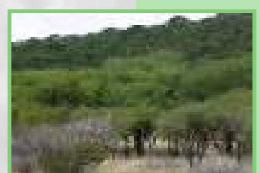
Namibia's Greenhouse Gas Inventory for Year 2000

Energy

Industrial Processes

Solvents & Other Products

Agriculture



Land-use Change and Forestry

Waste

Prepared For

Ministry of Environment and Tourism

Directorate of Environmental Affairs

Final Submission

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Directorate of Environmental Affairs

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Namibia's Greenhouse Gas Inventory for Year 2000

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LIST OF ABBREVIATIONS

a	annum
C	carbon
CDM	Clean Development Mechanism
CH_4	methane
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
COD	chemical oxygen demand
DM	dry matter
DNA	Designated National Authority
EF	emission factor
G	gram
Gg	gigagram
GHG	greenhouse gas
ha	hectare
IPCC	Intergovernmental Panel on Climate Change
kg	kilogram
kl	kiloliter
km	kilometer
km^2	square kilometer
kt	kiloton
LPG	liquid petroleum gas
LSU	livestock unit
m	meter
m^2	square meter
m^3	cubic meters
MAWRD	Ministry of Agriculture, Water and Rural Development
MET	Ministry of Environment and Tourism
MJ	Megajoule
mm	millimeter
MME	Ministry of Mines and Energy
MODIS	Moderate Resolution Imaging Spectroradiometer
N	nitrogen
NCCC	Namibia Committee on Climate Change
NM	nautical miles
SG	specific gravity
TJ	terrajoule
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
yr	year

EXECUTIVE SUMMARY

Introduction

The Namibian Greenhouse Gas Inventory for Year 2000 has been prepared for the Ministry of Environment and Tourism (MET) and is the second inventory to be prepared for Namibia. The *2000 Inventory* is one of a number of projects that are being implemented by MET during 2007 and 2008 and that will serve as input to *Namibia: Second National Communication to the United Nations Framework Convention on Climate Change* (UNFCCC) which will be prepared and submitted to UNFCCC in late 2008 / early 2009.

The 2000 Inventory is a comprehensive review of the anthropogenic (human caused) sources and sinks for greenhouse gases in Namibia. It is important to note that the inventory does not account for greenhouse gas emissions occurring 1) in other countries resulting from electricity imported to Namibia, 2) in Namibia, international open space or other countries resulting from international airplane flights to or from Namibia, or 3) in other countries resulting from the manufacture of consumer goods in other countries that are imported to Namibia. Some items, while not being included in the recorded total emissions/removal value, are quantified and presented as memo items. One example of a memo item is the amount of carbon dioxide emitted from the burning of biomass for residential cooking which, it is assumed, will be reabsorbed during the regrowth of biomass.

Summary and Discussion of Calculated Emissions & Removals

The inventory is broken down into the six sectors which have been prescribed by the IPCC's Revised 1996 Guidelines for National Greenhouse Gas Inventories. The following table summarises the calculated anthropogenic emissions and sequestration for the six sectors during year 2000, and compares the total CO_2-equivalent result of year 2000 to that of year 1994.

Table E1 Calculated Greenhouse Gas Emissions for Year 2000 and Comparison of Results with Year 1994

Sector	**Year 2000 Carbon Dioxide (CO_2) Emission (Gg)**	**Year 2000 Carbon Dioxide (CO_2) Removal (Gg)**	**Year 2000 Methane (CH_4) Emission (Gg)**	**Year 2000 Nitrous Oxide (N_2O) Emission (Gg)**	**Year 2000 Carbon Dioxide Equivalent (CO_2-e) Emission / Removal (Gg)[1]**	**Year 1994 Carbon Dioxide Equivalent (CO_2-e) Emission / Removal (Gg)[1]**	**Year 2000 Nitrogen Oxides (NO_x) Emission (Gg)**	**Year 2000 Carbon Monoxide (CO) Emission (Gg)**	**Year 2000 Sulphur Oxides (SO_x) Emission (Gg)**	**Year 2000 Non-Methane Volatile Organic Compounds (NMVOCs) Emission (Gg)**
Energy	2 018	0	5.7	0.2	**2 200**	**1 905**	14	171	11	26
Industrial Processes	0	0	0	0	**0**	**5**	0	0	0	4
Solvents					**not calculated**	**not calculated**				
Agriculture	0	0	310.5	0.7	**6 738**	**3 712**	27	1 580	0	0
Land Use Change and Forestry	6	-10 566	0	0	**-10 560**	**-5 716**	0	0	0	0
Waste	0	0	5.6	0.2	**180**	**63 (incomplete calculation)**	0	0	0	0
Total	2 024	-10 566	322	1	**-1 442**	**-31**	41	1 751	11	30

1: CO_2 equivalence factors are 21 for methane and 310 for nitrous oxide.

The results for CO_2-equivalent emissions and removals clearly indicate that the agriculture and energy sectors are most important with respect to emissions, and the land-use change and forestry sector (LUCF) is most important with respect to removals. The uncertainty of data for the agriculture, energy and LUCF sectors would appear to be greatest for the LUCF sector. While there is excellent supporting data available for the agriculture and energy sector emission calculations, the supporting data for the LUCF sector removal calculation is less definite. The large removal value is based on a rough estimate of the annual increase in mass of invader bush biomass. It has been estimated that approximately 26 million hectares of land are affected by the bush encroachment problem. A rough estimate of the annual amount of biomass growth for such a large area is clearly subject to some uncertainty. As mentioned in the 2005 report, *Review of Greenhouse Gas Emission Factors in Namibia*, more scientific data supported by new field tests and remote sensing is needed to reduce the uncertainty underlying the CO_2 removal calculations for bush encroachment.

The largest differences in emissions and removals between the Year 1994 and Year 2000 inventories occur in the agriculture and LUCF sectors. The primary reason for the change (increase) in the agriculture sector greenhouse gas emission is that improved emission factors were utilised to calculate emissions from farm animals in the Year 2000 inventory. The improved emission factors are generally higher than those utilised in the 1994 inventory. The primary reason for the change (increase) in LUCF greenhouse gas removal is that new data was available regarding the extent of the bush encroachment problem and the annual increase in mass resulting from the growth of invader bush.

Recommendations

A few detailed recommendations have been formulated that both would improve future greenhouse gas inventories, and would provide cross-cutting benefits related to carbon credit applications, promotion of renewable energy, and finding solutions to the bush encroachment problem. The following are the recommendations:

Recommendation 1:

Establish a greenhouse gas data collection unit within a Government body such as the National Planning Commission Central Bureau of Statistics or the Ministry of Environment and Tourism – Department of Environmental Affairs.

The process of contacting individuals and organisations during the data collection process is extensive and time consuming. The data to be collected is more than five years old and typically stored away in archive files. Furthermore, there is limited disaggregated data available in since key stakeholder institutions are not encouraged and monitored by any Government body to improve and communicate their record keeping of greenhouse gas data. The situation could be significantly improved if a government body was delegated with the responsibility of collecting relevant data and communicating with key stakeholder institutions on a continuous basis. In addition to being necessary for Namibia's greenhouse gas inventories, reliable and comprehensive greenhouse gas data will be critically important for the future preparation of carbon credit funding applications for projects and programmes that could prove highly beneficial for Namibia. It is important that the mission of the future greenhouse gas data collection unit include both of these objectives: improved greenhouse gas inventories, and optimal technical support of carbon credit applications.

Recommendation 2:

Conduct scientific studies that will significantly improve our understanding of the impact of invader bush encroachment on Namibia's greenhouse gas profile.

Bush encroachment is the single most significant factor in determining Namibia's greenhouse gas profile, yet the available data regarding the total area, mass density, and growth rate, is based largely on rough estimates performed by local experts. The vast potential of invader bush as a commercial resource for the electricity, liquid fuel, and cooking fuel sectors also warrants the funding of comprehensive scientific studies. Furthermore, the disastrous consequences that bush encroachment has had on the agriculture sector have prompted numerous stakeholders to call for wide-scale elimination of invader bush. It is important that future studies establish a better understanding and consensus of the pros and cons of large-scale bush harvesting and the underlying sustainability criteria. Similar to Recommendation 1, it is important that the funding and implementation of this recommendation be focused on more than just supporting the better greenhouse gas inventories in the future. There are other important economic and environmental objectives and benefits to be achieved simultaneously.

Recommendation 3:

Clarify the details of pre-anthropogenic baseline ecological conditions in Namibia.

A number of questions were raised at the stakeholder workshop regarding what are the baseline ecological conditions that define anthropogenic influence. Some examples of the questions raised include:

- To what extent can game numbers be increased on Namibian game farms before the impact is considered an anthropogenic factor to be quantified and recorded in the greenhouse gas inventory?
- What is the defining year and corresponding vegetative conditions after which the growth of invader bush is considered an anthropogenic influence?
- Have termite populations increased as result of anthropogenic factors?

It is recommended that the baseline ecological conditions that define the starting point of anthropogenic influences be better defined, and that selected issues such as the one related to termites be given more review and evaluation. This will help to ensure that the fundamental environmental principles that underlie Namibia's greenhouse gas inventory process are better understood by Namibia's environmental stakeholders and that there is consensus around those principles.

Recommendation 4:

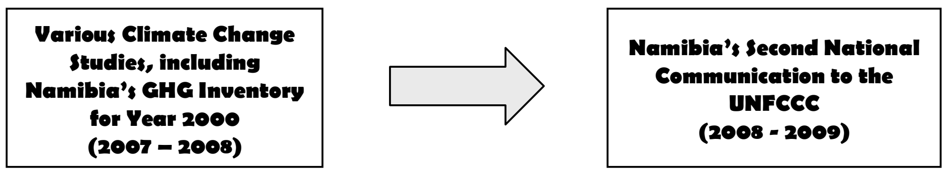
A review similar to the 2005 *Review of Emission Factors for Namibia* should be performed on the 2000 Inventory.

