwe	United Nations Framework on Climate Change Secretariat
Capacity building	Training on the national Tracking and Evaluation (T&E) system.	Mitigation and adaptation	January–May 2020	GIZ, through the World Resources Institute (WRI)
Capacity building	Training on the NGHGIS and compilation of the 2017 inventory, particularly, the AFOLU sector.	Inventory	August–Dec 2019	GIZ, through the Climate Support Programme
Capacity building	UNFCCC review course for review of Annex 1 GHG inventories for the agriculture sector.	Inventory and mitigation	March 2019	United Nations Framework on Climate Change Secretariat
Capacity building	IPCC basic training of GHG inventories and use of IPCC software in compilation of GHG inventories.	Inventory and mitigation	Oct 2019, Japan	IPCC
Capacity building	2050 Pathways Calculator Conference.	Mitigation and adaptation	November 2018, London, UK	Sponsored by the United Kingdom
Capacity building	Training in managing Global Governance.	Mitigation and Adaptation	3–7 December 2017 in Bahrain 9 August–2 December 2018	German Development Institute
Capacity building	V-LED meeting.	Mitigation	22–24 January 2019	Vertical Integration and Learning for Low Emission Development
Capacity building	Renewable Energy Systems in Power Integration.	Mitigation	17–28 June 2019	Denmark
Capacity building	Study tour Germany on the implementation of Sustainable Development Goals.	Mitigation and Adaptation	13–19 October 2019	Germany
Capacity building	International Symposium and High-level Action for Climate Empowerment Event.	Mitigation and Adaptation	13–14 October 2019	Austria

Type of support	Activity	Focus	Timeframe	Donor
Capacity building	Climate Policy for 2050.	Mitigation	14–20 October 2018 in Berlin, Germany	German Government
Capacity building	IPCC Expert meeting to collect the Emission Factor Database and software users' feedback.	Mitigation	15–17 October 2019	IPCC Trust Fund
Capacity building	Climate Opportunity 2019: C0-benefits for just Energy Futures Conference.	Mitigation and Adaptation	15–16 October 2019	The Independent Institute for Environmental Issues
Capacity building	Steering committee on the Global Environment Outlook.	Mitigation and Adaptation	31Octoer–1 November 2019	United Nations Environment Programme (UNEP)
Capacity building	International 2050 Calculator Conference.	Mitigation	12–16 November 2019	The Business Energy and Industry strategy, UK
Technical and capacity building	Building the technical capacity of local government officials to develop adaptation responses, undertake climate vulnerability assessments and review existing climate change adaptation strategies and action plans. 40 workshops were held between July and September 2018. A total of 1 236 stakeholders participated, of which 647 were municipal officials, other interested experts from civil society to institutions affiliated with municipalities, such as The National Disaster Management Service. The objectives of the Local Government Climate Change Support Programme were included.	Mitigation and adaptation	July–September 2018	GIZ, Germany through the Climate Support Programme

4.4. Climate financial outflows that South Africa contributes to regional and international organizations that benefit climate change action

South Africa is not only a recipient of climate finance support from international bodies; the country also commits financial and technical support to a number of regional and international organizations as its 'fair' share of the global climate action. These are contributions made by South Africa to regional and international organizations that benefit climate change action**.** The South African government contributed an estimated amount of USD44 million to regional and global organizations which benefit mitigation and adaption action (Table 4.4). Most of the contribution allocations are made to the African Union and the United Nations bodies.

Table 4.4: South Africa's contribution to regional and international organisations.

Organisation	Total in ZAR	Total in USD	Support Types Provided			Funding type	
			Mitigation	Adaptation	Capacity building	Loan	Grant
South African Development Partnership	9 776 000	708 920	X	X	X		X
African Union	227 416 000	16 491 371	X	X	X		X
India, Brazil, South Africa Trust Fund	19 023 000	1 379 478	X	X	X		X
African Peers Review Mechanism	3 243 000	235 170	X	X	X		X
Organisation for Economic Cooperation and Development	305 000	22 117	X	X	X		X
United Nations Environment Programme	7 260 000	526 468	X	X	X		X
African Caribbean and Pacific Group of States	5 122 000	371 429	X	X	X		X
Commonwealth of Nations	22 190 000	1 609 137	X	X	X		X
Southern African Development Community	22 190 000	1 609 137	X	X	X		X
United Nations	180 403 000	13 082 161	X	X	X		X
Indian Ocean Rim Research Centre	189 000	13 706	X	X	X		X
United Nations Development Programme in Southern Africa	1 492 000	108 194	X	X	X		X
United Technical Corporation	150 000	10 877	X	X	X		X
African Union Commission	3 653 000	264 902	X	X	X		X
National Association for Clean Air	14 400 000	1 000 695	X	X	X		X
Global Environmental Fund	23 500 000	1 633 079	X	X	X		X
Environmental Assessment Practitioner Association of South Africa	4 809 000	334 190	X	X	X		X

Kwa-Zulu Natal Conservation Board	1 287 000	89 437	X	X	X		X
Recycling Enterprise Support Programme	69 000 000	4 794 997	X	X	X		X
TOTAL	**615 408 000**	**44 285 465**					

4.5. Support Needs

The technical and capacity building needs for South Africa highlighted in the BUR3, and further identified in the Technical review of the BUR3, are summarised in Table 4.5. Progress towards addressing these needs over the last two years is also shown, so as to indicate needs that are still outstanding. Section 4.5.2 will discuss future technical and capacity requirements for South Africa.

Table 4.5: Summary of support needs previously identified and progress towards addressing these needs.

Focus	Type of Support	Activity identified in BUR3	Need identified in BUR3 Technical review	Progress towards addressing the need	Outstanding needs[8]
Inventory and mitigation	Capacity building	Develop training courses covering GHG inventory update process (IPCC guideline methodologies for sectors, QA/QC process and methods, uncertainty analysis, key category analysis, coordination and management of update process).	Enhancing technical capacity for GHG inventory development on a regular and continuous basis.	Gondwana is currently providing training for the DEFF inventory team on the National Greenhouse Gas Inventory Management System (NGHGIS), inventory process, inventory updating, QA/QC process, key category analysis and uncertainty (with all presentations and training material being uploaded onto the NGHGIS), however, specific training courses have not been developed yet.	Training courses still need to be developed, but this is planned and will be funded through the Capacity-Building Initiative for Transparency (CBIT).
			Enhancing technical capacity for the development of the GHG management system, including for: i. Operationalizing the system in terms of the personnel capacity to operate and maintain it. ii. Operationalizing QA/QC components, processes and plans.	Additional inventory team staff have been appointed at the DEFF to manage the NGHGIS and to compile the inventory. The GHG Inventory team is now responsible for full management of the National GHG management system. Training has been provided on overall functioning of the NGHGIS, and there are currently plans underway to provide operational training on the system management for the NGHGIS. Training on the QA/QC process has also been provided.	Operational training on the system is still required, but this is underway through World Resources Institute (WRI) funding.
Invent ory and	Technical		Enhancing capacity related to the use of surrogate data or other splicing techniques from the 2006	The inventory team is currently working on extending the time-series back to 1990 for the inventory and filling in data where it is	No further technical capacity is needed.

[8] These needs are carried through into Table 4.7 on technical and capacity needs going forward.

Focus	Type of Support	Activity identified in BUR3	Need identified in BUR3 Technical review	Progress towards addressing the need	Outstanding needs[8]
			IPCC Guidelines that can help fill data gaps and generate a consistent time series (including a dedicated project to specifically address the technical capacity and additional personnel needed to ensure that inventories are recalculated in cases where historical data or inventory years are missing).	missing. The full time-series has been completed for the AFOLU sector, while for other sectors this should be completed by the 6th BUR.	
		Support is needed for the production of updated land use change maps in the Agriculture, Forestry and Other Land Use (AFOLU) sector.		The DEFF GIS unit has set up a process to develop land cover maps internally, no external support is needed. The latest Land cover map has successfully been produced for 2018.	No further requirements
			Enhancing technical capacity for tracking land-use changes.	Not started.	Technical capacity is still required for this, but it is planned to be undertaken with CBIT funding.
Inventory and mitigation	Technical and Capacity building	Support sector-specific priority data generation processes to improve the GHG inventory. Projects to provide information on country specific emission factors in all sectors. Particular need to improve data in the transport and waste sectors.	Enhancing technical capacity for the development of country-specific Emission Factors for some key categories in the AFOLU sector, namely direct and indirect N_2O emissions from managed soils and land converted to cropland.	A GHG improvement programme was set up in 2011. This is on-going. A fuel consumption survey was done to improve activity data for the period 2000–2018. A model for road transportation has been created. The results of this study have started to be incorporated in the 2017 GHG Inventory, with all results being incorporated by the next inventory.	The National Greenhouse Gas Improvement Programme (GHGIP) is on-going in that additional projects are continually added. Therefore, technical and capacity support is

Focus	Type of Support	Activity identified in BUR3	Need identified in BUR3 Technical review	Progress towards addressing the need	Outstanding needs[8]
				Waste studies are still required, along with studies to develop country specific emission factors for direct and indirect N_2O from managed soils.	required to complete these focussed activities.
			Enhancing technical capacity for data collection on a regular basis in order to improve the accuracy of the emission estimates for both waterborne navigation and marine bunkers, including improving the capacity to develop modelling tools and estimate GHG emissions for the transport sector in general.	Fuel consumption study for road transport is in progress and should be completed by mid-2020.	Capacity is still required for regular data collection of waterborne navigation and marine bunkers.
Mitigation and actions	Capacity building	Build capacity around tracking of mitigation policies and measures and the assessment of mitigation policies and measures. Done through training courses (basic and complex).		No progress.	Support is still needed for this type of capacity building.
			Enhancing the capacity of data providers to estimate emission reductions, track the progress of mitigation actions and share data on emission reductions and progress on a regular and continuous basis.	Two studies are underway by the Council for Scientific and Industrial Research (CSIR) on quantification of actions for the Waste and AFOLU sectors.	No further capacity is required.

Focus	Type of Support	Activity identified in BUR3	Need identified in BUR3 Technical review	Progress towards addressing the need	Outstanding needs[8]
Mitigation and actions	Technical		Enhancing the technical capacity of the DEFF to track the progress of mitigation actions.	The national Tracking & Evaluation (T&E) system has been set up to assist the DEFF in tracking mitigation actions. The system is fully operational, but training of the DEFF staff is currently in progress. Assistance is being provided by Gondwana to populate the system and it should be fully operational by the next BUR.	No further capacity is required.
Mitigation and adaptation	Capacity building	Support for the development of more integrative and systematic approaches to studying climate change which link the land, air and ocean components of climate change.		No progress.	Capacity is still required to complete this activity.
			Building the capacity for undertaking comprehensive technical analyses to identify constraints and gaps at the operational level.	Complete.	No further support is required for this activity.
Mitigation and adaptation	Technical and Capacity building	Support for technological innovation around social-ecological systems and sustainability. Large scale interdisciplinary, multi-site, multiscale programmes are needed to address integrative research needs.		No progress.	Support is still needed for integrative research.

4.5.1. Financial support needs

Significant and scaled-up resources are needed in South Africa for mitigation and adaptation actions across all strata of the economy. The South African Government is putting in an enabling institutional environment that can support a sustainable climate finance model where mitigation and adaptation actions are funded over the long term and where this funding is accessible in a timeous manner to a broad range of stakeholders. Table 4.6 below presents support needed by South Africa for mitigation and adaptation actions by sectors.

Table 4.6: Support needed for mitigation and adaptation.

Support needed for mitigation and adaptation actions by sectors		Reference to programmes, policies and measures	Type of support needed			Funding by preferred type		
			Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	Grant
Agriculture, Forestry and Fisheries	**Agriculture sector** Support and promote activities related to: • Conservation agriculture. • Climate smart agriculture. • Developing water infrastructure and conservation measures. • Rangeland and livestock management. **Forestry sector** Support and promote activities related to: • Strengthening community-based forestry and diversification of livelihood skills. • Improving inter-departmental collaboration. • Identifying key strategic areas of project implementation. • Fire mitigation. • Implementing disaster management and early warning systems. • Integrating climate change into forestry curricula. • Supporting ecosystems-based adaptation. • Plan and implement multi-objective landscape level planning. • Establishing and maintaining quantified baselines. **Fisheries sector** Large scale: • Changing the target species according to changes in species mix, abundance and distribution. • Following the fish over large distances to maximize catch rates, made possible by the size, range and endurance of the vessels.	Draft Climate Change Adaptation and Mitigation Plan for South African Agriculture, Forestry, and Fisheries Sectors, 2018. Secondary Polices: - Draft Conservation Agriculture Policy, 2017 - Draft Climate Smart Agriculture Strategic Framework, 2018		X	X	X	X	X

Support needed for mitigation and adaptation actions by sectors		Reference to programmes, policies and measures	Type of support needed			Funding by preferred type		
			Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	Grant
	• Improving catching, processing and distribution efficiency through the introduction of new technologies. • Rationalising existing facilities within and between the companies. • Countering lower catches by reducing wastage, improving the value of existing products via product beneficiation, and introducing new and improved marketing strategies. • Stabilising and improving the skills of the labour force through the provision of support infrastructure and education and health facilities. • Selling less economic, less efficient vessels and selling or moving surplus processing machinery to another area or fishery. • Importing fish when production is unable to meet the local demand, thus retaining market share, preserving local markets and retaining the capacity to increase local production should conditions improve. • Coping with the problems of increased bad weather and damage to infrastructure within the companies' existing risk management strategies. **Small Boat Commercial Fisheries** • Uplift the small-scale fisheries sector by providing support mechanisms, infrastructure, and education and training programmes, and promoting participatory management practices.							
Coastal Zones Sector	• Priority 1: Develop Norms and standards for modelling of sea-level rise projections. • Priority 2: Develop norms and standards for modelling of storm surge projections. • Priority 3: Develop guidelines for coastal defence (e.g. environmental engineering approaches).	National Coastal Management Programme of South Africa, 2014 National Guideline Towards the Establishment of Coastal Management Lines (2017) Secondary policy:		X	X	X	X	X

Support needed for mitigation and adaptation actions by sectors		Reference to programmes, policies and measures	Type of support needed			Funding by preferred type		
			Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	Grant
	• Priority 4: Prepare a coastal hazard zone index and demarcate coastal hazard zones (including impacts from climate change). • Priority 5: Develop effluent emission limits or standards. • Priority 6: Develop a National Coastal Water Quality Monitoring and Assessment Programme. • Priority 7: Develop an ocean and coastal information management system with public access. • Priority 8: Develop a National Strategy for awareness, education and training in the coastal sector. Develop a Strategy to strengthen coastal awareness in school curricula. • Priority 9: Develop a strategy for engaging coastal traditional councils in management. • Priority 10: Establish Memorandums of Understanding with other institutions to strengthen research and capacity building for coastal management in South Africa.	- National Environmental Management Act: Integrated Coastal Management Act 24 of 2008						
Health Sector	The South African National Climate Change and Health Adaptation Plan is rooted in the key elements of a public health approach to climate change. The plan's actions are categorised into short-, medium- and long-term actions: • Short-term actions: Review the National Climate Change and Health Steering Committee; Capacity building interventions; Participate in International exchange and collaboration. • Medium-term actions: Review Monitoring and surveillance systems; Create Intersectoral action Health system readiness; Indicator development.	National Climate Change and Health Adaptation Plan, 2020–2024 Secondary policies: - National Heat Health Action Guidelines, 2019 - Department of Health Strategic Plan 2015–2020		X	X	X	X	X

Support needed for mitigation and adaptation actions by sectors		Reference to programmes, policies and measures	Type of support needed			Funding by preferred type		
			Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	Grant
	• Long-term actions: Conduct National Vulnerability Assessments; Research and development on risks of climate change to health; Conduct Health Impact Assessments; Model and Pilot Climate Change and Health Adaptation Projects; Identify adaptation actions.							
Biodiversity Sector	• Evaluate the spatial planning approaches which change the mix of activities which take place in given biomes, including the possibility of abandoning some uses completely and introducing new ones. • Management approaches which adjust the way in which the land uses are executed under a changing climate, for instance by changing the species used or the intensity of use. • Ecosystem-based adaptation, which sets out to support the inherent ability of ecosystems, including their human inhabitants and organisms, to adapt to climate change, principally by reducing the other stresses which might impede that capacity, and restoring ecosystem function where it has been damaged. • Biodiversity stewardship programmes, which, by expanding protected areas on private land and promoting sustainable land management through management agreements, can form corridors that will enhance the adaptive capacity outside of state-owned protected areas.	Climate Change Adaptation Plans for South African Biomes, 2015 Secondary policy: South African Ecosystem Based Adaptation Strategy 2016–2021		X	X	X	X	X
Urban and Rural Settlements Sector	• Environmentally sustainable land use development. • Integrated Development Planning. • Needs and priorities of people in informal settlements. • Environmentally sound low-cost housing and planning for housing development.	Environmental Implementation Plan 2015–2020 (Department of Human Settlements). Department of Rural Settlements' Climate Change Adaptation Sector Strategy for Rural Human Settlements, 2013		X	X	X	X	X

Support needed for mitigation and adaptation actions by sectors		Reference to programmes, policies and measures	Type of support needed		Funding by preferred type			
			Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	Grant
		Supporting policies: Draft National Spatial Development Framework, 2018. Department of Human Settlements Revised Strategic Plan 2015–2020						
Water Resources Sector	• Water governance – building adaptive institutions, creating intergovernmental relations, awareness, communication, research and development, stakeholder participation, regional development, and the review of strategy. • Infrastructure development, operation and maintenance – Multi-purpose water storage, water supply and sanitation, groundwater development and management, flood protection measures, infrastructure safety, hydro-geo-meteorological monitoring system. • Monitoring and Management – Data and information gathering, Scenarios and climate modelling, Vulnerability assessments, Planning, Water Allocation and authorisation, Optimisation of dam and groundwater operation, Water Conservation and water demand management, Water quality management, Resource management and protection.	Climate Change Response Strategy for the Water and Sanitation Sector, 2019 Supporting polices: Department of Water and Sanitation Revised Strategic Plan, 2015/16–2019/20		X	X	X	X	X
Actions in Energy Sector: 1A1 Energy Industries	• 12L tax incentive programme • Appliance Labelling project • Eskom Integrated Demand Management (IDM) programme • Municipal Energy Efficiency and Demand-side Management programme • The National Cleaner Production Centre (NCPC) programme • Private Sector Energy Efficiency (PSEE) programme		X		X	X	X	X

Support needed for mitigation and adaptation actions by sectors		Reference to programmes, policies and measures	Type of support needed			Funding by preferred type		
			Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	Grant
	• Private sector embedded solar generation • Renewable Energy - Landfill Gas to Energy Activities • Renewable Energy Independent Power Producer Procurement programme							
Actions in Energy Sector: A2 Manufacturing Industries and Construction	• Natural gas fuel switch programme		X		X	X	X	X
Actions in Energy Sector: 1A3 Transport	• Bus Rapid Transport System • Electric vehicles • Transnet Road-to-Rail programme		X		X	X	X	X
Actions in IPPU sector	• Nitrous oxide emission reductions • Carbon budgets and pollution prevention plans (only process emissions)		X		X	X	X	X
Actions in AFOLU sector: 3B Land	• Afforestation programme • Grassland rehabilitation programme		X		X	X	X	X
Actions in Waste sector	Waste Management Flagship programme: • The Climate Change Response Public Works Flagship Programme • The Water Conservation Flagship Programme • The Renewable Energy Flagship Programme		X		X	X	X	X

Support needed for mitigation and adaptation actions by sectors		Reference to programmes, policies and measures	Type of support needed			Funding by preferred type		
			Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	Grant
	• The Energy Efficiency & Management Flagship Programme • The Transport Flagship Programme • The Waste Management Flagship Programme • The Carbon Capture & Sequestration Flagship Programme • Long-term Adaptation Scenarios Flagship Research Programme							

4.5.2. Technical or capacity-building needs

The technical and capacity building needs for South Africa going forward are identified in Table 4.7.

Table 4.7: Technical and capacity building needs of South Africa.

Focus	Type of support	Activity
Inventory and mitigation	Capacity building	Enhance the capacity to include mitigation actions and activities into the AFOLU inventory.
		Improve capacity to undertake more complete uncertainty analysis on country inventory data for all sectors.
		Build capacity within the inventory team to complete LULUCF emission estimates.
	Technical	Enhance technical capacity to develop a land mapping system which allows for the integration of various spatial datasets to inform the land cover matrix
		Enhance technical capacity for data collection on a regular basis in order to improve the accuracy of the emission estimates for both waterborne navigation and marine bunkers.
	Technical and capacity building	Support sector-specific priority data generation processes to improve the GHG inventory. Projects to provide information on country specific emission factors in all sectors, particularly: i. Waste sector. ii. Direct and indirect N_2O emission factors for emissions from managed soils and manure management.
Mitigation and actions	Capacity building	Build capacity around tracking of mitigation policies and measures and the assessment of mitigation policies and measures. Done through training courses (basic and complex).
		Enhance the capacity to track mitigation actions and PAMs in all sectors, particularly the AFOLU sector.
Mitigation and adaptation	Capacity building	Support the development of more integrative and systematic approaches to studying climate change which link the land, air and ocean components of climate change.
		Enhance capacity to identify and assess co-benefits and wider impacts of actions.
	Technical and capacity building	Support technological innovation around social-ecological systems and sustainability. Large scale interdisciplinary, multi-site, multiscale programmes are needed to address integrative research needs.

4.6. Technology needs and barriers

The Technological Needs Assessment study was conducted in order to determine key sectors' mitigation and adaptation needs as part of the country's climate change response measures and development goals. The objective of the study was to provide a basis from which to understand the implication of climate change on these development goals and the sectors' climate change mitigation and adaptation needs.

A technology prioritisation process was conducted on a sector by sector basis. Through a series of technology prioritisation workshops, technologies were selected based on the country's priorities and ranked within each sector. The workshops were guided by the multi-criteria analysis (MCA) matrix to understand which climate change mitigation and adaptation technologies need to be prioritised in the context of their technological role in supporting the effective implementation of climate change initiatives in the country. The MCA was described by Dodgson et al. (2009) and was outlined in a guideline for countries conducting a technology needs assessment (Haselip et al., 2015).

The MCA approach assisted in determining to what extent each potential technology contributes to national development goals, reduces GHG emissions and/or benefits adaptation, while being cost effective. The MCA approach thus provided a structured framework which allowed the comparison of a number of technologies against multiple criteria and facilitated stakeholder participation relying on the technical expertise of stakeholders.

During the updating of the Technological Needs Assessment synthesis report, an analysis to highlight the key barriers to climate technology innovation, within the key sectors prioritised, was undertaken. This focussed on the identification and analysis of specific barriers to the development, transfer, diffusion and deployment or implementation of technologies for climate change mitigation and adaptation in the country.

A key input into this analysis was stakeholder input from discussions at the sectoral technology prioritisation workshops, as these workshops brought together stakeholders from various science councils, universities, national government departments and the private sector.

Based on a review of the literature and technology prioritization workshops, a barrier analysis workshop was held, with key stakeholders, to refine the outcomes of the analysis and to propose interventions to unlock the barriers. The following criteria were used for identifying and assessing barriers to climate technology innovation:

- Cost
- Public Policies
- Market Structure
- Socio-economic opportunities e.g. social inclusion and creation of new jobs
- Institutional arrangements and readiness
- Technological readiness

4.6.1. Technology needs

The Technological Needs Assessment prioritised technologies and identified two sectors for mitigation and five sectors for adaptation. These technologies can be implemented in the short-to-medium term.

4.6.1.1. Technology needs for mitigation

In terms of mitigation, the industrial sector has the potential to implement measures to improve its energy efficiency as well as switch from using raw materials to recycled materials (Table 4.8). These measures have significant potential to reduce GHG emissions and also to assist industries in terms of energy savings and job creation. Similarly, in the waste sector, technologies which had the most potential to reduce/avoid greenhouse gas emissions, scored the highest.

Table 4.8: Prioritised technologies for the mitigation sector (CSIR, 2019).

Mitigation sector	Prioritised Technology	Justification/motivation
Industry	Aluminium – Energy monitoring and management system.	• Sector plays an important role in national economic development. • Largest contributor to GHG emissions in the industrial sector. • Improving energy efficiency could make production of aluminium more competitive.
	Utilize waste material (such as old tyres) as fuel in cement production.	• Improves efficiency of cement production while reducing dependence of fossil fuels and GHGs. • Potential to supply waste energy through Combined Heat and Power combustion systems (CHP) and co-generation to neighbouring communities.
	Aluminum – Secondary production and recycling.	• Allows for re-use of aluminium scrap. • Environmentally sound process that is more energy efficient than primary production.
Waste	Higher value and marketable by-products from food waste.	• Enterprise development and diversion of organic waste from landfill.
	Separation at source and waste recovery services by small businesses.	• Increased community participation rates in recycling programs. Sustainable job creation.
	Anaerobic digestion (large scale).	• High mitigation potential. Production of electricity. Solid by-products can be turned into compost and fertilizer.

4.6.1.2. Technology needs for adaptation

Urban forestry, conservation tillage, wetland restoration and protection, and biorefinery were the technologies for the agriculture, biodiversity and forestry sector which scored the highest in addressing climate change and ecosystem benefits. Organic agriculture/farming, multiple land use, and managing and monitoring invasive alien species technologies were other potential technology options to consider in the sector (Table 4.9). The human settlement sector focused on disaster risk reduction in terms of improved storm water drainage and the use of fire-retardant building materials, as well as low elevation engineering which provided coastal protection measures.

Low pour flush toilets, rainwater harvesting, and desalination are currently being implemented across the country as the highest scoring prioritised technologies for the water sector. These technologies also have the potential to contribute to challenges around water pollution and water resource availability (Table 4.9).

Low pour-flush toilets, rainwater harvesting, and desalination are currently being implemented across the country as the highest scoring prioritised technologies for the water sector. These technologies also have the potential to contribute to challenges around water pollution and water resource availability.

Table 4.9: Prioritised technologies for the adaptation sector (CSIR, 2019).

Adaptation sector	Prioritised Technology	Justification/motivation
Agriculture, Biodiversity and Forestry	Urban forestry	Promote adaptation to heat stress by providing shading and evaporative cooling, rainwater interception, and storage and infiltration for cities. Potential to act as carbon sinks.
	Conservation tillage	Reduces risk though enhanced soil-moisture retention and minimising soil impaction. High ecosystem benefits through carbon sequestration in organic matter accumulation in the soil from use of residues and cover crops.
	Wetland restoration and protection	High ecosystem benefits. Contributes to water sector priorities. Potential for improved livelihoods.
	Biorefinery	Maximises value-added products obtained from biomass through more efficient, optimised processes. Cross-cutting in agriculture, forestry, fisheries, waste and industry sectors.
Fisheries	Rapid screening tools for imported wild caught, aquaculture products and bait	Supports rapid health assessment of wild and imported fish (and bait) in line with aquaculture requirements.
	Early warning systems for forecasting extreme events	Supports disaster risk management and adaptive responses to extreme weather events and has the potential to save lives.
	Early warning systems to detect changes in algal blooms	Risk reduction in terms of impact on aquatic ecosystems, human health, and the economy.
Human Settlements	Disaster risk reduction: Sustainable urban drainage systems	• Improving the resilience of urban built up environments to flooding. Enterprise development for the production of sustainable urban drainage system technologies. • Job creation. • Reduce the contamination of storm water from pollutants.
	Low elevation engineering	• Job creation in the building and construction sector. • Protection of coastal zones from flooding.

Adaptation sector	Prioritised Technology	Justification/motivation
	Disaster risk reduction: Fire-retardant building materials for low cost and informal housing	• Enterprise development for the formulation of fire-retardant materials and the design of fire-resistant houses. • Increase the adaptive capacity of human settlements to natural disasters.
Water	Low pour-flush toilets	• Suitable for areas with low water availability. • Water saving (uses 1–2 L per flush).
	Rainwater harvesting	• Increase diversity and optimisation of mix of water sources. • Improve the reliability of water supply in rural areas and municipalities where services are unreliable.
	Desalination technologies for brackish water, ground water, mine water, and seawater	• Increase ability to make use of more sources of water. • Potential to add jobs to the Blue Economy.

4.6.2. Barriers to climate technology

The technologies prioritised above are discussed in this section in terms of barriers to implementation and national actions to support these technologies.

4.6.2.1. Barriers to mitigation technologies

The Department of Science and Technology (DST) and the Department of Environmental Affairs (DEA) identified barriers to the first cluster of mitigation technologies in the following categories: policy and regulatory, access to information, technical, R&D, cost or financial, and technology transfer barriers. Table 4.10 to Table 4.12 provide an overview of barriers to technology in the energy, IPPU and waste sectors.

Table 4.10: Barriers to Energy-related mitigation technologies prioritised in the DEA and DST Mitigation Technology Plan (DEA and DST, 2015).

Mitigation Technology or Technological System	Description of Barriers
Carbon capture and storage (CCS)	• Lack of policy and regulatory clarity and certainty. • Poor knowledge of, and information on, the effectiveness of the technology. • Limited domestic R&D conducted in South Africa. • Weak or limited human skills-base to support CCS development. • Underdeveloped market and private sector interest in CCS are not articulated.

Mitigation Technology or Technological System	Description of Barriers
Advanced biofuels	• Lack of policy and regulatory clarity and certainty. • Poor knowledge of, and information on, the effectiveness of the technology. • Social resistance (mainly by environmental activists). • Socio-economic and environmental impacts research not well done. • The underdeveloped market for biofuels.
Smart grids	• Poor knowledge of, and limited information on, technology (its availability and effectiveness). • Underdeveloped market, and private sector investment is limited. • Poor or underdeveloped physical infrastructure for deploying the technology in rural areas.
Solar photovoltaics	• Weak human skills-base (limited number of skilled installers with technical skills). • Weak/lack of proper standards for performance and quality management. • Relatively high installation costs for rural poor households. • Limited public information/awareness of economic and environmental benefits of the technology. • Financing of technology commercialization is scarce or limited.
Solar water heaters	• Weak human skills-base (limited number of skilled installers with technical skills). • Weak/lack of proper standards for performance and quality management. • Relatively high installation costs for rural poor households. • Limited public information/awareness of economic and environmental benefits of the technology.
Energy efficient lighting	• Lack of policy and regulatory clarity and certainty. • Poor infrastructure and accessibility of technology in rural areas. • Relatively high cost of technology for poor rural households.
Variable speed drives and energy efficient motors	• High-cost large-scale rollout. • Limited public information/awareness of economic and environmental benefits of the technology. • Lack of incentives for private investment in the development of the technology. • Low/limited human skills-base (short supply of engineers and system designers).
Energy efficient appliances	• The relatively small market for energy efficient appliances such as refrigerators. • Limited public information/awareness of economic and environmental benefits of the technology. • High costs of acquiring the technology by rural poor households.
Energy storage technologies	• Poor knowledge of and limited information on technology (its availability and effectiveness). • Underdeveloped market, and private sector investment is limited. • Poor coordination and/or linkages between R&D (e.g. CSIR) and industry (e.g. IDC).

Mitigation Technology or Technological System	Description of Barriers
Hybrid electric vehicles	• Limited knowledge and information (awareness) of the technology and its effectiveness and economic as well as environmental benefits. • High upfront costs of purchasing hybrid electric vehicles. • Limited financing for domestic R&D on the technology. • Poor coordination between departments of transport, energy, science and technology, and finance undermines efforts to develop a national policy and strategy. • Intellectual property protection (barrier to local manufacturing).
Wind (onshore)	• Small domestic market and lack of incentives (including financing) for the private sector, particularly SMEs. • Weak manufacturing base for technology components. • Technological lock-in in coal-generated electricity by Eskom.
Nuclear pressured water reactor (PWR)	• Lack of policy and regulatory clarity on nuclear power/energy. • Social resistance and politicization. • Lack of incentives to attract domestic private sector investment. • Limited human skills-base to conduct R&D and develop as well as deploy the technology. • High costs of the technology.

Table 4.11: Barriers to Mitigation Technologies - Industrial Sector (CSIR, 2019).

Mitigation Technology or Technological System	Description of Barriers
Improving energy efficiency in primary aluminium products	• Limitations of the technologies used in the electrolysis process. • New equipment or changes to processes may also need to be implemented, these would be industry-site specific and could be costly. • The demand to produce more metal from existing capacity shifts the focus to increasing the electric current in the electrolytic process, rather than reducing it.
Anode technology selection for primary aluminium smelting	• Research and further investigations into the best available technology (based on the existing equipment and design) is required. • International development and testing of these new technologies are occurring, with a limited market in South Africa.
Switch from coal to biomass/residual wood waste in the Paper and pulp industry	• The investment costs of new equipment and retrofitting boilers inhibits private sector investment.
Basic Oxygen Furnace in the production of iron and steel	• The use and installation would be subject to limitations associated with the location of existing equipment and plant design. • The cost of the system might also prevent private sector investment.

Mitigation Technology or Technological System	Description of Barriers
Waste material as a fuel in cement production	• Scrapped tyres are spread out across the country, so the correct procedures for collection, classification and storage are required. • Public concern about the increase in air pollution emissions and the release of toxic gases, such as dioxins, might reduce interest in such an investment.
Combined heat and power in the Pulp and Paper Industry	• A significant barrier could be the initial capital costs of implementing a CHP system.
Energy Management and monitoring System	• Limited finances and awareness of the options available might make industries hesitant to invest, especially if the production process is complex. • Unless there are incentives to invest in energy efficiency, capital investment is likely to prioritise areas of the production process that require it more urgently (i.e. investments that can directly improve productivity).
Improvement of process monitoring and control	• The capital costs and the return time on investment would need to be understood to convince industries of the return on investment.
Top Gas Recycling (with CCS)	• The stage of development of such technologies and its track record might make private sector wary of investment.

Table 4.12: Barriers to Mitigation Technologies - Waste sector (CSIR, 2019).

Mitigation Technology or Technological System	Description of Barriers
Recycling - Higher value and marketable by-products from food waste	• Small scale operations not practical. • Contamination of post-consumer food waste usually from packaging, household objects and non-recyclables make extraction costly. • Contamination risks of post-consumer food waste from household hazardous waste. • Lack of enforcement of separation at source of commercial food waste, especially from shopping centers and restaurants.
Recycling - Separation at source and waste recovery services by small businesses	• Enforcement of separation at source in the residential, commercial and industrial sectors is weak. • The informal sector, which is recognized, is left largely to operate in its current form. • Lengthy engagements with informal waste pickers to integrate them into co-operatives and small businesses have shown that the loss of revenue for pickers makes participation in the formalization process unattractive to them.

Mitigation Technology or Technological System	Description of Barriers
	• Infrastructure and resources are lacking for the success of co-operatives, including transport, equipment, premises to work, and electricity supply. • Operational challenges include theft of recyclates, finding markets to sell recyclates, and networking. • Insufficient training of waste pickers to operate small businesses including technical, governance and business management skills. • Weak relationships between co-operatives and local government. • Lack of start-up and working capital.
Anaerobic digestion: large scale from both industrial and municipal waste	• Capital-intensive. • Source of GHG emissions. • Most organic waste ends up in landfills.
Anaerobic digestion of municipal and industrial wastewater sewage sludge with Combined Heat & Power (CHP)	• Poor gas yields due to issues relating to the sludge management component of the plant can result in lower gas production than anticipated. • Human fecal waste which mixes with municipal effluent cannot be used as a feedstock since pathogen reduction by mesophilic anaerobic digestion is insufficient.
In-vessel composting	• Capital intensive. • Requires extensive training of personnel. • High maintenance and operational costs.

4.6.2.2. Barriers to adaptation technologies

The implementation of the technologies listed for climate change adaptation can be impeded or hindered by a range of policy, institutional, social and technical factors. There are policy and institutional issues pertaining to land and resource tenure in general. Ownership of land and land size influences technology choice and implementation. The development and implementation of some of the technologies may be impeded by lack of policy and regulatory clarity as well as social resistance. Scarcity of human resources and limited funding are impediments to R&D. Barriers to implementation of technologies may include lack of information and high costs for small-scale rural farmers (Table 4.13–16).

Table 4.13: Barriers to technologies for climate change adaptation - Agriculture, Forestry and Biodiversity (CSIR, 2019).

Type of technology or technological system/field	Barriers to technology development and implementation
Urban forestry and vegetation	• High implementation cost depending on location. • Some municipal laws are an impediment, particularly land tenure restricts farming practices in municipalities.
Biorefinery	• High investment costs and operational expenses. • Need for development of skills to build and operate new technologies. • R&D funding constraints.
Integrated pest management	• Limited technical skills among farmers, particularly in rural areas. • High costs of equipment and other materials for small-scale farmers in rural areas. • Low incentives, particularly for small-scale farmers, due to limited potential to capitalize new investments.
Organic agriculture	• Weak incentives for implementation of organic agricultural technologies due to low potential to capitalize further investments. • Weak technical standards for inspection and certification of organic products from small-scale farmers in rural parts of the country.
Monitoring and managing invasive species	• Limited R&D funding. • Poor institutional coordination between provinces and national government departments. • Weak public-private sector collaboration.

Table 4.14: Barriers to technologies for climate change adaptation – Fisheries.

Type of technology or technological system/field	Barriers to technology development and implementation
Technologies for the rapid health assessment of wild and imported fish (and bait)	• Additional research and development are needed for application in the local context. • Protocols and training of customs/airport staff in aquatic health and hazards. • Training needed in local labs.
Early warning systems for forecasting extreme events	• R&D funding constraints. • User confidence in the degree of uncertainty.
Early warning systems for detecting changes in algal blooms	• R&D funding constraints. • Availability of good quality real-time data may be limited. • User confidence in the degree of uncertainty.

Type of technology or technological system/field	Barriers to technology development and implementation
	• Methods for communication of information to users and ownership of management i.e. who will manage system?

Table 4.15: Barriers to technologies for climate change adaptation – Water.

Type of technology or technological system/field	Barriers to technology development and implementation
Rainwater harvesting	• High cost to install across income groups. • Lack of incentives for broader adoption.
Desalination	• High infrastructure investment. • High financial viability and operational efficiency to be a successful alternative water supply. • High maintenance costs. • Energy-intensive. • Requires skilled personnel.
Protecting and restoring ecological infrastructure	• Need for secure financial flows for restoration and ongoing maintenance of ecological infrastructure. • Need for improved institutional capacity for investment in ecological infrastructure. • Competition for land.
Reducing system leakages	• Need for area-specific assessments and interventions – municipality needs vary depending on the root causes of water losses. • Lack of capital in most municipalities to buy the technology (models/software, and training costs). • Lack of implementation of the policies and regulations which are already in place when it comes to leak detection.
Low pour-flush toilets	• Needs a reliable water supply – assessment of the reliability of water supply must be done prior to implementation. • Local authorities must clarify the responsibilities of operation and maintenance. • Need for plans by municipalities for disposal of leach pits. • Assessment of suitability needed in areas with high water table or sensitive ecosystems.

Table 4.16: Barriers to technologies for climate change adaptation – Settlements.

Type of technology or technological system/field	Barriers to technology development and implementation
Disaster risk reduction - Improved stormwater drainage systems/upgrade	• High investment costs and availability of expertise required to successfully implement upgrades. • Depending on the level of existing infrastructure in an area, implementation could be expensive, for example, in an area with little existing infrastructure that is compatible with new technology.
Low elevation engineering	• The cost of construction of options such as new groynes or well-designed seawalls may limit the use. • A further barrier may be the availability and cost associated with the specialised equipment and contractors needed for processes such as dredging. • Some dune management options may have a requirement of an Environmental Impact Assessment before commencement. • A major barrier for artificial dune creation or dune rehabilitation projects is to convince the public and municipal officials of the need for it.
Disaster risk reduction - fire-retardant building materials for low cost and informal housing	• Typically undertaken as pilot projects – highlighting the need for innovation and markets for affordable materials to be developed. • Require community-civil society-government-private partnerships to roll out innovative upgrades to existing settlements.
Energy efficiency (e.g. combined heat and power; smart grids, smart cities)	• Capital and operational and maintenance costs are high. • The costs to maintain the system and the availability of existing skills to use the technology could lead to resistance/lack of buy-in. • In cities that are cash-strapped there may be a lack of political support in terms of providing financial support.
Climate adaptive buildings	• Limited low-cost adaptation measures and regulations/codes to enforce implementation of adaptation options. • Limited skilled capacity (engineers, architects and builders, inspectors) to develop standards and to enforce standards. This can increase the difficulty of implementing adaptation measures. • Enforcement procedures of national building regulations and local by-laws are sometimes limited or non-existent within local municipalities. • The availability of suitable materials at an affordable cost is also a barrier.
Heat resilient surfaces (e.g. warm mix asphalt and engineered cementitious composite)	• Capital scarcity for long-term capital-intensive investments. • South Africa's investment in R&D has been in steady decline. • The railway capacity is insufficient to support the transportation of large quantities of raw materials and recycled materials needed to produce new types of concrete and asphalt. • High transport and labour costs. • Volatility and low productivity of the workforce. • Shortage of skilled workers that can support the deployment of new concrete and asphalt technologies.