The 1994 Inventory received a thorough review in the 2005 *Review of Emission Factors for Namibia*; and this 2000 Inventory requires a similar, independent in-depth review. The review should in particular focus on how Source Categories Approach in the Energy Sector could be improved and become more independent of the Caltex Wholesaler's database upon which the Reference Approach is largely based. The review could also resolve potentially conflicting recommendations made in the 2005 Review and by the independent UNDP reviewer for this inventory regarding the need and significance of calculating emissions for manure in the Agriculture Sector.

1. INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

The Namibian Greenhouse Gas Inventory for Year 2000 (*2000 Inventory*) has been prepared for the Ministry of Environment and Tourism (MET) and is the second inventory to be prepared for Namibia. The first inventory was prepared for Year 1994; the third will be prepared for Year 2005. The *2000 Inventory* is one of a number of projects that are being implemented by MET during 2007 and 2008 and that will serve as input to *Namibia: Second National Communication to the United Nations Framework Convention on Climate Change* (UNFCCC) which will be prepared and submitted to UNFCCC sometime in late 2008 / early 2009.



Implementing agency: Department of Environmental Affairs - Ministry of Environment and Tourism
Oversight organisation: National Committee on Climate Change
Studies performed by: Various consultants and NGOs

The objective of this report is to assist the Namibian Government to fulfill its responsibilities to the UNFCCC, and to assist a broad range of Namibian stakeholders to better understand the underlying details and issues of Namibia's greenhouse gas emission profile.

The objective of the UNFCCC is to stabilize greenhouse gas emissions worldwide so that the world's climate system may remain stabile. In order to achieve this objective, the UNFCCC needs accurate data regarding the anthropogenic emissions and removals of all countries. According to *Managing the National Greenhouse Gas Inventory Process* (2005), the UNFCCC believes that preparing greenhouse gas inventories will benefit participating countries beyond their contribution to protecting the climate system. The envisaged benefits include:

- Providing data and information that would be beneficial to sustainable economic development and planning
- Providing information that would be useful and relevant to other environmental issues and initiatives
- Identifying shortcomings in the recording of nationally important data
- Providing data and information that would serve as the foundation for carbon credit schemes

1.2 DATA COLLECTION

While Namibia is fortunate that MET - DEA and the National Committee on Climate Change provide continuous support and oversight of climate change issues in Namibia, it must be pointed that the Namibia does not have a designated institution that is tasked with keeping track of greenhouse emission and removal data. As a result, DEA must rely on a consultant to do this work every five years. The process of contacting individuals and organisations during the data collection process is extensive and time consuming. The process could be significantly improved if a government entity such as the National Planning Commission Central Bureau of Statistics or MET – DEA would be funded and provided with staff to perform greenhouse gas record keeping on a continuous basis.

A detailed list of the approximately 50 people who were contacted during the preparation of this inventory is provided in Appendix 1.

1.3 KEY REFERENCE DOCUMENTS AND DATABASES

There are a few documents which were critical to the preparation of the *2000 Inventory* and which were referred to frequently:

- *First Greenhouse Gas Inventory: A Report on Sources and Sinks of Greenhouse Gases in Namibia in 1994 (1994 Inventory)*
- *Review of Greenhouse Gas Emission Factors in Namibia*
- *Revised 1996 Guidelines for National Greenhouse Gas Inventories: Reference Manual (Volumes 1-3)*
- *Namibia Energy Review for the UNFCCC*
- *Bush Encroachment in Namibia*
- *Petroleum Wholesalers' Database, Managed in South Africa by Caltex*

Sources and Sinks of Greenhouse Gases in Namibia: A Preliminary Overview:

Sources and Sinks of Greenhouse Gases in Namibia: A Preliminary Overview was commissioned in 1999 by MET and was one of three reports that served as the foundation for the *Initial National Communication to the United Nations Framework Convention on Climate Change* (2002). The report was referred to on several occasions in the development of approaches to obtain, confirm and present greenhouse gas emissions data. The author, Pierre du Plessis, also provided guidance at various times during the preparation of this report.

Review of Greenhouse Gas Emission Factors in Namibia:

The *Review of Greenhouse Gas Emission Factors in Namibia*, commissioned by MET and published in March 2005, provides a careful review of the Inventory prepared for year 1994, and makes a number of recommendations regarding how to reduce uncertainties in future greenhouse gas inventories for Namibia. The recommendations were followed whenever possible in the preparation of this report.

Revised 1996 Guidelines for National Greenhouse Gas Inventories (Volumes 1-3):

The Revised 1996 Guidelines were consulted frequently, and various default values required for the IPCC data sheets were obtained from the Reference Manual.

Namibia Energy Review for the UNFCCC (2007):

The final version of the *Namibia Energy Review for the UNFCCC* was recently submitted to MET. The report in one of several climate change-related reports that are being implemented by MET during 2007-2008 with funding assistance from UNDP. The report provided useful data regarding biomass consumption and growth.

Bush Encroachment in Namibia:

Bush Encroachment in Namibia was prepared by JN de Klerk for the Ministry of Environment and Tourism and was published in 2004. The report provides important data and information regarding bush encroachment in Namibia.

Petroleum Wholesalers' Database:

The Caltex head office in South Africa manages a database for all petroleum wholesalers in South Africa. The database includes records of all petroleum products exported to Namibia. The exports are recorded in disaggregated and detailed manner, identifying the sector in

Namibia who will receive the fuel, such as the fishing sector or the railway sector. The database was an invaluable resource for the preparation of the Energy Sector section of the *2000 Inventory*.

1.4 IMPROVEMENTS MADE IN THE YEAR 2000 INVENTORY AS COMPARED TO THE YEAR 1994 INVENTORY

A number of improvements have been incorporated into the Year 2000 Inventory. Most improvements are due to the thorough review of the Year 1994 Inventory that was performed in the 2005 report, *Review of Greenhouse Gas Emission Factors in Namibia*, and the recommendations contained therein. Other improvements made are due to the approach taken by the consulting team who prepared the Year 2000 Inventory.

The following is a summary of the improvements made in accordance with the recommendations of *Review of Greenhouse Gas Emission Factors in Namibia*:

- The specific gravity values for petroleum fuels provided in Appendix C of *Review of Greenhouse Gas Emission Factors in Namibia* were used instead of IPCC values.
- Used the calculated Tier 2 methane emission factors for domestic livestock that were provided in *Review of Greenhouse Gas Emission Factors in Namibia*.
- Utilised satellite mapping of fire scars and fuel load values and emission factors provided in *Review of Greenhouse Gas Emission Factors in Namibia* to determine the emissions from savannah burning.
- Estimated greenhouse gas emissions from wastewater treatment based on available data from the *2001 Population and Housing Census* and other population/sanitation sources, and on the nitrous oxide emission factor provided in *Review of Greenhouse Gas Emission Factors in Namibia.*

The following is a summary of the improvements made by the consulting team for the Year 2000 Inventory:

- The recorded amount of fuel consumed by the fishing, agricultural and mining sub-sectors were independently confirmed based on an approach that established a consistent correlation between the output production levels of the sub-sectors and the amount of fuel consumed.
- The amount of paint sold in Namibia was estimated, although this data could not be utilised to calculate greenhouse gas emissions because IPCC has not yet made available to non-Annex I countries excel worksheets, calculation methods or emission factors for the Solvents sector.
- Improved estimate of the amount of carbon dioxide removed from invader bush. New data was available for this Inventory which was not available for the Year 1994 Inventory. The data concerns the estimated annual increase in mass of invader bush. The data was obtained from the 2007 report, *Namibia Energy Review for the UNFCCC*, which sourced the data from MET-DEA.

1.5 SUMMARY OF INVENTORY RESULTS

The following Table 1-1 summarises the results of the calculated greenhouse gas emissions and removals.

Table 1-1 Calculated Greenhouse Gas Emissions for Year 2000 and Comparison of Results with Year 1994

Sector	**Year 2000 Carbon Dioxide (CO_2) Emission (Gg)**	**Year 2000 Carbon Dioxide (CO_2) Removal (Gg)**	**Year 2000 Methane (CH_4) Emission (Gg)**	**Year 2000 Nitrous Oxide (N_2O) Emission (Gg)**	**Year 2000 Carbon Dioxide Equivalent (CO_2-e) Emission / Removal (Gg)[1]**	**Year 1994 Carbon Dioxide Equivalent (CO_2-e) Emission / Removal (Gg)[1]**	**Year 2000 Nitrogen Oxides (NO_x) Emission (Gg)**	**Year 2000 Carbon Monoxide (CO) Emission (Gg)**	**Year 2000 Sulphur Oxides (SO_x) Emission (Gg)**	**Year 2000 Non-Methane Volatile Organic Compounds (NMVOCs) Emission (Gg)**
Energy	2 018	0	5.7	0.2	**2 200**	**1 905**	14	171	11	26
Industrial Processes	0	0	0	0	**0**	**5**	0	0	0	4
Solvents					**not calculated**	**not calculated**				
Agriculture	0	0	310.5	0.7	**6 738**	**3 712**	27	1 580	0	0
Land Use Change and Forestry	6	-10 566	0	0	**-10 560**	**-5 716**	0	0	0	0
Waste	0	0	5.6	0.2	**180**	**63 (incomplete calculation)**	0	0	0	0
Total	2 024	-10 566	322	1	**-1 442**	**-31**	41	1 751	11	30

1: CO_2 equivalence factors are 21 for methane and 310 for nitrous oxide.

2. ENERGY

2.1 INTRODUCTION

Namibia produces no fossil fuels of its own, nor refines / processes any fuels, thus only fuel consumption data is presented. The energy section utilises two different and independent methods for calculating emissions as specified by the IPCC process: the Reference Approach and the Source Categories Approach. The Reference Approach is the simpler method. The results of the Source Categories Approach, not the Reference Approach, are utilised in the calculation of the official total greenhouse gas emission.

The Reference Approach generally involves: 1) determining the total amounts of liquid and solid fossil fuels consumed by the economy, 2) adjusting those amounts to account for exports, international bunkers, and carbon storage when the fuels are used as raw materials, and 3) using IPCC conversion factors and emission factors to determine the amount (mass) of carbon dioxide emitted.

The Source Categories Approach generally involves determining fuel consumption according different source categories and using the IPCC conversion and emission factors to determine emissions. The following are the designated IPCC source categories: energy industries; manufacturing industries and construction; transport; other sectors (commercial/institutional sector, residential sector, and agriculture, fishing and forestry sector); and other sectors not specified.

2.2 REFERENCE APPROACH

2.2.1 Overview

Reference values for liquid fossil fuels, solid fossil fuels and biomass burned were first determined. In accordance with IPCC 1996 Revised Guidelines, carbon dioxide emitted from biomass combustion is reported as a memo item because it is assumed that the emitted carbon dioxide is removed during the re-growth of biomass.

The following table summarises the reference values for energy sector. The total calculated amount of carbon dioxide emission according to the Reference Approach is 1540 Gg.

Table 2-1 Summary of Namibian Energy Consumption and Emissions

Energy summary:	**Gg[1]**	**TJ**	**CO2 Gg**
Liquid fossil fuel inputs:			
Total use	719	31,312	
less international use (ship and plane)	-108	-4,607	
Subtotal liquid fossil fuel internal use	611	26,705	1,494
Solid fossil fuel inputs:			
Internal use	23	581	46
Total liquid and solid fossil fuel	634	27,286	**1,540**
Memo item (not counted as emissions)			
Woody biomass			
National stock	179,816	3,056,872	
Firewood use	716	12,170	1,330
Poles, saw and carvings (stored C)	234	117	
Charcoal production wood	203	3,443	
Annual replacement growth	12,479	212,140	
Net change in bio-stock[2]	11,326	196,410	

Notes: 1 - One Gigagram (Gg) is 1000 metric tons (kt); a Terrajoule (TJ) is a measure of energy content.
2 – Net change = Annual Repl. growth – firewood use – poles, saw and carvings – charcoal prod.

Figure 2-1 Example of One Terrajoule (TJ) of Fuel

2.2.2 Liquid Fossil Fuels

As mentioned above, all of Namibia's liquid fossil fuels are imported. Imported liquid fossil fuels have been equated to consumption. However, a 3-year average (1999, 2000, 2001) was performed to reduce the potential affect of occasional large deliveries and extended storage of fuels. The source data used is from the Petroleum Wholesalers' database which is located in Cape Town and managed by Caltex. Comparison of the Petroleum Wholesalers data with data from the Ministry of Mines and Energy (MME) shows that the data is generally comparable.

Table 2-2 Summary of Liquid Fossil Fuel Inputs

Product Summary (liquid fuels) consumed					Average of 1999 - 2001			
Liquid fuel type (litres)	**1999**	**2000**	**2001**	**Average**	**Specific gravity**	**Gg**	**Heat content MJ / kg**	**Energy content TJ**
AVGAS	2,777,217	2,075,907	2,066,045	2,306,390	0.788	2	44.80	81
DIESEL	368,858,355	372,420,446	445,823,808	395,700,870	0.839	332	43.33	14,385
FURNACE OILS	19,279,648	22,113,654	17,771,318	19,721,540	0.984	19	40.19	780
ILLUMINATING PARAFFIN	13,399,794	6,558,083	6,954,173	8,970,683	0.788	7	44.75	316
JET	56,937,175	64,222,514	31,288,405	50,816,031	0.788	40	44.59	1,786
LPG	7,500,820	5,042,407	12,901,596	8,481,608	0.650	6	47.31	261
MOGAS	299,045,456	293,615,346	314,279,881	302,313,561	0.723	219	44.80	9,792
POWER KERO	48,000	87,800	512,408	216,069	0.788	0	44.75	8
ASPHALT	4,462,494	3,077,540	11,015,458	6,185,164	1.000	6	40.19	249
Above data from Caltex, Cape town database, AJ Peens (note UNFCCC assumes 95% of asphalt / bitumen remains as stored carbon)								
Lubes								
Grease	237,489	299,744	280,610	272,614	1.000	0.27	40.19	11
Industrial oils	2,477,081	2,720,442	2,931,874	2,709,799	1.000	3	40.19	109
Motor oils	6,883,364	6,928,817	8,353,822	7,388,668	1.000	7	40.19	297
Total lubes	9,597,934	9,949,003	11,566,306	10,371,081	Total	10	40.19	417
Above data from Caltex, Cape town database, AJ Peens (note UNFCCC assumes 50% of lubes remain unburnt)								
International bunkers (to offshore shipping)								
Diesel	62,138,525	29,240,705	20,109,079	37,162,770	0.839	31	43.33	1,351
Marine Fuel Oil	43,531,138	2,355,257	3,722,358	16,536,251	0.984	37	40.19	1,470
Sum of energy content Gg / TJ						**719**		**31,312**
Above data from Caltex, Cape town database, AJ Peens								
Note: in UNFCCC 1.1 AVGAS added to gasoline; SG's from Review of GHG Emission Factors, 2005								

Fuels, lubricants and international bunker data are entered as above on the Petroleum Wholesalers' database; jet fuel is entered as international bunker data (not to be included in Namibia's reported emissions) as almost all such fuel is used for cross border flights. Lubricants to international bunkers were apportioned according to the ratio of bunker diesel to total consumption – approximately 10%. The volume of AvGas was added to that of gasoline (MOGAS).

IPCC default values were used throughout, with the exception of specific gravity values which were obtained from Appendix C of the *Review of Greenhouse Gas Emission Factors in Namibia*. The figure for carbon oxidation was reduced from .99 to .98 due to average old age of Namibian fleet (more than 60% older than 12 years according to NATIS data) which results in reduced combustion efficiency.

The total emission of carbon dioxide from liquid fossil fuels as calculated by the Reference Approach is 1494 Gg.

2.2.3 Solid fossil fuels

Primary coal data was obtained from TransNamib as all coal used in this period was imported from South Africa and delivered either by ground transport across Namibia's southern border or by ship to the Walvis Bay port. Major truck operators were unaware of any significant transport of coal by road in recent years. The average of imports is determined as stock levels are typically high in relation to consumption.

The main consumers of coal are NamPower for electricity generation, the Tsumeb smelter which recommenced operations in April 2000, and MeatCo's major abattoirs. The Otjiwarongo cement plant was closed in late 1998 and has subsequently been dismantled.

Regarding coal consumption at the Van Eck power station, the manager confirmed that 12% of the coal entering the combustion chamber remains as un-oxidised (residual) carbon. Furthermore, at least another 5% of Van Eck's imported coal is not combusted due to fines losses during handling and uncombusted particles blowing straight up the stacks. The above losses have been taken to account and are likely under-estimated due to the old age of Van Eck.

Tsumeb smelter residual / stored carbon is small with only occasional "wind losses" during converter operation; coke or wood were not used in this period. Coal quality is poor (< 26 MJ/kg). Handling losses are similar to NamPower, for similar reasons.

Table 2-3 Coal Imports and Power Generation Data

Power Generation Inputs				**1999 to 2001**	
(plus TransNamib coal imports)	**1999**	**2000**	**2001**	**Average**	**Energy input TJ**
Fuel inputs to NamPower					
Coal Gg	6.2	2.9	3.6	4.2	111
MJ/kg	24.9	27.2	27.2	26.1	
LFO Gg	0.017	0.023	0.022	0.021	1
MJ/kg	44.0	44.0	44.0	44.0	
HFO Gg	0.397	0.019	0.028	0.148	6
MJ/kg	43.4	43.4	43.4	43.4	
Source: Nampower, Researcher, Eli Kasai					
Rail movements of coal (Gg):					
TransNamib rail transport (both import ex SA and via W/bay)	27.4	15.9	26.1	23.2	581
Source: TransNamib, Operations Manager, Jack Dempsey / UNFCC MJ/kg = 25.1					

The total emission of carbon dioxide from liquid fossil fuels as calculated by the Reference Approach is 46 Gg.

2.2.4 Biomass Burned for Energy

In accordance with IPCC 1996 Revised Guidelines, carbon dioxide emission from the burning of biomass is noted as a memo item because it is assumed that the emitted carbon dioxide is removed during the re-growth of biomass. Note that absolute changes in biomass are accounted for under changes in Land Use.

Fuel wood remains a significant source of energy in Namibia and results in localised environmental degradation as its use provides informal income and "cheap" source of fuel. The data below indicates the woody stocks, usage and replacement during 2004. This data was assumed to be valid for year 2000 with no adjustments.

Charcoal wood consumption, retail / exports of firewood, and industrial use are noted at the end of this section and in more detail under the sector analysis; their impact is minimal.

Table 2-4 Woody Mass Availability, Use and Annual Replacement

Woodlands:

Source: NAMIBIA ENERGY REVIEW FOR THE UNFCCC, 20 July 2007

Forest woody volume (2004)	Density	Volume	Area (Calc)	Resource mass	Gross energy content
	m3/ha	million m3	km2	Gg	TJ
Total		257	825,090	179,816	3,056,872
Source: NAMIBIA ENERGY REVIEW FOR THE UNFCCC, 20 July 2007, DEA				Using 0.7t/m3	Using 17 MJ / kg

Harvested product: (2004)

	Annual replacement	Annual harvest	Usage gap	Annual addition to resource mass	Annual addition to energy content
	1000 m3 /yr	1000 m3 /yr	1000 m3 /yr	Gg	TJ
Fuel wood	16294	1023	15271	10,690	181,723
Poles	2716	334	2382	1,667	28,341
Saw timber	171	0	171	120	2,038
Totals	19181	1357	17824	12,477	212,102
Source: NAMIBIA ENERGY REVIEW FOR THE UNFCCC, 20 July 2007, DEA				Using 0.7t/m3	Using 17 MJ / kg

Source: Using 0.7t/m3 not .8 - (still high?) wood densities (dry) - ex FAO web site

Table 2-5 Charcoal Production and Related Woody Mass Use

Charcoal production:

Charcoal production:		1999	2000	2001	NCV MJ / kg	Energy content TJ
Charcoal produced	Gg	45	45	45	31	1395
Woody mass harvested	Gg	203	203	203	17	3443

Source: W.Enslin, NCAP, Grootfontein estimates as no central data, all exported (verbal)

Wood usage @ 4.5 t / t charcoal / NCV 31 MJ/kg as UNFCCC petroleum coke

Table 2-6 Domestic Woody Mass Use

Harvested woody mass: (2004)

Growth and usage.	Annual replacement	Annual harvest	Usage gap	Annual usage	Gross energy content
	1000 m3 /yr	1000 m3 /yr	1000 m3 /yr	Gg	TJ
Fuel wood	16294	1023	15271	716	12170
Poles	2716	334	2381	234	117
Saw timber	171	0	171	0	0
Totals	19180	1357	17823	950	12287
Source: NAMIBIA ENERGY REVIEW FOR THE UNFCCC, 20 July				Using 0.7t/m3	Using 50% C

Source: Using 0.7t/m3 not .8 - (still high?) wood densities (dry) - ex FAO web site

The charcoal data shown from the National Charcoal Producers Association (NCPA) is comparable to that reported in Appendix D of *Review of Greenhouse Gas Emission Factors in Namibia* (2005). No significant industrial consumers remain locally and local domestic consumption remains unknown; wholesalers indicate that much charcoal sold domestically is imported. An assumption has been made that 10% (4.5 kt) of charcoal produced in Namibia is consumed in Namibia.