Type of technology or technological system/field	Barriers to technology development and implementation
	• Slag by-product from manganese alloy production is classified as a hazardous material and cannot be sold in South Africa but could be used in new asphalt mixes.

4.6.2.3. Unlocking barriers to climate technology

Table 4.17 provides an overview of recommendations outlined above and identifies the locus of leadership for proposed interventions as well as some of the trade-offs or implications of reforms.

Table 4.17: Proposed interventions to unlock the barriers.

Barriers	Interventions to remove barriers	Leadership (public/ private)	Trade-offs/ Implications
Weak policy and regulatory frameworks	Review of existing policies, regulations and bylaws to identify specific issues in policies and regulations causing the barriers with the view to policy and regulatory reform. Create an enabling environment for effective policy implementation. This may involve conducting social impact assessments and regulatory impact assessments – this needs to be done for policies before they are submitted. Policy exemption period until implementation and validation of technology (sector specific) (exemptions with conditions) e.g. carbon tax bill (specific sectors exempt because of the validation process, postponed for 5 years if implemented).	Mainly national government departments particularly DST, the Department of Trade and Industry (DTI), DEA, National Treasury and DMRE	Some of the reforms may lead to less public revenue e.g. reduction in fuel tax if using biofuels. Cost of policy making is likely to increase if policy making is evidence-based. To reduce policy-making costs, learning from peers is needed. Multiplicity of stakeholders in policy review and reform may cause delays in decision making, thus slowing the removal of barriers.
Weak co-ordination between (public) R&D (including universities,	Establish mandatory coordination requirements and integrate them in regulations and laws.	Inter-departmental committee involving DST, dti, DEA, and	This will require optimization of human,

Barriers	Interventions to remove barriers	Leadership (public/ private)	Trade-offs/ Implications
science councils, government departments) and industry	Explicitly make provisions requiring public-private coordination in such legislation as the proposed climate change bill. Establish common technology missions and platforms for climate change, bringing all stakeholders together, including private sector and civil society.	Chamber of Commerce/Business	institutional and financial resources.
Underdeveloped markets for climate-smart technologies	Create and provide incentives to grow markets (at varying levels), e.g. subsidies for selected technologies. Establish public-sector technology development grants.	Government line departments, particularly, dti, DST, National Treasury	Evidence-based analysis is required (technology and sector specific) to guide government on specific measures to be taken. This will need expertise and financial resource allocation.
Declining private sector investment in climate change R&D and innovation	Strengthen private sector intellectual property development and management.	DST, National Intellectual Property Management Office (NIPMO) and DTI	Assumption is that private sector will utilize intellectual property as an incentive to increase investment in climate change R&D and innovation.
Weak public knowledge and information-base on some of the smart climate technologies in agriculture, forestry, water, settlement, etc.	Establish public awareness and information provision programmes on specific technologies.	All government departments should provide leadership through coordination by DEA and DST	This is will require budget allocation.
Weak skills-based training for implementation and maintenance (e.g. engineering capability).	Design and provide accreditation for middle-level programmes for technical training (specialised courses; development of and sustaining scarce skills such as engineering and technology). Integrate technical training into all (or be a core component of) sector roadmaps and be linked to specific technology missions.	Department of Higher Education and Training, DST and National Treasury	Will require a review of vocational and technical training curriculum.

Barriers	Interventions to remove barriers	Leadership (public/ private)	Trade-offs/ Implications
Weak technical standards for technology performance and quality management	Institute and enforce specific technical standards in terms of hardware (within the country, imports and exports). Review of existing technical standards.	South African Bureau of Standards (SABS), all standardization bodies in general, CSIR and DTI	Implications in terms of SABS budget and strengthening infrastructure for technical standards setting and enforcement.
High costs of technology procurement and implementation; high costs of R&D in certain sectors and on certain technologies	Conduct/commission a study to review economic costs of research and technology development in priority sectors. Provide subsidies for research and technology development for mitigation and adaptation.	Government departments, particularly DST, DEA and National Treasury in collaboration with the private sector	Increased national expenditure on R&D and increased demand on public revenue. Assumption is that subsidies will stimulate procurement and implementation of mitigation and adaptation technologies.

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5. SUPPORT RECEIVED FOR THE PREPARATION OF THE BUR4

South Africa received bilateral financial support from the German Government to develop the 4^{th} Biennial Update Report (BUR4). The funding was administered through the Gesellschaft für Internationale Zusammenarbeit (GIZ) as part of the Climate Change Support Programme to South Africa. The GIZ is the implementing agency of the German Federal Ministry for the Environment, Nature Conservation, Buildings and Nuclear Safety (BMUB). The funding was used to contract Gondwana Environmental Solutions International (Gondwana) to assist with data collection as well as integration of the BUR4 and technical editing. The chapters of BUR4 were drafted internally by the DEFF personnel from the International Climate Change Relations and Reporting as well as the Climate Change Monitoring and Evaluation Chief Directorates. The CSIR and Promethium Carbon provided additional technical support for the drafting of the 'Mitigation Actions and Effects' chapter. In addition, the CSIR completed a full Technical Needs Assessment. Gondwana provided additional technical support with drafting the 'Support Needed and Received' and the 'Technology Needs Assessment' sections of chapter 4.

At the time of completing the first draft, South Africa was still applying for funding from the Global Environment Facility for the 4^{th} BUR and the 4^{th} National Communication Report using the United Nations Environment as the implementation agency. The funding will be used to conduct the public consultation as well as independent review processes of BUR4.

6. MEASUREMENT, REPORTING AND VERIFICATION IN SOUTH AFRICA

6.1. Climate change monitoring and evaluation

The South African National Climate Change Information System (NCCIS), also referred to as the National Monitoring and Evaluation (M&E) system, is a web-based platform for the tracking, analysis and enhancement of South Africa's progress towards the country's transition to a low-carbon economy and climate-resilient society as put forward in the National Climate Change Policy (DEA, 2011). The platform collates climate related data and information from a range of sources (Figure 6.1) for the purposes of providing insights into the country's progress in responding to climate change and achieving national and international goals, commitments and targets including the National Determined Contributions (NDC). The NCCIS offers a series of decision support tools to inform policy and decision-making, as well as showcasing information for South Africa's domestic and international reporting. It informs national decision makers, including Parliament and Cabinet as well as presenting South Africa's position in various negotiating platforms such as the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

The NCCIS is supported by national, provincial, and local scale systems of data-collection to provide detailed, complete, accurate and up to date data on:

- Greenhouse gas emission reductions achieved through projects, policies and other related instruments/measures.
- Observed and projected climate change.
- Current, and future, risks, impacts and vulnerabilities.
- Climate resilience response measures.
- Analysis of the impact of adaptation and mitigation measures.
- Information on climate change financial flows.
- Tracking of technology transfer activities related to climate change initiatives.
- Climate change related tracking indicators.

It showcases vital climate action to inform domestic and international reporting. The NCCIS collects data and information from data custodians that use internationally recognized methodology to collect and analyse data/information (including quality assurance and control). One such example is the work that is led by the South African Weather Service on climate indices, which has adopted the methodology and guidelines from the World Meteorological Organization. Future work for the NCCIS includes the creation of subnational systems and sector specific systems, building on the work that has already been done on the NCCIS.

The South African Monitoring and Evaluation (M&E) system encompasses all three functional aspects of the measurement, reporting and verification (MRV) system, namely, MRV of GHG emissions, MRV of mitigation actions and MRV of Support. South Africa has adopted the approach of developing a climate change M&E system, which integrates the analysis of all aspects of climate change MRV at multiple scales, and also incorporates a national system for the compilation of GHG inventories, making the M&E system the national central depository and portal for climate change information in South Africa.

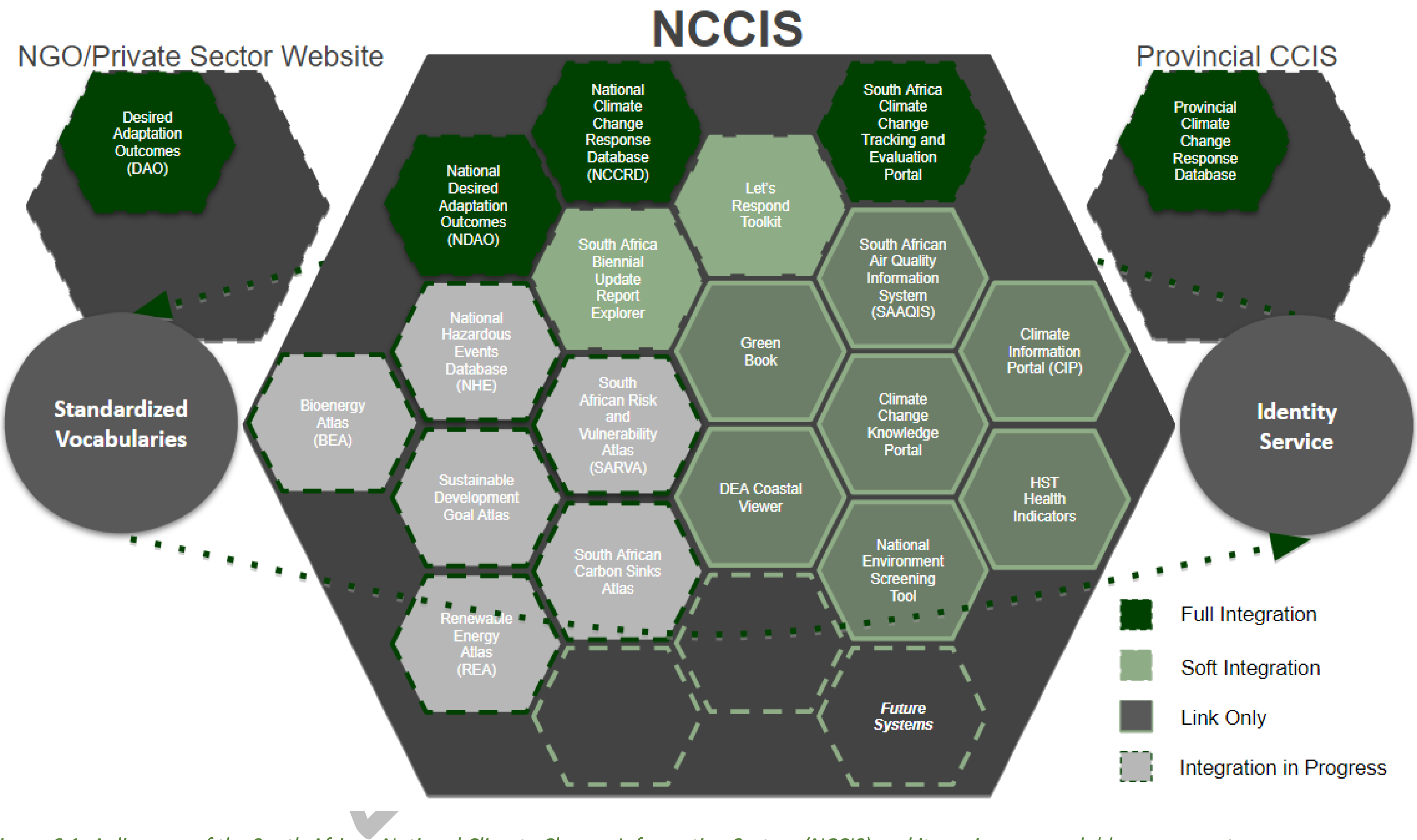

Figure 6.1: A diagram of the South African National Climate Change Information System (NCCIS) and its various expandable components.

6.2. Progress since BUR3

The NCCIS was launched in August 2019 and is composed of the following modules or subsystems to facilitate access to data and information on tracking South Africa's transition to a lower carbon and climate resilient society:

- **National Climate Change Response Database:** a portal for capturing and reporting climate change projects and their details.
- **National Desired Adaptation Outcomes:** designed as a monitoring and evaluation framework for climate change resilience through progress towards a series of adaptation goals.
- **Climate Information Centre:** a collection of actionable data sets and information relevant to the South African climate change field, distributed as required by data providers and formal sources.
- **Tracking & Evaluation (T&E) Portal:** a system which stores the data and information on the details of actions, indicators, impacts and related challenges, targets, and investments in climate change. This system also provides data visualisation, and provides outputs in formats required by the BUR. It will, therefore, assist the DEFF in producing BURs timeously.
- Portfolio of **online Atlases, decision support systems and tools.**
- **Services, tools, static content, documentation including reports, policies and guidelines, and other digital objects** developed by external partners and stakeholders.
- **Standardised vocabularies** serving as a common frame of reference for climate change reporting and monitoring.
- **Search and discovery capabilities**.

The current update provides progress made in terms of 'system refinement' and enhancement as outlined in the 3rd National Biennial Update Report (DEA, 2019) under Phase 3 of the system development. The system enhancements and refinements that were planned to be implemented in the 2019/2020 fiscal year encompassed the following system upgrades:

i. Expanded system integration and upgrades that incorporate additional domestic sub-systems.
ii. Enhanced user reporting, analytics and data visualisation capabilities.
iii. Setting up a fully operational system.
iv. Improved domestic reporting.

6.2.1. Milestones reached since the BUR3

A considerable amount of work has been done in terms of institutional arrangements, data flows and quality assurance since the 3rd Biennial Update Report. The institutional arrangements for the NCCIS have been designed to facilitate ownership and buy-in by national sector departments and provinces. This includes the creation of sectoral and provincial specific sub-systems that integrate into the NCCIS. The national sector departments and provinces assume the role of focal points for data collection and provision of data into the system. The Gauteng Climate Change Response Database (https://ccis.environment.gov.za/gccrd) is one such example, with the Gauteng Department of

Agriculture and Rural Development playing a major role in coordinating projects from key provincial stakeholders, verifying the projects and ensuring quality assurance and control. It is planned that further work will be done to include all components of the NCCIS in the Gauteng subsystem of the NCCIS. Provincial enhancements and coverage engagements are also underway for the following provincial governments: KwaZulu-Natal; Mpumalanga; Eastern Cape and Northern Cape. The information resources included in the NCCIS which integrates a series of existing national domestic systems and tools is accessible at https://ccis.environment.gov.za/#/info-tools. These tools complement the data and information in the NCCIS by providing information and data that is not currently in the Climate Change Information System.

6.3. Institutional arrangements for MRV

The UNFCCC focal point sits within the International Climate Change Relations and Negotiations (ICCRN) unit of the DEFF and they are responsible for submitting documents (National Inventory Reports (NIR), BUR, National Communications (NC)) to the UNFCCC. This unit is responsible for compiling the BUR and NC reports. The overall institutional arrangements and data flows for the MRV of GHG emissions, mitigation, adaptation and support are shown in Figure 6.2.

The compilation of the GHG emissions inventory and the NIRs are managed through the NGHGIS and are the responsibility of the Climate Change Monitoring and Evaluation (CCM&E) unit in the DEFF. The DEFF has been responsible for collecting all the data from various data providers for all sectors of the inventory, but this will change in the next inventory due to the introduction of the National Greenhouse Gas Emission Reporting Regulations (NGER) and the South African Greenhouse Gas Emissions Reporting System (SAGERS). The DEFF CCM&E is responsible for managing the SAGERS system. The CCM&E is responsible for drawing some information from the NCCIS to the inventory, for example, the terrestrial carbon stock data is obtained from the tools on the NCCIS. It should also be mentioned that the GIS unit at the DEFF also provides information on land cover for the AFOLU sector estimates. In the next inventory they will also provide burnt area data. The DEFF CCM&E unit is also responsible for initiating projects to update the tools on the NCCIS. This should be done every few years and will require financial support to complete.

The NCCIS is managed by the DEFF CCM&E unit, which has the responsibility of ensuring that various tools on the system are updated and that the data providers update their information on the system. The South African Weather Service is responsible for updating the climate data on the Climate Information Portal (CIP) and National Hazardous Events Database (NHED). The National Climate Change Response Database is currently updated by the DEFF CCM&E. In the future, a system can be set up to automatically filter data from the Provincial Climate Change Response Databases (PCCRD) to the national system, since similar vocabularies have been used to allow for integration. It is the responsibility of the provincial DEFF to update the Provincial Climate Change Response Databases. In the future, a system could be set up whereby data can be collected at the local municipality level and filtered through to the Provincial Climate Change Response Databases and then to the National Climate Change Response Database.

The DEFF CCM&E unit is responsible for updating mitigation, adaptation and finance data to the Tracking & Evaluation (T&E) system (Figure 6.3). The T&E Portal is a sub-module of the NCCIS, specifically designed as a platform for tracking South Africa's progress towards NDC goals and commitments. The T&E Portal tracks South Africa's climate action and transparency under the Climate Change Paris Agreement in a transparent, simple, interactive, dynamic and informative manner to inform both the domestic and international audience.

Financial data is requested by donor organisations from the DEFF CCM&E, which is also responsible for uploading the data to the T&E system. Not all components of the NCCIS are fully functional, and these issues will be discussed below.

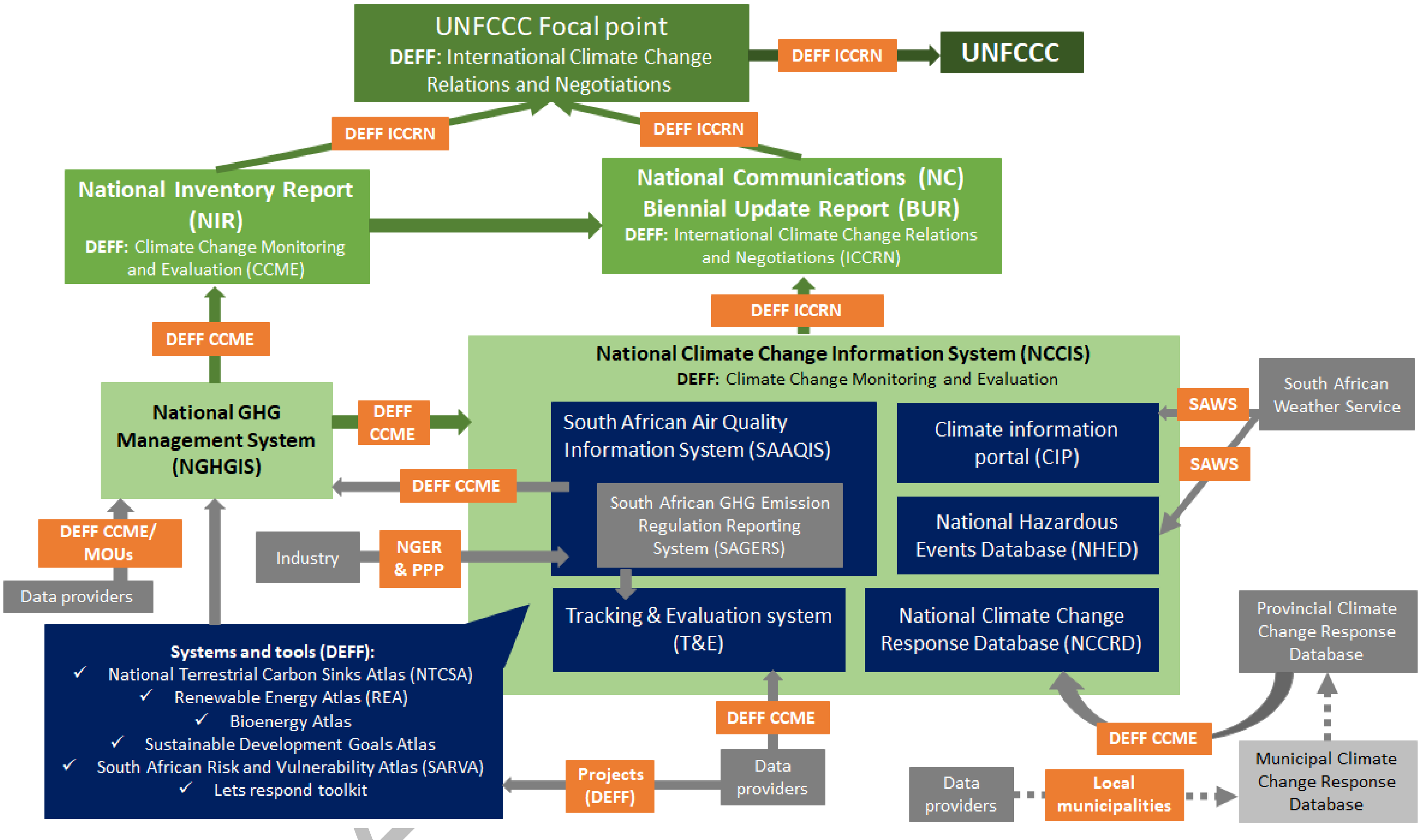

Figure 6.2: Diagram of the institutional arrangements and data flows for MRV in South Africa.

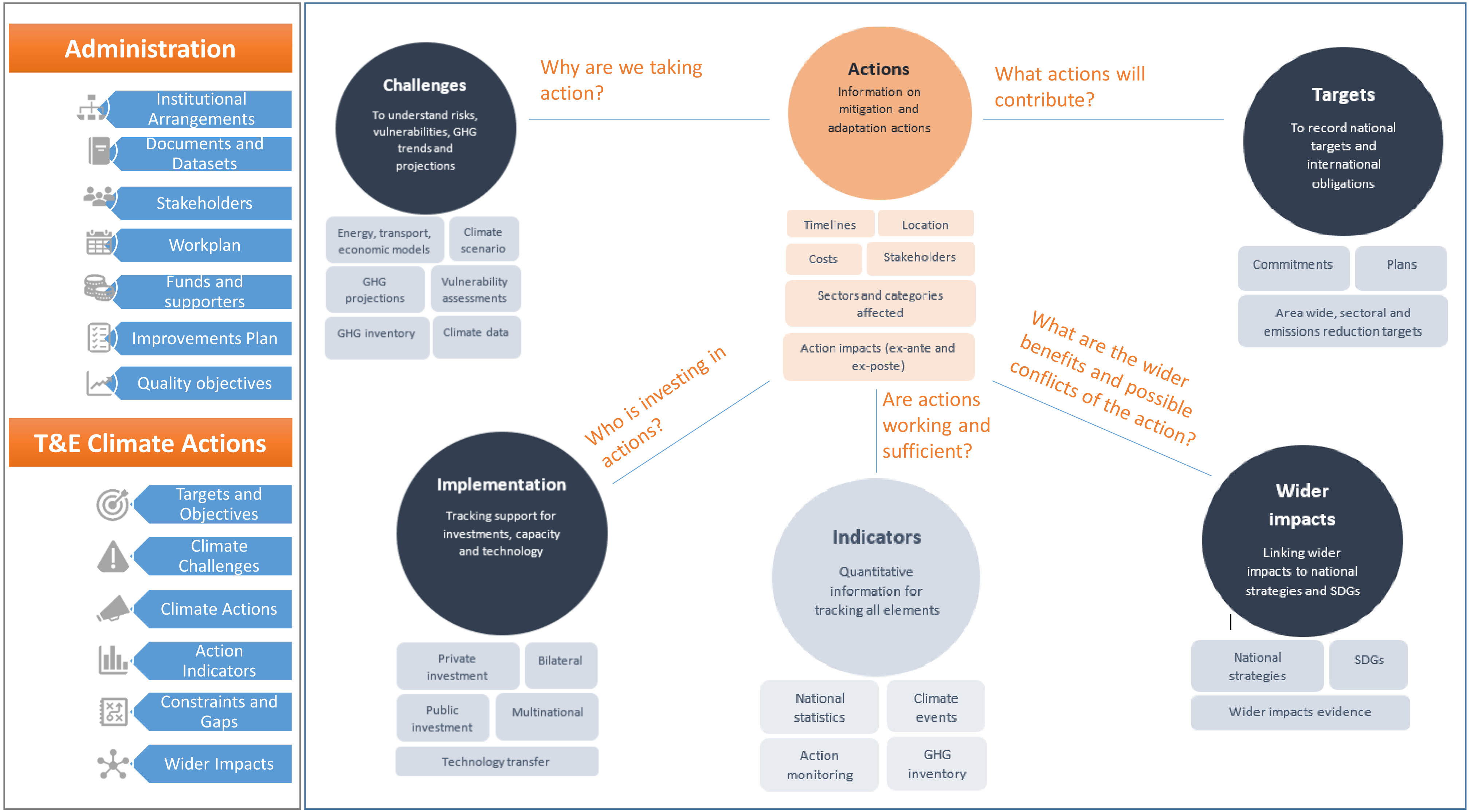

Figure 6.3: Components of South Africa's Tracking and Evaluation System.

6.3.1. GHG inventory MRV

The compilation of the GHG emissions inventory and the NIRs are managed through the NGHGIS and are the responsibility of the Climate Change Monitoring and Evaluation (CCM&E) unit in the DEFF. The NGHGIS is a secure web-based SharePoint platform that allows document management, sharing and storage. It serves as a GHG Inventory process management tool in order to facilitate inventory planning, preparation and management. The DEFF CCM&E manage this system, and each of the inventory sector leads have access to the system and are responsible for uploading sector-relevant information to the system. The DEFF CCM&E unit is responsible for the energy, IPPU and waste sectors, while an external consultant, Gondwana Environmental Solutions International (Gondwana) is responsible for the AFOLU sector.

The main data providers for the inventory are shown in Figure 2.1 in Chapter 2. In the 2017 and previous inventories, there has been a lack of legal and formal procedures for obtaining data and compiling the GHG emission inventory. Data collection was mostly done through a voluntary data collection process. It has been the responsibility of the inventory compilers (the DEFF and Gondwana) to obtain the input data from various data providers (Table 6.1). Gondwana is responsible for compiling the overall inventory estimates and the NIR which goes through an external review and public consultation process (see section 2.5.2) before being approved by the DEFF. The NIR is then reviewed by the steering committee and is presented to parliament before being approved for submission to the UNFCCC.

Table 6.1: Roles and responsibilities of the team involved in the GHG inventory compilation process.

Role	Responsible organisation	Main responsibilities
Single national entity	DEFF CCM&E	• Responsible for submissions and their consistency with other, related submissions. • Define the National System (determine who is involved and manage agreements/contracts). • Develop legal and contractual infrastructure. • Executive engagement with stakeholders (including data providers and users). • Ensure participation of relevant stakeholders. • Manage contracts and delivery of GHGI. • Prioritise and facilitate improvements.
National inventory co-ordinator	DEFF CCM&E	• Manage and support the National GHG Inventory team, schedule, and budget in order to develop the inventory in a timely and efficient manner. • Identify, assign, and oversee national inventory sector leads. • Assign cross-cutting roles and responsibilities. • Manage QA processes and inventory review periods (if applicable). • Provide technical support to single national entity with stakeholder engagement and setting up data supply agreements (designing specifications and timetables). • Manage NGHGIS. • Maintain and implement a national GHG inventory improvement plan. • Prepare the submission. • Obtain all necessary government approvals for the NIR before submission.

		• Submit the NIR to the UNFCCC. • Foster and establish links with related national projects, and other regional, international programmes as appropriate.
Steering committee	Intergovernmental Committee on Climate Change and the National Climate Change Committee	• Provide input to improvement planning. • Respond to requests to review high level data and assumptions.
Sector leads	Energy, IPPU and Waste (DEFF CCM&E) AFOLU (Gondwana)	• Collaborate with the national inventory co-ordinator to manage the sector budget and develop a sector-specific work plan. • Gather data and conduct technical engagements with data providers. • Compile the sector inventory estimates and the sector report. • Develop and implement a sector-specific plan for archiving. • Consider potential improvements identified in the previous inventory for the sector and assess whether to implement improvements. • Coordinate the response to comments received from QA (external) reviews of the sector GHG estimates and update the inventory if necessary. • Review the final sector GHG estimates and the narrative describing the assumptions, methodologies, and results. • Ensure consistency of data. • Coordinate with lead compilers of other sectors to ensure no double counting. • Oversee the development of the uncertainty analysis for the sector. • Identify and document any improvements needed. • Ensure all documents are submitted to the NIC. • Ensure all relevant information is incorporated into the NGHGIS.
QA/QC co-ordinator	Limited resources for coordinator. Sector leads responsible for sector QA/QC	• Ensure the timely and accurate completion of QA/QC checklists. • Ensure all uncertainty analysis has been completed and included in QA/QC lists. • Deliver documentation of QA/QC activities to the NIC and archive coordinator. • Coordinate external reviews of the inventory document and ensure that comments are incorporated into the inventory.
Document manager	Gondwana	• Obtain all sector reports from lead compilers and compile the overall NIR. • Complete the overall key category analysis. • Incorporate all the introductory information by liaising and obtaining information from the various section managers. • Complete all the overall trends (graphs, tables and text). • Complete all the Appendices. • Collect uncertainty data from sector leads and complete overall uncertainty analysis. • Perform document QA/QC checks.
Archive manager	Gondwana	• Ensure inventory compilation sheet are archived on the NGHGIS. • Serve as the keeper of the permanent archive and respond to future requests to view archive materials.

6.3.1.1. Challenges, gaps and constraints

Having limited resources has been a challenge for inventory compilation, however, the DEFF CCM&E unit has recently employed more staff so that there is expertise in each sector in-house. In addition, system managers have been brought into the team, so the inventory team is well placed to fully utilise the NGHGIS and compile the inventory in the next inventory cycle. The new team members may require inventory compilation training, but additional training courses are expected to be developed through the Capacity-Building Initiative for Transparency (CBIT) funding.

6.3.2. Mitigation MRV

In this BUR cycle, the DEFF was responsible for collecting all the information required for the BUR. The DEFF contracted Promethium Carbon to collate mitigation reduction data for the energy and IPPU sectors. In addition, they were tasked with estimating reductions from Cleaner Development Mechanism (CDM), Verified Carbon Standard (VCS), and Gold Standard projects, identifying co-benefits and also outlining institutional arrangements for mitigation action MRV. The Council for Scientific and Industrial Research (CSIR) were contracted to collect data on the emission reductions in the AFOLU and Waste sectors, and for compiling the overall emission reductions. The consultants contacted the various data providers in order to obtain the information (Table 6.2). Until now there has been no formal data collection system, however, with the NGER and an increase in the inclusion of climate change actions and targets in government strategies and plans, greater formality will be brought into the reporting process. Emission reductions were determined by the consultants, and these were reviewed and approved by the DEFF before being incorporated into the BUR. The BUR is subjected to an external review process prior to submission. The DEFF International Climate Change Relations and Negotiations unit is responsible for co-ordinating this review process and for submitting to the UNFCCC via the focal point.

Table 6.2: Data providers for the emission reduction analysis (Promethium Carbon, 2020).

Measures	Data providers
12L tax incentive programme	South African National Energy Development Institute (SANEDI)
Energy Efficiency Standards and Appliance Labelling project	Green House (2016) report
Eskom Integrated Demand Management (IDM) programme	Eskom IDM team
Municipal Energy Efficiency and Demand-side Management programme	DEFF
National Cleaner Production Centre (NCPC) Industrial Energy Efficiency programme	NCPC
Private sector energy-efficiency (PSEE) programme	National Business Initiative – PSEE programme report (PSEE, 2015)
Private sector embedded solar generation	Association of Renewable Energy Practitioners
Landfill Gas to Energy Activities	CDM project design documents
Renewable Energy Independent Power Producer Procurement programme	Eskom Annual Reports
Switch to natural gas	Department of Mineral Resources and Energy
Bus Rapid Transport System	Ex ante emission reductions from VCS-registered Rea Vaya project
Transnet Road-to-Rail programme	Transnet

Nitrous oxide emission reductions	Chemical Allied Industries Association
Carbon budget and pollution prevention plans	DEFF
Afforestation	DEFF
Grassland rehabilitation	DEFF
Waste management flagship programme	DEFF

6.3.2.1. Challenges, gaps and constraints

Uptake of the T&E system has been slow and the reasons for this are limited capacity, timing and awareness. The DEFF CCM&E unit increased its capacity at the beginning of the year to address this issue, but not all staff were trained on the T&E system before the BUR data collection process began. In addition, consultants, with limited access and system awareness, were brought in to complete the mitigation chapter. Due to these issues the T&E system was not fully utilised for the current BUR. Subsequent to this, additional training on the T&E system has been undertaken and offline data input templates were created to assist in the data collection process. All the information for this BUR will be uploaded onto the system once the BUR is complete and will be ready for use in the next BUR cycle. In future, the data can be updated annually on the T&E system so that information is readily available for the compilation of the next BUR. This will improve the consistency and transparency of the information going forward.

Data collection is always a challenge as resources are limited and it is time consuming obtaining each individual data set. The reporting for NGER will improve this process, however, these regulations are focussed on energy and IPPU. There is still a gap in the AFOLU and Waste data collection process. Currently, the DEFF is responsible for incorporating the data into the T&E system. Developing online data submission templates that are accessible to data providers could improve the data collection process. Often the issue, particularly in the AFOLU sector, is that programmes are not collecting appropriate indicator data as the projects are not designed specifically for mitigation. If templates are created, this could guide data providers as to what is required. In addition, increased stakeholder engagement (activities and workshops) around the various systems (what they can do and what data is required) would increase awareness and also contribute to improving the data collection process.

6.3.3. Future reporting and data flows

With the introduction of the National Greenhouse Gas Emission Reporting Regulations (NGERs) that took effect on the 3rd of April 2017, the SAGERS data collection system has been put in place. This will formalize the data collection process for the energy and IPPU sectors (Figure 6.4). GHG data collected through SAGERS will be utilized for inventory estimates for the next inventory cycle. The SAGERS reporting will also have implications for the monitoring and reporting of mitigation actions.

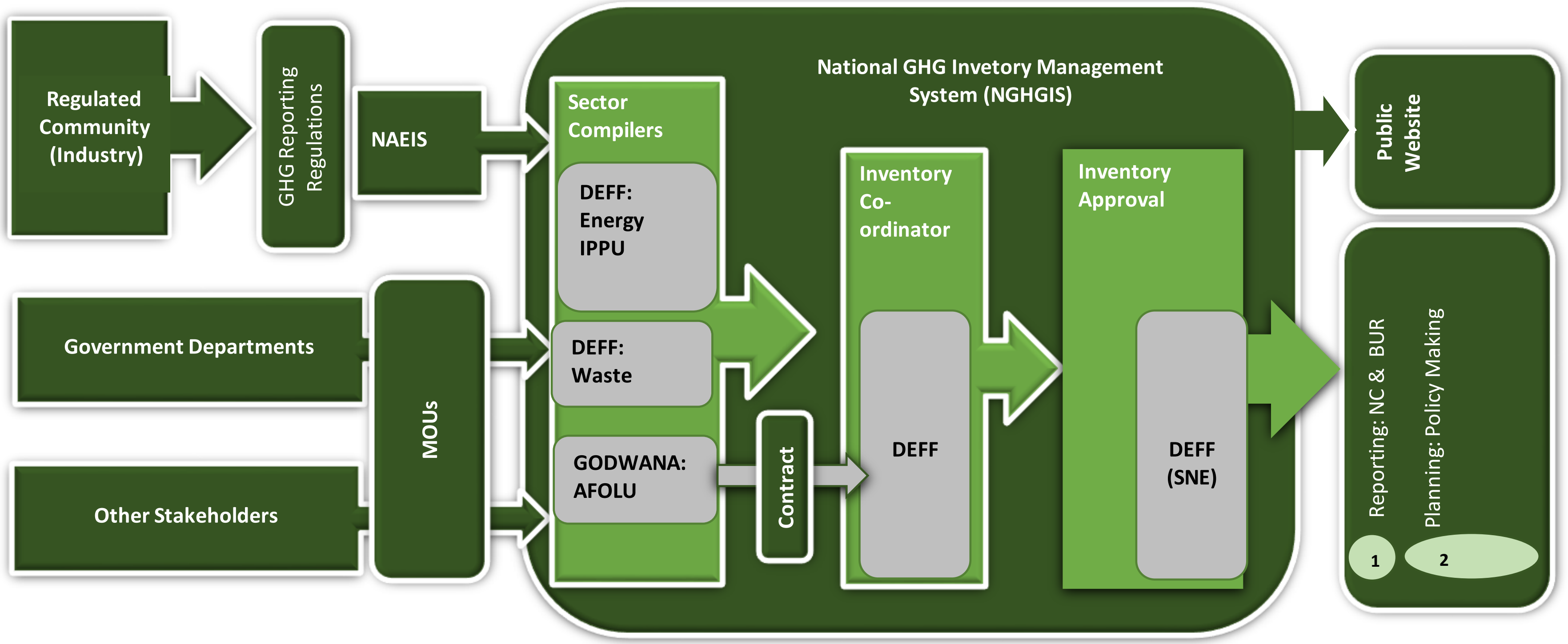

Figure 6.4: Data flows for data used in the inventory compilation.

6.3.3.1. SAGERS

The South African Greenhouse Gas Emissions Reporting System (SAGERS) portal has been developed as part of the National Atmospheric Emissions Inventory System (NAEIS) and is currently able to serve as a tool for the implementation of the online registration and reporting by data providers/industry in fulfilment of mandatory NGERs.

SAGERS allows the DEFF to support South Africa in meeting its reporting obligations under the UNFCCC, and the reporting provisions in the National Communication and the Biennial Update Report; as well as for tracking progress of the national NDC commitments and the associated transparency of action. Domestically, the system assists South Africa to:

- Fulfil section 6.7 of the National Climate Change Response that requires GHG emissions inventories that are accurate, complete and up to date.
- Inform government policy formulation and the South African general public.
- Avoid duplication of similar reporting requirements in South Africa.
- Evaluate mitigation options.
- Assess the effectiveness of policies and mitigation measures.
- Develop long term emissions projections.
- Monitor and evaluate the performance of South Africa in the reduction of GHG emissions.
- Inform policy makers on the country's progress in transitioning to a climate resilient society and lower carbon economy.
- Assess performance of the carbon budget and the Pollution Prevention Plans (PPPs).
- Strengthen the DEFF's capacity to implement and administer the national greenhouse gas data management system, and to standardize and improve accuracy and coverage of emissions reporting.
- Support the implementation and institutionalization of the mandatory GHG Reporting Regulations by industry through the National Atmospheric Emissions Inventory System (NAIES), including facilitating user registration and submissions for the reporting of emissions.
- Strengthen the institutionalization, validation and verification of GHG emissions for the administration of carbon tax (The carbon tax became effective as of June 2019 in South Africa).
- Enhance coordination among sectors in the verification of climate change information and data.
- Improve the archiving of GHG inventory datasets, methodologies, and assumptions for transparency in reporting.

The SAGERS portal is implemented and coordinated by the DEFF. The reporting platform is based on the 2006 International Panel on Climate Change (IPCC) reporting methodology. The portal (Figure 6.5) facilitates the efficient administration of, and the implementation of South Africa's QA/QC Plan for consistent compilation of National GHG Inventories. It also enables Industry to meet its GHG reporting requirements in a web-based, secure environment. It makes the estimation of the GHG emissions much simpler for industry role-players and relieves industry from the need to outsource such work to third parties which can often be burdensome and costly. The system provides an array of benefits to South Africa which include:

- The provision of a user-tailored platform for data providers to register and report their annual GHG emissions data and the associated activity data.
- The provision of methodological guidance on the quantification of GHG emissions and the embedded parameters for assessing annual GHG emissions.
- The facilitation of easy access to the parameters and GHG emissions factors database embedded into the system.
- Serving as an information hub for data providers for accessing information relevant to registration and reporting under the GHG Reporting Regulations 2016.
- The provision of relevant guidance, templates, guidelines and information relating to compliance under the GHG Reporting Regulations 2016, published under Government Notice 275 in Government Gazette No. 40762 of 03 April 2017, promulgated under the National Environmental Management: Air Quality Act No.39 of 2004.

In relation to the last point, the DEFF, in consultation with industry, has developed "Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry" (DEA, 2017). The Technical Guidelines provide detailed methodological guidance on how emissions are to be reported to the DEFF. Data providers are required to aggregate emissions at company level, whilst maintaining IPCC activity disaggregation.

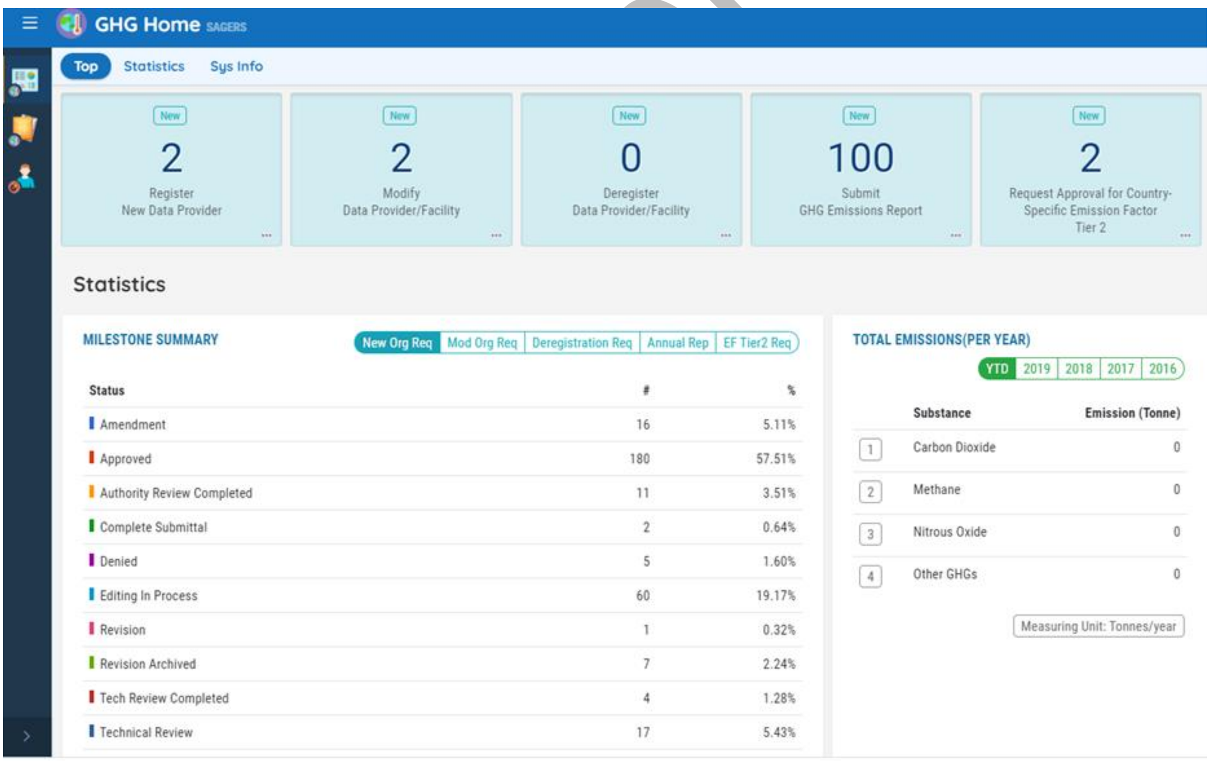

Figure 6.5: An example of a SAGERS portal dashboard.

6.3.3.2. Carbon offsets administration system

The Carbon offsets administration system has been developed as part of the Carbon Offset Regulation (DoE, 2016). This system allows for the approval of projects, listing of projects, transfer of ownership and retirement of credits (Figure 6.6). This system will allow for the tracking of carbon credit projects in South Africa.

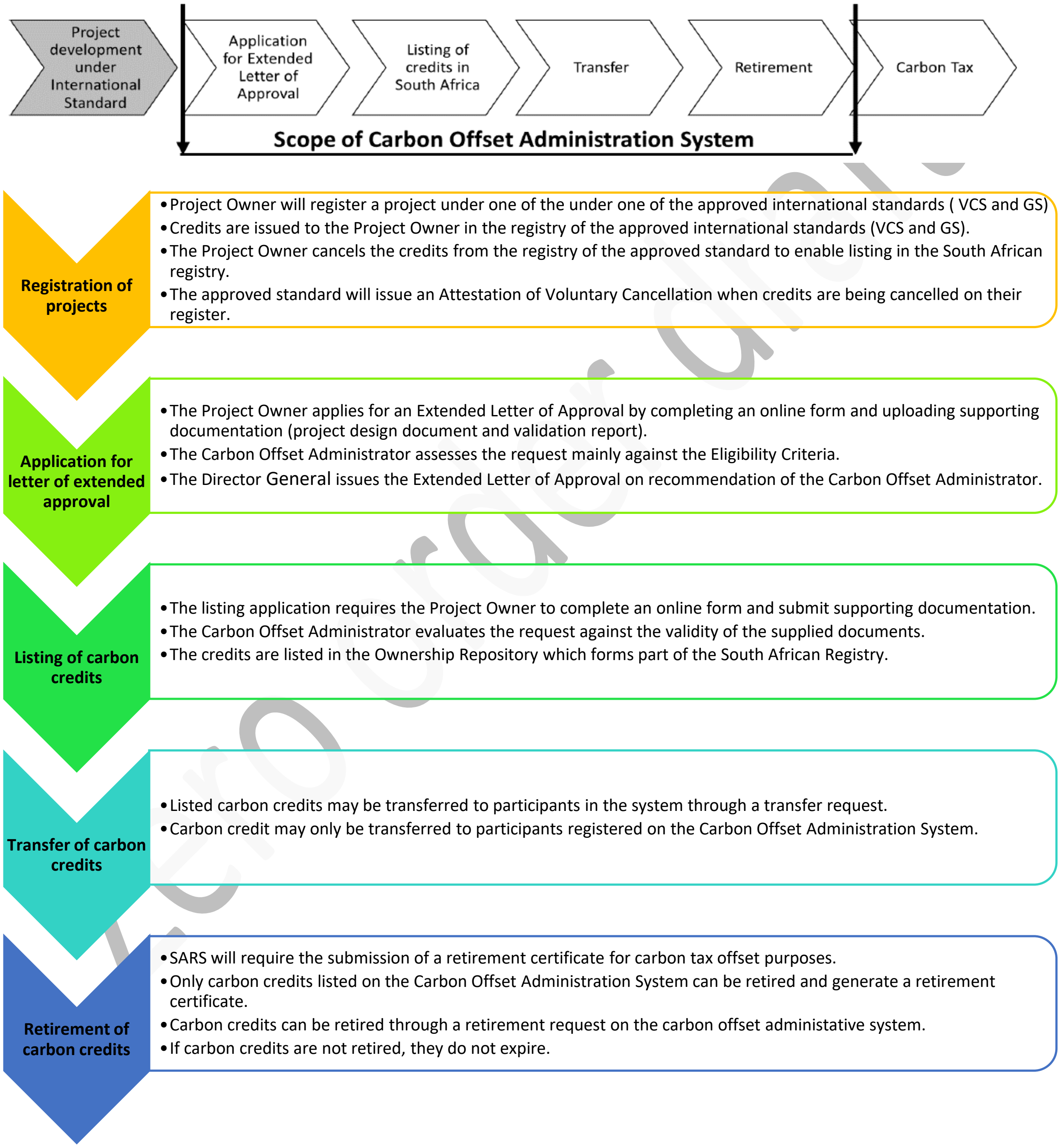

Figure 6.6: Description of the flow of information through the carbon offset administrative system (DoE, 2016).

6.4. Verification

Verification is incorporated into the inventory process, however, to date there has not been a formal verification process for the GHG inventory emission estimates or mitigation action emission reductions. Individual compilers have been responsible for verifying data inputs, emission outputs and emission reductions with available data. South Africa is currently (in line with the requirements of the NGERs) developing a fully-fledged verification scheme (DEA, 2020) in order to ensure transparency, accuracy, consistency and completeness of submissions made in terms of the NGERs (Figure 6.7). The Verification Programme will use a combination of system checks, reviews and on-site inspections by the Competent Authority (DEFF) and independent verification to obtain the required level of confidence over the Emissions Reports submitted to the Competent Authority. The Verification Programme aims to ensure that the GHG emissions and removals computed and submitted by Data Providers are complete, transparent and accurate. The Verification Programme is aligned to the reporting process described in the NGERs and the Methodological Guidelines.

To provide the modalities of the verification scheme, the DEFF has prepared a set of Verification Guidelines, and their primary purpose is to support the implementation of the mandatory GHG reporting regime in South Africa. The Verification Guideline provides direction to the Competent Authority, Data Providers and Independent Verifiers on the verification process for the NGERs and details the responsibilities of these role players. This Verification Guideline is applicable to all anthropogenic emissions by sources and removals by sinks as outlined in Annexure 1 of the NGERs.

In order to ensure alignment with existing verification schemes domestically and internationally, the DEFF has designed its verification programme in line with the South African National Accreditation System (SANAS). SANAS recently launched its latest accreditation programme for the accreditation of greenhouse gas (GHG) validation and verification bodies for use in related forms of GHG recognition against the requirements of SANS ISO 14065. However, taking into account both the challenges and opportunities associated with the accreditation process and the availability of accredited bodies under SANAS, the DEFF has designed a verification programme that follows a phased approached in order to enable flexibility and to enable domestic experts in the field to prepare themselves for the accreditation process under SANAS.

The phased verification approach is structured, from a timing perspective, to be aligned with the phases of the Carbon Tax and the proposed Carbon Budgets. Phase 1 will start on approval of the Verification Guideline and run until December 2022, and Phase 2 will start from January 2023.

One of the most important differences between Phase 1 and Phase 2 relates to the requirements of the Independent Verification process. In Phase 1, Independent Verifiers that meet specific competence requirements will be allowed to conduct independent verification. Additional detail on this is outlined in the verification guidelines. In Phase 2, only Independent Verifiers accredited in terms of ISO 14065 by the South African National Accreditation System (SANAS) will be allowed to conduct independent verification from January 2023. The rationale behind this is to allow time for Independent Verifiers to become accredited with SANAS, while at the same time initiating a process to ensure that the data reported to the Competent Authority is complete, accurate and transparent.

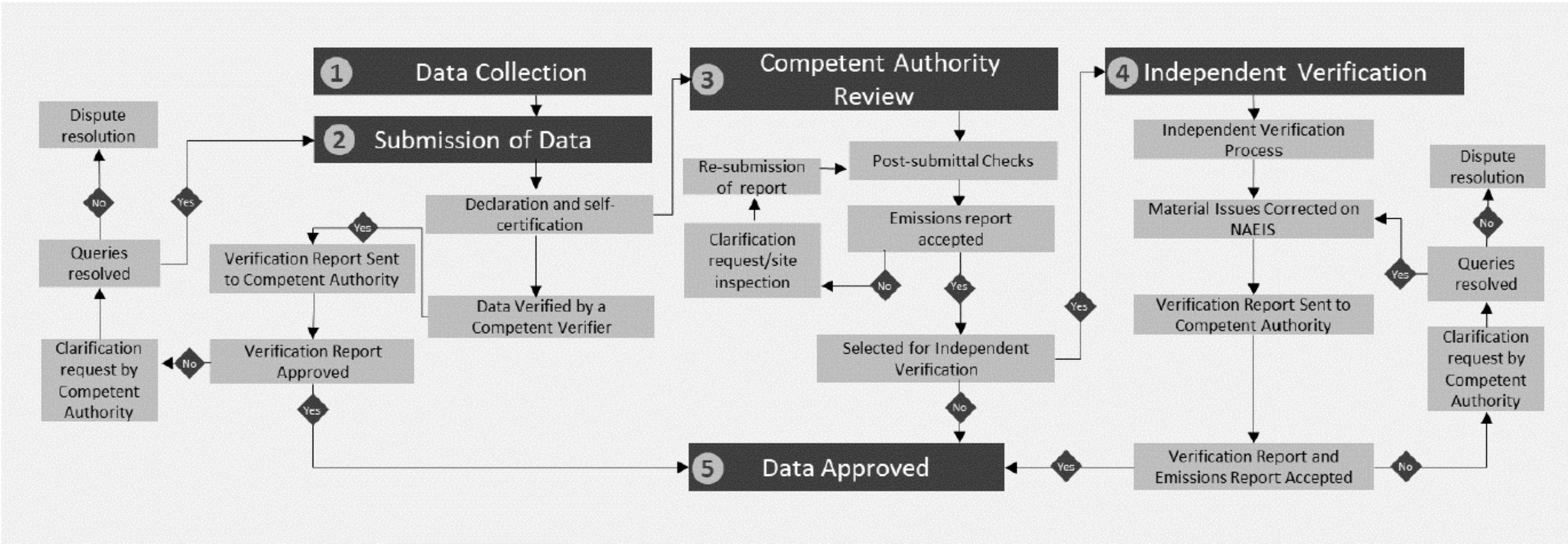

Figure 6.7: Process flow summary for the NGERS verification programme.

6.5. References

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ANNEXURE A: GHG INVENTORY QC CHECKS, KEY CATEGORY ANALYSIS, UNCERTAINTY ANALYSIS AND SECTORAL TABLES

Annex A1: Quality control checks for 2017 inventory

ID	Type of check	Description	Level
QC001	Activity data source	Is the appropriate data source being used for activity data?	Calculation file
QC002	Correct units	Check that the correct units are being used.	Calculation file
QC003	Unit carry through	Are all units correctly carried through calculations to the summary table? This includes activity data and emission factors.	Calculation file
QC004	Method validity	Are the methods used valid and appropriate?	Calculation file
QC005	Uncertainties	Carry out uncertainties analysis.	Supporting file
QC006	Double counting – Categories	Check to ensure no double counting is present at category level.	Calculation file
QC007	Notation keys	Review the use of notation keys, and the associated assumption, to ensure they are correct.	Calculation file
QC008	Trend check	Carry out checks on the trend to identify possible errors. Document any stand out data points.	Calculation file
QC009	Emission factor applicability	Where default emission factors are used, are they correct? Is source information provided?	Calculation file
QC010	Emission factor applicability	Where country specific emission factors are used, are they correct? Is source information provided?	Calculation file
QC011	Recalculations	Check values against previous submission. Explain any changes in data due to recalculations.	Calculation file
QC012	Sub-category completeness	Is the reporting of each sub-category complete? If not, this should be highlighted.	Calculation file
QC013	Time series consistency	Are activity data and emission factor time series consistent?	Calculation file
QC014	Colour coding	Has colour coding been used in a consistent and accurate manner? Are there any significant data gaps or weaknesses?	Calculation file
QC015	Cross check data	Where possible, cross check data against alternative data sources. This includes activity data and EF. If CS EF are used, they must be compared to IPCC values as well as any other available data sets.	Supporting file

ID	Type of check	Description	Level
QC016	Spot checks	Complete random spot checks on a data set.	Calculation file
QC017	Transcription checks	Complete checks to ensure data has been transcribed from models to spreadsheet correctly.	Calculation file
QC018	Transcription to document	Complete checks to ensure data has been transcribed from spreadsheets to documents correctly.	Sector report
QC019	Data source referencing	All source data submitted must be referenced.	Calculation file
QC020	Data traceability	Can data be traced back to its original source?	Calculation file
QC021	Links to source data	Where possible, links to the source data must be provided.	Calculation file
QC022	Raw primary data	All raw primary data must be present in the workbook.	Calculation file
QC023	QA review	Data must be reviewed and checked by a second person.	Calculation file
QC024	Verification	Where possible, have calculated emissions been checked against other data sets?	Sector report
QC025	Archiving	Are all supporting files and references supplied?	Archive manager
QC026	Data calculations	Can a representative sample of the emission calculations be reproduced?	Calculation file
QC027	Unit conversions	Have the correct conversion factors been used?	Calculation file
QC028	Common factor consistency	Is there consistency in common factor use between sub-categories (such as GWP, Carbon content, Calorific values)?	Calculation file
QC029	Data aggregation	Has the data been correctly aggregated within a sector?	Calculation file
QC030	Trend documentation	Have significant trend changes been adequately explained?	Sector report
QC031	Consistency between sectors	Identify parameters that are common across sectors and check for consistency.	Draft NIR
QC032	Data aggregation	Has the data been correctly aggregated across the sectors?	Draft NIR
QC033	Documentation - summary tables	Check that summary tables are included.	Draft NIR
QC034	Documentation - KCA	Check that key category analyses have been included.	Draft NIR
QC035	Documentation - Uncertainty	Check that uncertainty analyses have been included.	Draft NIR
QC036	Documentation - Overall trends	Check that overall trends are described both by sector and gas species.	Draft NIR

ID	Type of check	Description	Level
QC037	Documentation - NIR sections complete	Check that all relevant sections are included in the NIR.	Draft NIR
QC038	Documentation - Improvement plan	Check that the improvement plan has been included.	Draft NIR
QC039	Documentation - Completeness	Check for completeness.	Draft NIR
QC040	Documentation - Tables and figures	Check that numbers in tables match spreadsheet; check for consistent table formatting; check the table and figure numbers are correct.	Draft NIR
QC041	Documentation - References	Check consistency of references.	Draft NIR
QC042	Documentation - General format	Check general NIR format - acronyms, spelling, all notes removed; size, style and indenting of bullets are consistent.	Draft NIR
QC043	Documentation - Updated	Check that each section is updated with current year information.	Draft NIR
QC044	Double counting - Sectors	Check there is no double counting between the sectors.	Draft NIR
QC045	National coverage	Check that activity data is representative of the national territory.	Calculation file
QC046	Review comments implemented	Check that review comments have been implemented.	Calculation file
QC047	Methodology documentation	Are the methods described in sufficient detail?	Sector report
QC048	Recalculation documentation	Are changes due to recalculations explained?	Sector report
QC049	Trend documentation	Are any significant changes in the trend explained?	Sector report
QC050	Documentation - QA/QC	Check that the QA/QC procedure is adequately described.	Draft NIR
QC051	Complete uncertainty check	Check that the uncertainty analysis is complete.	Draft NIR
QC052	Consistency in methodology	Check that there is consistency in the methodology across the time series.	Calculation file
QC053	Data gaps	Is there sufficient documentation of data gaps?	Sector report
QC054	Steering committee review	Has the draft NIR been approved by the steering committee? Was there public consultation?	Draft NIR
QC055	Check calorific values	Have the correct net calorific values been used? Are they consistent between sectors? Are they documented?	Calculation file
QC056	Check carbon content	Have the correct carbon content values been used? Are they consistent between sectors? Are they documented?	Calculation file

ID	Type of check	Description	Level
QC057	Supplied emission check	If emissions are supplied by industry, have they been calculated using international standards? Have the methods been adequately described?	Sector report
QC058	Livestock population checks	Have the livestock population data been checked against the FAO database?	Calculation file
QC059	Land area consistency	Do the land areas for the land classes add up to the total land area for South Africa?	Calculation file
QC060	Biomass data checks	Have the biomass factors been compared to IPCC default values or the Emission Factor Database (EFDB)?	Calculation file
QC061	Fertilizer data checks	Has the fertilizer consumption data been compared to the FAO database?	Calculation file
QC062	Wastewater flow checks	Do the wastewater flows to the various treatments add up to 100?	Calculation file
QC063	Reference approach	Has the reference approach been completed for the Energy sector? Have the values been compared to the sector approach? Has sufficient explanation of differences been given?	Calculation file
QC064	Coal production checks	Has the industry-specific coal production been checked against the coal production statistics from Department of Mineral Resources?	Calculation file

Annex A2: Key category analysis

Table A2.1: Level Assessment for 2017 emissions (excl. FOLU) with key categories highlighted in green.

IPCC Category code	IPCC Category	Fuel type	GHG	2017 Ex,t (Gg CO2e)	Lx,t	Cumulative Total
1A1a	Electricity and Heat Production	Solid	CO_2	21 8959.2	0.381	0.381
1A3b	Road Transport	Liquid	CO_2	69 816.6	0.121	0.502
1A2	Manufacturing Industries and Construction	Solid	CO_2	31 855.1	0.055	0.558
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	CO_2	29 270.6	0.051	0.609
1A4b	Residential	Solid	CO_2	28 337.4	0.049	0.658
1B3	Other Emissions from Energy Production		CO_2	25 746.5	0.045	0.703
3A1a	Enteric Fermentation – Cattle		CH_4	21 589.7	0.038	0.741
3C4	Direct N_2O Emissions from Managed Soils		N_2O	18 081.0	0.031	0.772
4A	Solid Waste Disposal		CH_4	17 366.0	0.030	0.802
1A4a	Commercial/Institutional	Liquid	CO_2	16 176.0	0.028	0.830
2C1	Iron and Steel Production		CO_2	15 074.3	0.026	0.857
2C2	Ferroalloys Production		CO_2	12 572.3	0.022	0.878
2A1	Cement Production		CO_2	5 295.9	0.009	0.888
1A1a	Electricity and Heat Production	Liquid	CO_2	5 166.7	0.009	0.897
1A3a	Civil Aviation	Liquid	CO_2	4 539.7	0.008	0.905
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	CO_2	4 161.3	0.007	0.912
2F1	Refrigeration and Air Conditioning		HFCs	3 963.5	0.007	0.919
1A2	Manufacturing Industries and Construction	Gas	CO_2	3 817.9	0.007	0.925
3A1c	Enteric Fermentation – Sheep		CH_4	3 214.6	0.006	0.931
4D1	Wastewater Treatment and Discharge		CH_4	2 753.3	0.005	0.936
1A4a	Commercial/Institutional	Solid	CO_2	2 565.5	0.004	0.940

2C3	Aluminium Production		PFCs	2 453.4	0.004	0.944
3C5	Indirect N_2O Emissions from Managed Soils		N_2O	2 236.3	0.004	0.948
1A1b	Petroleum Refining	Gas	CO_2	2 215.0	0.004	0.952
1B3	Other Emissions from Energy Production		CH_4	2 183.9	0.004	0.956
1A4b	Residential	Liquid	CO_2	1 829.2	0.003	0.959
1A3d	Water-Borne Navigation	Liquid	CO_2	1 606.3	0.003	0.962
1A2	Manufacturing Industries and Construction	Liquid	CO_2	1 591.4	0.003	0.965
1B1a	Coal Mining and Handling		CH_4	1 587.4	0.003	0.968
2C3	Aluminium Production		CO_2	1 322.5	0.002	0.970
3C2	Liming		CO_2	1 222.1	0.002	0.972
1A5a	Stationary	Liquid	CO_2	1 199.3	0.002	0.974
1A3b	Road Transport	Liquid	N_2O	1 066.8	0.002	0.976
1A1a	Electricity and Heat Production	Solid	N_2O	1 057.8	0.002	0.978
2A2	Lime Production		CO_2	1 045.3	0.002	0.980
1A1b	Petroleum Refining	Solid	CO_2	934.9	0.002	0.981
3A2a	Manure Management – Cattle		N_2O	889.5	0.002	0.983
4D1	Wastewater Treatment and Discharge		N_2O	769.6	0.001	0.984
3A1d	Enteric Fermentation – Goats		CH_4	709.2	0.001	0.985
3C3	Urea Application		CO_2	679.6	0.001	0.986
1B2a	Oil		CO_2	641.8	0.001	0.988
3A2i	Manure Management – Poultry		N_2O	641.3	0.001	0.989
3C6	Indirect N_2O Emissions from Manure Management		N_2O	469.3	0.001	0.990
1A3c	Railways	Liquid	CO_2	442.8	0.001	0.990
3A2h	Manure Management – Swine		CH_4	438.6	0.001	0.991
1A3b	Road Transport	Liquid	CH_4	397.6	0.001	0.992
1A4b	Residential	Solid	N_2O	381.4	0.001	0.992
2B	Chemical Industry		C	C	0.001	0.993
2D1	Lubricant Use		CO_2	272.9	0.000	0.993

3A2a	Manure Management – Cattle		CH_4	245.0	0.000	0.994
3C1c	Biomass Burning in Grasslands		N_2O	241.8	0.000	0.994
2B	Chemical Industry		C	C	0.000	0.995
4C2	Open Burning of Waste		CH_4	240.7	0.000	0.995
3C1c	Biomass Burning in Grasslands		CH_4	204.8	0.000	0.995
1A1b	Petroleum Refining	Liquid	CO_2	178.1	0.000	0.996
2B	Chemical Industry		C	C	0.000	0.996
2B	Chemical Industry		C	C	0.000	0.996
1A2	Manufacturing Industries and Construction	Solid	N_2O	151.8	0.000	0.997
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	N_2O	141.4	0.000	0.997
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	CO_2	135.0	0.000	0.997
2B	Chemical Industry		C	C	0.000	0.997
3A1f	Enteric Fermentation – Horses		CH_4	122.0	0.000	0.997
2A3	Glass Production		CO_2	120.9	0.000	0.998
3C1a	Biomass Burning in Forest Land		CH_4	107.2	0.000	0.998
3A2c	Manure Management – Sheep		N_2O	103.6	0.000	0.998
3C1a	Biomass Burning in Forest Land		N_2O	98.2	0.000	0.998
4C2	Open Burning of Waste		N_2O	82.0	0.000	0.998
1A3b	Road Transport	Gas	CO_2	70.7	0.000	0.998
1A4b	Residential	Solid	CH_4	60.8	0.000	0.999
3A2i	Manure Management – Poultry		CH_4	59.2	0.000	0.999
3C1b	Biomass Burning in Croplands		CH_4	57.2	0.000	0.999
2F3	Fire Protection		HFCs	51.1	0.000	0.999
1A1a	Electricity and Heat Production	Solid	CH_4	47.8	0.000	0.999
1A3c	Railways	Liquid	N_2O	47.0	0.000	0.999
2C6	Zinc Production		CO_2	46.3	0.000	0.999
1A4a	Commercial/Institutional	Liquid	N_2O	40.4	0.000	0.999
3A1h	Enteric Fermentation – Swine		CH_4	39.1	0.000	0.999

4C2	Open Burning of Waste		CO_2	37.5	0.000	0.999
3A2h	Manure Management – Swine		N_2O	37.1	0.000	0.999
3A2d	Manure Management – Goats		N_2O	36.3	0.000	0.999
3A1g	Enteric Fermentation – Mules and Asses		CH_4	34.2	0.000	1.000
1A4a	Commercial/Institutional	Gas	CO_2	30.4	0.000	1.000
1A4a	Commercial/Institutional	Solid	N_2O	24.8	0.000	1.000
3C1b	Biomass Burning in Croplands		N_2O	21.9	0.000	1.000
2C5	Lead Production		CO_2	21.7	0.000	1.000
1B1a	Coal Mining and Handling		CO_2	20.8	0.000	1.000
3C1d	Biomass Burning in Wetlands		N_2O	13.8	0.000	1.000
1A4a	Commercial/Institutional	Liquid	CH_4	13.7	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	N_2O	12.9	0.000	1.000
1A3a	Civil Aviation	Liquid	N_2O	11.8	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	N_2O	10.5	0.000	1.000
3C1d	Biomass Burning in Wetlands		CH_4	10.2	0.000	1.000
1A3d	Water-Borne Navigation	Liquid	N_2O	9.7	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	CH_4	7.6	0.000	1.000
1A2	Manufacturing Industries and Construction	Solid	CH_4	7.4	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	CH_4	4.4	0.000	1.000
1A3a	Civil Aviation	Liquid	CH_4	4.0	0.000	1.000
1A2	Manufacturing Industries and Construction	Liquid	N_2O	4.0	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	CH_4	3.6	0.000	1.000
1A5a	Stationary	Liquid	N_2O	3.2	0.000	1.000
2C2	Ferroalloys Production		CH_4	3.1	0.000	1.000
1A3d	Water-Borne Navigation	Liquid	CH_4	3.1	0.000	1.000
2B	Chemical Industry		C	C	0.000	1.000
2D2	Paraffin Wax Use		CO_2	2.7	0.000	1.000
1A4b	Residential	Liquid	N_2O	2.4	0.000	1.000

3C1e	Biomass Burning in Settlements		N_2O	2.1	0.000	1.000
1A2	Manufacturing Industries and Construction	Gas	N_2O	2.1	0.000	1.000
1A1b	Petroleum Refining	Solid	N_2O	1.8	0.000	1.000
3C1e	Biomass Burning in Settlements		CH_4	1.6	0.000	1.000
1A2	Manufacturing Industries and Construction	Gas	CH_4	1.4	0.000	1.000
1A2	Manufacturing Industries and Construction	Liquid	CH_4	1.3	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	N_2O	1.3	0.000	1.000
1A1b	Petroleum Refining	Gas	N_2O	1.2	0.000	1.000
1A5a	Stationary	Liquid	CH_4	1.1	0.000	1.000
1A4b	Residential	Liquid	CH_4	1.0	0.000	1.000
3A2c	Manure Management – Sheep		CH_4	0.9	0.000	1.000
1A1b	Petroleum Refining	Gas	CH_4	0.8	0.000	1.000
3A2d	Manure Management – Goats		CH_4	0.8	0.000	1.000
1A1b	Petroleum Refining	Solid	CH_4	0.6	0.000	1.000
1A4a	Commercial/Institutional	Solid	CH_4	0.6	0.000	1.000
1A3c	Railways	Liquid	CH_4	0.5	0.000	1.000
1A1b	Petroleum Refining	Liquid	N_2O	0.4	0.000	1.000
1A1b	Petroleum Refining	Liquid	CH_4	0.1	0.000	1.000
3A2f	Manure Management – Horses		CH_4	0.1	0.000	1.000
2B	Chemical Industry		C	C	0.000	1.000
1A3b	Road Transport	Gas	N_2O	0.0	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	CH_4	0.0	0.000	1.000
1A3b	Road Transport	Gas	CH_4	0.0	0.000	1.000
1A4a	Commercial/Institutional	Gas	N_2O	0.0	0.000	1.000
3A2g	Manure Management – Mules and Asses		CH_4	0.0	0.000	1.000
1A4a	Commercial/Institutional	Gas	CH_4	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Gas	CO_2	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	CO_2	0.0	0.000	1.000

1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	CO_2	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Gas	CH_4	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	CH_4	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	CH_4	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Gas	N_2O	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	N_2O	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	N_2O	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	CO_2	0.0	0.000	1.000
1A3c	Railways	Gas	CO_2	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	CO_2	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	CH_4	0.0	0.000	1.000
1A3c	Railways	Gas	CH_4	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	CH_4	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	N_2O	0.0	0.000	1.000
1A3c	Railways	Gas	N_2O	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	N_2O	0.0	0.000	1.000
1A5a	Stationary	Solid	CO_2	0.0	0.000	1.000
1A5a	Stationary	Solid	CH_4	0.0	0.000	1.000
1A5a	Stationary	Solid	N_2O	0.0	0.000	1.000
2F2	Foam Blowing Agents		HFCs	0.0	0.000	1.000
2F4	Aerosols		HFCs	0.0	0.000	1.000
3A1j	Enteric Fermentation – Other Game		CH_4	0.0	0.000	1.000
3A2j	Manure Management – Other Game		CH_4	0.0	0.000	1.000
3C1f	Biomass Burning in Other Lands		CH_4	0.0	0.000	1.000
3C1f	Biomass Burning in Other Lands		N_2O	0.0	0.000	1.000

Table A2.2: Trend assessment between 2000 and 2017 for emissions (excl. FOLU) with key categories highlighted in green.

IPCC Category code	IPCC Category	Fuel type	GHG	2000 Ex,t (Gg CO2e)	2017 Ex,t (Gg CO2e)	Lx,t	Cumulative Total
1A3b	Road Transport	Liquid	CO_2	34 053.1	69 816.6	0.173	0.173
1A4b	Residential	Solid	CO_2	3 604.2	28 337.4	0.156	0.329
1A1a	Electricity and Heat Production	Solid	CO_2	185 027.4	218 959.2	0.117	0.446
1B3	Other Emissions from Energy Production		CO_2	28 146.6	25 746.5	0.068	0.513
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	CO_2	30 454.7	29 270.6	0.064	0.577
3A1a	Enteric Fermentation – Cattle		CH_4	23 344.7	21 589.7	0.054	0.631
3C4	Direct N_2O Emissions from Managed Soils		N_2O	20 072.5	18 081.0	0.050	0.681
1A4a	Commercial/Institutional	Liquid	CO_2	7 690.5	16 176.0	0.042	0.723
2C1	Iron and Steel Production		CO_2	16 410.5	15 074.3	0.039	0.762
1A2	Manufacturing Industries and Construction	Solid	CO_2	29 509.4	31 855.1	0.039	0.801
4A	Solid Waste Disposal		CH_4	10 533.9	17 366.0	0.026	0.826
2C2	Ferroalloys Production		CO_2	8 079.1	12 572.3	0.015	0.841
1A3a	Civil Aviation	Liquid	CO_2	2 040.0	4 539.7	0.013	0.854
1A4b	Chemical Industry	Liquid	C	C	C	0.012	0.866
2B	Nitric Acid Production		N_2O	1 644.5	292.6	0.012	0.878
3A1c	Enteric Fermentation – Sheep		CH_4	3 800.5	3 214.6	0.011	0.888
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	CO_2	2 207.2	4 161.3	0.009	0.897
2C3	Aluminium Production		PFCs	983.2	2 453.4	0.008	0.905
1A2	Manufacturing Industries and Construction	Gas	CO_2	2 217.7	3 817.9	0.006	0.912
3C5	Indirect N_2O Emissions from Managed Soils		N_2O	2 463.3	2 236.3	0.006	0.918
1B3	Other Emissions from Energy Production		CH_4	2 318.6	2 183.9	0.005	0.923
1A1b	Petroleum Refining	Gas	CO_2	2 307.1	2 215.0	0.005	0.928
3C2	Liming		CO_2	384.1	1 222.1	0.005	0.932
1B1a	Coal Mining and Handling		CH_4	1 806.8	1 587.4	0.005	0.937

1A1b	Petroleum Refining	Liquid	CO_2	670.0	178.1	0.004	0.942
3C1c	Biomass Burning in Grasslands		N_2O	668.6	241.8	0.004	0.946
1A2	Manufacturing Industries and Construction	Liquid	CO_2	778.3	1 591.4	0.004	0.950
2A2	Lime Production		CO_2	441.4	1 045.3	0.003	0.953
3A1d	Enteric Fermentation – Goats		CH_4	906.2	709.2	0.003	0.956
3C1c	Biomass Burning in Grasslands		CH_4	508.9	204.8	0.003	0.959
1A1b	Petroleum Refining	Solid	CO_2	1 065.5	934.9	0.003	0.961
1A3b	Chemical Industry	Liquid	C	C	C	0.003	0.964
2B	Titanium Dioxide Production		CO_2	437.6	152.4	0.003	0.967
2B	Chemical Industry		C	C	C	0.002	0.969
2A1	Cement Production		CO_2	3 870.6	5 295.9	0.002	0.972
1A3d	Water-Borne Navigation	Liquid	CO_2	1 513.5	1 606.3	0.002	0.974
1B2a	Oil		CO_2	752.0	641.8	0.002	0.976
3C3	Urea Application		CO_2	297.3	679.6	0.002	0.978
3C1a	Biomass Burning in Forest Land		N_2O	287.0	98.2	0.002	0.980
1A3c	Railways	Liquid	CO_2	551.5	442.8	0.002	0.981
1A4a	Commercial/Institutional	Solid	CO_2	1 800.9	2 565.5	0.002	0.983
3C1a	Biomass Burning in Forest Land		CH_4	270.6	107.2	0.002	0.985
3C1b	Biomass Burning in Croplands		CH_4	220.7	57.2	0.001	0.986
1A4b	Residential	Solid	CH_4	198.5	60.8	0.001	0.987
3A2a	Manure Management – Cattle		N_2O	844.1	889.5	0.001	0.989
3A2h	Manure Management – Swine		CH_4	487.7	438.6	0.001	0.990
1A4b	Residential	Solid	N_2O	424.0	381.4	0.001	0.991
1A3b	Road Transport	Liquid	CH_4	215.6	397.6	0.001	0.992
2C6	Zinc Production		CO_2	108.4	46.3	0.001	0.992
3C1b	Chemical Industry		C	C	C	0.001	0.993
1A1a	Electricity and Heat Production	Solid	N_2O	893.9	1 057.8	0.001	0.993
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	CO_2	171.5	135.0	0.001	0.994

2B	Ammonia Production		CH_4	65.6	167.2	0.001	0.995
2C3	Aluminium Production		CO_2	1 091.3	1 322.5	0.000	0.995
1A3b	Road Transport	Gas	CO_2	3.4	70.7	0.000	0.995
1A5a	Chemical Industry	Liquid	C	C	C	0.000	0.996
3C6	Indirect N_2O Emissions from Manure Management		N_2O	408.9	469.3	0.000	0.996
3A2c	Manure Management – Sheep		N_2O	122.5	103.6	0.000	0.997
2B	Petrochemical and Carbon Black Production		CO_2	138.6	127.2	0.000	0.997
3A2a	Manure Management – Cattle		CH_4	230.3	245.0	0.000	0.997
3A2i	Manure Management – Poultry		N_2O	466.5	641.3	0.000	0.998
1A3c	Railways	Liquid	N_2O	66.0	47.0	0.000	0.998
2D1	Lubricant Use		CO_2	188.5	272.9	0.000	0.998
1A2	Manufacturing Industries and Construction	Solid	N_2O	141.5	151.8	0.000	0.998
2C5	Lead Production		CO_2	39.2	21.7	0.000	0.998
2A3	Glass Production		CO_2	74.4	120.9	0.000	0.999
3A2d	Manure Management – Goats		N_2O	46.4	36.3	0.000	0.999
3C1e	Biomass burning in settlements		N_2O	15.1	2.1	0.000	0.999
3A1h	Enteric Fermentation – Swine		CH_4	43.5	39.1	0.000	0.999
1A4a	Commercial/Institutional	Liquid	N_2O	19.1	40.4	0.000	0.999
3A2h	Manure Management – Swine		N_2O	41.3	37.1	0.000	0.999
3C1e	Biomass Burning in Settlements		CH_4	11.2	1.6	0.000	0.999
3C1d	Biomass Burning in Wetlands		N_2O	20.2	13.8	0.000	0.999
4D1	Wastewater Treatment and Discharge		CH_4	2 144.1	2 753.3	0.000	0.999
3A1g	Enteric Fermentation – Mules and Asses		CH_4	34.4	34.2	0.000	0.999
1B1a	Coal Mining and Handling		CO_2	23.7	20.8	0.000	0.999
3C1d	Biomass Burning in Wetlands		CH_4	15.0	10.2	0.000	1.000
3A1f	Enteric Fermentation – Horses		CH_4	102.1	122.0	0.000	1.000
2D2	Paraffin Wax Use		CO_2	7.4	2.7	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	CH_4	10.6	7.6	0.000	1.000

1A4a	Commercial/Institutional	Liquid	CH_4	6.5	13.7	0.000	1.000
1A3a	Civil Aviation	Liquid	N_2O	5.3	11.8	0.000	1.000
1A4b	Residential	Liquid	N_2O	5.4	2.4	0.000	1.000
3A2i	Manure Management – Poultry		CH_4	43.1	59.2	0.000	1.000
1A1a	Electricity and Heat Production	Solid	CH_4	40.4	47.8	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	N_2O	5.6	10.5	0.000	1.000
4D1	Wastewater Treatment and Discharge		N_2O	599.3	769.6	0.000	1.000
1A4a	Commercial/Institutional	Solid	N_2O	17.4	24.8	0.000	1.000
1A3d	Water-Borne Navigation	Liquid	N_2O	9.1	9.7	0.000	1.000
1A3a	Civil Aviation	Liquid	CH_4	1.8	4.0	0.000	1.000
1A1b	Petroleum Refining	Liquid	N_2O	1.6	0.4	0.000	1.000
1A4b	Residential	Liquid	CH_4	2.0	1.0	0.000	1.000
1A2	Manufacturing Industries and Construction	Liquid	N_2O	1.9	4.0	0.000	1.000
2C2	Ferroalloys Production		CH_4	3.3	3.1	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	CH_4	1.9	3.6	0.000	1.000
1A2	Manufacturing Industries and Construction	Solid	CH_4	6.7	7.4	0.000	1.000
4C2	Open Burning of Waste		CH_4	187.5	240.7	0.000	1.000
1A1b	Petroleum Refining	Solid	N_2O	2.0	1.8	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	N_2O	1.7	1.3	0.000	1.000
1A4a	Commercial/Institutional	Gas	CO_2	23.2	30.4	0.000	1.000
1A3d	Water-Borne Navigation	Liquid	CH_4	2.9	3.1	0.000	1.000
1A1b	Petroleum Refining	Liquid	CH_4	0.5	0.1	0.000	1.000
1A2	Manufacturing Industries and Construction	Gas	N_2O	1.2	2.1	0.000	1.000
3A2d	Manure Management – Goats		CH_4	1.0	0.8	0.000	1.000
1A2	Manufacturing Industries and Construction	Liquid	CH_4	0.7	1.3	0.000	1.000
3A2c	Manure Management – Sheep		CH_4	1.0	0.9	0.000	1.000
1A1b	Petroleum Refining	Gas	N_2O	1.2	1.2	0.000	1.000
1A2	Manufacturing Industries and Construction	Gas	CH_4	0.8	1.4	0.000	1.000

1A3c	Railways	Liquid	CH_4	0.6	0.5	0.000	1.000
4C2	Open Burning of Waste		N_2O	63.9	82.0	0.000	1.000
2B	Chemical Industry		C	C	C	0.000	1.000
1A1b	Petroleum Refining	Solid	CH_4	0.7	0.6	0.000	1.000
1A1b	Petroleum Refining	Gas	CH_4	0.8	0.8	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	N_2O	110.3	141.4	0.000	1.000
1A5a	Stationary	Liquid	N_2O	2.6	3.2	0.000	1.000
4C2	Open Burning of Waste		CO_2	29.2	37.5	0.000	1.000
1A3b	Road Transport	Gas	CH_4	0.1	0.0	0.000	1.000
1A4a	Commercial/Institutional	Solid	CH_4	0.4	0.6	0.000	1.000
1A5a	Chemical Industry	Liquid	C	C	C	0.000	1.000
1A3b	Road Transport	Gas	N_2O	0.0	0.0	0.000	1.000
2B	Petrochemical and Carbon Black Production		CH_4	0.1	0.1	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	CH_4	0.0	0.0	0.000	1.000
3A2f	Manure Management – Horses		CH_4	0.1	0.1	0.000	1.000
3A2g	Manure Management – Mules and Asses		CH_4	0.0	0.0	0.000	1.000
1A4a	Commercial/Institutional	Gas	N_2O	0.0	0.0	0.000	1.000
1A4a	Commercial/Institutional	Gas	CH_4	0.0	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	CO_2	0.0	5 166.7	0.000	1.000
1A1a	Electricity and Heat Production	Gas	CO_2	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	CO_2	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	CO_2	0.0	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	CH_4	0.0	4.4	0.000	1.000
1A1a	Electricity and Heat Production	Gas	CH_4	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	CH_4	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	CH_4	0.0	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	N_2O	0.0	12.9	0.000	1.000
1A1a	Electricity and Heat Production	Gas	N_2O	0.0	0.0	0.000	1.000

1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	N_2O	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	N_2O	0.0	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	CO_2	0.0	0.0	0.000	1.000
1A3c	Railways	Gas	CO_2	0.0	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	CO_2	0.0	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	CH_4	0.0	0.0	0.000	1.000
1A3c	Railways	Gas	CH_4	0.0	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	CH_4	0.0	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	N_2O	0.0	0.0	0.000	1.000
1A3c	Railways	Gas	N_2O	0.0	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	N_2O	0.0	0.0	0.000	1.000
1A5a	Stationary	Solid	CO_2	0.0	0.0	0.000	1.000
1A5a	Stationary	Solid	CH_4	0.0	0.0	0.000	1.000
1A5a	Stationary	Solid	N_2O	0.0	0.0	0.000	1.000
2F1	Refrigeration and Air Conditioning		HFCs	0.0	3 963.5	0.000	1.000
2F2	Foam Blowing Agents		HFCs	0.0	0.0	0.000	1.000
2F3	Fire Protection		HFCs	0.0	51.1	0.000	1.000
2F4	Aerosols		HFCs	0.0	0.0	0.000	1.000
3A1j	Enteric fermentation – Other Game		CH_4	0.0	0.0	0.000	1.000
3A2j	Manure Management – Other Game		CH_4	0.0	0.0	0.000	1.000
3C1f	Biomass Burning in Other Lands		CH_4	0.0	0.0	0.000	1.000
3C1f	Biomass Burning in Other Lands		N_2O	0.0	0.0	0.000	1.000

Table A2.3: Level assessment for 2017 emissions (incl. FOLU) with key categories highlighted in green.