Firewood exported data will be used as reported in the *Review of Greenhouse Gas Emission Factors in Namibia* (2005) (56 kt) based on export permit source. Local sales are unavailable due to the informal nature of the business. An assumption has been made that local consumption is approximately 10% of exports (5.6 kt).

Fuel wood is a cause for concern because the amount consumed is large and estimates of the amount consumed show high variability. The sector analysis uses an alternative approach. The data presented here under the Reference Approach is that shown in the *Namibia Energy Review for the UNFCCC* (2007).

2.2.5 Methane to Energy at Gammans Sewage Plant

The methane emission from Gammans sewage plant digesters in Windhoek is related to the mass of organic matter. The boiler and fixed engine are currently both out of action and have been sporadically for some years. These systems when operational can generate about a third to half of the plant's power needs. Operational records are missing and it is assumed that all methane is vented (< 0.5 Gg pa), i.e. not consumed as an energy source.

2.3 SOURCE CATEGORIES APPROACH

2.3.1 Overview

There are five general designated categories to be considered in the Source Categories Approach: Energy Industries; Manufacturing Industries and Construction; Transport; Other Sectors (commercial/institutional sector, residential sector, and agriculture, fishing and forestry sector); and Other Sectors (not elsewhere specified). The prime source of fuel data for Source Categories Approach is the main consumers (ex. NamPower). However, accurate consumer fuel consumption information was, in several cases, not available or incomplete. For those cases, other relevant data was obtained that, together with educated assumptions and estimates, would lead to fuel consumption estimates. When that alternative approach also was not feasible, the disaggregated data available in the Caltex Petroleum Wholesalers' database was utilised as a last resort. However, the accuracy of the data was then confirmed using an innovative method based on output production figures from the respective categories (ex. the fishing sub-category).

The following table summarise the results of the Source Categories Approach for the above categories:

Table 2-7 Summary of Emissions (Gg) According to the Source Categories Approach

Category	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Energy Industries	239	0	0	0.6	0	0	3.8
Manufacturing Industries and Construction	99	0	0	0.3	0	0	1.1
Transport	1 025	0.2	0	10.7	74.4	13.9	1.4
Other Sectors (com./inst.;res.;ag., fish.&for.)	558	5.5	0.1	2.6	96.3	12.0	4.6
Other Sector (mining)	97	0	0	0	0	0	0
Total	2 018	5.7	0.1	14.2	170.7	25.9	10.9

2.3.2 Energy Industries Category

During year 2000, electricity generation fuel inputs were entirely accounted for by NamPower. Year 2000 was a time of high availability for electricity imports from South Africa; therefore relatively little fossil fuel was burnt at Van Eck compared to other years. In addition to Van Eck, fuel was fuel for electricity generation was consumed at NamPower's Paratus plant in Walvis Bay.

Table 2-8 NamPower Fuel Consumption Data

Input in Gg	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Av 99-01 Gg	Av 99-01 TJ
Coal	7.8	90.3	100.4	16.4	13.6	11.0	16.8	6.2	2.9	3.6	4.2	107
HFO				25.1	581.4	252.9	397.2	19.0	28.2	103.9	50.4	2024
LFO (Diesel)				17.4	33.8	29.6	17.2	23.5	21.7	12.5	19.2	833
Lubes								0.1	0.1	0.1	0.1	2
Total											73.9	2966
Local power GWh						*630*	*1 019*	*1 216*	*1 426*	*1 232*		*4 649*

Source: NamPower (Kasai) and Annual Report 2006

2.3.3 Manufacturing Industries and Construction Category

The manufacturing sector's contribution to the GDP, excluding fish processing (see later section), remains under 10% with the primary outputs of beer, beef and base metal smelting unchanged. The construction sector contributes 2-3% to GDP.

Fossil fuel inputs are primarily used for manufacturing process heat, although the Tsumeb smelter does consume some carbon during processing. Tsumeb copper production restarted in April 2000 and produced 5.1 Gg of blister copper that year. No wood, charcoal or coke was used. Coal consumption is based on 1.00 Mg of coal per Mg of copper. 5.1 Gg of coal usage was therefore estimated. A basic input of 60 l/hr is required to maintain "hot" services; this equates to 0.5 Gg of residual fuel oil (source: smelter manager, verbal).

Rössing Uranium produced 3.2 Gg of product and used 0.8 Gg LFO/diesel for acid plant production.

The cement plant at Otjiwarongo closed down permanently at the end of 1998. It is uncertain of the magnitude or disposal of coal stocks that remained.

Namibia Breweries (Windhoek and Swakopmund) used 3.6 Gg of residual fuel oil (average of 1999 to 2001 consumption). No coal was used in this period. Local beer production is not taken to account as this will be included in fuel for residential use as a split is not possible from available information. Production in 2000 was 1.0m hl (2007 will be about 1.6m hl). Beer making does involve carbon dioxide release in process but the gas is fully recycled and thus emissions are minimal (Namibia Breweries - verbal).

About 70% of animal slaughter is conducted by MeatCo at their Windhoek and Okahandja plants. MeatCo, Windhoek used 3.6 Gg of residual fuel oil and their Okahandja plant used 2.8 Gg of fossil fuels (est. coal 1.4 Gg; HFO 1.4 Gg). Interestingly, the latter plant is currently reverting to coal bias again due to oil prices. MeatCo (both abattoirs) slaughter 70% of livestock in the country. The total figure for fuel consumed in the meat industry was therefore based on a pro-rata adjustment of the available MeatCo data.

The construction industry is highly diversified and detailed information is unavailable; however it is assumed that a considerable amount of LFO/diesel is consumed, mainly on transport. Fuel for transport is covered in the transport category.

Lubricant data was obtained from the Caltex Petroleum Wholesaler's database (3.3 Gg).

Table 2-9 Fuel Consumption Data for the Manufacturing and Construction Category

Input in Gg	Smelting / Process	Beer	Meat	Cement	Other / no split	Total Gg	Total TJ
Coal	5.1	0.0	2.0	0.0		7.1	178
HFO	0.5	3.6	7.1	0.0		11.2	450
LFO (Diesel)	0.8					0.8	35
Lubes					*3.3*	3.3	133
Bitumen					*2.7*	2.7	5
Kerosene					*1.8*	1.8	81
LPG					*3.6*	3.6	170
Avgas					*1.8*	1.8	81
Jet					*0.0*	0.0	0
Gasoline (MOGAS)					*7.9*	7.9	354
Total:	6.4	3.6	9.1	0.0	21.1	40.2	1486

2.3.4 Transport Category

2.3.4.1 Tier 1 Analysis for Road and Rail Transport:

The transport category is the major consumer of liquid fuels; however, comprehensive fuel data, independent of the Caltex Petroleum Wholesaler's data, is not available. An alternative approach therefore is required to estimate fuel consumed in this category. The alternative approach is based on improved vehicle registration data available from the National Transport Information System (NATIS) from the beginning of 2001. Using the NATIS data, a rough estimate of fuel consumption has been made based on rough estimates of typical distances covered in conjunction with estimates of fuel consumption rates per vehicle class. NATIS data indicates a large percentage of the Namibian fleet (68% of passenger and 25% of commercial) was more than 9 years old in 2006 (Namibia Energy Review, 2007). Equivalent data is not available for the period prior to 2001 but it is likely that the situation was similar. As such, fuel efficiency is likely to be compromised.

Table 2-10 NATIS Data Expanded to Estimated Vehicle Fuel Usage

Source: NATIS data for January 2001	No of vehicles on books	Estimated km/y per vehicle	Estimated consumption l/100km	Estimate % diesel driven	Diesel used Gg	Gasoline used Gg
Motorcycle,-tricycle and quadrucycle	2869	3000	6	0	0.0	0.4
Light passenger mv less than 12 persons	69334	15000	10	10	8.7	67.7
Heavy passenger mv 12 or more persons	1942	100000	15	25	6.1	15.8
Light load vehicle GVM 3500Kg or less	67254	20000	12	20	27.1	93.4
Heavy load vehicle> GVM 3500Kg, not to draw	7171	40000	12	95	27.4	1.2
Heavy load vehicle> GVM 3500Kg, equipped to draw	2963	100000	18	100	44.7	0.0
Special vehicle	4067	20000	20	100	13.6	0.0
Total	155600				127.8	178.4

The NATIS analysis provides only a rough estimate. Some of the problems and uncertainties involved in making this estimate include: the number of vehicles registered may be significantly more than the actual number of vehicles that are used; fuel consumed by foreign owned and registered vehicles (trucks primarily) is not accounted for; fuel consumed by Namibian vehicles (such as long-distance trucks) may actually be purchased in other countries. It is impossible to determine the magnitude of the uncertainties involved with the NATIS analysis. It should be noted, however, that road transport makes up the largest part of transport category. Furthermore, the transport category is the largest emitter of all the source categories. As such, the road transport portion of the transport category likely accounts for the greatest source of uncertainty in the Energy Sector and possibly explains why the results of the Reference Approach and Source Categories Approach differ as much as they do. Nonetheless, the NATIS analysis represents the best estimate that could be achieved in the transport category for Source Categories Approach that is independent of the Caltex Petroleum Wholesaler's data that was utilised for the Reference Approach.