IPCC Category code	IPCC Category	Fuel type	GHG	2017 Ex,t (Gg CO2e)	Lx,t	Cumulative Total
1A1a	Electricity and Heat Production	Solid	CO_2	218 959.2	0.334	0.334
1A3b	Road Transport	Liquid	CO_2	69 816.6	0.106	0.440
1A2	Manufacturing Industries and Construction	Solid	CO_2	31 855.1	0.049	0.488
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	CO_2	29 270.6	0.045	0.533
1A4b	Residential	Solid	CO_2	28 337.4	0.043	0.576
3B1b	Land Converted to Forest Land - Net CO_2		CO_2	-26 613.8	0.041	0.617
1B3	Other Emissions from Energy Production		CO_2	25 746.5	0.039	0.656
3A1a	Enteric Fermentation – Cattle		CH_4	21 589.7	0.033	0.689
3C4	Direct N_2O Emissions from Managed Soils		N_2O	18 081.0	0.028	0.716
3B3b	Land Converted to Grassland - Net CO_2		CO_2	-17 662.3	0.027	0.743
4A	Solid Waste Disposal		CH_4	17 366.0	0.026	0.770
1A4a	Commercial/Institutional	Liquid	CO_2	16 176.0	0.025	0.794
3B6b	Land Converted to Other Lands - Net CO_2		CO_2	16 044.8	0.024	0.819
2C1	Iron and Steel Production		CO_2	15 074.3	0.023	0.842
3B1a	Forest Land Remaining Forest Land - Net CO_2		CO_2	-14 093.6	0.021	0.863
2C2	Ferroalloys Production		CO_2	12 572.3	0.019	0.882
2A1	Cement Production		CO_2	5 295.9	0.008	0.890
1A1a	Electricity and Heat Production	Liquid	CO_2	5 166.7	0.008	0.898
1A3a	Civil Aviation	Liquid	CO_2	4 539.7	0.007	0.905
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	CO_2	4 161.3	0.006	0.912
2F1	Refrigeration and Air Conditioning		HFCs	3 963.5	0.006	0.918
1A2	Manufacturing Industries and Construction	Gas	CO_2	3 817.9	0.006	0.923
3A1c	Enteric Fermentation – Sheep		CH_4	3 214.6	0.005	0.928
4D1	Wastewater Treatment and Discharge		CH_4	2 753.3	0.004	0.933

1A4a	Commercial/Institutional	Solid	CO_2	2 565.5	0.004	0.936
2C3	Aluminium Production		PFCs	2 453.4	0.004	0.940
3B2b	Land Converted to Cropland - Net CO_2		CO_2	2 321.3	0.004	0.944
3C5	Indirect N_2O Emissions from Managed Soils		N_2O	2 236.3	0.003	0.947
1A1b	Petroleum Refining	Gas	CO_2	2 215.0	0.003	0.951
1B3	Other Emissions from Energy Production		CH_4	2 183.9	0.003	0.954
1A4b	Residential	Liquid	CO_2	1 829.2	0.003	0.957
3B2a	Cropland Remaining Cropland - Net CO_2		CO_2	-1 793.0	0.003	0.959
1A3d	Water-Borne Navigation	Liquid	CO_2	1 606.3	0.002	0.962
1A2	Manufacturing Industries and Construction	Liquid	CO_2	1 591.4	0.002	0.964
1B1a	Coal Mining and Handling		CH_4	1 587.4	0.002	0.967
2C3	Aluminium Production		CO_2	1 322.5	0.002	0.969
3C2	Liming		CO_2	1 222.1	0.002	0.971
1A5a	Stationary	Liquid	CO_2	1 199.3	0.002	0.972
1A3b	Road Transport	Liquid	N_2O	1 066.8	0.002	0.974
1A1a	Electricity and Heat Production	Solid	N_2O	1 057.8	0.002	0.976
2A2	Lime Production		CO_2	1 045.3	0.002	0.977
1A1b	Petroleum Refining	Solid	CO_2	934.9	0.001	0.979
3A2a	Manure Management – Cattle		N_2O	889.5	0.001	0.980
3D1	Harvested Wood Products		CO_2	-776.9	0.001	0.981
4D1	Wastewater Treatment and Discharge		N_2O	769.6	0.001	0.982
3A1d	Enteric Fermentation – Goats		CH_4	709.2	0.001	0.983
3B5a	Settlements Remaining Settlements - Net CO_2		CO_2	-686.2	0.001	0.984
3C3	Urea Application		CO_2	679.6	0.001	0.985
3B4	Wetland		CH_4	666.6	0.001	0.986
1B2a	Oil		CO_2	641.8	0.001	0.987
3A2i	Manure Management – Poultry		N_2O	641.3	0.001	0.988
3B5b	Land Converted to Settlements - Net CO_2		CO_2	580.3	0.001	0.989

3B3a	Grassland Remaining Grassland - Net CO_2		CO_2	-510.3	0.001	0.990
3C6	Indirect N_2O Emissions from Manure Management		N_2O	469.3	0.001	0.991
1A3c	Railways	Liquid	CO_2	442.8	0.001	0.992
3A2h	Manure Management – Swine		CH_4	438.6	0.001	0.992
1A3b	Road Transport	Liquid	CH_4	397.6	0.001	0.993
1A4b	Residential	Solid	N_2O	381.4	0.001	0.993
2B	Chemical Industry		C	C	0.000	0.994
2D1	Lubricant Use		CO_2	272.9	0.000	0.994
3A2a	Manure Management – Cattle		CH_4	245.0	0.000	0.995
3C1c	Biomass Burning in Grasslands		N_2O	241.8	0.000	0.995
2B	Chemical Industry		C	C	0.000	0.995
4C2	Open Burning of Waste		CH_4	240.7	0.000	0.996
3C1c	Biomass Burning in Grasslands		CH_4	204.8	0.000	0.996
1A1b	Petroleum Refining	Liquid	CO_2	178.1	0.000	0.996
2B	Chemical Industry		C	C	0.000	0.997
2B	Chemical Industry		C	C	0.000	0.997
1A2	Manufacturing Industries and Construction	Solid	N_2O	151.8	0.000	0.997
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	N_2O	141.4	0.000	0.997
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	CO_2	135.0	0.000	0.997
2B	Chemical Industry		C	C	0.000	0.998
3A1f	Enteric Fermentation – Horses		CH_4	122.0	0.000	0.998
2A3	Glass Production		CO_2	120.9	0.000	0.998
3C1a	Biomass Burning in Forest Land		CH_4	107.2	0.000	0.998
3A2c	Manure Management – Sheep		N_2O	103.6	0.000	0.998
3C1a	Biomass Burning in Forest Land		N_2O	98.2	0.000	0.998
4C2	Open Burning of Waste		N_2O	82.0	0.000	0.999
1A3b	Road Transport	Gas	CO_2	70.7	0.000	0.999
1A4b	Residential	Solid	CH_4	60.8	0.000	0.999

3A2i	Manure Management – Poultry		CH_4	59.2	0.000	0.999
3C1b	Biomass Burning in Croplands		CH_4	57.2	0.000	0.999
2F3	Fire Protection		HFCs	51.1	0.000	0.999
1A1a	Electricity and Heat Production	Solid	CH_4	47.8	0.000	0.999
1A3c	Railways	Liquid	N_2O	47.0	0.000	0.999
2C6	Zinc Production		CO_2	46.3	0.000	0.999
1A4a	Commercial/Institutional	Liquid	N_2O	40.4	0.000	0.999
3A1h	Enteric Fermentation – Swine		CH_4	39.1	0.000	0.999
4C2	Open Burning of Waste		CO_2	37.5	0.000	0.999
3A2h	Manure Management – Swine		N_2O	37.1	0.000	0.999
3A2d	Manure Management – Goats		N_2O	36.3	0.000	1.000
3A1g	Enteric Fermentation – Mules and Asses		CH_4	34.2	0.000	1.000
1A4a	Commercial/Institutional	Gas	CO_2	30.4	0.000	1.000
1A4a	Commercial/Institutional	Solid	N_2O	24.8	0.000	1.000
3C1b	Biomass Burning in Croplands		N_2O	21.9	0.000	1.000
2C5	Lead Production		CO_2	21.7	0.000	1.000
1B1a	Coal Mining and Handling		CO_2	20.8	0.000	1.000
3C1d	Biomass Burning in Wetlands		N_2O	13.8	0.000	1.000
1A4a	Commercial/Institutional	Liquid	CH_4	13.7	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	N_2O	12.9	0.000	1.000
1A3a	Civil Aviation	Liquid	N_2O	11.8	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	N_2O	10.5	0.000	1.000
3C1d	Biomass Burning in Wetlands		CH_4	10.2	0.000	1.000
1A3d	Water-Borne Navigation	Liquid	N_2O	9.7	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	CH_4	7.6	0.000	1.000
1A2	Manufacturing Industries and Construction	Solid	CH_4	7.4	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	CH_4	4.4	0.000	1.000
1A3a	Civil Aviation	Liquid	CH_4	4.0	0.000	1.000

1A2	Manufacturing Industries and Construction	Liquid	N_2O	4.0	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	CH_4	3.6	0.000	1.000
1A5a	Stationary	Liquid	N_2O	3.2	0.000	1.000
2C2	Ferroalloys Production		CH_4	3.1	0.000	1.000
1A3d	Water-Borne Navigation	Liquid	CH_4	3.1	0.000	1.000
2B	Chemical Industry		C	C	0.000	1.000
2D2	Paraffin Wax Use		CO_2	2.7	0.000	1.000
1A4b	Residential	Liquid	N_2O	2.4	0.000	1.000
3C1e	Biomass Burning in Settlements		N_2O	2.1	0.000	1.000
1A2	Manufacturing Industries and Construction	Gas	N_2O	2.1	0.000	1.000
1A1b	Petroleum Refining	Solid	N_2O	1.8	0.000	1.000
3C1e	Biomass Burning in Settlements		CH_4	1.6	0.000	1.000
1A2	Manufacturing Industries and Construction	Gas	CH_4	1.4	0.000	1.000
1A2	Manufacturing Industries and Construction	Liquid	CH_4	1.3	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	N_2O	1.3	0.000	1.000
1A1b	Petroleum Refining	Gas	N_2O	1.2	0.000	1.000
1A5a	Stationary	Liquid	CH_4	1.1	0.000	1.000
1A4b	Residential	Liquid	CH_4	1.0	0.000	1.000
3A2c	Manure Management – Sheep		CH_4	0.9	0.000	1.000
1A1b	Petroleum Refining	Gas	CH_4	0.8	0.000	1.000
3A2d	Manure Management – Goats		CH_4	0.8	0.000	1.000
1A1b	Petroleum Refining	Solid	CH_4	0.6	0.000	1.000
1A4a	Commercial/Institutional	Solid	CH_4	0.6	0.000	1.000
1A3c	Railways	Liquid	CH_4	0.5	0.000	1.000
1A1b	Petroleum Refining	Liquid	N_2O	0.4	0.000	1.000
1A1b	Petroleum Refining	Liquid	CH_4	0.1	0.000	1.000
3A2f	Manure Management – Horses		CH_4	0.1	0.000	1.000
2B	Chemical Industry		C	C	0.000	1.000

1A3b	Road Transport	Gas	N_2O	0.0	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	CH_4	0.0	0.000	1.000
1A3b	Road Transport	Gas	CH_4	0.0	0.000	1.000
1A4a	Commercial/Institutional	Gas	N_2O	0.0	0.000	1.000
3A2g	Manure Management – Mules and Asses		CH_4	0.0	0.000	1.000
1A4a	Commercial/Institutional	Gas	CH_4	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Gas	CO_2	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	CO_2	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	CO_2	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Gas	CH_4	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	CH_4	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	CH_4	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Gas	N_2O	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	N_2O	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	N_2O	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	CO_2	0.0	0.000	1.000
1A3c	Railways	Gas	CO_2	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	CO_2	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	CH_4	0.0	0.000	1.000
1A3c	Railways	Gas	CH_4	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	CH_4	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	N_2O	0.0	0.000	1.000
1A3c	Railways	Gas	N_2O	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	N_2O	0.0	0.000	1.000
1A5a	Stationary	Solid	CO_2	0.0	0.000	1.000
1A5a	Stationary	Solid	CH_4	0.0	0.000	1.000
1A5a	Stationary	Solid	N_2O	0.0	0.000	1.000
2F2	Foam Blowing Agents		HFCs	0.0	0.000	1.000

2F4	Aerosols		HFCs	0.0	0.000	1.000
3A1j	Enteric Fermentation – Other Game		CH_4	0.0	0.000	1.000
3A2j	Manure Management – Other Game		CH_4	0.0	0.000	1.000
3B4a	Wetland remaining wetland		CO_2	0.0	0.000	1.000
3B4b	Land converted to wetland		CO_2	0.0	0.000	1.000
3C1f	Biomass Burning in Other Lands		CH_4	0.0	0.000	1.000
3C1f	Biomass Burning in Other Lands		N_2O	0.0	0.000	1.000

Table A2. 4: Trend assessment between 2000 and 2017 for emissions (incl. FOLU) with key categories highlighted in green.

IPCC Category code	IPCC Category	Fuel type	GHG	2000 Ex,t (Gg CO2e)	2017 Ex,t (Gg CO2e)	Lx,t	Cumulative Total
1A3b	Road Transport	Liquid	CO_2	34 053.1	69 816.6	0.153	0.153
1A4b	Residential	Solid	CO_2	3 604.2	28 337.4	0.133	0.286
3B1a	Forest Land Remaining Forest Land - Net CO_2		CO_2	1 633.2	-14 093.6	0.090	0.376
3B1b	Land Converted to Forest Land - Net CO_2		CO_2	-20 846.1	-26 613.8	0.060	0.436
1A1a	Electricity and Heat Production	Solid	CO_2	185 027.4	218 959.2	0.060	0.496
1B3	Other Emissions from Energy Production		CO_2	28 146.6	25 746.5	0.051	0.547
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	CO_2	30 454.7	29 270.6	0.048	0.595
3A1a	Enteric Fermentation – Cattle		CH_4	23 344.7	21 589.7	0.041	0.636
3C4	Direct N_2O Emissions from Managed Soils		N_2O	20 072.5	18 081.0	0.038	0.674
1A4a	Commercial/Institutional	Liquid	CO_2	7 690.5	16 176.0	0.037	0.711
2C1	Iron and Steel Production		CO_2	16 410.5	15 074.3	0.030	0.741
1A2	Manufacturing Industries and Construction	Solid	CO_2	29 509.4	31 855.1	0.027	0.767
3B3b	Land converted to grassland - Net CO2		CO_2	-17 631.1	-17 662.3	0.024	0.791
4A	Solid Waste Disposal		CH_4	10 533.9	17 366.0	0.024	0.815

3B6b	Land converted to other lands - Net CO2		CO_2	16 044.8	16 044.8	0.022	0.837
2C2	Ferroalloys Production		CO_2	8 079.1	12 572.3	0.014	0.851
1A3a	Civil Aviation	Liquid	CO_2	2 040.0	4 539.7	0.011	0.862
2B	Chemical Industry		C	C	C	0.010	0.872
1A4b	Residential	Liquid	CO_2	2 868.9	1 829.2	0.010	0.881
3A1c	Enteric fermentation - sheep		CH_4	3 800.5	3 214.6	0.008	0.890
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	CO_2	2 207.2	4 161.3	0.008	0.898
2C3	Aluminium Production		PFCs	983.2	2 453.4	0.007	0.905
1A2	Manufacturing Industries and Construction	Gas	CO_2	2 217.7	3 817.9	0.006	0.910
3C5	Indirect N_2O Emissions from Managed Soils		N_2O	2 463.3	2 236.3	0.005	0.915
3C2	Liming		CO_2	384.1	1 222.1	0.004	0.919
1B3	Other Emissions from Energy Production		CH_4	2 318.6	2 183.9	0.004	0.923
1B1a	Coal Mining and Handling		CH_4	1 806.8	1 587.4	0.004	0.927
1A1b	Petroleum Refining	Liquid	CO_2	670.0	178.1	0.004	0.930
1A1b	Petroleum Refining	Gas	CO_2	2 307.1	2 215.0	0.004	0.934
1A2	Manufacturing Industries and Construction	Liquid	CO_2	778.3	1 591.4	0.003	0.937
3B2a	Cropland remaining cropland - Net CO_2		CO_2	-1 569.4	-1 793.0	0.003	0.941
3C1c	Biomass Burning in Grasslands		N_2O	668.6	241.8	0.003	0.944
3B2b	Land converted to cropland - Net CO_2		CO_2	2 337.6	2 321.3	0.003	0.947
3D1	Harvested wood products		CO_2	-290.4	-776.9	0.003	0.950
3B5a	Settlements remaining settlements - Net CO_2		CO_2	-245.4	-686.2	0.003	0.953
2A2	Lime Production		CO_2	441.4	1 045.3	0.003	0.956
2A1	Cement Production		CO_2	3 870.6	5 295.9	0.003	0.959
3B3a	Grassland Remaining Grassland - Net CO_2		CO_2	-1 272.6	-510.3	0.003	0.961
1A3b	Road Transport	Liquid	N_2O	515.1	1 066.8	0.002	0.964
3C1c	Biomass Burning in Grasslands		CH_4	508.9	204.8	0.002	0.966
3A1d	Enteric Fermentation – Goats		CH_4	906.2	709.2	0.002	0.968
2B	Chemical Industry		C	C	C	0.002	0.970

1A1b	Petroleum Refining	Solid	CO_2	1 065.5	934.9	0.002	0.973
2B	Chemical Industry		C	C	C	0.002	0.975
1A4a	Commercial/Institutional	Solid	CO_2	1 800.9	2 565.5	0.002	0.977
3C3	Urea Application		CO_2	297.3	679.6	0.002	0.978
1B2a	Oil		CO_2	752.0	641.8	0.002	0.980
1A3d	Water-Borne Navigation	Liquid	CO_2	1 513.5	1 606.3	0.002	0.981
3C1a	Biomass Burning in Forest Land		N_2O	287.0	98.2	0.001	0.983
1A3c	Railways	Liquid	CO_2	551.5	442.8	0.001	0.984
3C1a	Biomass Burning in Forest Land		CH_4	270.6	107.2	0.001	0.985
3B5b	Land converted to settlements - Net CO_2		CO_2	644.9	580.3	0.001	0.987
3C1b	Biomass Burning in Croplands		CH_4	220.7	57.2	0.001	0.988
1A4b	Residential	Solid	CH_4	198.5	60.8	0.001	0.989
3A2h	Manure Management – Swine		CH_4	487.7	438.6	0.001	0.990
3B4	Wetland		CH_4	666.6	666.6	0.001	0.991
3A2a	Manure Management – Cattle		N_2O	844.1	889.5	0.001	0.992
1A4b	Residential	Solid	N_2O	424.0	381.4	0.001	0.992
1A3b	Road Transport	Liquid	CH_4	215.6	397.6	0.001	0.993
4D1	Wastewater Treatment and Discharge		CH_4	2 144.1	2 753.3	0.001	0.994
2C6	Zinc Production		CO_2	108.4	46.3	0.000	0.994
2B	Chemical Industry		C	C	C	0.000	0.995
3C1b	Biomass Burning in Croplands		N_2O	84.5	21.9	0.000	0.995
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	CO_2	171.5	135.0	0.000	0.996
1A3b	Road Transport	Gas	CO_2	3.4	70.7	0.000	0.996
3A2i	Manure Management – Poultry		N_2O	466.5	641.3	0.000	0.996
1A1a	Electricity and Heat Production	Solid	N_2O	893.9	1 057.8	0.000	0.997
3A2c	Manure Management – Sheep		N_2O	122.5	103.6	0.000	0.997
2B	Chemical Industry		C	C	C	0.000	0.997
3A2a	Manure Management – Cattle		CH_4	230.3	245.0	0.000	0.997

2D1	Lubricant Use		CO_2	188.5	272.9	0.000	0.997
3C6	Indirect N_2O Emissions from Manure Management		N_2O	408.9	469.3	0.000	0.998
1A3c	Railways	Liquid	N_2O	66.0	47.0	0.000	0.998
2C3	Aluminium Production		CO_2	1 091.3	1 322.5	0.000	0.998
2A3	Glass Production		CO_2	74.4	120.9	0.000	0.998
2C5	Lead Production		CO_2	39.2	21.7	0.000	0.998
4D1	Wastewater Treatment and Discharge		N_2O	599.3	769.6	0.000	0.999
1A5a	Stationary	Liquid	CO_2	985.6	1 199.3	0.000	0.999
1A2	Manufacturing Industries and Construction	Solid	N_2O	141.5	151.8	0.000	0.999
3A2d	Manure Management – Goats		N_2O	46.4	36.3	0.000	0.999
1A4a	Commercial/Institutional	Liquid	N_2O	19.1	40.4	0.000	0.999
3C1e	Biomass Burning in Settlements		N_2O	15.1	2.1	0.000	0.999
3A1h	Enteric Fermentation – Swine		CH_4	43.5	39.1	0.000	0.999
3A2h	Manure Management – Swine		N_2O	41.3	37.1	0.000	0.999
3C1e	Biomass Burning in Settlements		CH_4	11.2	1.6	0.000	0.999
3C1d	Biomass Burning in Wetlands		N_2O	20.2	13.8	0.000	0.999
1B1a	Coal Mining and Handling		CO_2	23.7	20.8	0.000	0.999
3A1g	Enteric Fermentation – Mules and Asses		CH_4	34.4	34.2	0.000	0.999
3C1d	Biomass Burning in Wetlands		CH_4	15.0	10.2	0.000	1.000
4C2	Open Burning of Waste		CH_4	187.5	240.7	0.000	1.000
2D2	Paraffin Wax Use		CO_2	7.4	2.7	0.000	1.000
3A2i	Manure Management – Poultry		CH_4	43.1	59.2	0.000	1.000
1A4a	Commercial/Institutional	Liquid	CH_4	6.5	13.7	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	CH_4	10.6	7.6	0.000	1.000
1A3a	Civil Aviation	Liquid	N_2O	5.3	11.8	0.000	1.000
3A1f	Enteric Fermentation – Horses		CH_4	102.1	122.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Solid	N_2O	110.3	141.4	0.000	1.000
1A4b	Residential	Liquid	N_2O	5.4	2.4	0.000	1.000

1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	N_2O	5.6	10.5	0.000	1.000
1A4a	Commercial/Institutional	Solid	N_2O	17.4	24.8	0.000	1.000
4C2	Open Burning of Waste		N_2O	63.9	82.0	0.000	1.000
1A1a	Electricity and Heat Production	Solid	CH_4	40.4	47.8	0.000	1.000
1A3a	Civil Aviation	Liquid	CH_4	1.8	4.0	0.000	1.000
1A3d	Water-Borne Navigation	Liquid	N_2O	9.1	9.7	0.000	1.000
1A1b	Petroleum Refining	Liquid	N_2O	1.6	0.4	0.000	1.000
1A2	Manufacturing Industries and Construction	Liquid	N_2O	1.9	4.0	0.000	1.000
1A4a	Commercial/Institutional	Gas	CO_2	23.2	30.4	0.000	1.000
1A4b	Residential	Liquid	CH_4	2.0	1.0	0.000	1.000
4C2	Open Burning of Waste		CO_2	29.2	37.5	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Liquid	CH_4	1.9	3.6	0.000	1.000
2C2	Ferroalloys Production		CH_4	3.3	3.1	0.000	1.000
1A2	Manufacturing Industries and Construction	Solid	CH_4	6.7	7.4	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	N_2O	1.7	1.3	0.000	1.000
1A1b	Petroleum Refining	Solid	N_2O	2.0	1.8	0.000	1.000
1A2	Manufacturing Industries and Construction	Gas	N_2O	1.2	2.1	0.000	1.000
1A1b	Petroleum Refining	Liquid	CH_4	0.5	0.1	0.000	1.000
1A2	Manufacturing Industries and Construction	Liquid	CH_4	0.7	1.3	0.000	1.000
1A3d	Water-Borne Navigation	Liquid	CH_4	2.9	3.1	0.000	1.000
3A2d	Manure Management – Goats		CH_4	1.0	0.8	0.000	1.000
3A2c	Manure Management – Sheep		CH_4	1.0	0.9	0.000	1.000
1A2	Manufacturing Industries and Construction	Gas	CH_4	0.8	1.4	0.000	1.000
2B	Chemical Industry		C	C	C	0.000	1.000
1A1b	Petroleum Refining	Gas	N_2O	1.2	1.2	0.000	1.000
1A3c	Railways	Liquid	CH_4	0.6	0.5	0.000	1.000
1A1b	Petroleum Refining	Solid	CH_4	0.7	0.6	0.000	1.000
1A1b	Petroleum Refining	Gas	CH_4	0.8	0.8	0.000	1.000

1A4a	Commercial/Institutional	Solid	CH_4	0.4	0.6	0.000	1.000
1A5a	Stationary	Liquid	N_2O	2.6	3.2	0.000	1.000
1A3b	Road Transport	Gas	CH_4	0.1	0.0	0.000	1.000
1A3b	Road Transport	Gas	N_2O	0.0	0.0	0.000	1.000
1A5a	Stationary	Liquid	CH_4	0.9	1.1	0.000	1.000
2B	Chemical Industry		C	C	C	0.000	1.000
1A4c	Agriculture/Forestry/Fishing/Fish Farms	Solid	CH_4	0.0	0.0	0.000	1.000
3A2g	Manure Management – Mules and Asses		CH_4	0.0	0.0	0.000	1.000
3A2f	Manure Management – Horses		CH_4	0.1	0.1	0.000	1.000
1A4a	Commercial/Institutional	Gas	N_2O	0.0	0.0	0.000	1.000
1A4a	Commercial/Institutional	Gas	CH_4	0.0	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	CO_2	0.0	5 166.7	0.000	1.000
1A1a	Electricity and Heat Production	Gas	CO_2	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	CO_2	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	CO_2	0.0	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	CH_4	0.0	4.4	0.000	1.000
1A1a	Electricity and Heat Production	Gas	CH_4	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	CH_4	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	CH_4	0.0	0.0	0.000	1.000
1A1a	Electricity and Heat Production	Liquid	N_2O	0.0	12.9	0.000	1.000
1A1a	Electricity and Heat Production	Gas	N_2O	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Liquid	N_2O	0.0	0.0	0.000	1.000
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Gas	N_2O	0.0	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	CO_2	0.0	0.0	0.000	1.000
1A3c	Railways	Gas	CO_2	0.0	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	CO_2	0.0	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	CH_4	0.0	0.0	0.000	1.000
1A3c	Railways	Gas	CH_4	0.0	0.0	0.000	1.000

1A3d	Water-Borne Navigation	Gas	CH_4	0.0	0.0	0.000	1.000
1A3a	Civil Aviation	Gas	N_2O	0.0	0.0	0.000	1.000
1A3c	Railways	Gas	N_2O	0.0	0.0	0.000	1.000
1A3d	Water-Borne Navigation	Gas	N_2O	0.0	0.0	0.000	1.000
1A5a	Stationary	Solid	CO_2	0.0	0.0	0.000	1.000
1A5a	Stationary	Solid	CH_4	0.0	0.0	0.000	1.000
1A5a	Stationary	Solid	N_2O	0.0	0.0	0.000	1.000
2F1	Refrigeration and Air Conditioning		HFCs	0.0	3 963.5	0.000	1.000
2F2	Foam Blowing Agents		HFCs	0.0	0.0	0.000	1.000
2F3	Fire Protection		HFCs	0.0	51.1	0.000	1.000
2F4	Aerosols		HFCs	0.0	0.0	0.000	1.000
3A1j	Enteric Fermentation – Other Game		CH_4	0.0	0.0	0.000	1.000
3A2j	Manure Management – Other Game		CH_4	0.0	0.0	0.000	1.000
3B4a	Wetland Remaining Wetland		CO_2	0.0	0.0	0.000	1.000
3B4b	Land Converted to Wetland		CO_2	0.0	0.0	0.000	1.000
3C1f	Biomass Burning in Other Lands		CH_4	0.0	0.0	0.000	1.000
3C1f	Biomass Burning in Other Lands		N_2O	0.0	0.0	0.000	1.000

Annex A3: Uncertainty analysis

IPCC Category		Gas	Base year emissions/ removals (2000)	Year t emissions/ removals (2017)	Activity data uncertainty		Emission factor/estimation parameter uncertainty		Combined uncertainty		Contribution to variance in Year t	Uncertainty in trend in national emissions introduced by EF/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Gg CO2e	Gg CO2e	(-)%	(+)%	(-)%	(+)%	(-)%	(+)%	(fraction)	%	%	%
1A1a	Electricity and Heat Production	CO_2	185 027.4	224 125.9	3	5	7	7	7.62	8.60	13.13	0.09	3.70	13.68
1A1b	Petroleum Refining	CO_2	4 042.6	3 328.0	3	5	7	7	7.62	8.60	0.00	0.03	0.05	0.00
1A1c	Manufacture of Solid Fuels and Other Energy Industries	CO_2	30 454.7	29 270.6	3	5	7	7	7.62	8.60	0.22	0.14	0.48	0.25
1A1a	Electricity and Heat Production	CH_4	40.4	52.1	3	5	75	75	75.06	75.17	0.00	0.00	0.00	0.00
1A1b	Petroleum Refining	CH_4	2.1	1.6	3	5	75	75	75.06	75.17	0.00	0.00	0.00	0.00
1A1c	Manufacture of Solid Fuels and Other Energy Industries	CH_4	10.6	7.6	3	5	75	75	75.06	75.17	0.00	0.00	0.00	0.00
1A1a	Electricity and Heat Production	N_2O	893.9	1 070.7	3	5	75	75	75.06	75.17	0.02	0.01	0.02	0.00
1A1b	Petroleum Refining	N_2O	4.9	3.4	3	5	75	75	75.06	75.17	0.00	0.00	0.00	0.00
1A1c	Manufacture of Solid Fuels and Other Energy Industries	N_2O	110.3	141.4	3	5	75	75	75.06	75.17	0.00	0.00	0.00	0.00
1A2	Manufacturing Industries and Construction	CO_2	32 505.4	37 264.4	5	10	7	7	8.60	12.21	0.73	0.05	1.23	1.51

1A2	Manufacturing Industries and Construction	CH_4	8.2	10.2	5	10	75	75	75.17	75.66	0.00	0.00	0.00	0.00
1A2	Manufacturing Industries and Construction	N_2O	144.7	157.9	5	10	75	75	75.17	75.66	0.00	0.00	0.01	0.00
1A3a	Civil Aviation	CO_2	2 040.0	4 539.7	5	5	1.5	1.5	5.22	5.22	0.00	0.01	0.07	0.01
1A3b	Road Transport	CO_2	34 056.5	69 887.3	5	5	2	2	5.39	5.39	0.50	0.13	1.15	1.35
1A3c	Railways	CO_2	551.5	442.8	5	5	2	2	5.39	5.39	0.00	0.00	0.01	0.00
1A3d	Water-Borne Navigation	CO_2	1 513.5	1 606.3	5	5	3	3	5.83	5.83	0.00	0.00	0.03	0.00
1A3a	Civil Aviation	CH_4	1.8	4.0	5	5	70	50	70.18	50.25	0.00	0.00	0.00	0.00
1A3b	Road Transport	CH_4	215.7	397.6	5	5	9	9	10.30	10.30	0.00	0.00	0.01	0.00
1A3c	Railways	CH_4	0.6	0.5	5	5	9	9	10.30	10.30	0.00	0.00	0.00	0.00
1A3d	Water-Borne Navigation	CH_4	2.9	3.1	5	5	50	50	50.25	50.25	0.00	0.00	0.00	0.00
1A3a	Civil Aviation	N_2O	5.3	11.8	5	5	70	50	70.18	50.25	0.00	0.00	0.00	0.00
1A3b	Road Transport	N_2O	515.1	1 066.8	5	5	70	72	70.18	72.17	0.02	0.07	0.02	0.01
1A3c	Railways	N_2O	66.0	47.0	5	5	70	72	70.18	72.17	0.00	0.01	0.00	0.00
1A3d	Water-Borne Navigation	N_2O	9.1	9.7	5	5	40	140	40.31	140.09	0.00	0.00	0.00	0.00
1A4a	Commercial/Institutional	CO_2	9 514.6	18 771.9	5	10	7	7	8.60	12.21	0.19	0.11	0.62	0.40
1A4b	Residential	CO_2	6 473.1	30 166.6	5	10	7	7	8.60	12.21	0.48	0.36	1.00	1.12
1A4c	Agriculture/Forestry/Fishing/ Fish Farms	CO_2	2 378.7	4 296.4	5	10	7	7	8.60	12.21	0.01	0.02	0.14	0.02
1A4a	Commercial/Institutional	CH_4	6.9	14.3	5	10	75	75	75.17	75.66	0.00	0.00	0.00	0.00
1A4b	Residential	CH_4	200.5	61.8	5	10	75	75	75.17	75.66	0.00	0.03	0.00	0.00
1A4c	Agriculture/Forestry/Fishing/ Fish Farms	CH_4	1.9	3.6	5	10	75	75	75.17	75.66	0.00	0.00	0.00	0.00
1A4a	Commercial/Institutional	N_2O	36.6	65.2	5	10	75	75	75.17	75.66	0.00	0.00	0.00	0.00
1A4b	Residential	N_2O	429.4	383.7	5	10	75	75	75.17	75.66	0.00	0.03	0.01	0.00
1A4c	Agriculture/Forestry/Fishing/ Fish Farms	N_2O	7.2	11.8	5	10	75	75	75.17	75.66	0.00	0.00	0.00	0.00
1A5a	Stationary	CO_2	985.6	1 199.3	3	5	7	7	7.62	8.60	0.00	0.00	0.02	0.00
1A5a	Stationary	CH_4	0.9	1.1	3	5	75	75	75.06	75.17	0.00	0.00	0.00	0.00

1A5a	Stationary	N_2O	2.6	3.2	3	5	75	75	75.06	75.17	0.00	0.00	0.00	0.00
1B1a	Coal Mining and Handling	CO_2	23.7	20.8	10	10	63	63	63.79	63.79	0.00	0.00	0.00	0.00
1B1a	Coal Mining and Handling	CH_4	1 806.8	1 587.4	10	10	63	63	63.79	63.79	0.04	0.10	0.05	0.01
1B2a	Oil	CO_2	752.0	641.8	25	25	75	75	79.06	79.06	0.01	0.05	0.05	0.01
1B3	Other Emissions from Energy Production	CO_2	28 146.6	25 746.5	25	25	75	75	79.06	79.06	14.63	1.61	2.12	7.10
1B3	Other Emissions from Energy Production	CH_4	2 318.6	2 183.9	25	25	75	75	79.06	79.06	0.11	0.12	0.18	0.05
2A1	Cement Production	CO_2	3 870.6	5 295.9	30	30	4.5	4.5	30.34	30.34	0.09	0.01	0.52	0.27
2A2	Lime Production	CO_2	441.4	1 045.3	30	30	6	6	30.59	30.59	0.00	0.01	0.10	0.01
2A3	Glass Production	CO_2	74.4	120.9	5	5	60	60	60.21	60.21	0.00	0.00	0.00	0.00
2B1	Ammonia Production	CO_2	C	C	5	5	6	6	7.81	7.81	0.00	0.01	0.00	0.00
2B1	Ammonia Production	CH_4	C	C	5	5	6	6	7.81	7.81	0.00	0.00	0.00	0.00
2B2	Nitric Acid Production	N_2O	C	C	2	2	10	10	10.20	10.20	0.00	0.04	0.00	0.00
2B5	Carbide Production	CO_2	C	C	5	5	10	10	11.18	11.18	0.00	0.00	0.00	0.00
2B6	Titanium Dioxide Production	CO_2	C	C	5	5	10	10	11.18	11.18	0.00	0.01	0.00	0.00
2B8	Petrochemical and Carbon Black Production	CO_2	C	C	10	10	85	85	85.59	85.59	0.00	0.01	0.00	0.00
2B8	Petrochemical and Carbon Black Production	CH_4	C	C	10	10	85	85	85.59	85.59	0.00	0.00	0.00	0.00
2C1	Iron and Steel Production	CO_2	16 410.5	15 074.3	5	5	10	10	11.18	11.18	0.10	0.12	0.25	0.08
2C2	Ferroalloys Production	CO_2	8 079.1	12 572.3	5	5	10	10	11.18	11.18	0.07	0.06	0.21	0.05
2C2	Ferroalloys Production	CH_4	3.3	3.1	5	5	25	25	25.50	25.50	0.00	0.00	0.00	0.00
2C3	Aluminium Production	CO_2	1 091.3	1 322.5	5	5	10	10	11.18	11.18	0.00	0.00	0.02	0.00
2C3	Aluminium Production	PFCs	983.2	2 453.4	5	5	24	24	24.52	24.52	0.01	0.07	0.04	0.01
2C5	Lead Production	CO_2	39.2	21.7	5	5	15	15	15.81	15.81	0.00	0.00	0.00	0.00
2C6	Zinc Production	CO_2	108.4	46.3	10	10	50	50	50.99	50.99	0.00	0.01	0.00	0.00
2D1	Lubricant Use	CO_2	188.5	272.9	10	10	50	50	50.99	50.99	0.00	0.00	0.01	0.00
2D2	Paraffin Wax Use	CO_2	7.4	2.7	10	10	50	50	50.99	50.99	0.00	0.00	0.00	0.00

2F1	Refrigeration and Air Conditioning	HFC	0.0	3 963.5	25	25	25	25	35.36	35.36	0.07	0.23	0.33	0.16
2F2	Foam Blowing Agents	HFC	0.0	0.0	25	25	25	25	35.36	35.36	0.00	0.00	0.00	0.00
2F3	Fire Protection	HFC	0.0	51.1	25	25	25	25	35.36	35.36	0.00	0.00	0.00	0.00
2F4	Aerosols	HFC	0.0	0.0	25	25	25	25	35.36	35.36	0.00	0.00	0.00	0.00
3A1a	Enteric Fermentation – Cattle	CH_4	23 344.7	21 589.7	5.1	20.62	20	20	20.64	28.72	1.36	0.34	1.47	2.28
3A1c	Enteric Fermentation – Sheep	CH_4	3 800.5	3 214.6	11.2	20.62	20	20	22.91	28.72	0.03	0.07	0.22	0.05
3A1d	Enteric Fermentation – Goats	CH_4	906.2	709.2	11.2	20.62	20	20	22.91	28.72	0.00	0.02	0.05	0.00
3A1f	Enteric Fermentation – Horses	CH_4	102.1	122.0	11.2	11.18	30	50	32.02	51.23	0.00	0.00	0.00	0.00
3A1g	Enteric Fermentation – Mules and Asses	CH_4	34.4	34.2	11.2	11.18	30	50	32.02	51.23	0.00	0.00	0.00	0.00
3A1h	Enteric Fermentation – Swine	CH_4	43.5	39.1	11.2	20.62	20	20	22.91	28.72	0.00	0.00	0.00	0.00
3A1j	Enteric fermentation – Other Game	CH_4	0.0	0.0					0.00	0.00	0.00	0.00	0.00	0.00
3A2a	Manure Management – Cattle	CH_4	230.3	245.0	15.8	28.72	20	20	25.51	35.00	0.00	0.00	0.02	0.00
3A2c	Manure Management – Sheep	CH_4	1.0	0.9	12.2	21.21	20	20	23.45	29.15	0.00	0.00	0.00	0.00
3A2d	Manure Management – Goats	CH_4	1.0	0.8	12.2	21.21	20	20	23.45	29.15	0.00	0.00	0.00	0.00
3A2f	Manure Management – Horses	CH_4	0.1	0.1	12.2	12.25	20	20	23.45	23.45	0.00	0.00	0.00	0.00
3A2g	Manure Management – Mules and Asses	CH_4	0.0	0.0	11.4	11.36	20	20	23.00	23.00	0.00	0.00	0.00	0.00
3A2h	Manure Management – Swine	CH_4	487.7	438.6	18.7	18.71	20	20	27.39	27.39	0.00	0.01	0.03	0.00
3A2i	Manure Management – Poultry	CH_4	43.1	59.2	18.7	25.5	20	20	27.39	32.40	0.00	0.00	0.00	0.00

3A2j	Manure management – Other Game	CH_4	0.0	0.0					0.00	0.00	0.00	0.00	0.00	0.00
3A2a	Manure Management – Cattle	N_2O	844.1	889.5	52.7	57.88	25	50	58.32	76.49	0.02	0.02	0.17	0.03
3A2c	Manure Management – Sheep	N_2O	122.5	103.6	51.7	54.54	25	50	57.45	73.99	0.00	0.01	0.02	0.00
3A2d	Manure Management – Goats	N_2O	46.4	36.3	51.7	54.54	25	50	57.45	73.99	0.00	0.00	0.01	0.00
3A2h	Manure Management – Swine	N_2O	41.3	37.1	27.8	32.79	25	50	37.42	59.79	0.00	0.00	0.00	0.00
3A2i	Manure Management – Poultry	N_2O	466.5	641.3	27.8	32.79	25	50	37.42	59.79	0.01	0.01	0.07	0.00
3B1a	Forest Land Remaining Forest Land - Net CO_2	CO_2	1 633.2	-14 093.6	18	18.03	25	25	30.82	30.82	0.67	0.94	0.84	1.59
3B1b	Land Converted to Forest Land - Net CO_2	CO_2	-20 846.1	-26 613.8	21.2	21.21	30	30	36.74	36.74	3.38	0.05	1.86	3.47
3B2a	Cropland Remaining Cropland - Net CO_2	CO_2	-1 569.4	-1 793.0	12.8	12.81	20	20	23.75	23.75	0.01	0.01	0.08	0.01
3B2b	Land Converted to Cropland - Net CO_2	CO_2	2 337.6	2 321.3	15.6	15.62	30	30	33.82	33.82	0.02	0.04	0.12	0.02
3B3a	Grassland Remaining Grassland - Net CO_2	CO_2	-1 272.6	-510.3	14.1	14.14	25	25	28.72	28.72	0.00	0.06	0.02	0.00
3B3b	Land Converted to Grassland - Net CO_2	CO_2	-17 631.1	-17 662.3	18	18.03	30	30	35.00	35.00	1.35	0.30	1.05	1.19
3B4a	Wetland Remaining Wetland	CO_2	0.0	0.0	11.2	11.18	30	30	32.02	32.02	0.00	0.00	0.00	0.00
3B4b	Land Converted to Wetland	CO_2	0.0	0.0	14.1	14.14	30	30	33.17	33.17	0.00	0.00	0.00	0.00
3B4	Wetland	CH_4	666.6	666.6	11.2	11.18	20	20	22.91	22.91	0.00	0.01	0.02	0.00
3B5a	Settlements Remaining Settlements - Net CO_2	CO_2	-245.4	-686.2	14.1	14.14	30	30	33.17	33.17	0.00	0.03	0.03	0.00
3B5b	Land Converted to Settlements - Net CO_2	CO_2	644.9	580.3	14.1	14.14	30	30	33.17	33.17	0.00	0.02	0.03	0.00

3B6b	Land Converted to Other Lands - Net CO_2	CO_2	16 044.8	16 044.8	18	18.03	30	30	35.00	35.00	1.11	0.27	0.95	0.98
3C1a	Biomass Burning in Forest Land	CH_4	270.6	107.2	40.6	40.62	40	40	57.01	57.01	0.00	0.02	0.01	0.00
3C1b	Biomass Burning in Croplands	CH_4	220.7	57.2	21.2	21.21	40	40	45.28	45.28	0.00	0.02	0.00	0.00
3C1c	Biomass Burning in Grasslands	CH_4	508.9	204.8	75.8	75.83	40	40	85.73	85.73	0.00	0.04	0.05	0.00
3C1d	Biomass Burning in Wetlands	CH_4	15.0	10.2	75.2	75.17	40	40	85.15	85.15	0.00	0.00	0.00	0.00
3C1e	Biomass Burning in Settlements	CH_4	11.2	1.6	40.3	40.31	40	40	56.79	56.79	0.00	0.00	0.00	0.00
3C1f	Biomass Burning in Other Lands	CH_4	0.0	0.0	11.2	11.18	40	40	41.53	41.53	0.00	0.00	0.00	0.00
3C1a	Biomass Burning in Forest Land	N_2O	287.0	98.2	40.3	40.31	27	27	48.52	48.52	0.00	0.02	0.01	0.00
3C1b	Biomass Burning in Croplands	N_2O	84.5	21.9	20.6	20.62	27	27	33.97	33.97	0.00	0.01	0.00	0.00
3C1c	Biomass Burning in Grasslands	N_2O	668.6	241.8	75.2	75.17	48	48	89.19	89.19	0.00	0.07	0.06	0.01
3C1d	Biomass Burning in Wetlands	N_2O	20.2	13.8	75.2	75.17	48	48	89.19	89.19	0.00	0.00	0.00	0.00
3C1e	Biomass Burning in Settlements	N_2O	15.1	2.1	40.3	40.31	27	27	48.52	48.52	0.00	0.00	0.00	0.00
3C1f	Biomass Burning in Other Lands	N_2O	0.0	0.0	11.2	11.18	48	48	49.28	49.28	0.00	0.00	0.00	0.00
3C2	Liming	CO_2	384.1	1 222.1	75	75	50	50	90.14	90.14	0.04	0.09	0.30	0.10
3C3	Urea Application	CO_2	297.3	679.6	10	10	50	50	50.99	50.99	0.00	0.04	0.02	0.00
3C4	Direct N_2O Emissions from Managed Soils	N_2O	20 072.5	18 081.0	15	53.81	70	200	71.59	207.11	49.52	3.19	3.21	20.48
3C5	Indirect N_2O Emissions from Managed Soils	N_2O	2 463.3	2 236.3	15	200.6	80	400	81.39	447.47	3.54	0.77	1.48	2.78
3C6	Indirect N_2O Emissions from Manure Management	N_2O	408.9	469.3	23.5	115.5	80	400	83.39	416.35	0.13	0.04	0.18	0.03

3D1	Harvested Wood Products	CO_2	-290.4	-776.9	15	15	30	30	33.54	33.54	0.00	0.03	0.04	0.00
4A	Solid Waste Disposal	CH_4	10 533.9	17 366.0	50	50	40	40	64.03	64.03	4.37	0.40	2.86	8.37
4C2	Open Burning of Waste	CO_2	29.2	37.5	50	50	40	40	64.03	64.03	0.00	0.00	0.01	0.00
4C2	Open Burning of Waste	CH_4	187.5	240.7	50	50	100	100	111.80	111.80	0.00	0.00	0.04	0.00
4C2	Open Burning of Waste	N_2O	63.9	82.0	50	50	100	100	111.80	111.80	0.00	0.00	0.01	0.00
4D1	Wastewater Treatment and Discharge	CH_4	2 144.1	2 753.3	50	50	40	40	64.03	64.03	0.11	0.01	0.45	0.21
4D1	Wastewater Treatment and Discharge	N_2O	599.3	769.6	50	50	90	90	102.96	102.96	0.02	0.01	0.13	0.02
			428 652.9	532 173.3							96.13			67.71
										Uncertainty in total inventory	9.80		**Trend uncertainty**	8.23

C = Confidential

Annex A4: Sectoral summary sheets

Table A4.1: Energy sector summary for 2017.

Categories	Emissions (Gg)							Emissions
	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2	(Gg CO_2e)
1 - Energy	**451 308.2**	**206.1**	**9.6**	**0.0**	**0.0**	**0.0**	**0.0**	**458 609.7**
1.A - Fuel Combustion Activities	**424 899.2**	**26.5**	**9.6**	**0.0**	**0.0**	**0.0**	**0.0**	**428 429.2**
1.A.1 - Energy Industries	**256 724.5**	**2.9**	**3.9**	**0.0**	**0.0**	**0.0**	**0.0**	**258 001.3**
1.A.1.a - Main Activity Electricity and Heat Production	224 125.9	2.5	3.5	NE	NE	NE	NE	225 248.7
1.A.1.a.i - Electricity Generation	*224 125.9*	*2.5*	*3.5*	NE	NE	NE	NE	225 248.7
1.A.1.a.ii - Combined Heat and Power Generation (CHP)				NE	NE	NE	NE	0.0
1.A.1.a.iii - Heat Plants				NE	NE	NE	NE	0.0
1.A.1.b - Petroleum Refining	3 328.0	0.1	0.0	NE	NE	NE	NE	3 333.0
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	29 270.6	0.4	0.5	NE	NE	NE	NE	29 419.6
1.A.1.c.i - Manufacture of Solid Fuels	*29 270.6*	*0.4*	*0.5*	NE	NE	NE	NE	29 419.6
1.A.1.c.ii - Other Energy Industries	*NE*	*NE*	*NE*	NE	NE	NE	NE	NE
1.A.2 - Manufacturing Industries and Construction	**37 264.4**	**0.5**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**37 432.5**
1.A.2.a - Iron and Steel				NE	NE	NE	NE	0.0
1.A.2.b - Non-Ferrous Metals				NE	NE	NE	NE	0.0
1.A.2.c - Chemicals				NE	NE	NE	NE	0.0
1.A.2.d - Pulp, Paper and Print				NE	NE	NE	NE	0.0
1.A.2.e - Food Processing, Beverages and Tobacco				NE	NE	NE	NE	0.0
1.A.2.f - Non-Metallic Minerals				NE	NE	NE	NE	0.0
1.A.2.g - Transport Equipment				NE	NE	NE	NE	0.0
1.A.2.h - Machinery				NE	NE	NE	NE	0.0
1.A.2.i - Mining (Excluding Fuels) and Quarrying				NE	NE	NE	NE	0.0

1.A.2.j - Wood and Wood Products				NE	NE	NE	NE	0.0
1.A.2.k - Construction				NE	NE	NE	NE	0.0
1.A.2.l - Textile and Leather				NE	NE	NE	NE	0.0
1.A.2.m - Non-Specified Industry				NE	NE	NE	NE	0.0
1.A.3 - Transport	**76 476.1**	**19.3**	**3.7**	**0.0**	**0.0**	**0.0**	**0.0**	**78 016.6**
1.A.3.a - Civil Aviation	4 539.7	0.2	0.0	NE	NE	NE	NE	4 555.5
1.A.3.a.i - International Aviation (International Bunkers) (1)								*0.0*
1.A.3.a.ii - Domestic Aviation	*4 539.7*	*0.2*	*0.0*	*NE*	*NE*	*NE*	*NE*	*4 555.5*
1.A.3.b - Road Transportation	69 887.3	18.9	3.4	NE	NE	NE	NE	71 351.8
1.A.3.b.i - Cars				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.b.i.1 - Passenger Cars with 3-way Catalysts				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.b.i.2 - Passenger Cars without 3-way Catalysts				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.b.ii - Light-Duty Trucks				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.b.ii.1 - Light-Duty Trucks with 3-way Catalysts				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.b.ii.2 - Light-Duty Trucks without 3-way Catalysts				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.b.iii - Heavy-Duty Trucks and Buses				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.b.iv - Motorcycles				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.b.v - Evaporative Emissions from Vehicles				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.b.vi - Urea-Based Catalysts				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.c - Railways	442.8	0.0	0.2	NE	NE	NE	NE	490.3
1.A.3.d - Water-Borne Navigation	1 606.3	0.1	0.0	NE	NE	NE	NE	1 619.0
1.A.3.d.i - International Water-Borne Navigation (International Bunkers) (1)								*0.0*
1.A.3.d.ii - Domestic Water-Borne Navigation	*1 606.3*	*0.1*	*0.0*	*NE*	*NE*	*NE*	*NE*	*1 619.0*
1.A.3.e - Other Transportation				*NE*	*NE*	*NE*	*NE*	*0.0*
1.A.3.e.i - Pipeline Transport	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*
1.A.3.e.ii - Off-Road	*IE*	*IE*	*IE*	*NE*	*NE*	*NE*	*NE*	*NE*
1.A.4 - Other Sectors	**53 234.9**	**3.8**	**1.5**	**0.0**	**0.0**	**0.0**	**0.0**	**53 775.3**
1.A.4.a - Commercial/Institutional	18 771.9	0.7	0.2	NE	NE	NE	NE	18 851.4

1.A.4.b - Residential	30 166.6	2.9	1.2	NE	NE	NE	NE	30 612.1
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	4 296.4	0.2	0.0	NE	NE	NE	NE	4 311.7
1.A.4.c.i - Stationary	*4 296.4*	*0.2*	*0.0*	NE	NE	NE	NE	4 311.7
1.A.4.c.ii - Off-Road Vehicles and Other Machinery	*IE*	*IE*	*IE*	NE	NE	NE	NE	NE
1.A.4.c.iii - Fishing (Mobile Combustion)	*IE*	*IE*	*IE*	NE	NE	NE	NE	NE
1.A.5 - Non-Specified	**1 199.3**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1 203.6**
1.A.5.a - Stationary	1 199.3	0.1	0.0	NE	NE	NE	NE	1 203.6
1.A.5.b - Mobile				NE	NE	NE	NE	0.0
1.A.5.b.i - Mobile (Aviation Component)	*NE*	*NE*	*NE*	NE	NE	NE	NE	NE
1.A.5.b.ii - Mobile (Water-Borne Component)	*NE*	*NE*	*NE*	NE	NE	NE	NE	NE
1.A.5.b.iii - Mobile (Other)	*NE*	*NE*	*NE*	NE	NE	NE	NE	NE
1.A.5.c - Multilateral Operations (1)(2)								0.0
1.B - Fugitive emissions from fuels	**26 409.1**	**179.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**30 180.4**
1.B.1 - Solid Fuels	**20.8**	**75.6**		**0.0**	**0.0**	**0.0**	**0.0**	**1 608.2**
1.B.1.a - Coal Mining and Handling	20.8	75.6		NE	NE	NE	NE	1 608.2
1.B.1.a.i - Underground Mines	*20.8*	*75.6*		NE	NE	NE	NE	1 608.2
1.B.1.a.i.1 - Mining	*16.9*	*61.3*		NE	NE	NE	NE	1 303.5
1.B.1.a.i.2 - Post-Mining Seam Gas Emissions	*3.9*	*14.3*		NE	NE	NE	NE	304.7
1.B.1.a.i.3 - Abandoned Underground Mines	*NE*	*NE*		NE	NE	NE	NE	NE
1.B.1.a.i.4 - Flaring of Drained Methane or Conversion of Methane to CO_2	*NE*	*NE*		NE	NE	NE	NE	NE
1.B.1.a.ii - Surface Mines	*0.0*	*0.0*		NE	NE	NE	NE	0.0
1.B.1.a.ii.1 - Mining	*0.0*	*0.0*		NE	NE	NE	NE	0.0
1.B.1.a.ii.2 - Post-Mining Seam Gas Emissions	*0.0*	*0.0*		NE	NE	NE	NE	0.0
1.B.1.b - Uncontrolled Combustion and Burning Coal Dumps	NE	NE	NE	NE	NE	NE	NE	NE
1.B.1.c - Solid Fuel Transformation	NE	NE	NE	NE	NE	NE	NE	NE
1.B.2 - Oil and Natural Gas	**641.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**641.8**
1.B.2.a - Oil	641.8	0.0	0.0	NE	NE	NE	NE	641.8
1.B.2.a.i - Venting	*NE*	*NE*		NE	NE	NE	NE	NE

1.B.2.a.ii - Flaring	*641.8*	*NE*		NE	NE	NE	NE	NE
1.B.2.a.iii - All Other				NE	NE	NE	NE	0.0
1.B.2.a.iii.1 - Exploration				NE	NE	NE	NE	0.0
1.B.2.a.iii.2 - Production and Upgrading				NE	NE	NE	NE	0.0
1.B.2.a.iii.3 - Transport				NE	NE	NE	NE	0.0
1.B.2.a.iii.4 - Refining				NE	NE	NE	NE	0.0
1.B.2.a.iii.5 - Distribution of Oil Products				NE	NE	NE	NE	0.0
1.B.2.a.iii.6 - Other				NE	NE	NE	NE	0.0
1.B.2.b - Natural Gas				NE	NE	NE	NE	0.0
1.B.2.b.i - Venting				NE	NE	NE	NE	0.0
1.B.2.b.ii - Flaring				NE	NE	NE	NE	0.0
1.B.2.b.iii - All Other				NE	NE	NE	NE	0.0
1.B.2.b.iii.1 - Exploration				NE	NE	NE	NE	0.0
1.B.2.b.iii.2 - Production				NE	NE	NE	NE	0.0
1.B.2.b.iii.3 - Processing				NE	NE	NE	NE	0.0
1.B.2.b.iii.4 - Transmission and Storage				NE	NE	NE	NE	0.0
1.B.2.b.iii.5 - Distribution				NE	NE	NE	NE	0.0
1.B.2.b.iii.6 - Other				NE	NE	NE	NE	0.0
1.B.3 - Other Emissions from Energy Production	**25 746.5**	**104.0**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
1.C - Carbon Dioxide Transport and Storage	**0.0**			**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
1.C.1 - Transport of CO_2	**0.0**			**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
1.C.1.a - Pipelines	NE			NE	NE	NE	NE	NE
1.C.1.b - Ships	NE			NE	NE	NE	NE	NE
1.C.1.c - Other (please specify)	NE			NE	NE	NE	NE	NE
1.C.2 - Injection and Storage	**0.0**			**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
1.C.2.a - Injection	NE			NE	NE	NE	NE	NE
1.C.2.b - Storage	NE			NE	NE	NE	NE	NE
1.C.3 - Other	**0.0**			**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Table A4.2: IPPU sector summary for 2017.

Categories	(Gg)			CO_2 Equivalents(Gg)							Emissions
	CO_2	CH_4	N_2O	HFCs	PFCs	SF6	NOx	CO	NMVOCs	SO_2	(Gg CO_2e)
2 - Industrial Processes and Product Use	**36 298.7**	**8.1**	**0.9**	**4 014.5**	**2 453.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**43 229.5**
2.A - Mineral Industry	**6 462.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6 462.1**
2.A.1 - Cement Production	**5 295.9**						**NE**	**NE**	**NE**	**NE**	**5 295.9**
2.A.2 - Lime Production	**1 045.3**						**NE**	**NE**	**NE**	**NE**	**1 045.3**
2.A.3 - Glass Production	**120.9**						**NE**	**NE**	**NE**	**NE**	**120.9**
2.A.4 - Other Process Uses of Carbonates	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.A.4.a - Ceramics	*NE*						*NE*	*NE*	*NE*	*NE*	*NE*
2.A.4.b - Other Uses of Soda Ash	*NE*						*NE*	*NE*	*NE*	*NE*	*NE*
2.A.4.c - Non Metallurgical Magnesia Production	*NE*						*NE*	*NE*	*NE*	*NE*	*NE*
2.A.4.d - Other (please specify) (3)	*NE*						*NE*	*NE*	*NE*	*NE*	*NE*
2.A.5 - Other (please specify) (3)							**NE**	**NE**	**NE**	**NE**	**NE**
2.B - Chemical Industry	**523.9**	**8.0**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**983.7**
2.B.1 - Ammonia Production	**C**	**C**					**NE**	**NE**	**NE**	**NE**	**C**
2.B.2 - Nitric Acid Production			**C**				**NE**	**NE**	**NE**	**NE**	**C**
2.B.3 - Adipic Acid Production			**NE**				**NE**	**NE**	**NE**	**NE**	**NE**
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production			**NE**				**NE**	**NE**	**NE**	**NE**	**NE**
2.B.5 - Carbide Production	**C**	**NE**					**NE**	**NE**	**NE**	**NE**	**C**
2.B.6 - Titanium Dioxide Production	**C**						**NE**	**NE**	**NE**	**NE**	**C**
2.B.7 - Soda Ash Production	**NE**						**NE**	**NE**	**NE**	**NE**	**NE**
2.B.8 - Petrochemical and Carbon Black Production	**C**	**C**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**C**
2.B.8.a - Methanol	*NO*	*NO*					NO	NO	NO	NO	NO
2.B.8.b - Ethylene	*NO*	*NO*					NO	NO	NO	NO	NO
2.B.8.c - Ethylene Dichloride and Vinyl Chloride Monomer	*NO*	*NO*					NO	NO	NO	NO	NO

2.B.8.d - Ethylene Oxide	*NO*	*NO*					NO	NO	NO	NO	NO
2.B.8.e - Acrylonitrile	*NO*	*NO*					NO	NO	NO	NO	NO
2.B.8.f - Carbon Black	*C*	*C*					NE	NE	NE	NE	*C*
2.B.9 - Fluorochemical Production	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.B.9.a - By-product emissions (4)				*NE*			NE	NE	NE	NE	*NE*
2.B.9.b - Fugitive Emissions (4)							NE	NE	NE	NE	*0.0*
2.B.10 - Other (Please specify) (3)							**NE**	**NE**	**NE**	**NE**	**0.0**
2.C - Metal Industry	**29 037.2**	**0.1**	**0.0**	**0.0**	**2 453.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**31 493.6**
2.C.1 - Iron and Steel Production	**15 074.3**	**0.0**					**NE**	**NE**	**NE**	**NE**	**15 074.3**
2.C.2 - Ferroalloys Production	**12 572.3**	**0.1**					**NE**	**NE**	**NE**	**NE**	**12 575.4**
2.C.3 - Aluminium production	**1 322.5**				**2 453.4**		**NE**	**NE**	**NE**	**NE**	**3 775.8**
2.C.4 - Magnesium production (5)	**NO**					**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.C.5 - Lead Production	**21.7**						**NE**	**NE**	**NE**	**NE**	**21.7**
2.C.6 - Zinc Production	**46.3**						**NE**	**NE**	**NE**	**NE**	**46.3**
2.C.7 - Other (please specify) (3)	**0.0**						**NE**	**NE**	**NE**	**NE**	**0.0**
2.D - Non-Energy Products from Fuels and Solvent Use (6)	**275.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**275.6**
2.D.1 - Lubricant Use	**272.9**						**NE**	**NE**	**NE**	**NE**	**272.9**
2.D.2 - Paraffin Wax Use	**2.7**						**NE**	**NE**	**NE**	**NE**	**2.7**
2.D.3 - Solvent Use (7)							**NE**	**NE**	**NE**	**NE**	**0.0**
2.D.4 - Other (please specify) (3), (8)							**NE**	**NE**	**NE**	**NE**	**0.0**
2.E - Electronics Industry	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
2.E.1 - Integrated Circuit or Semiconductor (9)				**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.E.2 - TFT Flat Panel Display (9)					**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.E.3 - Photovoltaics (9)					**NE**		**NE**	**NE**	**NE**	**NE**	**NE**
2.E.4 - Heat Transfer Fluid (10)					**NE**		**NE**	**NE**	**NE**	**NE**	**NE**
2.E.5 - Other (please specify) (3)							**NE**	**NE**	**NE**	**NE**	**NE**

2.F - Product Uses as Substitutes for Ozone Depleting Substances	**0.0**	**0.0**	**0.0**	**4 014.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4 014.5**
2.F.1 - Refrigeration and Air Conditioning	**0.0**	**0.0**	**0.0**	**3 963.5**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	***3 963.5***
2.F.1.a - Refrigeration and Stationary Air Conditioning				*1 919.7*			NE	NE	NE	NE	*1 919.7*
2.F.1.b - Mobile Air Conditioning				*2 043.7*			NE	NE	NE	NE	*NE*
2.F.2 - Foam Blowing Agents				**0.0**			**NE**	**NE**	**NE**	**NE**	**0.0**
2.F.3 - Fire Protection				**51.1**	**NE**		**NE**	**NE**	**NE**	**NE**	**51.1**
2.F.4 - Aerosols				**0.0**			**NE**	**NE**	**NE**	**NE**	**0.0**
2.F.5 - Solvents				**NE**	**NE**		**NE**	**NE**	**NE**	**NE**	**NE**
2.F.6 - Other Applications (please specify) (3)				**NO**	**NO**		**NO**	**NO**	**NO**	**NO**	**NO**
2.G - Other Product Manufacture and Use	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
2.G.1 - Electrical Equipment	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.G.1.a - Manufacture of Electrical Equipment					NE	NE	NE	NE	NE	NE	NE
2.G.1.b - Use of Electrical Equipment					NE	NE	NE	NE	NE	NE	NE
2.G.1.c - Disposal of Electrical Equipment					NE	NE	NE	NE	NE	NE	NE
2.G.2 - SF6 and PFCs from Other Product Uses	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.G.2.a - Military Applications					NE	NE	NE	NE	NE	NE	NE
2.G.2.b - Accelerators					NE	NE	NE	NE	NE	NE	NE
2.G.2.c - Other (please specify) (3)					NE	NE	NE	NE	NE	NE	NE
2.G.3 - N_2O from Product Uses	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2.G.3.a - Medical Applications			NE				NE	NE	NE	NE	NE
2.G.3.b - Propellant for Pressure and Aerosol Products			NE				NE	NE	NE	NE	NE
2.G.3.c - Other (Please specify) (3)			NE				NE	NE	NE	NE	NE
2.G.4 - Other (Please specify) (3)							**NE**	**NE**	**NE**	**NE**	**NE**
2.H - Other	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
2.H.1 - Pulp and Paper Industry							**NE**	**NE**	**NE**	**NE**	**0.0**
2.H.2 - Food and Beverages Industry							**NE**	**NE**	**NE**	**NE**	**0.0**

2.H.3 - Other (please specify) (3)							**NE**	**NE**	**NE**	**NE**	**0.0**

Table A4.3: Total AFOLU sector summary table for 2017.

	Net CO_2 emissions / removals	Emissions					Total emissions
	(Gg)						(Gg CO_2e)
	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	
3 - Agriculture, Forestry, and Other Land Use	**-41 288.06**	**1 309.57**	**73.78**	**487.79**	**20.29**	**27.24**	**9 085.24**
3 - AFOLU (excluding FOLU)	**1 901.70**	**1 277.83**	**73.78**	**487.79**	**20.29**	**27.24**	**51 608.40**
3.A - Livestock	**0.00**	**1 259.69**	**5.51**	**0.00**	**0.00**	**0.00**	**28 161.29**
3.A.1 - Enteric Fermentation	0.00	1 224.23	0.00	0.00	0.00	0.00	25 708.88
3.A.1.a - Cattle		1 028.08					21 589.73
3.A.1.a.i - Dairy Cows		*144.31*					*3 030.42*
3.A.1.a.ii - Other Cattle		*883.78*					*18 559.31*
3.A.1.b - Buffalo		*NO*					NO
3.A.1.c - Sheep		*153.08*					3 214.58
3.A.1.d - Goats		*33.77*					709.22
3.A.1.e - Camels		*NO*					NO
3.A.1.f - Horses		*5.81*					122.01
3.A.1.g - Mules and Asses		*1.63*					34.19
3.A.1.h - Swine		*1.86*					39.14
3.A.1.j - Other		*NO*					NO
3.A.2 - Manure Management (1)	0.00	35.45	5.51	0.00	0.00	0.00	2 452.41

3.A.2.a - Cattle		11.67	2.87				1 134.50
3.A.2.a.i - Dairy cows		*10.49*	*0.35*				330.13
3.A.2.a.ii - Other cattle		*1.17*	*2.52*				804.37
3.A.2.b - Buffalo		*NO*	*NO*				NO
3.A.2.c - Sheep		*0.04*	*0.33*				0.88
3.A.2.d - Goats		*0.04*	*0.12*				0.80
3.A.2.e - Camels		*NO*	*NO*				NO
3.A.2.f - Horses		*0.00*	*0.00*				0.09
3.A.2.g - Mules and Asses		*0.00*	*0.00*				0.02
3.A.2.h - Swine		*20.89*	*0.12*				438.59
3.A.2.i - Poultry		*2.82*	*2.07*				59.21
3.A.2.j - Other		*NO*	*NO*				NO
3.B - Land	**-42 412.84**	**31.74**	**0.00**	**0.00**	**0.00**	**0.00**	**-41 746.24**
3.B.1 - Forest land	-40 707.43	0.00	0.00	0.00	0.00	0.00	-40 707.43
3.B.1.a - Forest Land Remaining Forest Land	-14 093.58						-14 093.58
3.B.1.b - Land Converted to Forest Land	-26 613.85						-26 613.85
3.B.1.b.i - Cropland Converted to Forest Land	*-2 928.81*						-2 928.81
3.B.1.b.ii - Grassland Converted to Forest Land	*-21 821.33*						-21 821.33
3.B.1.b.iii - Wetlands Converted to Forest Land	*-106.56*						-106.56
3.B.1.b.iv - Settlements Converted to Forest Land	*-452.61*						-452.61
3.B.1.b.v - Other Land Converted to Forest Land	*-1 304.54*						-1 304.54
3.B.2 - Cropland	528.27	0.00	0.00	0.00	0.00	0.00	528.27
3.B.2.a - Cropland Remaining Cropland	-1 793.05						-1 793.05
3.B.2.b - Land Converted to Cropland	2 321.32						2 321.32
3.B.2.b.i - Forest Land Converted to Cropland	*2 594.32*						2 594.32
3.B.2.b.ii - Grassland Converted to Cropland	*-248.22*						-248.22
3.B.2.b.iii - Wetlands Converted to Cropland	*2.05*						2.05
3.B.2.b.iv - Settlements Converted to Cropland	*15.73*						15.73

3.B.2.b.v - Other Land Converted to Cropland	*-42.57*						-42.57
3.B.3 - Grassland	-18 172.65	0.00	0.00	0.00	0.00	0.00	-18 172.65
3.B.3.a - Grassland Remaining Grassland	-510.35						-510.35
3.B.3.b - Land Converted to Grassland	-17 662.31						-17 662.31
3.B.3.b.i - Forest Land Converted to Grassland	*4 708.09*						4 708.09
3.B.3.b.ii - Cropland Converted to Grassland	*-1 133.96*						-1 133.96
3.B.3.b.iii - Wetlands Converted to Grassland	*1.25*						1.25
3.B.3.b.iv - Settlements Converted to Grassland	*-319.77*						-319.77
3.B.3.b.v - Other Land Converted to Grassland	*-20 917.92*						-20 917.92
3.B.4 - Wetlands	0.00	31.74	0.00	0.00	0.00	0.00	666.60
3.B.4.a - Wetlands Remaining Wetlands	0.00	31.74					666.60
3.B.5 - Settlements	-105.85	0.00	0.00	0.00	0.00	0.00	-105.85
3.B.5.a - Settlements Remaining Settlements	-686.16						-686.16
3.B.5.b - Land Converted to Settlements	580.31						580.31
3.B.5.b.i - Forest Land Converted to Settlements	*299.93*						299.93
3.B.5.b.ii - Cropland Converted to Settlements	*79.77*						79.77
3.B.5.b.iii - Grassland Converted to Settlements	*236.33*						236.33
3.B.5.b.iv - Wetlands Converted to Settlements	*-1.03*						-1.03
3.B.5.b.v - Other Land Converted to Settlements	*-34.69*						-34.69
3.B.6 - Other Land	16 044.82	0.00	0.00	0.00	0.00	0.00	16 044.82
3.B.6.a - Other Land Remaining Other Land	0.00						0.00
3.B.6.b - Land Converted to Other land	16 044.82						16 044.82
3.B.6.b.i - Forest Land Converted to Other Land	*1 817.48*						1 817.48
3.B.6.b.ii - Cropland Converted to Other Land	*201.97*						201.97
3.B.6.b.iii - Grassland Converted to Other Land	*13 435.95*						13 435.95
3.B.6.b.iv - Wetlands Converted to Other Land	*535.96*						535.96
3.B.6.b.v - Settlements Converted to Other Land	*53.46*						53.46

3.C - Aggregate Sources and Non-CO_2 Emissions Sources on Land (2)	**1 901.70**	**18.14**	**68.27**	**487.79**	**20.29**	**27.24**	**23 447.11**
3.C.1 - Emissions from Biomass Burning	0.00	18.14	1.22	487.79	20.29	27.24	758.75
3.C.1.a - Biomass Burning in Forest Lands	IE	5.10	0.32	121.47	4.27	10.24	205.41
3.C.1.b - Biomass Burning in Croplands	IE	2.72	0.07	92.80	2.52	0.00	79.08
3.C.1.c - Biomass Burning in Grasslands	IE	9.75	0.78	257.67	13.37	16.17	446.61
3.C.1.d - Biomass Burning in Wetlands	IE	0.49	0.04	13.73	0.00	0.72	23.96
3.C.1.e - Biomass Burning in Settlements	IE	0.08	0.01	2.12	0.13	0.11	3.70
3.C.1.f - Biomass Burning in Other Lands	IE	0.00	0.00	0.00	0.00	0.00	0.00
3.C.2 - Liming	1 222.09						1 222.09
3.C.3 - Urea Application	679.61						679.61
3.C.4 - Direct N_2O Emissions from Managed Soils (3)			58.33				18 081.05
3.C.5 - Indirect N_2O Emissions from Managed Soils			7.21				2 236.26
3.C.6 - Indirect N_2O Emissions from Manure Management			1.51				469.35
3.C.7 - Rice Cultivations	NO	NO	NO				NO
3.C.8 - Other (please specify)							0.00
3.D - Other	**-776.92**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-776.92**
3.D.1 - Harvested Wood Products	-776.92						-776.92
3.D.2 - Other (please specify)							0.00

Table A4.4: Land category emission and removal summary for 2017.