TransNamib LFO / diesel consumption for rail movements in during the 2000-2001 financial year was 12.9 Gg (TransNamib table supplied). A complex analysis approach, such as the one required for road transport, was not required for rail transport given the availability of the TransNamib data.

2.3.4.2 Tier 2 Analysis for Civil Aviation:

The Ministry of Works, Transport and Communications (MWTC) Civil Aviation has developed a real time record of all aircraft movements from controlled airports[1]; data entry is entered by the air traffic controllers as movements occur. Over-flights are recorded similarly, but on a different linked system. Reliable electronic records are available from 1 January 2005 to present time; the 139,108 records used in this analysis cover the period to 2 July 2007. Records are not available in a usable form prior 1 January 2005. It is important to note that "over fly" data is becoming available.

This data has enabled the analysis to be reduced to the 13 aircraft types listed below (Table 2-11) while maintaining a high level of confidence. This was achieved by using the product of the distance traveled in Namibian airspace in nautical miles (NM) and the maximum take off weight (in kg) for each type of aircraft. Sorting these various totals indicated that the 13 aircraft types represented a very high proportion of fuel consumed (>99%); this allowed significant reduction of the approximately 270 types of aircraft represented.

Thus the number of landings (and take-offs) and the total distance traveled in Namibia for each of the 13 types allows a Tier 2 calculation to be manageable and fully representative of energy input.[2] Table 2-12 shows the pertinent percentages of the total for the 3-year data covered by these movements.

[1] The number of flights travelling between two uncontrolled airstrips is statistically very small and is ignored in this exercise.

[2] Motive power efficiencies may skew this relationship marginally but is not considered significant.

Table 2-11 Summary Analysis of Take-off Data to Identify Most Significant Plane Types

Plane type	Fuel type	2005 kgNMX10^{-9}	2006 kgNMX10^{-9}	2007 kgNMX10^{-9}	Total kgNMX10^{-9}	LTOs 05-07 Number	NM total Nautical Miles
A346	jet	11,606	68,789	17,009	97,404	4,024	2,166,092
B744	jet	41,511	38,192	9,145	88,847	4,381	2,379,504
A343	jet	12,329	18,506	10,344	41,179	3,496	1,555,896
B732	jet	15,265	12,842	1,754	29,860	9,119	2,068,608
C210	avgas	3,922	6,273	2,613	12,807	55,352	5,770,802
CRJ2	jet	4,102	3,577	881	8,560	6,845	1,753,523
B190	jet	3,279	2,746	988	7,012	12,929	2,456,678
A332	jet	672	1,593	552	2,816	1,038	504,298
B738	jet	568	676	167	1,412	2,110	313,295
F406	jet	653	520	78	1,250	6,149	1,290,093
A342	jet	130	538	542	1,210	581	225,138
C208	avgas	179	234	84	497	5,074	845,003
C310	avgas	195	227	44	466	5,275	1,007,839
Totals		96,415	156,719	46,208	293,323	116,373	22,336,769

The units used are a little esoteric! (kgNMx10-9) but are directly proportional to the more familiar kgfm. Note 2007 only 6 months data. Source: MWTC, Civil Aviation Directorate (derived)

Table 2-12 Energy-Related Percentages Attributed to the 13 Most Significant Types of Aircraft

Data shows % of total for annual database total	Maximum take off weight - kg (MTOW)	Distance travelled in Namibia (NM)	No of landings	Product MTOW x NM flown
Year	% of kg lifted	% of Nautical miles	% of landings covered	% of work - kgNM
2005	97,3	76,5	74,6	99,7
2006	97,0	77,0	72,3	99,7
2007	98,4	76,0	75,1	99,9

Source: MWTC, Civil Avaiation Directorate - derived from database

Table 2-13 Back-Projected Take Off and Landing Count Data for Year 2000

Plane type	2000	2001	2002	2003	2004	2005	2006	2007
A346	690	742	798	858	923	992	1,999	2,070
B744	1,346	1,447	1,556	1,674	1,800	1,935	1,652	1,592
A343	845	908	976	1,050	1,129	1,214	1,437	1,692
B732	2,635	2,833	3,046	3,275	3,522	3,787	3,728	3,208
C210	8,767	9,427	10,137	10,899	11,720	12,602	16,574	22,210
CRJ2	2,031	2,184	2,349	2,526	2,716	2,920	2,467	2,916
B190	3,405	3,662	3,937	4,234	4,552	4,895	5,380	5,308
A332	296	319	343	368	396	426	375	474
B738	591	636	684	735	791	850	855	810
F406	1,900	2,043	2,197	2,362	2,540	2,731	2,486	1,866
A342	104	112	121	130	140	150	212	438
C206	340	366	393	423	455	489	472	478
C310	1,377	1,481	1,593	1,713	1,841	1,980	2,274	2,044
Total LTO	24,329	26,160	28,129	30,246	32,523	34,971	39,911	45,106

Note: Data for 2007 is that to end June, doubled.

Note: Data for 2000 - 2004 based on 2005/7 data deflated at 7%

The engine consumption and emission characteristics have been obtained for each of the 13 aircraft types from the ICAO database and used in the calculations.

Table 2-14 The 13 Aircraft, Their Engines and LTO data

Plane type	No of engines	Engine name	Fuel type	Fuel LTO cycle / engine(Mg)	Plane LTO cycle all engines (Mg)	
A346	4	TRENT 556	jet	0.843	3.372	1
B744	4	PW4062	jet	0.887	3.548	2
A343	4	CFM56-5C2	jet	0.466	1.864	3
B732	2	JT8D-9/15	jet	0.433	0.866	4
C210	1	TS10-520-R	avgas	0.011	0.011	5
CRJ2	2	GE CF34-3B1	jet	0.164	0.328	6
B190	2	PT6A-67D	jet	0.033	0.066	7
A332	2	CF6-80E	jet	0.928	1.856	8
B738	2	CFM56-7B27	jet	0.456	0.912	9
F406	2	PT6A-112	jet	0.026	0.052	10
A342	4	CFM56-5C2	jet	0.466	1.864	11
C208	1	PT6A-114	avgas	0.026	0.026	12
C310	2	TS10-520B	avgas	0.011	0.022	13

Source: ICAO engine test database

The only aircraft using jet fuel with substantial internal flights is the B190, but as the work load (kg x NM [nautical miles]) is so small in comparison to the international jets it is assumed that all jet fuel should be included under international bunkers as a memo item. All avgas is assumed to be for internal flights as the proportion of cross border flights is small – and thus all reports to Namibian emissions. IPCC ignores piston engine inputs as insignificant worldwide, but Namibia flies a considerable number of such flights. Therefore, as Tier 2 emission factors are not available in detail for such engines, the LTO fuel usage is combined with the data shown in the 1996 IPCC Reference Manual Tables 1.47 / 1.52 where ICAO / manufacturer information is not available.

2.3.4.3 Summary of Fuel Inputs in the Transport Category:

Table 2-15 Transport Sector Fuel Inputs

Input in Gg	Road Transport	Rail	Air (domestic)	Other / no split	Total Gg	Total TJ
LFO (Diesel)	127.8	12.9			140.7	6097
Gasoline/ AvGas	178.4		1.8	*7.9*	188.1	8427
Kerosene				*1.2*	1.2	54
LPG				*0.1*	0.1	5
Jet				*0.0*	0.0	0
Lubricants				*1.9*	1.9	38
Total:	306.2	12.9	1.8	9.2	330.1	14619

Data in *italics* sourced from Caltex database

Jet all reports to international bunkers.	Total Gg	Total TJ
	17.4	776

2.3.5 Commercial and Institutional Sub-category

The wholesale/retail and Government sectors represent about 9% and 30% of GDP respectively. Their prime fossil fuel use is for transport, stationary engines and various small boiler and incinerator purposes. The Caltex Petroleum Wholesaler's database is the only dependable source of data for this sub-category, and indicates a use of 19.9 Gg and 9.9 Gg of diesel and gasoline respectively. It is suspected (but not confirmed), however, that this fuel was used mainly for transport, which could partially explain the gap between the NATIS based transport fuel estimate and the Caltex transport fuel data. Nonetheless, this data was utilised for this sub-category, with the addition of the Caltex data for furnace oil (6.3 Gg) and LPG (0.7 Gg) which was used for institutional heating and for which no independent source data is available.

Coal has been estimated as a nominal 1 Gg as it is known that various small activities burn coal, but only a minimal amount.

To retain consistency with the Greenhouse Gas Inventory for Year 1994, charcoal production is reported under this sub-category. While carbon dioxide emissions do only require reporting as a memo item, there are other greenhouse gas emissions which have been calculated under this source sub-category. The National Charcoal Producers Association (NCPA) does not keep central production figures but Mr. W. Enslin (Chairman) at Grootfontein and Mr. D. Coetzee (Manager) at Otjiwarongo both confirmed that production has been steady at 45 Gg for many years. They estimate 3.5 to 4.5 dm/t per t/charcoal, and that between 60 - 75% of the wood's carbon ends up in the charcoal, although yields vary according to feedstock. Almost all charcoal produced is exported. Estimates of local retail consumption of charcoal (and firewood) are unavailable as it is an *ad hoc* and localised business.