Categories	Activity Data		Net carbon stock change and CO_2 emissions									Net CO_2 emissions (Gg CO2)
			Biomass				Dead Organic Matter			Soils		
	Total Area (ha)	Thereof: Area of organic soils (ha)	Increase (Gg C)	Decrease (Gg C)	Carbon emitted as CH_4 and CO from fires (1) (Gg C)	Net carbon stock change (Gg C)	Carbon stock change (Gg C)	Carbon emitted as CH_4 and CO from fires (1) (Gg C)	Net carbon stock change (Gg C)	Net carbon stock change in mineral soils (2) (Gg C)	Carbon loss from drained organic soils (Gg C)	
3.B - Land	**122 518 007**	**0**	**22 679.72**	**-14 064.54**	**0.00**	**7 151.85**	**0.00**	**0.00**	**1 523.38**	**520.45**	**0.00**	**-42 412.84**
3.B.1 - Forest land	**22 753 961**	**0**	**21 411.65**	**-12 970.86**	**0.00**	**8 440.79**	**0.00**	**0.00**	**648.19**	**2 013.05**	**0.00**	**-40 707.43**
3.B.1.a - Forest Land Remaining Forest Land	16 006 306	NE	15 837.07	-12 164.75		3 672.32			171.38	0.00	NE	-14 093.58
3.B.1.b - Land Converted to Forest land	6 747 655	NE	5 574.58	-806.11	IE	4 768.47	IE	IE	476.81	2 013.05	NE	-26 613.85
3.B.1.b.i - Cropland Converted to Forest Land	*515 244*	NE	*357.71*	*-52.92*		*304.79*	IE		*16.20*	*477.78*	NE	*-2 928.81*
3.B.1.b.ii - Grassland Converted to Forest Land	*5 846 206*	NE	*4 933.24*	*-717.71*		*4 215.53*	IE		*425.82*	*1 309.93*	NE	*-21 821.33*
3.B.1.b.iii - Wetlands Converted to Forest Land	*34 369*	NE	*29.50*	*-4.23*		*25.27*	IE		*3.79*	*0.00*	NE	*-106.56*
3.B.1.b.iv - Settlements Converted to Forest Land	*109 910*	NE	*92.11*	*-13.09*		*79.02*	IE		*10.88*	*33.54*	NE	*-452.61*
3.B.1.b.v - Other Land Converted to Forest Land	*241 927*	NE	*162.01*	*-18.15*		*143.86*	IE		*20.12*	*191.80*	NE	*-1 304.54*
3.B.2 - Cropland	**13 793 331**	**0**	**443.50**	**-645.12**	**0.00**	**-201.62**	**0.00**	**0.00**	**304.27**	**-1 192.12**	**0.00**	**528.27**
3.B.2.a - Cropland Remaining Cropland	12 112 976	NE	341.36	-42.01		299.36			60.38	129.28	NE	-1 793.05
3.B.2.b - Land Converted to Cropland	1 680 355	NE	102.13	-603.11	IE	-500.98	IE	IE	243.89	-1 321.39	NE	2 321.32
3.B.2.i - Forest Land Converted to Cropland	*544 741*	NE	*73.06*	*-583.22*		*-510.16*	IE		*82.58*	*-279.96*	NE	*2 594.32*

3.B.2.b.ii - Grassland Converted to Cropland	*1 081 003*	NE	*26.99*	*-18.12*		*8.87*	IE		*155.04*	*-96.21*	NE	*-248.22*
3.B.2.b.iii - Wetlands Converted to Cropland	*4 337*	NE	*0.29*	*0.71*		*1.00*	IE		*0.72*	*-2.28*	NE	*2.05*
3.B.2.b.iv - Settlements Converted to Cropland	*43 357*	NE	*0.72*	*-3.06*		*-2.35*	IE		*3.61*	*-5.55*	NE	*15.73*
3.B.2.b.v - Other Land Converted to Cropland	*6 918*	NE	*1.08*	*0.58*		*1.65*	IE		*1.94*	*8.02*	NE	*-42.57*
3.B.3 - Grassland	**67 831 841**	**0**	**571.69**	**0.00**	**0.00**	**-704.22**	**0.00**	**0.00**	**885.13**	**4 921.30**	**0.00**	**-18 172.65**
3.B.3.a - Grassland Remaining Grassland	59 798 527	NE	389.63	-535.66		-146.04			295.07	-9.85	NE	-510.35
3.B.3.b - Land Converted to Grassland	8 033 314	NE	571.69	-1 275.90	IE	-704.22	IE	IE	590.06	4 931.15	NE	-17 662.31
3.B.3.b.i - Forest Land Converted to Grassland	*3 637 034*	NE	*169.47*	*-1 172.71*		*-1 003.24*	IE		*198.12*	*-478.90*	NE	*4 708.09*
3.B.3.b.ii - Cropland Converted to Grassland	*1 109 796*	NE	*43.02*	*-55.88*		*-12.86*	IE		*-14.11*	*336.24*	NE	*-1 133.96*
3.B.3.b.iii - Wetlands Converted to Grassland	*52 194*	NE	*2.79*	*-0.50*		*2.29*	IE		*4.44*	*-7.07*	NE	*1.25*
3.B.3.b.iv - Settlements Converted to Grassland	*147 879*	NE	*2.80*	*-2.43*		*0.37*	IE		*5.15*	*81.70*	NE	*-319.77*
3.B.3.b.v - Other Land Converted to Grassland	*3 086 411*	NE	*353.61*	*-44.38*		*309.23*	IE		*396.46*	*4 999.19*	NE	*-20 917.92*
3.B.4 - Wetlands (1)	**2 445 103**	**NE**	**0.00**	**0.00**	**0.00**	**0.00**	**IE**	**0.00**	**0.00**	**0.00**	**NE**	**0.00**
3.B.5 - Settlements	**3 243 421**	**0**	**252.89**	**-96.33**	**0.00**	**-30.87**	**0.00**	**0.00**	**52.36**	**-180.05**	**0.00**	**-105.85**
3.B.5.a - Settlements Remaining Settlements	2 785 592	NE	206.68	-19.25		187.43			0.11	-0.41	NE	-686.16
3.B.5.b - Land Converted to Settlements	457 829	NE	46.21	-77.09	IE	-30.87	IE	IE	52.24	-179.64	NE	580.31
3.B.5.b.i - Forest Land Converted to Settlements	*128 889*	NE	*19.07*	*-54.98*		*-35.91*	IE		*18.31*	*-64.20*	NE	*299.93*
3.B.5.b.ii - Cropland Converted to Settlements	*65 503*	NE	*5.99*	*-8.44*		*-2.45*	IE		*13.94*	*-33.25*	NE	*79.77*
3.B.5.b.iii - Grassland Converted to Settlements	*257 853*	NE	*20.84*	*-13.63*		*7.22*	IE		*19.38*	*-91.05*	NE	*236.33*

3.B.5.b.iv - Wetlands Converted to Settlements	*1 068*	NE	*0.31*	*-0.01*		*0.30*	IE		*0.59*	*-0.61*	NE	*-1.03*
3.B.5.b.v - Other Land Converted to Settlements	*4 516*	NE	*0.00*	*-0.03*		*-0.03*	IE		*0.02*	*9.47*	NE	*-34.69*
3.B.6 - Other Land	**12 450 349**	**0**	**0.00**	**-352.23**	**0.00**	**-352.23**	**0.00**	**0.00**	**-366.57**	**-3 657.07**	**0.00**	**16 044.82**
3.B.6.a - Other Land Remaining Other land	9 932 899	NE								0.00	NE	0.00
3.B.6.b - Land Converted to Other land	2 517 450	NE	0.00	-352.23	IE	-352.23	0.00	0.00	-366.57	-3 657.07	NE	16 044.82
3.B.6.b.i - Forest Land Converted to Other Land	*151 522*	NE	*0.00*	*-56.40*		*-56.40*			*-210.50*	*-228.78*	NE	*1 817.48*
3.B.6.b.ii - Cropland Converted to Other Land	*13 688*	NE	*0.00*	*-2.51*		*-2.51*			*-34.83*	*-17.74*	NE	*201.97*
3.B.6.b.iii - Grassland Converted to Other Land	*2 273 833*	NE	*0.00*	*-292.75*		*-292.75*			*-109.00*	*-3 262.60*	NE	*13 435.95*
3.B.6.b.iv - Wetlands Converted to Other Land	*73 546*	NE	*0.00*	*0.00*		*0.00*			*0.00*	*-146.17*	NE	*535.96*
3.B.6.b.v - Settlements Converted to Other Land	*4 862*	NE	*0.00*	*-0.57*		*-0.57*			*-12.23*	*-1.78*	NE	*53.46*
CH_4 Emissions	***Gg CH4***	***Gg CO_2e***										
3.B.4 - Wetlands (1)	*31.74*	*666.60*										

Table A4.5: Waste sector summary for 2017.

Categories	Emissions (Gg)							Emissions
	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2	(Gg CO_2e)
4 - Waste	**37.47**	**969.52**	**2.75**	**NE**	**NE**	**NE**	**NE**	**21 248.95**
4.A - Solid Waste Disposal		**826.95**		**0.00**	**0.00**	**0.00**	**0.00**	**17 365.96**
4.A.1 - Managed Waste Disposal Sites				NE	NE	NE	NE	NE
4.A.2 - Unmanaged Waste Disposal Sites				NE	NE	NE	NE	NE
4.A.3 - Uncategorised Waste Disposal Sites				NE	NE	NE	NE	NE
4.B - Biological Treatment of Solid Waste		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
4.C - Incineration and Open Burning of Waste	**37.47**	**11.46**	**0.26**	**0.00**	**0.00**	**0.00**	**0.00**	**360.18**
4.C.1 - Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE
4.C.2 - Open Burning of Waste	37.47	11.46	0.26	NE	NE	NE	NE	360.18
4.D - Wastewater Treatment and Discharge	**0.00**	**131.11**	**2.48**	**0.00**	**0.00**	**0.00**	**0.00**	**3 522.81**
4.D.1 - Domestic Wastewater Treatment and Discharge		IE	IE	NE	NE	NE	NE	NE
4.D.2 - Industrial Wastewater Treatment and Discharge		IE		NE	NE	NE	NE	NE
4.E - Other (please specify)				**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

ANNEXURE B: MITIGATION ACTIONS, EMISSION REDUCTIONS, METHODS AND ASSUMPTIONS

Annex B1: Domestic mitigation actions

Table B1.1: Mitigation actions in the energy sector

Name of action	Primary Objective	Description	Nature of action	Administering government/ Agency/ Actor	Coverage	Quantitative goals	Status and Progress (Steps taken or envisaged to achieve the action)	Progress indicators	Methodology and assumptions	Actual emission reductions ($MtCO_2e$ till 2019)	Co-benefits
12L tax incentive programme	Improve uptake of lower carbon technologies /initiatives to reduce greenhouse gas emissions in the industrial and commercial sectors and to stimulate job creation in the green economy	The tax incentive aims to encourage the efficient utilisation of energy in an effort to combat the adverse effects of greenhouse gas emissions related to fossil fuel-based energy use on climate change. 12L provides for a 95c per verified kWh (or kWh equivalent) of energy efficiency savings, that has been signed off by the monitoring and verification body and has	Public tax incentive	South African National Energy Development Institute (SANEDI)	CO_2 Energy sector	The 12L tax incentive does not set any quantitative goals, however it is hope that the number of applicants can be doubled during the extension period from 2020 to 2022. The 12L tax incentive programme can contribute to the targets set out in the Post-2015	Ongoing - 2013 - 2022 The incentive was promulgated 1st of November 2013 and was claimable until the 1st of January 2020. In 2015 amendments were made and the minister announced the increase from 45c/kWh to 95c/kWh increase of the incentive. Further to the changes, initially only waste heat recovery was claimable as savings in co-generation, but now co-generation in terms of combined heat and power are also	kWh savings; Reduction of CO_2 through the efficient use of energy	No calculations were conducted on the primary data received from SANEDI. The $kgCO_2e$ saved by each project was provided directly by SANEDI. These values consider the various energy carriers present in the projects. The SANEDI emission data sets are based on information provided by claimants which is assured by an accredited entity. The process is initiated by the compilation and submission of a baseline benchmarking) model and report to SANEDI for approval, which	2015: 5.1 2016: 6.1 2017: 10.8 2018: 16.8 2019: 17.9 Total savings- 56.7 Mt CO_2e	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purpose. Increase in jobs due to uptake of energy efficient technologies. Increase in green economy due to uptake of energy efficient technologies.

		been approved by the SANEDI 12 L evaluation panel for the assessment year in question. The tax incentive is applicable for a period of 12 months of savings.				NEES industry and mining targets: (a) 16% reduction in the weighted mean specific consumption of manufacturing by 2030 relative to 2015 baseline; (b) 40 PJ cumulative annual savings from energy efficient interventions in mining.	claimable. The tax incentive has now been extended until 31 December 2022.		outlines the business as usual scenario in which the energy saving measure would not have been implemented. Once the baseline is approved, the energy performance assessment report must be compiled which demonstrates the energy savings for the assessment year. The baseline and performance assessment must be conducted by a monitoring and verification professional certified by the South African National Accreditation System. The energy savings must then be certified by SANEDI through issuing of a savings certificate. Assumption: An average project lifetime of 5 years is assumed for the savings.		
Energy Efficiency Standards and Appliance Labelling project	To ensure that consumers are informed about the relative energy efficiency of an appliance before purchasing.	The information provided on the label informs users of the energy efficiency rating of each appliance, the manufacturer and product	Public sector procure-ment programme; Policy & Standards	Department of Mineral Resources and Energy (DMRE)	CO_2. Energy sector	This will contribute to the targets set out in the post-2015 NEES, particularly the residential	Ongoing - 2011 - 2030 In 2005 the first National Energy Efficiency Strategy was developed along with the introduction of a	kWh savings; Reduction of CO_2 through the efficient use of energy	No calculations were undertaken as part of this report, as only high-level, secondary data values (in Mt CO_2e) were provided for the period 2011 – 2030. The data relates to the cumulative	Between 7.6 Mt CO2e (low autonomous energy efficiency improvement scenario) and 22.7	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purposes.

		model. For some appliances, the label will also have non energy data such as water consumption per cycle and appliance noise level. (DoE, 2017)Mandatory labelling of household appliances is in place (DTI, 2014), and minimum energy performance standards (MEPS) have been introduced or are proposed for most of the major categories of appliances.				target of a 33% reduction in the average specific energy consumption of new household appliances purchased by 2030 relative to the 2015 baseline.	voluntary labelling scheme. This was the precursor to the mandatory standards and Labelling (S&L) programme. The voluntary scheme targeted directly only refrigerators. Thereafter the South African Bureau of Standards (SABS) developed the South African National Standard "SANS 941 - Energy Efficiency for Electrical and Electronic Apparatus". Minister of Trade and Industry published the 'Compulsory Specification for Energy Efficiency and Labelling of Electrical and Electronic Apparatus' in 2014 and the first mandatory standards came into force in 2015. The first covered set of appliances includes refrigerators, washing machines, dryers, dishwashers, electric water heaters, ovens, A/C and heat pumps.)		energy savings from technological advancements related to electrical appliances. The emission savings are calculated based on a time-dependent grid emission factor (which is assumed to decrease over time due to the introduction of renewable energy on the grid).	Mt CO_2e (high autonomous energy efficiency scenario).	Increase in jobs due to uptake of energy efficient technologies. Increase in green economy due to uptake of energy efficient technologies.

Eskom IDM programme	Provides for the efficient use of energy resources and related incentives/rebates.	Promotes energy efficiency and load management. The programme has promoted the implementation of energy efficiency technologies by providing various rebates for energy efficiency; management and conservation measures, as well as solar water heater installations.	Public sector subsidy programme	Eskom IDM team	CO_2. Energy sector	975 MW savings, with the residential lighting target set at 455MW (Eskom, 2016)	Ongoing – 2005 to present The IDM programme was placed on hold in 2014 due to Eskom's prevailing financial constraints. The IDM programme was revived in February 2015 to pursue industrial energy efficiency and residential lighting projects. As part of the residential energy efficiency projects rolled out, a total of 30 million compact fluorescent lamps have been distributed (Eskom COP17 Fact sheet).	kWh savings; Reduction of CO2 through the efficient use of energy	Emission savings (Mt CO_2e) = activity data (GWh) x grid emission factor (tCO2e/GWh) The emission savings were calculated by multiplying the activity data (primary data set provided by Eskom IDM Department) by the relevant grid emission factor. Assumption: It was assumed that the measures run for 5 years. In the absence of activity 2019 data, it was also assumed that the 2019 activity data value was the same as the value provided for 2018.	2005: 0.1 2006: 0.4 2007: 1.2 2008: 3.7 2009: 7.7 2010: 12.1 2011: 18.0 2012: 24.7 2013: 31.7 2014: 38.7 2015: 45.8 2016: 51.3 2017: 56.3 2018: 59.2 2019: 61.5 Total Cumulative Savings- 412.40 Mt CO_2e	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purpose. Increase in jobs due to uptake of energy efficient technologies. Increase in green economy due to uptake of energy efficient technologies.

Municipal Energy Efficiency and Demand-side Manageme nt programme	Provides for the efficient use of energy resources and related incentives/ rebates.	Disbursement of grant funding to municipalities to implement energy efficient retrofits within the municipal infrastructure.	Public sector grant funding programme .	DEFF	CO_2. Energy sector	Energy Conservation Target: energy efficiency potential is between 20-30% across many segments. This action will contribute to the Post-2015 NEES targets for municipalities : 20% reduction in the energy intensity in the provision of electricity-intensive municipal services.	Ongoing – Implementation period was 2011 – 2018 but assumed that reductions continue for 5 years. Since its start significant funding (over R1 billion) has been dedicated towards this programme and 54 municipalities have participated.)	kWh savings; Reduction of CO_2 through the efficient use of energy	Emission savings (Mt CO_2e) = activity data (GWh) x grid emission factor (tCO2e/GWh) The emission savings were calculated by multiplying the activity data (secondary data set provided by Department of Environment, Forestry and Fishers) by the relevant grid emission factor. The Department of Environment, Forestry and Fisheries provided high-level data (in GWh) for the period 2011 – 2015. Values were also provided for the period 2015 – 2018, however these were classified as "expected savings". Assumption: It was assumed that the measures are ongoing and that the annual emission savings were the equivalent to the amount recorded for 2019. It was further assumed that the measures run for 5 years.	2012: 0.1 2013: 0.2 2014: 0.4 2015: 0.9 2016: 1.9 2017: 3.7 2018: 7.3 2019: 14.4 Total cumulative Savings- 28.94 Mt CO_2e	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purpose. Increase in jobs due to uptake of energy efficient technologies. Increase in green economy due to uptake of energy efficient technologies.
The National Cleaner Production Centre South	The action aims to facilitate energy efficiency measures, particularly in	Implement projects in the private sector that achieve energy savings and improved	Private sector energy efficiency funding	National Cleaner Production Centre	CO_2. Energy sector	No specific quantitative gals are provided but will contribute	Ongoing – 2011 to present	kWh savings; Reduction of CO_2 through the	The savings in this report are based on the emission calculations conducted by the	2011: 0.1 2012: 0.1 2013: 0.1 2014: 0.3 2015: 0.5 2016: 0.5	Reduced air pollution due to the mitigation of fossil fuel combustion for energy

Africa (NCP C) programme	the industrial and commercial sectors, as a means to mitigate greenhouse gas emissions related to the energy sector and stimulate job creation in the green economy.	economic competitiveness in South African businesses through resource and process efficiency.	programme.			towards South Africa's energy efficiency targets.		efficient use of energy	NCPC. The NCPC calculates the emission savings for the projects based on the energy carrier relevant to each specific project. These emissions were aggregated and provided by the NCPC for each year the programme has run for. Assumptions: assumed that project savings implemented during the programme remain for a period of 5 years.	2017: 0.5 2018: 0.7 2019: 0.5 Total cumulative savings- 3.27 Mt CO2e	generation purposes. Increase in jobs due to uptake of energy efficient technologies. Increase in green economy due to uptake of energy efficient technologies.
PSEE programme	The action aims to facilitate energy efficiency measures, particularly in the industrial and commercial sectors, as a means to mitigate greenhouse gas emissions related to the energy sector and stimulate job creation in the green economy.	Implement projects in the private sector that achieve energy savings and improved economic competitiveness in South African businesses through resource and process efficiency.	Private sector energy efficiency projects; economic incentive.	Private sector	CO_2. Energy sector	No specific targets provided but this action will contribute to the Post-2015 NEES industry and mining targets: (a) 16% reduction in the weighted mean specific consumption of manufacturing by 2030 relative to the 2015 baseline; (b) 40 PJ cumulative annual	Completed 2013 to 2015 however assumes that projects remain in place to date. Potential sources of funding, effective delivery mechanism and an appropriate hosting body will be identified to allow the development of a permanent successor scheme.	kWh savings	Emission savings (Mt CO_2e) = activity data (GWh) x grid emission factor (tCO_2e/GWh) The calculations in this report are based on secondary data sets (energy savings in GWh), accessed from the National Business Initiative report on the outcomes of the programme. The activity data sets are multiplied by the South African grid emission factor for that year (calculated using data in the related Eskom annual report) to derive the Mt CO_2e value.	2014: 0.1 2015: 0.1 2016: 0.1 2017: 0.1 2018: 0.1 2019: 0.1 Total cumulative savings: 0.75 Mt CO_2e	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purposes. Increase in jobs due to uptake of energy efficient technologies. Increase in green economy due to uptake of energy efficient technologies.

						savings from energy efficient interventions in mining.			Assumptions: assumed that projects implemented during the programme remain in place to date.			
Private sector embedded solar generation	Solar photovoltaic (PV) generation, which can be quickly deployed, is expected to be the key technology behind small-scale embedded generation	Installation of embedded solar PV for electricity generation	Private sector energy efficiency projects; economic incentive.	South Africa Solar PV update published by the Association for Renewable Energy Practitioners	CO_2. Energy sector	This action will contribute to the solar PV targets set in the IRP (2019). By 2030, South Africa aims for additional capacity of 6 GW solar power. It is expected that another 114 MW will come online in 2020, followed by 300 MW in 2021, and 400 MW in 2022, when an additional 1 GW will be added as well. By 2030 the cumulative total is expected to be 8,288 MW.	Ongoing – 2017 to present	kWh generated and MW installed capacity; Reduction of CO_2 through the use of cleaner energy sources	Emission savings (Mt CO_2e) = activity data (GWh) x grid emission factor (tCO_2e/GWh) The calculations in this report are based on secondary activity data sets (new installed capacity additions in MW, converted to GWh), accessed from the South Africa Solar PV Update Report published by the Association for Renewable Energy Practitioners.7 Assumptions: Assumed a capacity factor of 15% for the solar PV panels and an operational time of 6hrs each day. These assumptions were used to calculate an estimate of the electricity generated by the installed solar PV in each year. This was then multiplied by the grid emission factor to obtain the carbon emission reductions.	2018: 0.1 2019: 0.2 Total cumulative savings- 0.36 Mt CO_2e	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purposes. Increase in jobs due to uptake of renewable energy technologies. Increase in green economy due to uptake of renewable energy technologies.

Renewable Energy Independent Power Producer Procurement programme	The Integrated Resource Plan makes provision for the generation of 17.8 GW of renewable energy by 2030, to be commissioned under the Programme.	Competitive procurement programme, where prospective power producers submit bids to supply Eskom with renewable energy. The Department of Mineral Resources and Energy adjudicates the bids according to various criteria, price being the most critical.	Public sector renewable energy procurement programme.	Eskom	CO_2. Energy	17.8 GW of renewable energy by 2030.	Ongoing – 2011 to present	kWh renewable energy; Reduction of CO_2 through the use of cleaner energy sources	Emission savings (Mt CO_2e) = activity data (GWh) x grid emission factor (tCO_2e/GWh) The secondary activity data sets (electricity generated by renewable energy projects in each year sourced from Eskom Integrated Annual reports) are multiplied by the appropriate annual grid emission factor to yield the emissions that are avoided through the use of renewable energy generation. A conversion factor of 0.277778 was used to convert GJ to MWh in order to convert the coal emission factor to the correct unit. Assumption: Coal generation baseline was assumed.	2012: 1.4 2013: 1.2 2014: 1.3 2015: 2.1 2016: 3.1 2017: 4.0 2018: 3.3 2019: 3.9 Total cumulative savings- 20.44 Mt CO_2e	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purposes. Increase in jobs due to uptake of renewable energy technologies. Increase in green economy due to uptake of renewable energy technologies.
Natural gas fuel switch programme	To provide an economical and eco-friendly energy, by supplying natural gas to CNG refuelling stations, gas distribution networks, industries and power generation systems, and to customers who are not on the	Switch to natural gas from emission intensive fuels	Public and private sector programme	Department of Mineral Resources and Energy	CO_2. Energy sector	Short-term target: 600 vehicles and 1000 minibus taxis converted by Jan 2015, using 330,000 litres gas/month; Medium term targets: 14000 vehicles converted, 28	Ongoing – 2000 to present While an accurate number of converted taxis does not exist at this point, it is estimated that in the Cities of Johannesburg, Tshwane and Ekurhuleni combined there are approximately 1,000 CNG taxis.	tCO2e savings; Reduced emissions from fuel use	The total primary natural gas supply in the country was taken from the Department of Mineral Resources and Energy's Energy Balance. The emission savings from this was assumed to be the difference between the emissions from coal and the emissions from natural gas. In order to calculate the savings, the GJ of gas supplied was	2000 – 2010: 43.3 2011: 6.7 2012: 6.7 2013: 6.3 2014: 7.1 2015: 7.1 2016: 6.4 2017: 6.4 2018: 6.4 2019: 6.4 Total cumulative savings-	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purposes. Increase in jobs due to uptake of energy efficient technologies.

	existing gas network. CNG is transported by road to customers not on the existing gas pipeline and CNG equipment, advice and support provided to help industrial users and transport owners convert to natural gas.					CNG Filling facilities, 28 Conversion workshops, and 7,700,000 Litres equivalent of gas (295,000 GJ) per month dispensed.			multiplied by the difference between the emission factors for coal and natural gas. An assumption for the years 2017 to 2019 was made to equal the 2016 energy balance number. These figures should be updated as the Department of Mineral Resources and Energy releases the energy balance	102.82 Mt CO_2e	Increase in green economy due to uptake of energy efficient technologies.

Table B1.2: Domestic mitigation actions in the transport sector

Name of action	Primary Objective	Description	Nature of action	Administering government/ Agency/ Actor	Coverage	Quantitative goals	Status and Progress (Steps taken or envisaged to achieve the action)	Progress indicators	Methodology and assumptions	Actual emission reductions ($MtCO_2e$ till 2019)	Co-benefits
Bus Rapid Transport System	Promotes the efficient use of energy resources and the limitation of adverse environmental impacts in relation to	Provision of quick and safe public transport by bus. Implemented in Tshwane, Johannesburg, Durban and Cape Town. The reduction of GHG emissions is	Public sector project	Department of Transport and Local Governments	CO_2 Energy sector	Modal shift in Green Transport Strategy: 20% shift of passenger transport from private cars to public transport and non-motorised transport by 2022.	Ongoing – 2007 to 2022 The National Land Transition Act is repealed by the gazetted National Land Transport Act in April 2009. The draft Green Transport Strategy replaced the Public Transport Strategy	kWh savings	ASIF approach (Eichhorst et al. 2018) Weekday average BRT Passenger trips: MyCiti (2011-2019): 56023; GoGeorge (2016-2019): 12949; A Re Yeng (2016-2019): 6663; Libhongolethu (2017-2019): 9882;	2011: 0.001 2012: 0.001 2013: 0.001 2014: 0.001 2015: 0.001 2016: 0.001 2017: 0.001 2018: 0.001 2019: 0.001 Total cumulative	Reduced air pollution due to the mitigation of fossil fuel combustion for energy purposes. Increase in jobs due to uptake of energy

	land transport.	primarily achieved by modal shift from private passenger cars to public transport.				DoT Annual Performance Plan 2019/20: Strategic Goal 3: Improved rural access, infrastructure and mobility; Develop and monitor implementation of detailed Integrated Public Transport Network (IPTN) plans in 16 district municipalities by 2022/23; Strategic Goal 4: Improved public transport services; Fund and monitor implementation of Integrated Public Transport Networks (IPTNs) in thirteen (13) cities by 2022/23; Strategic Goal 4: Improved public transport services; Monitor implementation of the Transport Appeal Tribunal (TAT) Amendment Act.	from August 2017. The City of Cape Town's MyCiTi BRT system started operations in May 2010, just before the 2010 World Cup. Its first service was a shuttle from the Airport to the CBD. The initial Phase 1A trunk and feeder services started operating in May 2011. The Go George BRT system began operation in December 2014. The Tshwane A Re Yeng BRT services began operations in November 2014 with the launch of Phase 1A		(Derived from National Treasury Budget Reports) Average trip length: 23 km (van Ryneveld, 2014) Modal Shift car: 10% minibus-taxi: 61% bus: 8% (DEA, 2016d) Occupancy Car: 1.4 minibus-taxi:14 (Stone et al. 2018) BRT: 56 (derived from DEA, 2016d) Fuel split of road transport modes (Stone et al. 2018) car gasoline: 96% car diesel:4% car hybrid gasoline: 0.02% minibus-taxi gasoline: 92% minibus-taxi diesel: 8% bus diesel:100% Energy consumption factor (L/100km) of road transport (Stone et al. 2018) car gasoline: 7.8 car diesel: 7.4 car hybrid gasoline: 6 minibus-taxi: gasoline: 13.7 minibus-taxi diesel: 12.7 Net calorific values per fuel type (MJ/l) Gasoline:34.2 Diesel: 38.1 (DEA, 2018e) Emission Factors for CO2 per fuel type (kg/TJ) Gasoline:69300 Diesel: 74100 (IPCC, 2006)	savings- 0.01 Mt CO_2e	efficient technologies. Increase in green economy due to uptake of energy efficient technologies.

									GWP (IPCC, 1996) Average trip distance information of GoGeorge; A Re Yeng and Libhongolethu were not available. Modal shift information for GoGeorge; A Re Yeng and Libhongolethu were not available. The modal shift information for Rea Vaya BRT was used instead.		
Transnet Road-to-Rail programme	Promotes the efficient use of energy resources and the limitation of adverse environmental impacts in relation to land transport.	Encourages the shift of freight from road to rail.	Public sector project.	Transnet	CO_2 Energysector	A 30% shift in freight rom road to rail by 2050 (Green Transport Strategy)	Ongoing – 2012 to present Accelerating modal shift from road to rail is included in the Minister of Public Enterprises' Statement of Strategic Intent (SSI). Government's National Climate Change Response White Paper, 2011, identifies a modal shift from road to rail as a flagship carbon mitigation programme for South Africa. (MJ savings and Reduction of CO_2 through switching to a lower intensity mode of transport)	MJ savings	Data sets provided by Transnet.	2012: 0.2 2013: 0.2 2014: 0.5 2015: 0.4 2016: 0.2 2017: 0.6 2018: 0.7 2019: 0.1 Total cumulative savings: 2.88 Mt CO_2e	Reduced air pollution due to the mitigation of fossil fuel combustion for energy purposes. Increase in jobs due to uptake of energy efficient technologies. Increase in green economy due to uptake of energy efficient technologies.

Electric vehicles	Shift to electric vehicle use from internal combustion engine vehicles	The support of EV local development (OEMs, Chargers, and EV innovation), EV businesses including suppliers funding, and banks buy-in on EVs by structuring vehicle finance for EVs	Economic	Department of Environmental Affairs	CO_2, CH_4, N_2O Energy sector	No quantitative goals provided	Ongoing – 2007 to 2025 The charging network in South Africa is growing, there are currently around 214 public chargers in South Africa The DST in partnership with the Technology Innovation Agency (TIA) is supporting the development of electric vehicle components (motors, battery management systems) and research on the use as well as localisation of renewable energy based charging points.	tCO2e avoided	Average battery electric vehicle (BEV) population (2013-2018): 236 (derived from IEA, 2018) Average plugin hybrid electric vehicle (PHEV) population (2015-2018): 456 (derived from IEA, 2018) Distance travelled per vehicle: 21000 km (Stone et al. 2018) Substitution fuel ratio for PHEVs (petrol: electric): 60%/40% Vehicle energy economy: BEV – 0.69 MJ/km PHEV – 1.68 MJ/km fuel split of road transport modes (Caetano et al. 2017) Modal split in baseline scenario: car gasoline: 96% car diesel:4% (Stone et al. 2018) Energy consumption factor (L/100km) of road transport (Stone et al. 2018) car gasoline: 7.8 car diesel: 7.4 Net calorific values per fuel type (MJ/l) Gasoline:34.2 Diesel: 38.1 (DEA, 2018e) Emission Factors for CO_2 per fuel type (kg/TJ) Gasoline:69300 Diesel: 74100 (IPCC, 2006) GWP (IPCC, 1996)	2013: 0.1 2014: 0.2 2015: 1.2 2016: 2.6 2017: 3.4 2018: 3.9 2019: 3.9 Total cumulative savings 15.3 Mt CO_2	Reduce energy consumption; Reduce air pollution

Table B1.3: Domestic mitigation actions in the IPPU sector

Name of action	Primary Objective	Description	Nature of action	Administering government/ Agency/ Actor	Coverage	Quantitative goals	Status and Progress (Steps taken or envisaged to achieve the action)	Progress indicators	Methodology and assumptions	Actual emission reductions ($MtCO_2e$ till 2019)	Co-benefits
Nitrous oxide reduction projects	Reduced nitrous oxide emissions during the production of nitric acid	Reduction of nitrous oxide emissions in nitric acid production	Private sector project	Private sector	N_2O IPPU sector	No quantitative goals provided	Ongoing – 2006 to present	Nitrous Oxide reductions	No calculations were conducted as the emission reductions were available from the data provided by the Chemical Allied Industries Association (CAIA).	17.87 Mt CO_2e	Not quantified
Carbon budgets (only process emissions)	Reduction of CO_2 through the efficient use of energy; cleaner technologies and other measures.	The aim of the carbon budgets is to reduce process related emissions in the industrial sectors and incentivise the uptake of cleaner technologies.		DEFF	CO_2 IPPU sector	No quantitative goals provided	Ongoing – 2017 to present	tCO2e savings	No data available for quantification at the time of writing. Data could be sourced from the pollution prevention plan reports provided by industrial entities to the Department of Environment, Forestry and Fisheries.	To be incorporate when data becomes available	Reduced air pollution due to the mitigation of fossil fuel combustion for energy generation purposes. Increase in jobs due to uptake of energy efficient technologies. Increase in Green economy due to uptake of energy efficient technologies.

Table B1.4: Domestic mitigation actions in the AFOLU sector

Name of action	Primary Objective	Description	Nature of action	Administering government/ Agency/ Actor	Coverage	Quantitative goals	Status and Progress (Steps taken or envisaged to achieve the action)	Progress indicators	Methodology and assumptions	Actual emission reductions ($MtCO_2e$ till 2019)	Co-benefits
Afforestation	Encourages and supports sustainable land use practices, raising awareness and promoting resource conservation ethics.	Department of Environment, Forestry and Fisheries afforestation programmes, including the Working for Land and Working for Ecosystems afforestation programmes.	Regulations and standards	DEFF	CO_2 AFOLU sector (Land sub-sector)	To afforest 100,000 hectares of land in certain parts of the country. Potential emission savings has been estimated at 2.2 Mt CO_2 if 100000ha are afforested (DEFF, 2020[9])	Ongoing – 2006 to present. The National Forestry Action Programme was published in 1997 and had the expressed purpose of mobilising and organising national and international resources and catalysing action to implement programmes and plans in a coordinated manner. A review of the NFAP in 2003, led to the development of the National Forest Policy, a globally adopted framework for national forest policy development, planning and implementation. The process of developing a long-term strategy for the forestry sector was initiated in 2007, resulting in the	tCO2e sequestered; afforested area (ha)	Number of hectares planted/afforested annually were obtained from Forestry South Africa fact sheets[10] Mitigation potential factor: 1.5 t C/ha/yr (DEFF, 2020[9]). Assumption: A plantation reaches a long-term C balance after 5 years (half rotation length).	2000 – 2010: 0.9 2011: 0.07 2012: 0.06 2013: 0.04 2014: 0.03 2016: 0.03 2017: 0.03 2018: 0.04 2019: 0.04 Total cumulative savings 1.3 Mt CO_2	Sustainable, performing ecosystems and increased land productivity. Increased biodiversity and soil quality can improve subsistence farming which can positively impact human health. Improvements in subsistence farming can increase economic livelihoods and therefore resilience to negative climate impacts.

[9] DEFF. (2020). Draft Strategic approach towards the management and enhancement of carbon sinks in the agriculture, forestry and other land-use (AFOLU) sector in South Africa. Department of Environment, Forestry and Fisheries, Pretoria, South Africa.

[10] FSA. (2018). South African Forestry and Forest Product Industry Facts 1980–2018. Forestry South Africa, Pietermaritzburg, KwaZulu-Natal

							Forestry 2030 Roadmap, which was finalised after a two-year period of consultation and deliberation between government and industry. Recently (2019) included plantations >100ha in the GHG emission Reporting Regulation to obtain more accurate data on afforested and deforested areas.				
Conservation Agriculture	Aims are to promote sustainability within the agriculture sector. Reduction of the carbon footprint in Agriculture.	Advocates for implementation of minimum soil disturbance (no-tillage), permanent cover and crop association Increase the absorption of CA into farming of cereal crops,	Programmes	Department of agriculture through Landcare programme and SANBI; Grain SA	CO_2 AFOLU sector (Land sub-sector)	The AFOLU Strategy (DEFF, 20209) indicates that there is 6302642 ha to be converted to CA over the next 20 years. Potential accumulated emission reductions are estimated to be 119Mt CO_2 by 2040.	Ongoing On February the 9^{th} 2018 the Minister published the Draft Conservation Agriculture Policy for public comment, and in August 2018 the Draft Climate Smart Agriculture Strategic Framework was published for public comment.	tCO_2e sequestered; area under conservation agriculture	AFOLU strategy (DEFF, 2020[9]) indicates that conservation area was 14% of the annual crop area in 2018, growing at a rate of 7.5% per year. Annual crop area in 2018: 11 126 022 ha (DEA, 2019[11]). Area extrapolate for each year based on this. Mitigation potential factor: 0.2 tC/ha/yr. DEFF 2020[9] applied a value of 0.3 tC/ha/yr, but not all conservation activities are adopted (Findlater et al,	2000-2010: 3.7 2011: 0.5 2012: 0.6 2013: 0.6 2014: 0.7 2015: 0.7 2016: 0.8 2017: 0.8 2018: 0.9 2019: 1.0 Total cumulative savings: 10.3 Mt CO_2	Reduced soil erosion, improved sustainability and productivity; improved livelihoods. Increased biodiversity and soil quality can improve subsistence farming which can positively impact human health. Improvements in subsistence farming can increase economic livelihoods

11 DEA. (2019). South African National Land-Cover 2018: Report and Accuracy Assessment. Department of Environment, Forestry and Fisheries, Pretoria, South Africa.

									2019[12]) therefore a value of 0.2 tC/ha/yr was applied. Assumptions: Soil carbon was assumed to accumulate for the IPCC default period of 20 years; Annual growth rate in conservation area remains constant at 7.5% per annum.		and therefore resilience to negative climate impacts.
Forest and woodland restoration and rehabilitation	To restore ad rehabilitate forests and woodlands so as to improve sustainability, ecosystem services and biodiversity	Restoring state forests and woodlands stem from the Draft Climate Change Plan for South African Agriculture and Forestry Sectors (2010) and the DAFF Strategic Plan 2015/2016 to 2019/2020.	Regulations and standards	Public sector programme; DEFF	CO_2 AFOLU sector (Land sub-sector)	To restore an additional 80,000 hectares of agricultural land and 2,500 hectares of state forests and woodlands. Furthermore, to replant 8,625 hectares of temporary unplanted (TUP) Category B and C State plantations per annum to address the approximately 30,000 hectares of TUP areas. AFOLU strategy[9] indicates the	Ongoing	tCO2e sequestered; forest area rehabilitated	Number of hectares restored were derived from DAFF Annual Reports. Mitigation potential factor: 1.8 tC/ha/yr (DEFF, 2020[9]). Assumptions: mitigation potential factor is as for indigenous forests; growth occurs for more than 20 years. Clearing of alien invasive species is not included as there was insufficient data	2013: 0.005 2014: 0.009 2015: 0.01 2016: 0.01 2017: 0.02 2018: 0.02 2019: 0.02 Total cumulative savings: 0.1 Mt CO_2	Improved ecosystem services, sustainability and biodiversity. Improved waster use. Creation of jobs

[12] Findlater, K.M., Kandlikar, M., & Satterfield, T. (2019). Misunderstanding conservation agriculture: Challenges in promoting, monitoring and evaluating sustainable farming. Environmental Science & Policy, 100:47-54. doi:10.1016/j.envsci.2019.05.027.

						potential for 6 Mt CO_2 savings by 2040 through the EPWP government programme.			for the quantification of its impacts.		
Thicket restoration	To restore and rehabilitate thickets to reduce land degradation and enhance carbon storage.	Thickets have been shown to have a large carbon storage capacity. Restoration projects involve replanting of thicket vegetation to increase carbo storage in the biomass and soil.	Regulations and standards	Public sector programme; DEFF	CO_2 AFOLU sector (Land sub-sector)	AFOLU strategy[9] indicates the potential for 34 Mt CO_2 savings by 2040 through thicket restoration, with the EPWP government programme estimated to potentially contribute 3.5 Mt CO_2 savings in this time period.	Ongoing	tCO2e sequestered; thicket area rehabilitated	Not yet quantified due to a lack of data.	Emission reductions not yet quantified.	Improved ecosystem services, sustainability and biodiversity. Improved waster use. Creation of jobs

Grassland rehabilitation (VeldCare - LandCare Programe)	To restore ad rehabilitate grasslands and grazing lands and to reduce soil erosion.	Grassland rehabilitation programme. The programme supports grassland rehabilitation by providing a framework to promoting sustainable grazing management that limits topsoil loss and disturbance, enhance forage production and cover and maintain key forage species diversity amongst others.	Regulations and standards	Public sector programme.	CO_2 AFOLU sector (Land sub-sector)	AFOLU Stategy (DEFF, 2020[9]) indicates that there is another 935 000 ha grassland that can be rehabilitated. It is indicated that the EPWP government programmes have the potential to reduce emissions by 0.76 Mt CO_2 over the next 20 years.	Ongoing.	tCO2e sequestered; grassland area rehabilitated	Annual area of rangeland and grazing land rehabilitated or restored under VeldCare was obtained from reported performance of the LandCare Grant in the Annual Division of Revenue Bill. Mitigation potential factor: 0.6 tC/ha/yr (DEFF, 2020[9]). Assumptions: Soil carbon was assumed to accumulate for the IPCC default period of 20 years; Bush encroachment and clearing of alien vegetation was not included due to a lack of information for its quantification.	2007: 0.01 2008: 0.02 2009: 0.02 2009: 0.02 2010: 0.02 2011: 0.03 2012: 0.04 2013: 0.4 2014: 0.5 2015: 0.6 2016: 0.6 2017: 0.6 2018: 0.6 2019: 0.7 Total cumulative savings: 4.25 Mt CO_2	Sustainable, performing ecosystems and increased land productivity. Increased biodiversity and soil quality Reduced soil erosion and degradation. Improved grazing conditions which can lead to improved livelihoods. Job creation.

Table B1.5: Domestic mitigation actions in the waste sector

Name of action	Primary Objective	Description	Nature of action	Administering government/ Agency/ Actor	Coverage	Quantitative goals	Status and Progress (Steps taken or envisaged to achieve the action)	Progress indicators	Methodology and assumptions	Actual emission reductions ($MtCO_2e$ till 2019)	Co-benefits
National Waste Management Strategy	Encourages and supports sustainable land use practices, raising awareness and promoting resource conservation ethics.	Provides the overall approach to national waste management during the lifecycle of waste, including waste avoidance and reduction, re-use and recycling, recovery, and treatment and disposal.	Regulations and standards	Public sector programme.	CH_4 Waste sector	Existing. By 2016: 25% of recyclables diverted from landfill sites for re-use, recycling or recovery.; All metropolitan municipalities, secondary cities and large towns have initiated separation at source programmes; 95% of urban households and 75% of rural households have access to adequate levels of waste collection services; 80% of waste disposal sites have permits; 69 000 new jobs created in the waste sector; 80% of municipalities running local awareness campaigns.(Selected list of goals)	Ongoing – 2011 to present The 2018 Revised and Updated NWMS is released for public comment together with a Status Quo Assessment of Waste Management in South Africa and a State of Waste Report that updates the National Waste Information Baseline Report of 2012 in December 2019. Since implementation of the 2011 NWMS, there are some improvements in waste collection and disposal services, including a successful programme to license landfills and the initiation of separation at source programmes in some metropolitan areas.	t CO2e mitigation; percentage of waste recycled	No calculations were undertaken as part of this report. High-level, secondary data sets were provided (in Mt CO_2e) by the Department of Environment, Forestry and Fisheries for the years 2011-2017. The provided data sets were aggregated per category (biogas, composting and material recovery facility projects) and per year. Assumptions: It was assumed that the waste diversion projects are ongoing and saving the equivalent amount of Mt CO_2e as in the last recorded year (2017).	2000 – 2010: 2.6 2011: 0.2 2012: 0.2 2013: 0.1 2014: 0.2 2015: 0.1 2016: 0.1 2017: 0.1 2018: 0.1 2019: 0.1 Total cumulative savings: 3.69 Mt CO_2e	Prevents pollution of water, soil and air. Reduces waste to landfill which has positive health impacts on society. Stimulate job creation in the green economy through waste reduction, reuse and recycling.

Annex B2: International market-based mechanism actions

Table B2.1: Actions in the Energy Sector (UNFCCC, 2018)

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Bethlehem Hydroelectric project	Generate hydroelectricity, which will be distributed into the currently coal intensive South African grid	From 2009-2023	0.33	CO_2	205391	energy industries	CDM	Registered with issuances	AMS-I.D.
Coega Industrial Development Zone Windfarm	Construction and operation of 25 wind turbines which will generate 141.7 GWh annually	From 2013-2020	0.65	CO_2	0	energy industries	CDM	Registered	ACM0002
De Aar Grid Connected 10 MW Solar Park, South Africa	Construction and operation of a solar park with the rated capacity of 10 MW	From 2013-2020	0.11	CO_2	0	energy industries	CDM	Registered	AMS-I.D.
Trigeneration at Mobile Telephone Networks (MTN), 14th Avenue Commercial Site South Africa	Installation of an on-site, energy efficient, 2.126 MW trigeneration plant	From 2013-2022	0.05	CO_2	0	energy demand	CDM	Registered with a monitoring report/s	AMS-II.K.
Grahamstown Invasive Biomass Power Project	Involves the utilization of wood chips from Invasive Alien Plants as the sustainable biomass feedstock	From 2013-2022	0.15	CO_2	0	energy industries	CDM	Registered	AMS-I.D.
Dassieklip Wind Energy Facility in South Africa	Establish a commercial Wind Energy Facility and associated infrastructure on a site located near the town of Caledon in the Western Cape Province	From 2013-2023	0.40	CO_2	0	energy industries	CDM	Registered	ACM0002

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Prieska Grid Connected 20 MW Solar Park, South Africa	The project envisages the construction and operation of a solar park with the installed capacity of 20.65 MWh. The solar park will be equipped with several arrays of photovoltaic (PV) panels. It is expected that Trina PV solar panels supplied by Gestamp Solar will be used for this project. Produced electricity will be supplied to the Eskom electricity network.	From 2013-2023	0.23	CO_2	0	energy industries	CDM	Registered	ACM0002
Neusberg Grid Connected Hydroelectric Power Plant, South Africa	Building a new anaerobic lagoon for a piggery and line it with an impermeable membrane and seal it with an expandable membrane roof. Harvesting of the biogas produced as an energy source.	From 2014-2021	0.33	CO_2	0	energy industries	CDM	Registered	AMS-I.D.
Kathu Grid Connected 100 MW Solar Park, South Africa	The project development envisages the construction and operation of a solar park with an output capacity of up to and including 100 MW. The solar park will be equipped with a cluster of photovoltaic (PV) panel arrays, and the associated infrastructure. Produced electricity will be supplied to the Eskom electricity network.	From 2014-2023	1.19	CO_2	0	energy industries	CDM	Registered	ACM0002

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Cookhouse Wind Farm in South Africa	African Clean Energy Developments (ACED) is proposing to establish a commercial Wind Energy Facility and associated infrastructure on a site located near the town of Cookhouse in the Eastern Cape Province Of South Africa	From 2014-2024	1.69	CO_2	0	energy industries	CDM	Registered	ACM0002
Red Cap Kouga Wind Farm	Red Cap Kouga Wind Farm (Pty) Ltd is developing the Kouga Wind Farm in Oyster Bay, South Africa. The project will comprise the installation of 32 Nordex N90 2500 HS wind turbines, each turbine of 2.5MW with a total installed capacity of 80 MW. This site will be able to generate 290,500 MWh per year, using a P50 capacity	From 2014-2024	1.32	CO_2	0	energy industries	CDM	Registered	ACM0002
Hopefield wind energy facility in South Africa	The establishment of a commercial wind energy facility and associated infrastructure on a site near Hopefield in the Western Cape Province. This proposed project will be a greenfield wind energy facility.	From 2014-2024	0.86	CO_2	0	energy industries	CDM	Registered	ACM0002
Fuel Switch at Corobrik's Driefontein Brick Factory in South Africa	A complete fuel switch was implemented in December 2007 at Driefontein Brick Factory , This fuel was used in the clay brick –firing tunnel kiln . The fuel conversion was from coal to natural gas and involved the extension of the Sasol- owned	From 2015-2021	0.26	CO2	0	energy industries	CDM	End of crediting period	AMS-III.B.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
	natural gas pipeline and the installation of a combustion system.								
TWE Golden Valley Wind Power Project	The purpose of the TWE Golden Valley Wind Power Project is the construction of a 147.6 MW wind power plant in the Eastern Cape Province of South Africa.	From 2015-2022	1.77	CO_2	0	energy industries	CDM	Registered	ACM0002
Lomati Biomass Power Generation Project in Mpumalanga Province	A greenfield grid-connected biomass cogeneration power plant is proposed at Barberton town, Umjindi municipality, Mpumalanga province, South Africa. The plant will be owned by Lomati Energy (Pty) Ltd, an independent energy company.	From 2015-2024	0.26	CO_2	0	energy industries	CDM	Registered	AMS-I.C.
West Coast 1 Wind Farm in South Africa	The project developer Moyeng Energy (Pty) Ltd is proposing to establish a commercial Wind Energy Facility and associated infrastructure on a site located near the town of Vredenburg in the Western Cape Province of South Africa.	From 2015-2024	1.07	CO_2	0	energy industries	CDM	Registered	ACM0002

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Karoo Renewable Energy Facility (Nobelsfontein Solar PV)	The Karoo Renewable Energy Facility (Nobelsfontein Wind) Project is developed by South African Renewable Green Energy Pty Ltd. The project site is located within the Northern Cape and Western Cape provinces, approximately 34 km south of the town of Victoria West. The majority of the site is located within the Ubuntu Local Municipality, with a smaller portion within the Beaufort West Local Municipality.	From 2014-2024	4.28	CO_2	0	energy industries	CDM	Registered	ACM0002
Rheboksfontein Wind Energy Facility	Micawber 895 (Pty) Ltd is developing the Rheboksfontein Wind Energy Facility (hereinafter the "Project") in Western Cape, South Africa. The project will comprise the installation of 35 Vestas V112 wind turbines, each turbine of 3MW with a total installed capacity of 105 MW and is expected to generate 360,500 MWh/year.	From 2015-2025	1.25	CO_2	0	energy industries	CDM	Registered	ACM0002
Amakhala Emoyeni Grid Connected 138.6 MW Wind Farm, Phase 1, South Africa	The proposed "Amakhala Emoyeni Grid Connected 138.6 MW Wind Farm, Phase 1, and South Africa" project is a Greenfield renewable energy power plant. The aim of the project is to supply wind-generated electricity to the grid of the Republic of South Africa.	From 2016-2026	1.11	CO_2	0	energy industries	CDM	Registered	ACM0002

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Bokpoort Concentrating Solar Power Project, South Africa	The purpose of the proposed project activity is to reduce greenhouse gas emissions by installing a greenfield grid-connected parabolic trough concentrated solar thermal power plant. This type of technology is clean, safe, sound and environmentally friendly in comparison to conventional sources of fossil fuel power generation in South Africa.	From 2016-2026	0.62	CO_2	493366	energy industries	CDM	Registered with issuances	ACM0002
Transalloys Manganese Alloy Smelter Energy Efficiency Project	An industrial energy efficiency project that will reduce the electricity consumption in the production of silicomanganese alloy (a key component in steel making) at its Witbank facility in South Africa	From 2004-2014	0.83	CO_2	648606	energy industries; metal production	CDM	End of crediting period	ACM0002; AM0038
Fuel switch project on the Gluten 20 dryer of Tongaat Hulett Starch Pty (Ltd) Germiston Mill	The purpose of the project is to reduce greenhouse gas emissions and unpleasant offgas smells in a product dryer of Tongaat Hulett Starch (Pty) Ltd by switching fuel from coal to natural gas.	From 2010-2017	0.05	CO_2	0	energy industries	CDM	End of crediting period	AMS-III.B.
The Capture and Utilisation of Methane at the Sibanye Gold Owned Beatrix Mine in South Africa	The proposed project activity involves the destruction and utilisation of methane at this mine.	From 2011-2018	2.00	CH4 CO2	89966	fugitive emissions from fuels	CDM - VCS	End of crediting period (CDM); Registered (VCS)	AM0064

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Tongaat Hulett Sugar Refinery Steam Optimisation Project	The proposed project activity is a steam optimisation project centred on a step change in the sugar crystallisation process that allows for the use of waste heat vapour in the evaporation process as an alternative energy source to the primary steam currently used within this process.	From 2014-2024	0.48	CO_2	0	energy demand	CDM	Registered	AM0018
Use of waste gas at Namakwa Sands in South Africa	The project will use cleaned furnace off-gas, which was previously flared, to generate electricity using internal combustion engines. The actual quantity of gas available for the project depends on the furnace performance and availability.	From 2013-2022	0.51	CO_2	222006	energy industries; manufacturing industries	CDM	Registered	ACM0012
IFM Integrated Clean Energy Project	The purpose of the proposed project activity is to utilise waste furnace off-gas as a source of energy to generate clean electricity and contribute to lower greenhouse gas emissions by replacing fossil fuel-based electricity from the South African national grid.	From 2013-2023	0.86	CO_2	0	energy industries; manufacturing industries	CDM	Registered	ACM0012
SA Calcium Carbide Furnace Waste Gas to Electricity	SA Calcium Carbide (SACC) (Pty) Ltd in Newcastle, South Africa is to develop an electricity generation project utilizing furnace waste gas that has been flared since the construction of the industrial facility.	From 2013-2023	0.21	CO_2	0	manufacturing industries	CDM	Registered	AMS-III.Q.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Hernic's Electricity Generation from Waste Gas Project	The proposed project activity is an initiative to recover combustible waste gas from four existing closed ferrochrome furnaces at Hernic. The envisaged project will use the combustible waste gas in fifteen internal combustion gas engines with a maximum capacity rating (MCR) of 1.698MW each.	From 2014-2024	0.76	CO_2	0	energy industries; manufacturing industries	CDM	Registered	ACM0012
Samancor Chrome Middelburg Electricity from Waste Gas	The proposed project activity is an initiative to recover waste energy in the form of flared waste gas from two existing ferrochrome closed furnaces at MFC. The envisaged project will use the combustible waste gas in an estimated twenty gas engines with a guaranteed maximum continuous rating (MCR) of 1.698 MW2 each.	From 2014-2024	0.95	CO_2	0	energy industries	CDM	Registered	ACM0012
Samancor Chrome Witbank Electricity from Waste Gas	The proposed project activity is an initiative to recover waste energy in the form of flared waste gas from two existing closed ferrochrome furnaces at FMT. The envisaged project will use the combustible waste gas in fourteen gas engines with a guaranteed maximum continuous rating (MCR) of 1.698 MW2 each.	From 2014-2024	0.71	CO_2	0	energy industries; manufacturing industries	CDM	Registered	ACM0012

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Distributed Energy Generation's Waste Heat to Power Project at XAWO	The proposed project activity is an initiative to recover waste heat in a non-combustible waste gas from six existing semi-closed type ferrochrome furnaces at XAWO. The envisaged project will divert the waste heat to an Organic Rankine Cycle (ORC) facility, which will convert low-grade heat into usable electrical energy.	From 2016-2025	0.79	CO_2	0	energy industries; manufacturing industries	CDM	Registered	ACM0012
Kanhym Farm manure to energy project	Kanhym is the biggest pig farm in South Africa, home at any given time to more than 45,000 pigs. The proposal is to build a new anaerobic lagoon upstream from the current one line it with an impermeable membrane and seal it with an expandable membrane roof.	From 2008-2015	0.36	CH4, CO2	0	energy industries; agriculture	CDM	Registered	AMS-I.D.; AMS-III.D.
Manufacture and utilization of bio-coal briquettes in Stutterheim,	The project activity involves setting up a production facility to manufacture bio-coal pellets and briquettes in Sutterheim, Eastern Cape of South Africa. The briquettes shall be sold to existing customers wherein fossil fuel - coal is presently used or proposed to be used, as the primary fuel for generation of thermal energy in absence of project activity. Thus the project activity will replace coal combustion in coal-fired boilers.	From 2015-2024	0.53	CO2, N2O	0	Biomass energy	CDM	Registered	ACM0022

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Mondi Richards Bay Biomass Project	The project activity includes the collection of biomass residues from plantations and nearby Chipping facilities, transported to Mondi Business Paper Richards Bay (hereafter referred to as Mondi), cleaned (for example removal of metal objects and sand), shredded and fired as fuel in a co-fired boiler, replacing coal. The proposed project activity is designed to increase the use of self-generated bark and enable the introduction of third party generated biomass residues as feed into a co-fired boiler for the generation of steam.	From 2005-2015	6.60	CO2, CH4	0	Biomass energy	CDM	Validation Replaced	AMS-I.C.; AMS-III.E.
Green Power for South Africa	The objective of the proposed programme of activities is to install wind and solar projects to generate electricity. The generated electricity will be connected to the national grid	2011-2039	8.63	CO_2	598331	Solar PV	CDM	Registered with issuances	ACM0002
SASSA Low Pressure Solar Water Heater Programme	The objective of the PoA is to install South African Bureau of Standards approved non-pressure storage tank and vacuum tube solar collectors of SASSA to low income households.	2011-2038	2.61	CO_2	99170	Solar water heating	CDM	Registered with issuances	AMS-I.C.
South Africa Renewable Energy Programme (SA-REP)	The purpose of the PoA is to support the development and implementation of small scale grid connected renewable energy project	2012-2040	0.45	CO_2	88537	Solar & wind & other	CDM	Registered with an issuance request	AMS-I.D.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Kuyasa low-cost urban housing energy upgrade project, Khayelitsha (Cape Town; South Africa)	Energy efficiency project involving the installation of solar water heaters, ceiling insulation and compact fluorescent light bulbs (CFLs) in RDP houses.	2005-2012	0.05	CO_2	9532	EE households	CDM	End of crediting period	AMS-I.C.; AMS-II.C.; AMS-II.E.
Compressed Air Energy Efficiency PoA	The purpose of the PoA is to reduce green house gas emissions through the implementation of energy efficiency measures in the compressed air system	2012-2038	0.19	CO_2	0	EE industry	CDM	Validation Terminated	AMS-II.D.
Green Steam Low Pressure Solar Water Heater Programme for South Africa	Installations of low pressure vacuum tube solar water heaters to low income households across South Africa	2011-2039	0.09	CO_2	0	Solar water heating	CDM	Validation	AMS-I.C.
Technology Transfer mechanism Introduction of Vertical Shaft Brick Kiln (VSBK) Technology at Vhavenda Brick South Africa	The project will involve a technology transfer mechanism upgrading from Clamp Kilns to Vertical Shaft Brick Kilns (VSBKs) – proven to be the cleanest and most energy efficient way of firing clay masonry products.	2013-2023	0.16	CH4, CO2	0	EE industry	CDM	Registering	AMS-III.Z.
CDM Africa Wind and Solar Programme of Activities for South Africa	Programme for the installation of either wind or solar projects generating electricity into the national grid across South Africa	2013-2039	13.41	CH4, CO2	0	Solar & wind	CDM	Registered	ACM0002
Market Coke Waste Heat Recovery Project	Exxaro Resources Limited (Exxaro) plans to construct the Market Coke Plant (the project facility) at their Grootegeluk Coal Mine in Limpopo Province of South Africa	2015-2025	1.66	CO_2	0	EE own generation	CDM	Rejected	ACM0012

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Indwe Wind Project	The objective of the proposed project is to construct a grid connected wind energy project in South Africa. It will have installed electricity generation capacity of 57.5 MW. The generated electricity will be sold to Eskom in order to diversify the grid generation.	2012-2041	1.08	CH4, CO2	0	Wind	CDM	End of crediting period	ACM0002
Kloof #3 Ice Chiller project	The project involves the introduction of ice- chiller system where ice would be the prime carrier of chill energy as opposed to water	2010-2017	0.38	CO_2	0	EE industry	CDM	End of crediting period	AMS-II.D.
Sustainability CFL Replacement Programme of Activities in South Africa	The objective of the project is to maintain energy efficiency of S.A s residential lighting stock achieved by the previous Eskom CFL projects by distributing the Compact Flourescent Lamps (CFLs) free of charge	2012-2039	0.21	CO_2	0	EE households	CDM	Registered	AMS-II.J.
Dorper Wind Farm (Pty) Ltd	The objective of the project is to build grid connected wind energy project in South Africa and contribute to the necessary energy expansion needed	2013-2031	6.31	CH_4 , CO_2	0	Wind	CDM	End of crediting period	ACM0002
Omnia Steam Turbine Project	The proposed project activity will generate energy from the wasted pressure release. This will be done by replacing the pressure reducing the valves with a steam turbine which will generate electricity. The technology to be	2009-2016	0.10	CO_2	0	manufacturing industries	CDM	End of crediting period	AMS-III.Q.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
	employed involves the installation of a steam turbine								
Solar Energy and Energy Efficiency in Africa	This programme will install South African Bureau of Standards (SABS) approved solar water heaters and PVA to households free of charge or at minimal cost	2012-2040	0.00	CO_2	0	Solar	CDM	Validation Terminated	AMS-I.D.; AMS-I.J.; AMS-II.C.
Vertical Shaft Brick Kiln (VSBK) Programme of Activities for South Africa	The goal of the PoA is to improve the energy efficiency of the brick firing process n South Africa	2012-2040	0.04	CH_4 , CO_2	0	EE industry	CDM	Validation	AMS-III.Z.
Energy Efficient Cook stoves in South Africa	The proposed small scale CPA involves the installation of energy efficient improved biomass based improved cooking stoves in households	2012-2040	0.22	CO_2 , CH_4 , N_2O	0	EE households	CDM	Registered	AMS-II.G.
NCP fuel switch and energy efficient boiler project	The project is a fuel switch from coal to methane gas at the NCP manufacturing facility	2011-2020	0.36	CO_2	0	Fossil fuel switch	CDM	Validation	AMS-II.D.
Grid Connected Wind Power Plant in Witberg, South Africa	The objective of the project is to reduce green house gases by installing a wind power plant with a generating capacity of 150 MW and supply it into SAs national electricity	2014-2020	2.64	CO_2 , CH_4 , N_2O	0	Wind	CDM	Validation Terminated	ACM0002
Karbochem Combined Heat and Power Project	The project involves the replacement of coal with Sasol gas as energy source for the steam production	2009-2016	1.64	CO_2 , CH_4 , N_2O	0	Fossil fuel switch	CDM	End of crediting period	AM0049

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Cogeneration from Waste Smelter Gas at Richards Bay Minerals in South Africa	The project activity involves the use of the flared waste gas to generate electricity and heat. The cogeneration plant will be made up of 6 internal combustion engines, each providing an electrical output of 1.5MW of electricity. The engines will run entirely on the furnace gas which is currently flared into the atmosphere.	2010-2017	0.20	CO_2 , CH_4 , N_2O	0	EE own generation	CDM	End of crediting period	ACM0012
Refrigeration Plant Efficiency Programme of Activities	The goal of this project is to retrofit commercial refrigeration plants in up to 167 Pick n Pay stores across South Africa		0.35	CO_2 , CH_4 , N_2O	0	EE service	CDM	Validation	AMS-II.E.
South African Wind Power Projects	The goal of the project is to promote the installation of grid connected wind energy generation facilities across South Africa	2012-2019	0.65	CO_2 , CH_4 , N_2O	0	Wind	CDM	Registered	ACM0002
Silicon Smelters Energy Efficiency Improvement Project (Furnace F)	The project will reduce greenhouse gases emissions by reducing the use of fossil fuel based electricity consumption by installing more energy efficient cylindrical rotating electric arc furnace, electrode assemblies, and control and peripheral systems	2012-2022	0.16	CO_2 , CH_4 , N_2O	0	EE industry	CDM	Validation Terminated	AM0038
Tubatse Chrome 30 MW Waste Energy Recovery & Power Generation Project	The waste energy recovery power generation project at Tubatse Chrome will recover thermal energy from exhaust gases removed from	2013-2023	0.98	CO_2 , CH_4 , N_2O	0	EE own generation	CDM	Validation Terminated	ACM0012

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
	6 ferrochrome submerged arc furnaces (SAF)								
Springbok Grid Connected 55.5 MW Wind Farm, South Africa	The aim of the proposed project is to construct and operate a wind farm with an installed capacity of up to 55.5mw and supply electricity generated to the National Grid.	2014-2021	0.64	CO_2 , CH_4 , N_2O	0	Wind	CDM	Registering	ACM0002
Wind and solar PoA in South Africa	The objective of the proposed programme is to install wind and solar projects into the grid of South Africa.	2012-2019	0.12	CO_2 , CH_4 , N_2O	0	Hybrid renewables	CDM	Registered	ACM0002
Renewable Energy Carbon Programme for Africa (RECPA)	The purpose of the programme is to support the development and implementation of small-scale renewable energy projects in South Africa in order to displace grid-connected, fossil fuel based electricity generation, thereby reducing GHG emissions.	2012-2019	0.93	CO_2 , CH_4 , N_2O	0	Hybrid renewables	CDM	Registered	ACM0002
Grid-Connected Wind Power Programme in South Africa	The objective of the proposed programme is to reduce greenhouse gas emissions through the production of electricity from wind.	2013-2020	2.12	CO_2 , CH_4 , N_2O	0	Wind	CDM	Validation Terminated	ACM0002
Waste energy to electricity at ArcelorMittal's Vanderbijlpark Steel, South Africa	The objective of the project is to construct and operate a new waste energy recovery system which consists of the two new direct reduction kilns. It will have an installed power capacity of 40 MW.	2012-2021	1.77	CO_2 , CH_4 , N_2O	0	EE own generation	CDM	Validation Terminated	ACM0012

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
New Denmark Colliery CMM flaring project South Africa	The project proposes destruction of methane from New Denmark Colliery mine by flaring	2010-2017	0.17	CO_2 , CH_4 , N_2O	0	Coal bed/mine methane	CDM	End of crediting period	ACM0008
New Energies Commercial Solar Water Heating Programme in South Africa	The project aims at retrofitting of existing electric water heating technologies with solar based water heating technologies and installation of new solar water heating at at newly built facilities.	2008-2015	0.01	CO_2 , CH_4 , N_2O	0	Solar	CDM	Validation	AMS-I.C.
New England Landfill Gas to Energy Project	The project propose to collect and utilize the landfill gas (LFG) generated at the New England Landfill site.	2010-2017	0.36	CO_2 , CH_4 , N_2O	0	Landfill gas	CDM	End of crediting period	ACM0001
South African Solar Water Heater Programme	The PoA is a programme for the installation of Solar Water Heaters in SA for domestic use	2009-2016	0.05	CO_2 , CH_4 , N_2O	0	Solar	CDM	Validation Terminated	AMS-I.C.
Biomass Energy Generation through Gasification or Direct Combustion in South Africa	The Programme of Activities will involve renewable energy projects in South Africa, where energy will be derived from renewable biomass through gasification or direct combustion.	2012-2020	0.00	CO_2 , CH_4 , N_2O	0	Biomass energy	CDM	Withdrawn Before Publication	AMS-I.C.; AMS-I.D.; AMS-I.F.
Standard Bank Low Pressure Solar Water Heater Programme for South Africa	The objective of the Programme of Activities is to install South African Bureau of Standards (SABS) approved non-pressure (also called low-pressure) Solar Water Heaters to low income households at minimal cost.	2012-2019	1.41	CO_2 , CH_4 , N_2O	0	Solar	CDM	Registered	AMS-I.C.
Caledon Wind Farm in South Africa	The purpose of the project activity is to generate power from wind energy in the Western Cape, South Africa. The electricity will be sold to Eskom.	2015-2025	1.48	CO_2 , CH_4 , N_2O	0	Wind	CDM	Registering	ACM0002

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Grid Connected Wind Power Plant in Klawer, South Africa	The objective of the proposed project is to use wind turbine to generate electricity	2014-2020	0.41	CO_2 , CH_4 , N_2O	0	Wind	CDM	Validation Terminated	ACM0002
Solar Energy Programme for South Africa	The goal of the PoA is to develop Solar PV (Photovoltaic) facilities that will supply renewable electricity into the South African national grid.	2012-2019	2.43	CO_2 , CH_4 , N_2O	0	Solar	CDM	Registered	ACM0002
South African Large Scale Grid Connected Solar Park Programme	The programme seeks to develop a series of grid connected solar power projects that supply clean electricity to either the national grid of the RSA or an identified consumer via RSA's grid.	2012-2019	0.46	CO_2 , CH_4 , N_2O	0	Solar	CDM	Registered	ACM0002
NuPlanet Small Scale Hydropower PoA	The purpose of the project is to support the development of hydropower projects that will supply renewable electricity into the grid.	2012-2019	0.17	CO_2 , CH_4 , N_2O	0	Hydro	CDM	Registered	AMS-I.D.
ACP Thermal Harvesting Project	The aim of the project activity is to convert waste heat into electricity. The ACP Thermal Harvesting™ Project envisages the construction and operation of a Waste Energy Recovery System	2018-2027	0.02	CO_2 , CH_4 , N_2O	0	EE own generation	CDM	Registered	AMS-III.Q.
Southern Cape Cleaner Energy Project	The project activity will reduce greenhouse gas (GHG) emissions by supplying clean electricity into the national grid and replacing electricity generated from fossil fuel sources	2009-2019	0.63	CO_2 , CH_4 , N_2O	0	Biomass energy	CDM	End of crediting period	AMS-I.D.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Capture and combustion of Methane in coal mines	The objective of the proposed PoA is to reduce green house gas emission through capturing and flaring of mine methane.	2012-2019	1.26	CO_2 , CH_4 , N_2O	0	Coal bed/mine methane	CDM	Validation Terminated	ACM0008
Installation of energy efficient ventilation fans at the KDC East Gold Mine in South Africa	The purpose of the PoA is to reduce green house gas emissions through the implementation of energy efficiency ventilation project in underground mining operations	2013-2022	0.21	CO_2 , CH_4 , N_2O	0	EE industry	CDM	Registering	AMS-II.C.
BioTherm Hernic Ferrochrome Cogeneration Project	The aim of this project is to flare the poisonous CO rich off gas produced as a by-product of the smelting process, into CO2. A proposed power generation facility will use the off gas as the primary fuel source. The electricity produced will be fed back into Hernic substation	2011-2021	1.49	CO_2 , CH_4 , N_2O	0	EE own generation	CDM	Validation Terminated	ACM0012
Boskor Renewable Electricity Plant (BREP)	The project activity involves to generate electricity from sawmill residues, for sale onto the national grid.	2008-2018	0.14	CO_2 , CH_4 , N_2O	0	Biomass energy	CDM	End of crediting period	AMS-I.D.
Olifantsrivier Wind	The objective of the proposed project activity is to supply renewable energy, generated from solar resources to the South African national grid	2015-2024	2.88	CO_2 , CH_4 , N_2O	0	Wind	CDM	Validation Terminated	ACM0002
Cogeneration and/or trigeneration at commercial sites	The objective of the proposed project is to install and operate a new 2.136 MWe natural gas based tri-generation unit at an existing site of MTN.	2012-2019	0.03	CO_2 , CH_4 , N_2O	0	EE supply side	CDM	Registered	AMS-II.K.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Langa Energy Photovaltaic Solar Energy Facility, South Africa	The objective of the proposed project is to construct and operate a solar park with installed capacity of about 100 MW of electricity	2013-2023	0.81	CO_2 , CH_4 , N_2O	0	Solar	CDM	Validation Terminated	ACM0002
The Consteel energy efficiency project at Cape Gate, South Africa	The proposed project involves the installation of energy efficient consteel system. The Consteel technology, which was implemented in this project reduces energy consumption of steel production, while also increasing the output	2012-2021	0.15	CO_2 , CH_4 , N_2O	0	EE industry	CDM	Validation Terminated	AMS-II.D.
LED's kick-off	The CDM Programme of Activities (CPA) will involve the distribution of Light Emitting Diode lighting devices in mining and petrochemical plant activities.	2012-2019	0.34	CO_2 , CH_4 , N_2O	0	EE service	CDM	Registered	AMS-II.C.
Microscale solar electrical programme, South Africa	The objective of the proposed Programme of Activities (PoA) is to promote small scale activities (CPAs) that installs solar photovoltaic electrical systems.	2011-2018	0.04	CO_2 , CH_4 , N_2O	0	Solar	CDM	Validation Terminated	AMS-I.F.
ETA Solar Water Heater Programme in South Africa	The objective of the project is increase the use of solar water heaters in residential and commercial applications throughout S.A. by installing and supplying solar water heaters.	2012-2019	0.14	CO_2 , CH_4 , N_2O	0	Solar	CDM	Registered	AMS-I.J.
Residential Hot Water Efficiency Programme in South Africa	The objective of the PoA is to install solar water heaters and heat pumps at residential facilities throughout SA.	2012-2019	0.20	CO_2 , CH_4 , N_2O	0	Solar	CDM	Registered	AMS-I.J.; AMS-II.C.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
South African Grid Connected Wind Farm Programme	The objective of the proposed programme of Activities (PoA) is to contribute to the development and promotion of renewable energy in the South Africa. It seeks to develop a series of grid connected wind power projects	2012-2019	2.20	CO_2 , CH_4 , N_2O	0	Wind	CDM	Registered	ACM0002
Heat Retention Cooking in South Africa	The aim of this project is to introduce a heat-retention cooker known as Wonder bag. This is an insulated container designed to hold a hot-pot safely for several hours, so that food can be cooked through heat retention.	2012-2019	0.37	CO_2 , CH_4 , N_2O	0	EE households	CDM	Validation Terminated	AMS-II.C.
Clanwilliam Hydro Electric Power Scheme	The objective of the project is to supply clean electricity to the grid of the Republic of South Africa. It envisages the construction and operation of a run-off-river hydroelectricity power plant	2008-2015	0.08	CO_2 , CH_4 , N_2O	0	Hydro	CDM	End of crediting period	AMS-I.D.
North West, KwaZulu-Natal & Eastern Cape CFL Replacement Project (2) in South Africa	The proposed Programme of Activities (PoA) objective is to boost the energy efficiency of South Africa's residential lighting stock by distributing Compact Fluorescent Lamps (CFLs) free of charge	2012-2022	0.15	CO_2 , CH_4 , N_2O	0	EE households	CDM	Registered	AMS-II.J.
Southern African Solar Electrical Energy Programme (SASEE)	The objective of the proposed Programme of Activities (PoA) is to promote small scale activities (CPAs) that installs solar photovoltaic electrical systems	2011-2018	0.19	CO_2 , CH_4 , N_2O	0	Solar	CDM	Validation	AMS-I.F.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Sasol Gas Turbine Co-generation at Sasol Secunda Synfuels plant, South Africa	The objective of the project is to substitute some of the electricity imported from Eskom with electricity generated on site at Secunda using natural gas and project fuel	2010-2020	10.84	CO_2 , CH_4 , N_2O	0	EE own generation	CDM	Validation Terminated	AM0049
Grid Connected Photovoltaic (PV) Renewable Electricity Generating Facilities PoA	The goal of the PoA is to develop grid connected concentrated solar power and Photovoltaic (PV) power generating facilities in South Africa	2012-2019	0.13	CO_2 , CH_4 , N_2O	0	Solar	CDM	Registered	ACM0002
Small Scale Grid-connected Solar Power Programme	The objective of the proposed Programme of Activities (PoA) is to promote small scale activities (CPAs) that installs solar photovoltaic electrical systems.	2012-2019	0.08	CO_2 , CH_4 , N_2O	0	Solar	CDM	Registered	AMS-I.D.
Body Coal and Clamp Kiln Fuel Switch at Allbrick, South Africa	The objective of the proposed project involves implementing a fuel switch from coal to charcoal produced from wood waste in the clamp kilns	2013-2022	0.03	CO_2 , CH_4 , N_2O	0	Biomass energy	CDM	Rejected	AMS-III.Z.
Grid Connected Wind Power Plant in Nelson Mandela Bay, South Africa	The project will aim to produce 60 MW of electricity for the NMBM, and will be sold from the project developer to the Municipality on a yearly basis. This will replace the conventional manner of relying on coal to produce electricity	2013-2020	0.45	CO_2 , CH_4 , N_2O	0	Wind	CDM	Validation	ACM0002
Compressed air energy efficiency at Harmony Gold Mining Company	The objective of the proposed project activity is to reduce green house gas emissions through the implementation of energy efficiency measures in the compressed air	2012-2022	0.24	CO_2 , CH_4 , N_2O	0	EE industry	CDM	Validation Terminated	AMS-II.D.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Installation of energy efficient ventilation fans at South Deep and Beatrix Gold Mines in South Africa	The purpose of the PoA is to reduce green house gas emissions through the implementation of energy efficiency ventilation project in underground mining operations	2013-2022	0.13	CO_2 , CH_4 , N_2O	0	EE industry	CDM	Registered	AMS-II.C.
Gauteng, Free State, Mpumalanga, Limpopo & Northern Cape CFL Replacement Project (1) in South Africa	The objective of the PoA is to boost the energy efficiency of South Africa's residential lighting stock by distributing Compact Fluorescent Lamps (CFLs) free of charge to households across South Africa	2012-2022	0.16	CO_2 , CH_4 , N_2O	0	EE households	CDM	Registered	AMS-II.J.
Biomass residues power generation Programme	The Biomass residues power generation Programme aims to promote and support the implementation, replacement or retrofit of power-and-heat plants	2014-2021	1.35	CO_2 , CH_4 , N_2O	0	Biomass energy	CDM	Registered	ACM0006
Electricawinds 30 MW Wind Project at Riverbank	The project will see Electrawinds Seweco (Pty) Ltdinstall 10 wind turbines of 3 MW, making a total power capacity of 30 MW for this project. Together the 10 wind turbines will generate 80,300 Gwh annually	2013-2020	0.57	CO_2 , CH_4 , N_2O	0	Wind	CDM	Validation Terminated	ACM0002
Hot Water Heating Programme for South Africa	The objective of this small scale programme of activities is to install heat pumps and solar water heaters throughout South Africa	2012-2019	0.08	CO_2 , CH_4 , N_2O	0	Solar	CDM	Registered	AMS-I.C.; AMS-II.C.
South Africa Wind Energy	The objective of the proposed Programme of Activities (PoA) is to construct and operate wind farms in South Africa.	2012-2019	0.66	CO_2 , CH_4 , N_2O	0	Wind	CDM	Registered	ACM0002

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Karoo Renewable Energy Facility (Nobelsfontein Solar PV)	The objective of the proposed project activity is to supply renewable energy, generated from solar resources to the South African national grid,	2015-2024	0.37	CO_2 , CH_4 , N_2O	0	Solar	CDM	Registered	ACM0002
Small Scale Renewable Energy Carbon Programme (SRECP)	The purpose of the programme is to support the development and implementation of small-scale renewable energy projects in South Africa	2012-2019	0.16	CO_2 , CH_4 , N_2O	0	Hybrid renewables	CDM	Registered	AMS-I.D.
Installation of energy efficient ventilation fans	The goal of the Programme of Activities is to reduce greenhouse gas emissions through the installation of energy efficiency ventilation fans at sites across South Africa	2012-2019	0.41	CO_2 , CH_4 , N_2O	0	EE industry	CDM	Validation Terminated	AMS-II.C.
Lighting up Africa	Solar Lamp Project will replace kerosene-based lighting with purpose designed solar lamps	2014-2024	0.00	CO_2	0	1. Energy (renewable/ non-renewable)	VCS	Registered	ACM0002
The Capture and Utilisation of Methane at the Sibanye Gold Owned Beatrix Mine in South Africa	The proposed project activity involves the destruction and utilisation of methane at this mine.	2011-2020	0.08	CH_4 , CO_2	9643	11. Fugitive emissions from industrial gases	VCS	Registered	AM0064
Saving the Planet, one stew at a time	This project regards broad adoption of a heat-retention-cooking device in kitchens throughout South Africa. By using the device trademarked the "Wonderbag"	2010-2020	0.51	CO_2	159221	1. Energy (renewable/ non-renewable)	VCS	Registered	AMS-II.C.