Table 2-16 Charcoal Production Data

Data in Gg	1997	1998	1999	2000	2001
Wood harvested	203	203	203	203	203
Charcoal produced	45	45	45	45	45
Conversion ratio t wood / t Charcoal	4.5	4.5	4.5	4.5	4.5
Est. carbon retained in product %	60.0	60.0	60.0	60.0	60.0

Table 2-17 Commercial and Institutional Inputs

Input in Gg	Government	Retail and tourism	Charcoal	Other / no split	Total Gg	Total TJ
Wood (dm / Gg)			203.0		203.0	3451
LFO (Diesel)				*19.9*	*19.9*	862
Gasoline/ AvGas				*9.9*	*9.9*	444
Furnace oils				*6.3*	*6.3*	253
Kerosene				*0.1*	*0.1*	4
LPG				*0.7*	*0.7*	33
Lubricants				*0.4*	*0.4*	9
Total:	*0.0*	*0.0*	*203.0*	*37.3*	*240.3*	5056

Data in *italics* sourced from Caltex database

2.3.6 Residential Sub-category

Electricity, paraffin and LPG are energy inputs into the more formal residential sector for heating, lighting and appliance use; detailed information to build up source data is not available and relatively small. It was therefore necessary to use Caltex Petroleum Wholesaler's data for Paraffin (1.1 Gg) and LPG (1.3 Gg). Note that fuel wood is included as a memo item – refer to section 2.3.8 below.

Table 2-18 Residential and Commercial Energy Use

Input in Gg	Residential	Total Gg	Total TJ
Wood (dm / Gg)		0.0	0
LFO (Diesel)		*0.0*	0
Gasoline/ AvGas		*0.0*	0
Furnace oils		*0.0*	0
Kerosene	*1.3*	*1.3*	58
LPG	*1.1*	*1.1*	52
Lubricants		*0.0*	0
Total:	*2.4*	*2.4*	110

Data in *italics* sourced from Caltex database

2.3.7 Fishing, Agriculture and Forestry Sub-categories

2.3.7.1 Fishing Sub-category:

The fishing industry was, in general reluctant to release fuel data information relating to fleet operations as it was regarded considered commercially sensitive data; contacts also indicated that data for 2000 was not readily available anyway as it is buried away in archives. Thus building up input based on independent inputs from producers for the fishing sub-sector proved impracticable due to a lack of individual producer information. Nonetheless, an approach to performing a sectoral analysis was developed. The approach is based on historical catch data; comparing the catch data to the historical, disaggregated fuel usage reported in the Petroleum Wholesalers' database; and concluding whether or not a correlation is evident that supports the disaggregated figures presented by the Wholesalers' database. The analysis shows that there is a correlation between fuel usage and the amount of fish caught. It was also observed that the amount of fuel required per unit weight of catch is increasing over time -- a trend which was confirmed (off-record) by a fishing industry insider. It was determined that 200 litres of fuel per ton of catch was an acceptable number to utilise in the sectoral analysis. The analysis supports the fuel usage figures for the fishing sub-sector presented in the Petroleum Wholesalers' database.

Table 2-19 Fishing Sub-category Energy Use Ratios Based on Catch Data and Petroleum Wholesalers' Database

Summary Data:	1999	2000	2001	2002	2003	2004	2005
Reported catch:							
in Gg							
Total fish harvest	580	590	557	625	633	567	552
Source MFMR web site.							
Fossil fuel inputs:							
in Gg							
Total:	101	96	107	128	132	121	116
Source Caltex dBase							
in TJ (calculated)							
Total:	4,395	4,157	4,653	5,547	5,721	5,242	5,011
Indicator ratios							
TJ energy / Gg catch	7.6	7.0	8.4	8.9	9.0	9.2	9.1
Avg 99-01 TJ / Gg catch		7.7					
Equiv litre diesel / t catch	208	194	230	244	249	254	250

2.3.7.2 Agriculture Sub-category:

Agricultural fuel use, as recorded in the agriculture sub-category, is equally obscure. Therefore a similar analysis approach as that used for the fishing sub-category was used for the agriculture sub-category. It is reasonable to assume that the area planted is approximately proportional to agricultural fuel use. The area planted for controlled crops (maize / wheat) is well documented in the *Namibian Agronomic Annual Report*; note the data for the period under review used is for the financial year 1999 / 2000. While marketed output of dry land farming is unpredictable due to rain and pricing variability, relating the disaggregated data for Farmers and Agricultural Crop from the Petroleum Wholesalers' database to the planted area indicates that there is a reasonable correlation between fuel usage and planted area, which is approximately

0.1TJ / ha planted. In the end, the analysis supports the fuel usage figures for the agricultural sub-sector presented in the Petroleum Wholesalers' database.

Table 2-20 Agricultural Sub-category Energy Use Ratios Based on Planted Area and Petroleum Wholesalers' Database

Summary Data:		1999	2000	2001	2002	2003	2004	2005
Grain production data:								
Total area planted	ha	15 838	10 247	8 869	12 258	14 971	15543	15361
Total yield of maize / wheat	Gg	15	41	30	34	37	67	53
Total raw value marketed	NM$	9	24	24	29	28	47	42
Source: Namibian Agronomic Board Annual Report 2005/6								
Fossil fuel inputs:								
Liquid fossil fuels (mass)	Gg	34	35	33	36	33	33	28
Liquid fossil fuels (energy)	TJ	1 493	1 513	1 440	1 553	1 422	1 431	1 224
Source Caltex dBase - Farmers and Agricultural Coop disaggregation								
Indicator ratios								
TJ / ha planted		0.09	0.15	0.16	0.13	0.09	0.09	0.08
N$ value marketed output / TJ		6 273	15 895	16 365	18 875	19 447	32 947	34 214
TJ / Gg marketed		100	37	49	46	39	21	23
Avg 99-01 TJ / ha planted			0.135					

2.3.7.3 Forestry Sub-category:

Energy use in the forestry sub-category is assumed to be totally transport orientated. However, unlike the fishing and agricultural sub-sectors, the amount of fuel consumed for forestry is very small and can thus be ignored.

2.3.7.4 Available Fuel Data for Agriculture, Forestry and Fishing Sub-categories:

The following disaggregated fuel data was available from the Petroleum Wholesalers' database. This data is also incorporated within the general figures presented in the Reference Approach.

Table 2-21 Disaggregated Fuel Data for the Agriculture, Forestry and Fishing Sub-categories as Available in the Petroleum Wholesalers' Database

Input in Gg	Fishing	Agriculture	Forestry	Other / no split	Total Gg	Total TJ
Kerosene	0.0	0.8	0	0	0.8	36
LFO (Diesel)	95.5	31.0	0	0	126.4	5479
Gasoline/ AvGas	0.2	3.2	0	0	3.3	149
Furnace oils	5.3	0.0	0	0	5.3	211
LPG	0.0	0.0	0	0	0.0	1
Lubricants	1.7	1.3	0	0	3.0	61
Total:	102.6	35.5	0	0	138.1	5936

Data sourced from Petroleum Wholesalers' database, as managed by Caltex

2.3.8 Fuel Wood Consumption in the Other Sectors Source Category for Commercial, Institutional, Residential, Fishing, Forestry, and Agriculture

Fuel wood, despite being a memo item, is a cause for concern both as it is a large number and the various sources show high variability. Thus an alternative approach was sought. The comparison between Botswana and Namibia below is based on independent figures for broadly comparable situations and adjusted appropriately. This data has been backtracked to 2000 based on population. The outcome indicates that the data shown in the *Namibia Energy Review For The UNFCCC* (2007) may overall be on the low side but, for urban and domestic use, is remarkably similar; a positive outcome as informal activity is difficult (and expensive) to measure and thus there is a tendency to underestimate. It is also similar to the "high" figure (635 Gg) reported in Appendix D of the *Review of Greenhouse Gas Emission Factors in Namibia* (2005).

Usage for institutional (schools mainly) use is unavailable and has been roughly estimated as 100 Gg based on biomass figures below and the increased access to electricity in rural schools.

Rural industries (beer and bread) is used as below.

Thus total estimated fuel wood consumption for the 808 Gg (398+301+9+100).

Table 2-22 Fuel Wood Estimate Based on Botswana / Namibia Comparison

Fuelwood usage patterns (1991): (page 69)

	Botswana 1991		Household consumption	Total consumption	Namibia 2000	Household consumption	Total consumption estimate
	%	No. of	t/yr	Gg	No. of	t/yr	Gg
Rural Households	50.9	201789	1.9	375.3	209546	1.9	398
Urban households	18.9	63269	2.2	139.2	136909	2.2	301
Rural industries	1.2			8.8			9
Institutions	29			213.6			100
Total	100			736.9			808

Comparative information:

	Botswana	Namibia
Populations 1991 census	1335845	1409920
Surface area	582000	824000

Similar rainfall patterns and vegetation

Source: Biomass Energy Poicy, Selected case studies, Papers 2,3 relating to Botswana - ISBN Pb 1-85649-520-5, Kgathi, Mlotshwa, Sekhwela.

Namibia household data from 2001 Population and Housing Survey.

Poles are used for traditional dwellings and kraals; they are report as stored carbon. The 2001 Population and Housing Census indicates that there 143,810 such dwellings in Namibia; 4718 and 139,092 in urban and rural areas respectively. The 1998 estimate of 694 Gg of poles in storage, as reported in Appendix D of the 2005 *Review of Emission Factors in Namibia*, combines with an annual harvest of poles of 2.38 Gg per year, as reported in the 2007 *Namibia Energy Review* would indicate an approximate stock of 698 Gg in 2000. This figure is used.
Crafts and roots are small, assumed to be exported and have been ignored.

2.3.9 Mining Source Sub-category

Mining is essentially a materials handling exercise with liquid fossil fuels being used for materials transport and electricity being the prime processing energy input. Note that smelting and value added processes are covered under the Industrial sector – where coal and liquid fuels are used additionally. As there are multiple producers with numerous different products, it was decided that an approach similar to that used for the fishing and agricultural sub-categories should be adopted. The approach taken for the mining sub-category involved confirming whether there is a correlation between material moved and the disaggregated fuel use reported in the Petroleum Wholesalers' database. Mining data was derived from the Namibian Chamber of Mines Report.

Once the different mining processes were categorised into diamonds, concentrate production, and industrial chemicals, the analysis yielded manageable and practical correlations with sufficient consistency to suggest that the disaggregated data in the Petroleum Wholesalers' database is reliable. Thus the disaggregated data for the mining sub-category is regarded as fit for input into the IPCC data sheets without change, apart from using a 3-year average for the period 1999 to 2001.

Table 2-23 Correlation of Materials Handled with Fossil Fuel Consumption

		1997	1998	1999	2000	2001	2002	2003	2004	2005
Total product, diamonds	'000 carets	1,418	1,440	1,712	1,552	1,410	2,825	2,936	3,866	3,720
Total product, concentrates	Gg	275	157	92	128	201	172	238	217	158
Total product, chemicals	Gg	531	533	528	682	731	776	835	907	782
Material moved ratio (carats)	t/carat	20	20	20	20	20	20	20	20	20
Material moved ratio (carats)	t/ t concs	8	8	8	8	8	8	8	8	8
Material moved ratio (carats)	t/t chemical	2	2	2	2	2	2	2	2	2
Total material moved (total)	Gg	31,626	31,115	36,030	33,423	31,262	59,440	62,303	80,865	77,231
Total mining fossil fuel input	Gg	26	25	17	31	55	58	49	53	62
Total mining fossil fuel input	TJ	1,108	1,093	758	1,327	2,386	2,510	2,107	2,289	2,680
Energy / material moved	TJ/Gg	0.035	0.035	0.021	0.040	0.076	0.042	0.034	0.028	0.035
Energy / material moved	kWh/t	10	10	6	11	21	12	9	8	10

Table 2-24 Disaggregated Fuel Data for the Mining Sub-category as Available in the Petroleum Wholesalers' Database

Input in Gg	Mining	Total Gg	Total TJ
Wood (dm / Gg)	0.0	0.0	0
LFO (Diesel)	*24.2*	24.2	1048
Gasoline/ AvGas	*2.2*	2.2	99
Furnace oils	*1.1*	1.1	45
Kerosene	2.3	2.3	101
LPG	*0.0*	0.0	1
Bitumen	*2.8*	2.8	6
Lubricants	*1.7*	1.7	35
Total:	*34.3*	*34.3*	1334

Data sourced from Petroleum Wholesalers' database, as managed by Caltex

2.4 COMPARISON OF THE RESULTS OF THE REFERENCE APPROACH TO THE RESULTS OF THE SOURCE CATEGORIES APPROACH

As the following table indicates, the calculated total emissions of carbon dioxide based on the Reference Approach and on the Source Categories Approach differ significantly.

Table 2-25 Reference Approach vs Source Categories Approach

Approach	Total Calculated CO_2 Emission (Gg)
Reference Approach	1 540
Source Categories Approach	2 018

The data utilised for both approaches has been reviewed in detail. It has been concluded that there is no other source of available data that could be obtained, and no change to the calculation methods followed and developed that could be reasonably justified, to reduce the difference in results between the two approaches. It has also been concluded, however, that the greatest potential source of uncertainty/difference most likely lies in the Source Categories Approach (in particular the road transport section of the transport category) since it includes a greater number of assumptions and estimates than does the Reference Approach, which is based on a limited number of data sources that are generally regarded as dependable. This is not to say that there are no uncertainties associated with the comprehensiveness and accuracy of the data utilised in the Reference Approach; only that there appears to be greater potential for error in the Source Categories Approach.

The following are a few possible explanations that together could help explain the difference in results between the two approaches:

1) It is likely that there were imports of liquid fuels to Namibia from neighbouring countries which were performed unofficially and not recorded in the Caltex Wholesaler’s database. This source of uncertainty has greater relevance for the Reference Approach.
2) The number of vehicles registered by NATIS is probably greater than the actual number of vehicles that are active in Namibia. There is no assumption that can be reasonably justified, however, that would ensure a more accurate estimate of the number of active vehicles in Namibia. The other assumptions and rough estimates made in the NATIS analysis are also subject to significant uncertainty. Nonetheless, the innovative NATIS analysis that was developed for this inventory should be retained since it allows the liquid fuels used for transport sector (highly significant) to be quantified independently of the Caltex Wholesaler’s database, upon which the Reference Approach is based. It is recommended that the NATIS analysis be further investigated for possible improvements that could be made in future inventories.
3) The amount of fuel obtained by Namibian vehicles (in particular international commercial trucks) in other countries is not recorded anywhere and would be very difficult to estimate reasonably.

3. INDUSTRIAL PROCESSES

The Industrial Processes category covers those industrial processes that transform materials, chemically or physically. It does not include inputs for process heat, as this is shown under the Energy Sector section. The IPCC broadly classifies this sector into seven industrial processes, of which three are most relevant to Namibia: Mineral Products (for road paving with asphalt); Metal Production (for copper smelting); and Other Production (for food and drink production).

Namibia's industrial sector remains small and little changed over the years; its total Gross Domestic Product (GDP) contribution remains just over 10% with on-shore fish and meat processing representing 0.7% and 1.6% of this total. Beer and cool-drink production make up the majority of the balance.

Cement production at Otjiwarongo ceased in 1998.

The Tsumeb smelting facility was re-commissioned in mid-2000 under new ownership – their production of 5.8 Gg blister copper would have resulted in the release of approximately 6 Gg sulphur (30%Cu in concentrate, 30%S in concentrate).

Fish meal production is fairly constant over the years at about 18 Gg / annum – using approximately 3 Gg of fuel oil / annum – all as process heat (Etosha and United fishing companies only).

Vegetable oil products – very small and negligible.

Grains (wheat and maize data only) are consumed either as bread (wheat based) or as mealie porridge (mainly maize). Using wheat data available from the Namibian Agronomic Board, the data below is used for input (80% of milled grain reports as flour – source: Bokomo).

Table 3-1 Flour and bread production

Year		1998/9	1990/2000	2000/1
Marketed production	t	2,896	3,429	6,119
Wheat imports	t	61,392	47,485	49,317
Flour ex imports/ production	t	51,430	40,731	44,349
Wheaten flour imports	t	6,569	5,906	5,563
Wheaten flour exports	t	8,839	4,664	5,230
Total flour consumed locally	t	38,874	33,827	35,812
flour kg / kg bread	t	0.61	0.61	0.61
Bread output	Gg	63.6	55.4	58.6

Beer production in year 2000 was 1 million hl (about 1.6 in 2006). All carbon dioxide is captured and recycled. Locally produced brew is assumed to also be 1 million hl.

Road paving: the stored mass of bitumen from the Energy Sector section is used as input for NMVOC calculation.

4. SOLVENTS AND OTHER PRODUCT USE

Solvents and related compounds are a significant source of emissions of non-methane volatile organic compounds (NMVOCs) (IPCC, 1996). The Solvents and Other Product Use category includes chemical cleaning substances used in dry cleaning, printing, metal degreasing, and a variety of industrial applications as well as household use. Also included in this category are paints, lacquers, thinners and related materials used in coatings in a variety of industrial, commercial and household applications. Greenhouse gas emissions for the Solvents and Other Product Use category could not be calculated because the calculation instructions and excel worksheets that were available for the other categories were not available for this category. Nonetheless, the items under this category were investigated and rough estimated data for paint was obtained.

Paint: it is estimated that 6,000,000 litres/annum (about 6 Gg/annum) of paint is sold in Namibia. With only 3 major manufacturers, it is understandable that the product breakdown and the imported component are commercially sensitive. However, it was suggested by a supplier that the cheaper varieties are made locally and probably represent 60% of the volume sold.

Autobody finishing is an unknown quantity.

Industrial cleansing is an unknown quantity.

Nitrous oxide emissions from medical waste are unknown, but could be investigated in future inventories.

Note that data for paint imports and cleaning solvents may become available from 2006 as the Customs and Excise ASYCUDA system becomes available for analysis.

5. AGRICULTURE

The *Revised 1996 IPCC Guidelines* indicate that agricultural greenhouse gas emission sources to be considered for the 2000 Inventory are unchanged from the 1994 Inventory. Methane remains the most significant emission, and as Namibia cultivates only a miniscule amount of rice in flooded fields, the areas of significance remain:

- Domestic livestock: Enteric fermentation and manure management
- Burning of savannas
- Field burning of agricultural residues
- Agricultural soils

The nature of Namibian agriculture in year 2000 changed little since the 1994 Inventory report -- extensive ranching and dry-land cropping with differing methods and productivity between the commercial and subsistence growers. One small feedlot for cattle is in operation. Dairy operations supplied about half the nation's needs: all fresh milk was produced locally while all ultra high temperature (UHT) products were imported (UHT locally produced from 2007).

5.1 DOMESTIC LIVESTOCK

Records of domestic livestock are well maintained by the Meat Board. The numbers of livestock are steadily rising apart from Ostrich where profitability has decreased from 2003 onwards. Methane emissions are significant especially when the environmental impact of methane is 21 times that of carbon dioxide. The emission factors for enteric digestion, the bodyweights, and the food and protein consumption input were obtained from the *Review of Greenhouse Gas Emission Factors in Namibia,* calculated according to the Tier 2 method (IPCC 1997 – Table 5) requirements, and are summarised below.

The emissions of the dairy herd of 2190 (year 2000) makes minimal impact, and as 90% of milk production comes from Namibian Diaries whose average yield is 25 litres/head/day, the Western European emission factor of 100 was used (*Review of Greenhouse Gas Emission Factors in Namibia* recommends a figure of 77.9 for beef cattle). Other diary farmers have lower yields, but as their output is so low their different circumstances and thus emissions are ignored.

The discussion of the anthropod related decline in game numbers over the past 150 years, and thus the "saving" of methane emissions remains in question, and thus game emissions (ex. game farms) have not been taken to account. Note that although game count data is not available for year 2000, the rapid expansion of both communal and commercial conservancies with their reporting requirements will result in numbers becoming available.

It is important to note that the 2005 *Review of Greenhouse Gas Emission Factors in Namibia* concluded that emissions from manure are negligible in Namibia and indicated that the calculations for such emissions could be eliminated from the 2000 Inventory, even though those worksheets were completed in the 1994 Inventory. Emissions from manure were therefore not calculated in this inventory.