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
BRT REA VAYA PHASE 1A AND 1B, SOUTH AFRICA	The objective of the project is to establish an efficient, safe, rapid, convenient, comfortable and effective modern public transport system based on articulated buses which run on separated exclusive bus trunk lanes	2009-2021	0.40	CO_2 , CH_4 , N_2O	0	7. Transport	VCS	Registered	AM0031
Ngodwana Biomass to Energy Project	The proposed project activity concerns a newly built, greenfield biomass to energy plant, situated in the Mpumalanga Province. Residual biomass feedstock (i.e. biomass by-products, residues and waste streams) will be sourced from Sappi Southern Africa Ltd.'s Ngodwana Mill operations for the generation of power.	2020-2030	0.00	CO_2	0	1. Energy (renewable/ non-renewable)	VCS	Registration Requested	ACM0018
Longyuan Mulilo De Aar 2 North Wind Energy Facility	The project envisages the installation of a new grid connected wind farm on a farm located in the Pixley Ka Seme District close to the town of De Aar in the Northern Cape Province	2017-2020	0.87	CO_2	0	1. Energy (renewable/ non-renewable)	VCS	Registration Requested	ACM0002
Longyuan Mulilo De Aar Maanhaarberg Wind Energy Facility	The project envisages the installation of a new grid connected wind farm on a farm located in Swartkoppies and Maanhaarberge mountains to the south west of the town of De Aar in the Northern Cape Province	2017-2020	0.57	CO_2	0	1. Energy (renewable/ non-renewable)	VCS	Registration Requested	ACM0002
One True Measure (Pty) Ltd Solar PV Grouped Project in South Africa	Purpose of the grouped project is to generate electricity by using	2014-2024	0.01	CO_2	0	1. Energy (renewable/	VCS	Under Validation	AMS-I.F

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
	solar PV technology, and to deliver the electricity to the users.					non-renewable)			

Table B2.2: Emission Reductions of Actions in the IPPU Sector

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
Project for the catalytic reduction of N2O emissions with a secondary catalyst inside the ammonia reactor of the No. 9 nitric acid plant at African Explosives Ltd ("AEL"), South Africa	The sole purpose of the proposed project activity is to significantly reduce current levels of N2O emissions from the production of nitric acid at one of AEL's nitric acid plants (the "No. 9 Plant") at Modderfontein, South Africa.	From 2007-2017	1.40	N_2O	348255	chemical industries	CDM	Registered	AM0034
Sasol Nitrous Oxide Abatement Project	Nitrous Oxide (N2O) is an undesired by-product gas from the manufacture of nitric acid. Nitrous oxide is formed during the catalytic oxidation of Ammonia. Over a suitable catalyst, a maximum 98% (typically 92-96%) of the fed Ammonia is converted to Nitric Oxide (NO).	From 2007-2021	11.52	N_2O	4340063	chemical industries	CDM	Registered	AM0034
Omnia N2O Abatement Project II	A new nitric acid plant is currently being built and expected to be commissioned in the first half of 2012. This new plant is designed by Uhde GmbH with a confirmed production capacity of 400,000 tonnes 100% concentrated nitric acid per year.	From 2012-2022	2.44	N_2O , CO_2	1696219	chemical industries	CDM	Registered	ACM0019

Omnia Fertilizer Limited Nitrous Oxide (N2O) Reduction Project	The project activity involves the installation of an N2O catalytic Destruction Facility, EnviNox™, in the tail gas section of the process downstream of the absorption column at Omnia Fertilizer nitric acid plant in Sasolburg, South Africa.	From 2008-2022	5.21	CO_2 , N_2O	3439556	chemical industries	CDM	Registered	AM0028
N_2O abatement project at AEL 9_	This project aims at reducing waste gas emissions of nitrous oxide (N2O) produced during the production of nitric acid (HNO3).	2007-2027	1.12	N_2O	67 604 (CDM)	5. Chemical Industry	VCS	Registered	AM0034 (Version 2)
N_2O abatement project at AEL 11_	This project aims at reducing waste gas emissions of nitrous oxide (N2O) produced during the production of nitric acid (HNO3).	2008-2028	2.97	N_2O	332 002 (CDM)	5. Chemical Industry	VCS	Registered	AM0034 (Version 2)

Table B2.3: Emission Reductions of Actions in the Agriculture, Forestry and Other Land Uses Sector

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Co-benefits per sectoral scope	Credit type	Project Status	Methodology Reference
Kuzuko Lodge Private Game Reserve thicket restoration project	he project is restoring more than 5000 hectares of degraded thicket vegetation in the Kuzuko Lodge Private Game Reserve in the Eastern Cape of South Africa. The restoration entails planting cuttings of the indigenous thicket tree, Portulacaria afra – commonly known as spekboom – into desertified landscape	2014-2040	0.22	CH_4 , N_2O	0	14. Agriculture, Forestry, Land Use		VCS	Registered	AR-ACM0003
Renencom Afforestation/Reforestation Grouped Project	Renencom's afforestation project (project 1) consisted of planting of Bamboo on land situated within South Africa (Magaliesburg) which is unutilized (fallow grassland)	2010-2030	0.00	CO_2	0	14. Agriculture, Forestry, Land Use		VCS	Registered	AR-AMS0007
Peri-urban bamboo planting around South African townships	As part of the project bamboo plantations will be planted and managed under the Bamboo for Africa (BFA) Programme using funding specifically earmarked by sponsors for carbon offsetting. Plantations will be on community-owned, marginal lands and small holdings on the outskirts of townships across South Africa	2011-2031	0.13	CO_2 , CH_4	0	14. Agriculture, Forestry, Land Use		VCS	Registered	AR-AMS0002

Tree Planting in South African townships	The project will plant fruit trees and indigenous trees in townships across South Africa using funding specifically earmarked by sponsors for carbon offsetting	2011-2051	0.00	CO_2, CH_4	0	14. Agriculture, Forestry, Land Use		VCS	Registered	AR-AM0002

Table B2.4: Emission Reductions of Actions in the Waste Sector

Name of Project	Project description	Time Horizon	Actual Emission Reductions (MtCO2e) i.e. results achieved till 2019	Coverage (Greenhouse Gas Targeted)	Amount of CERs issued	Sector	Credit type	Project Status	Methodology Reference
EnviroServ Chloorkop Landfill Gas Recovery Project.	The objective of the project is to extract landfill gas at the Site and combust the landfill gas (LFG) by flaring. Landfill gas consists of approximately 50% methane, which has a global warming potential 211 times greater than CO2. Through the destruction of methane, the emissions of greenhouse gases are reduced.	From 2008-2022	2.07	CH_4 , CO_2	857308	energy industries; waste	CDM	Registered	AM0011
Alton Landfill Gas to Energy Project	The objective of the Project is to collect and destruct/utilize the LFG generated at the closed Alton landfill. The purpose of LFG flaring is to dispose of the flammable constituents, particularly methane, safely and to control odour nuisance, health risks and adverse environmental impacts. Hence this will involve investing in a highly efficient gas collection system as well as flaring equipment.	From 2009-2019	0.26	CH_4 , CO_2	0	energy industries; waste	CDM	Registered	AMS-I.D.; AMS-III.G.
Ekurhuleni Landfill Gas Recovery Project – South Africa	The Ekurhuleni Metropolitan Municipality (the EMM) is proposing a CDM project activity at four landfills owned by the EMM in Gauteng province, South Africa. Greenhouse gas emission reductions will be achieved by the combustion of recovered methane contained in landfill gas that would be otherwise emitted to the atmosphere and by the generation of electricity from the gas which will displace largely coal-fired power generation on the South African grid.	From 2010-2017	2.54	CH_4 , CO_2	62526	13. Waste handling and disposal	CDM	Registered	ACM0001

PetroSA Biogas to Energy Project	PetroSA is a state owned corporation that has since 1987 operated a gas to liquids plant at Duinzicht, some 12 kilometres from the town of Mossel Bay on the south coast of South Africa. The production process at Duinzicht leads to waste process water that since the inception of the Plant has been dealt with by way of anaerobic digestion. The anaerobic digestion is continuous and a critical process for the operation of the PetroSA plant. In the anaerobic digestion process biogas is naturally generated.	From 2006-2017	0.36	CH_4 , CO_2	32730	waste	CDM	Registered	AMS-I.D.
Tugela Mill Fuel Switching Project	Currently, thermal energy produced for use at the Tugela Pulp and Paper Mill is supplied by coal fired boilers. Reducing the inputs of bark into landfill will result in climate benefits, by reducing emissions of methane to the atmosphere, as well as reducing pressure on the capacity of the existing landfill.	From 2007-2015	0.62	CH_4 , CO_2	104938	waste handling and disposal	CDM	Registered	AMS-I.C.
Durban Landfill-gas-to-electricity project ? Mariannhill and La Mercy Landfills	The project involves the recovery of landfill methane for electricity generation	2006-2020	0.89	CH_4 , CO_2	275745	Landfill power	CDM	Registered with issuances	AM0010
Small-scale solar electrical programme, South Africa	Installation of solar electrical systems at the demand-side where there was no solar electrical system operating prior to the implementation of the activity; or a capacity addition envisages an increase in the installed power generation capacity of an existing solarelectrical system	2012-2040	0.11	CO_2	0	13. Waste handling and disposal	CDM	Registered	AMS-I.D.; AMS-I.F.

City of Cape Town Treatment of Organic Waste Streams CDM Projects	The project objective is to capture the biogas produced by the anaerobic digestion (AD) of sludge at waste water treatment works. The biogas produced will be combusted to generate "green energy" (electricity and heat) on site, at waste water treatment facilities, within the Cape Town area	2013-2041	0.29	CH_4 , CO_2	0	13. Waste handling and disposal	CDM	Validation Terminated	AMS-I.C.; AMS-III.H.
City of Cape Town Landfill Gas Extraction and Utilisation Programme	The objective of the PoA is to capture and combust landfill gas (LFG) to generate electricity and heat at solid waste disposal sites (landfills) in the municipality of Cape Town, South Africa.	2014-2021	0.17	CH_4 , CO_2	0	Landfill gas	CDM	Registered	ACM0001
Buffalo City Landfill Gas to Electricity Project	The objective of the project is to extract the biogas produced by three Buffalo City Municipality owned landfill sites and use it to generate electricity.	2010-2020	0.31	CO_2 , CH_4 , N_2O	0	Landfill gas	CDM	Validation Terminated	ACM0001
Anaerobic Digestion and Renewable Energy Generation in South Africa	The objective of the Programme of Activities is to generate renewable energy through anaerobic digestion and biogas-based energy generation.	2013-2020	0.02	CO_2 , CH_4 , N_2O	0	Methane avoidance	CDM	Registered	AMS-I.C.; AMS-III.AO.; AMS-III.D.
Humphries Boerdery (Edms) Bpk piggery methane capture and electricity generation	The project aims at generating electricity from anaerobic digestion of piggery manure at the Humphries Boedery Farm near Bela-Bela.	2009-2016	0.08	CO_2 , CH_4 , N_2O	0	Methane avoidance	CDM	End of crediting period	AMS-I.D.
City of Cape Town Treatment of Organic Waste Streams CDM Projects	The project objective is to capture the biogas produced by the anaerobic digestion (AD) of sludge at waste water treatment works. The biogas produced will be combusted to generate "green energy" (electricity and heat) on site, at waste water treatment facilities, within the project	2013-2020	0.13	CO_2 , CH_4 , N_2O	0	Methane avoidance	CDM	Validation Terminated	AM0025
Landfill Gas Utilisation Programme of South Africa	Under thisPoA, landfill gas (LFG) will be captured at participating landfills in South Africa.	2012-2019	0.34	CO_2 , CH_4 , N_2O	0	Landfill gas	CDM	Validation	ACM0001

Reliance Composting Project in Cape Town	Using "green" waste – in the form of plant material – collected from drop-off facilities within the City of Cape Town Municipality (CoCT), Reliance produces compost that is suitable for both conventional and organic farming.	2008-2027	0.54	CO_2 , CH_4	74396	13. Waste handling and disposal	VCS	Registered	AMS-III.F
Interwaste Landfill gas Grouped Project	Interwaste has developed a municipal waste landfill gas recovery project and is looking towards producing compressed biogas fuel that can be supplied in to external customers with the distribution in trucks. The project instance is located at the Interwaste FG landfill site.	2016-2016	0.12	CO_2 , CH_4	76438	1. Energy (renewable/non-renewable) waste	VCS	Registered	ACM0001
Joburg Landfill Gas to Energy Project	The objective of the project is to collect and destroy/utilise the LFG generated at the Johannesburg landfill sites.	2012-2020	2.13	CH4, CO2	94527	13. Waste handling and disposal	VCS	Registered	ACM0001
Durban Landfill-Gas Bisasar Road	The project consists in an enhanced collection of landfill gas at the Bisasar Road landfill site of the municipality of Durban and the use of the recovered gas to produce electricity. The produced electricity will be fed into the municipal grid and replace electricity that the municipal electric company is currently buying from other suppliers.	2009-2023	3.79	CO_2 , CH_4	124884	13. Waste handling and disposal	VCS	Registered	AM0010
The New Horizons (ATHLONE) Waste to Energy Project	The New Horizons (Athlone) Waste to Energy Project aims to improve municipal solid waste (MSW) management through the installation of a unique materials recovery facility (MRF) and an anaerobic digestion system.	2017-2026	0.06	CH_4	0	13. Waste handling and disposal	VCS	Under Development	ACM0022

ANNEXURE C: FINANCIAL SUPPORT DETAILS

Annex C1: Bilateral financial support

Table C1.1: Additional information on bilateral financial support committed between 2018 and 2019.

Financial Flows/ Support	Donor	Amount in (ZAR)	Amount in USD	Type of funding						Principal Focus Official Development Assistance	Co-Financing (USD)	Specific Purpose of Funding
				Mitigation	Adaptation	Capacity Building	Technical Support	Technology Support	General			
Grant	Belgium - Government of Flanders	64 079 071	4 858 155		X							Department of Environmental Affairs (DEA) Adaptive Capacity Facility.
Grant	Belgium - Government of Flanders	137 770	10 444		X							Formulation of a project proposal for the DEA on Climate Change Adaptation.
Grant	Belgium - Government of Flanders	641 446	48 631		X							Harnessing Climate Change Adaptation for SMME Development in SA: Experiences from the Water Sector (TIPS).
Grant	Belgium - Government of Flanders	6 406	118 347		X							Support to the DEA for the hosting of the 2019 Partnership for Action on the Green Economy (PAGE) Ministerial Conference.

Grant	Belgium - Government of Flanders	15 188 436	1 151 511		X							Towards an inclusive green economy by showcasing sustainable land use management projects in the Kruger to Canyons Biosphere Region (Kruger to Canyons National Planning Commission).
Grant	Belgium - Government of Flanders	12 510 619	948 493		X							Communal Agricultural Transformation (CAT) Empowering People - Restoring Land (Olive Leaf Foundation).
Grant	Belgium - Government of Flanders	14 426 419	1 093 739		X							Micro Aquaponics Lappies – Proof of concept of community embedding (Belgium Campus).
Grant	Belgium - Government of Flanders	16 593 414	1 258 030		X							Towards Enhanced Climate Change Adaptation and an Inclusive Adaptive Green Economy in South Africa (Idalo Inclusive).
Grant	Belgium - Government of Flanders	12 846 640	973 968		X							Enabling community-based adaptation in the Mkhuze River Ecosystem, KwaZulu-Natal (Wildlands).
Grant	Belgium - Government of Flanders	508 747	38 571		X							Consultancy services: call for proposal: Climate Change Adaptation and the Inclusive Adaptive Green Economy.
Grant	Belgium - Government of Flanders	468 300	35 504		X							Consultancy gender mainstreaming.

Grant	Belgium - Government of Flanders	26 225	1 988		X							Facilitation of strategic planning workshop in the framework of Country Strategy III (Government of Flanders–Government of South Africa).
Grant	Belgium - Government of Flanders	1 560 539 505	86 889 727		X							Building climate resilience of coastal communities, ecosystems and small-scale fishers through implementing community and ecosystem-based adaptation activities (WWF).
Grant	Belgium - Government of Flanders	1 559 231 387	114 456		X							Women for Climate Justice (GenderCC SA): Building resilience and reducing vulnerability of smallholder farmers by focusing on mango farming enterprises, water and ecosystem-based services to reduce negative impacts of climate change.
Grant	Belgium - Government of Flanders	1 560 539 505	118 312 320		X							Support to the DEA for the hosting of the 2019 PAGE Ministerial Conference.
Grant	Belgium - Government of Flanders	1 559 231 387	118 213 145		X							Street Art Meets Climate Change competition (WTG Media house) Formulation of a project proposal for the DEA on Climate Change Adaptation.
Grant	Denmark	8 840 000	641 044	X		X						Danish–South African Energy Partnership Program: Decouple economic growth in the Republic of South Africa from the growth in the overall

												Greenhouse Gas (GHG) emissions. The intermediate objective is to increase the deployment of low carbon technologies in the energy sector.
Grant	Denmark	8 840 000	641 044	X		X						Strategic Water Sector Program: The purpose of the program is to support the South African government agencies and other relevant stakeholders in developing and implementing strategy, management and regulatory frameworks to contribute to the National Water Resource Strategy (2013), namely that “*water is efficiently and effectively managed for equitable and sustainable growth and development.*”
Grant	Denmark	8 840 000	641 044	X		X						Strategic Smart and Sustainable Cities Sector Cooperation Programme with the City of Tshwane: The program focuses on solutions to create smart and sustainable cities by exchanging know-how on regulatory frameworks between the two cities and extending networks of competences within the private sector. More specifically, the program focuses on activities around: • City planning and development

												• Growth – business, workplaces and livelihood • Water and energy.
Grant	Denmark	2 684 394	203 517	X								Implementation of 'Smart Metering' in South Africa: Danish RE EE Program Advisory Board, at its meeting 22 March 2018, approved that the remaining unspent funds to be transferred to WASA to support the WASA 1 masts until December 2018. An Addendum to the WASA 2 Agreement was made to extend the WASA 2 Agreement, as well as the operation of the WASA 1 masts by the CSIR to Dec 2018, and to raise funds in support of WASA 1 masts April 2018 to Dec 2018.
Grant	European Union	789 408	59 849	X	X	X						Sustainable use of natural resources to improve resilience in South Africa: A grassroots women's initiative – Implemented from 2013 to 2018 by OXFAM GB.
Grant	European Union	1 796 293	136 186	X	X				X			Natural Resource Conservation and Management for the Generation of Water-linked Green Economy in the Eastern Cape and Southern KwaZulu-Natal, South Africa – Implemented from 2013 to 2018 by EWT.

Grant	European Union	26 380 000	2 000 000	X	X	X	X					SWITCH Africa Green I - Supporting SMEs in the area of SCP - Dedicated SA call Implemented from 2013 to 2018 by United Nations Environment Programme (UNEP)- United Nations Development Programme (UNDP) and DEA.
Grant	European Union	16 548 000	1 200 000	X	X	X						PAGE – Implemented from 2015 to 2020 by UNEP, ILO, UNDP, UNIDO, UNITAR in 17 countries, SA being one of them.
Grant	European Union	105 520 000	8 000 000	X	X		X					Green Economy Coalition (to support knowledge platforms and dialogue hubs). SA is one of beneficiaries – Implemented from 2016 to 2020. Implemented agencies in SA are: TIPS and African Centre for green Economy.
Grant	European Union	7 195 000	500 000		X	X						Inclusive Green Economy Policy Making for Sustainable Development Goals: from Implementation to Evaluation – Implemented from 2016 to 2019 by UNEP in three countries, SA being one of them.
Grant	European Union	4 730 497	328 735	X		X	X	X				H2020 - AfriAlliance: Africa-EU Innovation Alliance for Water and Climate – Implemented from 2016 to 2021. Implementation partners in SA: Council for Scientific and

												Industrial Research (CSIR), Water Research Commission, ICLEI.
Grant	European Union	22 304 500	1 550 000	X	X	X						Promoting market-based deployment of clean energy technology solutions in municipal waterworks: Pilot Initiative in South Africa – Implemented from 2017 to 2019 by UNIDO and REEEP.
Grant	European Union	3 358 444	243 542	X			X					Entrepreneurial and Environmental Empowerment for South Africa’s Youth – Implemented from 2017 to 2020 by Teach A Man to Fish, WESSA and BWDT
Grant	European Union	105 520 000	8 000 000	X	X	X						Urban Low Emissions Development Strategy (LEDS) II: Promoting Urban Low-Emissions Development Strategies in Emerging Economy Countries – Implemented from 2017 to 2021 by UN-HABITAT and ICLEI in 8 countries, SA being one of them.
Grant	European Union	2 516 408	174 872	X	X	X	X					Climate Reality Project: Promoting Broader and Effective Participation of South African Civil Society in Environmental Governance – Implemented from 2017 to 2021 by Foods and Trees for Africa.

Grant	European Union	5 845 412	322 483	X	X	X	X					SWITCH Africa Green II - Smallholder access to high value horticultural markets – Implemented from 2018 to 2020 by Solidaridad.
Grant	European Union	3 676 633	248 016	X	X	X	X					SWITCH Africa Green II - Promoting Inclusive Sustainable Practices in the South African Clay Brick Sector – Implemented from 2018 to 2020 by Clay Brick Association.
Grant	European Union	4 814 864	1 200 000	X		X		X				SWITCH Africa Green II - Waste to Wing – Greening African Aviation – Implemented from 2018 to 2020 by Waste to Wing (currently suspended).
Grant	European Union	40 031 650	3 035 000	X	X		X					H2020 - PreMa: Energy efficient, primary production of manganese ferroalloys through the application of novel energy systems in the drying and pre-heating of furnace feed materials – Implemented from 2018 to 2022. Implementation Partners in SA: MINTEK, Transalloys Pty Ltd, SU.
Grant	European Union	2 677 570	165 000	X			X					Strategic partnerships for the implementation of the Paris Agreement (SPIPA) – Implemented from 2019 to 2021 by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)-South Africa Bilateral Component, noting that South Africa is also benefitting from SPIPA multi-

												country actions with additional funding.
Grant	European Union	10 552 000	800 000	X		X	X					Transition towards the circular economy - economic and policy analysis – Implemented from 2018 to 2021 by OECD, SA being one of them.
Grant	European Union	1 079 250	75 000	X		X						Dialogue Facility: South Africa’s Science, Technology and Innovation Circular Economy Agenda – Implemented in 2019 by the Department of Science and Innovation
Grant	European Union	3 057 875	212 500	X			X					H2020 - Southern Ocean Carbon and Heat Impact on Climate. Implemented from 2019 to 2023. Implementing partner in SA: CSIR.
Grant	European Union	60 674 000	4 600 000	X		X	X					Partnership for Market Readiness – Implemented by the World Bank and the SA National Treasury from 2017 to 2020.
Grant	European Union	57 560 000	4 000 000	x	x		x	x				CfP Climate Change champions: Support to CSOs – To be committed in 2020. Implementation from 2021 to 2025.
Grant	European Union	120 000 000	909 780	X		X						The overall objective of the programme is to achieve a net zero energy and emissions reduction through improving and optimizing energy

												consumption of the municipality's wastewater treatment plants and the government buildings energy ratings. The project will be implemented from 2020-2022.
Loan	France: Agence Française de Développement	1 453 140 000	110 169 826	x								Society in Environmental Governance – Implemented from 2017 to 2021 by Foods and Trees for Africa.
Grant	France: Agence Française de Développement	5 166 730	374 672	x					X			Energy Research Centre (University of Cape Town) - Modelling energy consumption. Assignment of an international expert.
Grant	France: Agence Française de Développement	5 489 000	416 149	x	x							Studies about climate risk and vulnerability, and alternative energy.
Grant	France: Agence Française de Développement	2 421 000	183 548	x					X			Consumer Price Index study - Understanding the impact of a low carbon transition on South Africa.
Loan	France: Agence Française de Développement	2 155 200 000	156 287 165	x								2 South-African banks.
Grant	France: Agence Française de Développement	53 880 000	4 023 898	x								South African National Energy Development Institute (SANEDI).
Grant	France: Agence Française de Développement	3 771 600	273 503	x								Passenger Rail Agency of South Africa (PRASA)
Grant	Germany: German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety	249 760 000	18 935 557	x	x							Climate Support Programme. The project supports the South-African DEA in implementing the national climate change

	(BMUB). Implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)											response policy in the areas of mitigation, adaptation and MRV. In addition, the DEA will be strengthened in its catalytic role to induce other departments and the private sector to implement concrete, climate-relevant projects.
Grant	German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMUB). Implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)	67 513 250	5 118 518	X								Energy Efficiency in Public Buildings and Infrastructure Programme within the framework of the Nationally Appropriate Mitigation Actions Facility.
Grant	German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMUB)(2015 to 2018)	5 164 850	358 267	x	x	x	x		x			Project name: Low Carbon Development Frameworks in South Africa. The project builds on the DEA's programme under the White Paper and supports its further rollout across government and uptake by non-governmental role players in business and civil society. It does this through driving highest realistic mitigation ambition at sectoral level, based on evidence and deeper analysis than has been possible

												to date in the DEA process, and through providing knowledge and perspectives independent of government and business, both of which can be perceived as partisan to their special interests.
Grant	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW.	62 440 000	4 733 889									Promotion of Innovation in procurement of Renewable Energy and Preparation of Regional Transmission Lines.
Grant	Germany: German Federal Ministry for Economic Affairs and Energy (BMWi). Implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)	187 320 000	14 201 668	X								South African-German Energy Partnership. Supports the development of a sustainable energy infrastructure (in particular low-carbon electricity production through the use of renewable energies) and increasing energy efficiency in South Africa.
Grant	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW (German Development Bank).	156 100 000	11 834 723	X	X							Green Goal – Non-Motorized Transport: Johannesburg, eThekwini, Polokwane
Grant	Germany: German Federal Ministry for Economic Cooperation and	280 980 000	21 302 502	X								Renewable Energy in South African Municipalities (RESAM),

	Development (BMZ). Implemented by KfW.											Municipality of Nelson Mandela Bay.
Grant	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW.	577 570 000	43 788 476	X								Small IPP Support Programme / FIRST
Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ) + IDC. Implemented by KfW.	1 170 750 000	88 760 425		X							South African Facility for Green Growth.
Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ) + DBSA. Implemented by KfW.	2 965 900 000	224 859 742	X								Programme for Renewable Energies and Energy Efficiency in the Southern African Power Pool.
Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ) + HIS. Implemented by KfW.	388 610 950	29 462 543	X	X							Energy Efficient Housing/International Housing Solutions Fund II.
Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW.	1 334 188 027	101 151 480	X		X						Renewable Grid Integration and Strengthening Programme with ESKOM.

Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW.	702 450 000	53 256 255	X								Mooi–Mgeni Transfer Scheme II, City of eThekwini.
Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW.	3 122 000 000	236 694 466	X								Financing of Electric Locomotives with Transnet.
Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW.	1 267 532 000	96 097 953		X							Climate Initiative Urban Wastewater Management, Cape Town.
Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW.	1 561 000 000	118 347 233	X	X							Climate Friendly Urban Mobility, eThekwini Metropolitan Municipality.
Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW.	4 683 000 000	355 041 698	X								Eskom Renewable Grid Integration/Transmission.
Loan	Germany: German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by KfW.	7 851 830 000	595 286 581	X	X							Green Energy Efficiency Fund Phase I.

Grant	German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMUB). Implemented by World Resources Institute (WRI)	1 763 069	132 764	X			X	X				Tracking and Strengthening Climate Action (TASCA):TASCA provides governments with tools and resources to track the implementation and effects of their Nationally Determined Contributions, and the underlying policies that support them and strengthen climate action. The project works in five countries to strengthen systems and capacities to track progress toward tackling climate change: Colombia, Ethiopia, India, Indonesia, and South Africa. In addition to work in the project countries, TASCA advances global research and organizes convenings to advance critical issues related to transparency and ambition.
Grant	German Federal Ministry for Economic Cooperation and Development (BMZ). Implemented by World Resources Institute (WRI)	6 275 650	455 087	x				X				Support South Africa's climate change mitigation and monitoring and evaluation activities, including: • Support development and operationalization of the Climate Change Tracking and Evaluation System. • Development of climate

												change tracking, data visualization and communication tools. • Development of guidelines and capacity building to support implementation of the Climate Change Tracking and Evaluation System. • Assessment of mitigation actions and policies to evaluate their impact in reducing greenhouse gas emissions and achieving other benefits. • Support South Africa's biennial update report.
Grant	Ministry for Environment, Land and Sea Protection of the Italian Republic	615 000	46 500	X		X					118 000	In the context of the Executive Programme on Scientific and Technological Co-operation between the Italian Republic and the Republic of South Africa for the years 2018-2020, the Ministry for Environment, Land and Sea Protection of the Italian Republic has financed the research project "Integration of High Power Energy Storage Systems for Sustainable Water and Renewable Sources Management", a collaboration between the University of Bologna and the University of

												Pretoria. The amount shown was financed for 2018.
Grant	Ministry for Environment, Land and Sea Protection of the Italian Republic	809 000	56 000	X		X					112 000	In the context of the Executive Programme on Scientific and Technological Co-operation between the Italian Republic and the Republic of South Africa for the years 2018-2020, the Ministry for Environment, Land and Sea Protection of the Italian Republic has financed the research project "Integration of High Power Energy Storage Systems for Sustainable Water and Renewable Sources Management", a collaboration between the University of Bologna and the University of Pretoria. The amount shown was financed for 2019.
Investment	Enel Green Power. Italian Republic	3 200 000	222 000	X								Training activities financed by the company in South Africa.
Investment	Enel Green Power. Italian Republic	76 600 000	5 300 000	X	X							In the framework of the Renewable Energy Independent Power Producers Procurement Programme, Enel Green Power has devolved the amount indicated to projects of Economic Development and Socio-Economic Development in

												favour of the communities around the 7, already active, renewable energy plants.
Investment	Enel Green Power. Italian Republic	18 742 320 000	1 417 200 000	X		X						In the framework of the Round 4 Renewable Energy Independent Power Producers Procurement Programme, Enel Green Power has been awarded the implementation of 5 140 MW wind farms projects. The wind farms are under construction and they will represent a unique contribution to the South African economy in consideration of the advanced technologies which are being used.
Grant	RES4AFRICA Foundation. Italian Republic	242 600	16 800	X	X							RES4AFRICA Foundation financed the full scholarships and travel expenses for 3 South African officials to take part in the Advanced Training Course “Deployment of renewable energy solutions: challenges and opportunities” which took place in Milan in November 2019.
Grant	Ministry for Environment, Land and Sea Protection of the Italian Republic	615 000	46 500	X		X					118 000	In the context of the Executive Programme on Scientific and Technological Co-operation between the Italian Republic

												and the Republic of South Africa for the years 2018-2020, the Ministry for Environment, Land and Sea Protection of the Italian Republic has financed the research project “Genomics for a Blue Economy”, a collaboration between the “Stazione Zoologica Anton Dohrn” and the University of the Western Cape. The amount shown was financed for 2018.
Grant	RES4AFRICA Foundation. Italian Republic	3 273 000	218 000		X							RES4AFRICA Foundation will be carrying out 4 studies on the energy sector in South Africa in collaboration with various South African institutions (e.g. CSIR).
Grant	Ministry for Environment, Land and Sea Protection of the Italian Republic	809 000	56 000	X		X					112 000	Just Energy Transition Study.
Grant	The Government of Japan (GoJ)	49 799 827	3 611 300	X	X	X	X					In order to reduce the amount of plastic leaking into the environment (including the marine environment) in South Africa, the GoJ and the UNIDO signed an agreement for grant funding of US$1 805 650 for a project to support a transition from conventional plastics to more environmentally

												sustainable alternatives in South Africa. The project will be implemented by UNIDO, in collaboration with the CSIR over a period of three years. The project has the potential to reduce plastic leakage to the environment and unlock new economic opportunities - both of which are urgently needed for South Africa.
Grant	Norway- Norwegian Ministry of Foreign Affairs Agreement Partner: Department of Science & Technology with National Research Foundation (NRF) as Implementing Agency	2 510 760	190 353				X					The goal of the Programme is: Enhanced knowledge-based policies by government institutions and decisions for sustainable development in the areas of oceans and ocean space (blue economy), environment, climate change and sustainable energy in South Africa and Norway (SANOCEAN).
Grant	Norwegian Ministry of Foreign Affairs in Agreement Partner : SA Department of Environmental Affairs	1 864 425	231 236				X					The objective of the project was to build capacity within the South African National Inventory Unit to develop a system for national greenhouse gas inventories in South Africa, including the reporting to the UN Framework Convention on

												Climate Change (UNFCCC) through national communications. The project was implemented in partnership with KLIF (the Norwegian Climate and Pollution Agency).
Grant	Switzerland	152 660 000	11 070 341	X								Energy Efficient Street Lighting Retrofit Project (implemented under SAGEN).
Grant	Switzerland	42 206 000	3 060 624	X								Provision of Technical assistance for SUNREF II Energy Efficiency/Renewable Energy Credit Line
Grant	Switzerland	31 699 400	2 298 724	X								Agri-Processing Resource Efficiency.
Grant	Switzerland	23 707 200	1 719 159	X								Partnership for Action on Green Economy.
Grant	Switzerland	53 880 000	3 907 179	X								ElectriFI: Solarise Africa Ltd.
Loan	United Kingdom	754 320 000	54 700 508	X								The objective of the project is to consolidate renewable energy sources in South Africa through a financing agreement that will support the development of 254 MW of clean energy projects across South Africa.
Grant	United States of America: United States Agency for	35 963 475	1 449 828	X		X	X			Low emissions development (climate change mitigation)		SA-LED is strengthening public sector capacity, focusing on the provincial and local

	International Development (USAID)											governments, through technical assistance, engaging with private sector developers to enhance the quality of LED project pipelines, and facilitating LED investment in line with DEA's National Flagship Programs: Renewable Energy; Energy Efficiency and Demand-Side Management; Waste Management; and Sustainable Transport. The programme helps municipalities plan, finance, and implement LED projects.

Annex C2: Multilateral support

Table C2.1: Additional information on Multilateral financial support committed between 2018 and 2019.

Financial flows/ Support	Donor	Implementing organisation	Amount in ZAR	Amount in USD	Type of funding						Principal focus Official Development Assistance	Co-financing (USD)	Specific purpose of funding
					Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	General			
Grant	World Wide Fund for Nature South Africa funded by WWF US	World Wide Fund for Nature South Africa	333 425	25 000						X			Project name: Alliance for Climate Action: South Africa Pilot. The intent is to improve global climate change mitigation outcomes through domestic actions, the impact of which can then be
Grant	World Wide Fund for Nature South Africa funded by WWF US	World Wide Fund for Nature South Africa	700 500	50 000									Project name: Alliance for Climate Action South Africa – Phase II. The intent is to improve global climate change mitigation outcomes through domestic actions, the impact of which can then be multiplied by bringing them onto an international stage. In South Africa we will focus the initiative most on cities and business, as holding the greatest potential impact in relation to the theory of change and leveraging off existing relationships. The global partnerships will be picked

													up nationally with the National Business Initiative (local arm of both We Mean Business and Carbon Disclosure Project), C40 and SA-CAN.
Grant	World Wide Fund for Nature South Africa funded by WWF International (Switzerland)	World Wide Fund for Nature South Africa	419 480	29 098	X	X				X		124 439 330	multiplied by bringing them onto an international stage. In South Africa we will focus the initiative most on cities and business, as holding the greatest potential impact in relation to the theory of change and leveraging off existing relationships.
Loan	France: Agence Française de Développement African Development Bank Clean Technology Fund and World Bank	Eskom	2 110 400 000	160 000 000	X								To enhance Eskom's renewable energy sources through financing the development of 100 MW wind farms.
Grant	Global Environment Facility		1 521 510	104 931	X			X				416 00	To accelerate and expand the introduction of Energy Management Systems, Industrial Energy Systems Optimization, and the Energy Management Standard ISO 50001 within the South African industrial (and selected commercial) context. The aim is to realize increased investment in industrial energy efficiency through the wide-scale adoption of the two

													methodologies and ISO 50001 under (i) enhanced institutional frameworks and regulatory environments, (ii) technical and implementation assistance to industry and multi-level engineer, technician and operator capacity building programmes.
Grant	Global Environment Facility		626 421	9 083 113	X			X				2.4 M	To accelerate and expand the introduction of Energy Management Systems, Industrial Energy Systems Optimization, and the Energy Management Standard ISO 50001 within the South African industrial (and selected commercial) context. The aim is to realize increased investment in industrial energy efficiency through the wide-scale adoption of the two methodologies and ISO 50001 under (i) enhanced institutional frameworks and regulatory environments, (ii) technical and implementation assistance to industry and (iii) multi-level engineer, technician and operator capacity building programmes.
Grant	Adaptation Fund	SANBI	33 452 667	5 402 225		x						38 439 000	The South African National Biodiversity Institute (SANBI)is implementing two projects which are both funded by the

													Adaptation Fund. Both projects are in their 4th year of implementation. The first project is being implemented in KwaZulu Natal titled “Building resilience in the Greater uMngeni Catchment, South Africa”. The second project is a small grants project titled “Taking adaptation to the ground: A Small Grants Facility for enabling local level responses to climate change in South Africa” which is being implemented in Northern Cape and Limpopo.
Loan	DEA_Green Climate Fund		8 055 000 000	537 000 000									The Green Climate Fund (GCF)-Development Bank of Southern Africa (DBSA) Embedded Generation Investment Programme will support the implementation of renewable energy projects with a capacity of 330 MW, which is comprised of 280 MW Solar PV and 50 MW Wind. 2019–2043.
Loan	DEA_Green Climate Fund		195 000	2 386 220									SANBI is also an accredited entity of the Green Climate Fund. To date, SANBI has received a Readiness Grant from the GCF aimed at developing Concept Notes and Funding Proposals for submission to the GCF amongst other technical activities. 2018.
Loan	DEA_Green Climate Fund		18 690 929	1 417 053	X								Waste Management Flagship Programme: The purpose of the Programme would be to implement the organic waste

													treatment solutions identified in the 6 pilot municipalities and thereafter, upscale implementation to 24 additional municipalities through a programmatic approach. The programmatic approach will allow subsequent 24+ subprojects to learn from the first 6 fore-runners and replicate the solutions in a streamlined, cost-efficient manner.
Loan	DEA_Green Climate Fund		4 195 211	318 060									Project preparation funding is being requested to conduct a detailed feasibility study to evaluate the optimal financial & institutional model for a Public & Private Sector Energy Efficiency Programme in South Africa. Additionally, funding will be used to prepare the full concept feasibility study and application to the GCF, and to conduct both gender impact, and ESS studies. The estimated budget is $ 318 060, to complete the studies within 9 months.
Loan	DEA_Green Climate Fund		195 000	2 386 220									SANBI is an accredited entity of the Green Climate Fund. To date, SANBI has received a Readiness Grant from the GCF aimed at developing Concept Notes and Funding Proposals for submission to the GCF amongst other technical activities. 2018.

Annex C3: Domestic financial flows

Table C3.1: Domestic financial flow for climate change response actions

Financial flows/ Support	Donor	Amount in (ZAR)	Amount in USD	Type of funding						Specific purpose of funding
				Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	General	
Grant	The Department of Agriculture, Forestry and Fisheries	2 121 100 000	153 814 358							Programme 5: Forestry and Natural Resources Management: Natural Resources Management. Facilitates the development of infrastructure and the sustainable use of natural resources through an enabling framework for the sustainable management of woodlands and indigenous forests, and the efficient development and revitalisation of irrigation schemes and water use. This sub programme also facilitates climate change mitigation and adaptation, and risk and disaster management; and promotes, regulates and coordinates the sustainable use of natural resources, particularly land and water.
Grant	The Department of Agriculture, Forestry and Fisheries	1 650 400	119 681							Programme 6: Climate Change and Designated National Authority. Ensures that climate change and environment response measures, in terms of mitigation and adaptation, are implemented within the energy sector. It also ensures the fulfilment of international energy commitments and obligations under the United Nations Framework Convention on Climate Change.

Financial flows/ Support	Donor	Amount in (ZAR)	Amount in USD	Type of funding						Specific purpose of funding
				Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	General	
Grant	The Department of Energy	937 758	68 003							Programme 6: Clean Energy. Manages and facilitates the development and implementation of clean and renewable energy initiatives, as well as energy efficiency and demand-side management initiatives.
Grant	Department of Environmental Affairs	63 902	4 634							Climate Change Management, Mitigation and Adaptation.
Grant	Department of Environmental Affairs	2 827 971	205 074							Environmental Protection and Infrastructure Programme.
Grant	Department of Environmental Affairs	206 000	14 938							Information Management and Sector Coordination.
Grant	Department of Environmental Affairs	206 000	14 938							Green Fund.
Grant	Department of Environmental Affairs	4 429 185	321 188							Natural Resource Management.

Financial flows/ Support	Donor	Amount in (ZAR)	Amount in USD	Type of funding						Specific purpose of funding
				Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	General	
Grant	Cooperative Governance and Traditional Affairs	696 000 000	50 471 356							National Disaster Management Centre.
Grant	Cooperative Governance and Traditional Affairs	99 000	7 506							Disaster Management Institute.
Grant	Cooperative Governance and Traditional Affairs	220 100	15 961							Municipal disaster recovery grant.
Grant	The Department of Agriculture, Forestry and Fisheries	295 006	21 393							Comprehensive agricultural support programme grant: Disasters: (flood damaged infrastructure).
	The Department of Agriculture, Forestry and Fisheries	266 500	19 326							Comprehensive agricultural support programme grant: Disasters: (Drought relief).

Financial flows/ Support	Donor	Amount in (ZAR)	Amount in USD	Type of funding						Specific purpose of funding
				Mitigation	Adaptation	Capacity Building	Technical Support	Technology support	General	
Grant	The Department of Transport	1 008 152	73 107							Provincial Maintenance roads maintenance Grant: Disaster Relief component.
Grant	Department of Human Settlements	194 000 000	14 488 424							Municipal disaster recovery grant.
Grant	Department of Human Settlements	247 000 000	18 446 602							Human settlements development grant: Kwazulu-Natal disaster recovery funding.
Grant	Department of Public Works	1 421 493	103 081							Expanded public works programme.