Table 5-1 Livestock Inventory

Namibia Totals	1996	1997	1998	1999	2000	2001	2002	2003
Cattle	1,989,947	2,055,416	2,192,359	2,278,569	2,504,948	2,508,570	2,329,553	2,336,094
Sheep	2,198,436	2,429,328	2,086,434	2,160,651	2,446,146	2,369,809	2,764,253	2,955,454
Goats	1,786,150	1,821,009	1,710,190	1,689,770	1,849,569	1,769,055	2,110,092	2,086,812
Camels	49	38	50	40	N/A	N/A	88	124
Horses	56,988	57,099	53,325	49,777	61,885	52,502	47,220	47,542
Donkeys	169,678	166,296	162,973	164,496	167,548	169,314	134,305	119,828
Pigs	18,923	16,884	14,706	18,731	23,148	21,854	47,805	46,932
Poultry	458,158	522,618	403,937	450,513	476,331	502,356	883,950	894,027
Ostriches	38,891	46,725	52,393	33,116	47,823	59,309	62,976	18,930

Source MeatCo data sheets

Table 5-2 Major Livestock Distribution – Commercial / Communal

Distribution	1996	1997	1998	1999	2000	2001	2002	2003
Cattle % in communal areas	62.7	61.5	62.4	63.6	66.2	63.6	63.0	59.4
Sheep % in communal areas	14.5	13.0	17.2	13.6	14.7	11.2	9.6	9.6
Goats % in communal areas	69.5	70.0	71.9	72.7	73.4	66.2	69.0	71.5
Slaughter data								
% offtake from NCA						1.2	2.2	1.7

Table 5-3 Methane Emissions

For 2000	Mean body mass	Namibian herd size	Protein in diet	Emission factor	Total emission
	kg		%	g CH_4 /y/head	Gg CH_4 /y
Dairy cattle	400	3,190	12	100,000	0
Cattle	330	2,504,948	9	77,931	195
Sheep	60	2,446,146	9	12,990	32
Goats	60	1,849,569	9	8,713	16
Horses / donkeys	350	229,433	4	30,244	7
Pigs	130	23,148	13	3,417	0
Total					**250.4**

5.2 SAVANNA BURNING

Satellite mapping of fire scars has improved analysis of bush fires, although the data for year 2000 is incomplete. Use of 2001 – 2003 data iterated by use of the available Kavango / Caprivi data enabled a reasonable estimate of the burn area for year 2000.

The tables below show data from two different sources for comparison purposes. The first is based upon Table 8 of the *Review of Greenhouse Gas Emission Factors in Namibia* which was based on MODIS analysis, the Mendelsohn vegetation categorisation, and gave a practical indication of fuel loading and consumption. This report simplified the 29 “Mendelsohn zones” to the 14 Giess zones. While this is based upon "overlap" estimates which result in some area discrepancies, it is fortunate that the discrepancies occur in areas that suffer little or no fire damage. The data available was for year 2003. Small, insignificant discrepancies were identified in some of the data obtained.

The comparative data was obtained from maps published by the National Remote Sensing Centre for years 2001 through 2003 (LandSat). Tabulated data was included in these maps indicating burn by region (year 2003 only indicated a total).

Table 5-6 indicates the extent of fire burn over a 13 year period for the Kavango / Caprivi regions, where the fireburn is most significant and provides a proxy for the "fire level" in other regions. It is evident that year 2000 was a year of serious fireburn, perhaps as a result of late rains and a high fuel load. The indication is that 30,000 to 50,000 km^2 per year burn which equates to about 3.5% to 6.0% of Namibia's total land area. 3.5-6.0% is relatively low compared to the Mendelsohn estimate of 6-13% in the *Review of Greenhouse Gas Emission Factors in Namibia*.

As fireburn fuel consumption depends on many variables – humidity, rainfall, wind, temperature, last burn, fuel load and numerous other degrees of freedom -- the accuracy of emission calculations remains problematic. It should be noted with concern that the apparent enthusiasm for data collection on fireburn has waned, and data after year 2003 appears to be thin. This may prove problematic for preparation of the 2005 Inventory. The lack of tabulated data for management purposes is of considerable concern.

With respect to whether fireburn is anthropogenic or not, almost all those spoken to in the course of data collection were of the opinion that fires in communal areas are started by man and generally left to burn. The definition of fires is given by the Directorate of Forestry (on their maps) as:

> "Fires in Namibia are a mixture of uncontrolled fires, controlled fires, prescribed fires and naturally occurring fires. Naturally occurring fires happen in the late dry season and are a result of lightning. Prescribed fires occur in April - May, while the other man-made fires mainly occur between July and October. The majority of fires are still uncontrolled and started by people".

Fires in commercial areas appear to be controlled or extinguished for economic reasons. Thus, as a matter of policy, fireburn is considered as anthropogenic but the carbon dioxide emitted from fireburn is not counted towards recorded national emissions as it is assumed that re-growth of flora compensates the emissions (carbon-neutral).

Table 5-4 Fireburn Data for Year 2003
(from Review of Greenhouse Gas Emission Factors in Namibia)

Giess code	Giess Vegetation Category	Area sq km	Burn area sq km	% burn area of total	Fuel consumed
1	North Namib	20,893	0	0	0
2	Saline Desert with Dwarf Savanna	9,956	199	2	68
3	Forset Savanna & Woodlands	161,550	29,706	18	16,850
4	Kamel Thorn Savanna	60,945	390	1	146
5	Mixed Tree & Shrub Savanna	68,361	0	0	0
6	Central Namib	32,096	5	0	0
7	Southern Namib	47,304	2	0	0
8	Desert succulent and steppe	20,265	2	0	1
9	Semi Desert & Savanna Transition	78,804	521	1	159
10	Mopanie	112,748	3,172	3	1,406
11	Mountain Savanna & Karstveld	14,366	274	2	214
12	Thorn Bush Savanna	42,495	17	0	10
13	Highland Savanna	23,801	126	1	55
14	Dwarf Shrub Savanna	131,995	47	0	7
	Totals	**825,579**	**34,460**	**4**	**18,916**

Table 5-5 Fireburn Data for Year 2001 – 2003 (NRSC maps)

Region	Area of Region km[2]	Fireburn 2001 km[3]	Fireburn 2002 km[4]	Fireburn 2003 km[5]
Caprivi	14,528	9,556	7,147	
Erongo	63,579	957	0	
Hardap	109,651	440	0	
Karas	161,215	0	0	
Kavango	48,463	8,681	21,000	
Khomas	37,007	2,370	142	
Kunene	115,293	6,367	39	
Ohangwena	10,703	0	77	
Omaheke	84,612	5,294	2,390	
Omusati	26,573	3,556	395	
Oshana	8,653	601	0	
Oshikoto	38,653	1,470	113	
Otjozondjupa	105,185	9,494	5,145	
Totals	**824,115**	**48,786**	**36,448**	**31,369**

Data from NPC database - regional area data, population

Fireburn data - from NRSC maps 2001 through 2003 (2003, no diaggregation)

It is also pertinent to note the Verlinden (NPC, Lux Cooperation) has firescar figures of 48,570 and 52,453 km^2 for years 2001 and 2002 respectively, from his work from LandSat images.

Table 5-6 Fireburn Data for Caprivi / Kavango 1989 – 2001 (Verlinden NPC / Le Roux MET)

% firescar.

Name	Area km2	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Caprivi	31532	37%	35%	23%	35%	22%	28%	35%	31%	23%	16%	20%	29%	24%
Kavango	46718	26%	36%	38%	40%	31%	47%	21%	26%	23%	32%	26%	50%	22%

The figure used for fireburn mass consumed in year 2000 is 24,000 Gg (25% above 2003), as 2000 was a high fire year. As recommended in *Review of Greenhouse Gas Emission Factors in Namibia*, emissions from manure and the burning of agricultural residue are entered as zero.

6. LAND USE CHANGE AND FORESTRY

Vegetation growth captures carbon dioxide and increases the rate of transpiration; vegetation clearing has the reverse effect. The following general types of anthropogenic impacts on land-use and forestry are considered:

- Deforestation, primarily in northern areas but also around expanding urban areas
- Clearance for commercial agricultural purposes
- Bush encroachment resulting to a large extent from commercial ranching practices subsequent to colonisation in the early 1900's.

In terms of the IPCC worksheets, the Land Use Change and Forestry sector is comprised of the following sub-sectors:

- Changes in Forest and Other Woody Biomass
- Forest and Grassland Conversion – CO_2 from Biomass
- Non-CO_2 Trace Gases Released by On-site Burning of Biomass
- Abandonment of Managed Lands, Soil Carbon, Organic Soils and Liming

As indicated in the IPCC data sheets, the impact of bush encroachment is highly significant for Namibia's greenhouse gas emissions profile; the bush encroached area serves as a huge, anthropogenic CO_2 sink.

New information regarding the extent and nature of bush encroachment was published subsequent to the preparation of the 1994 Inventory, and can now be utilised for this 2000 Inventory. The most notable contribution to the study of bush encroachment is a report by JN de Klerk which as published in 2004 and entitled *Bush Encroachment in Namibia*. The report highlights earlier work performed by Bessie Bester which indicates that bush encroachment occurs over an area of approximately 26 million hectares; this is significantly larger than the estimated 10 million hectares upon which calculations in the 1994 Inventory were based. The issue of woody mass growth is discussed at length in the *Review of Greenhouse Gas Emission Factors in Namibia*, which emphasises the need for extensive field studies to be performed. While new field studies have yet been performed, an estimate of the average growth rate of invader bush was calculated in the 2000 Inventory using data presented in *Namibia Energy Review for the UNFCCC* (2007) which was sourced from MET-DEA. The *Namibia Energy Review* report provides data on the growth of woody biomass for each region during year 2004. After reviewing the regions where bush encroachment is most predominant, data from four regions (Omusati, Oshikoto, Otjozondjupa and Omaheke) was utilised to calculate an estimate of the average growth rate for woody biomass in the bush encroachment area. Data provided in *Namibia Energy Review for the UNFCCC* is summarised in the following Table 6-1.

Table 6-1 Total Woody Mass and Woody Biomass Growth in Namibia by Region

Summary of Namibia's woody stock data:

Land category:	km^2
Total area:	824000
Desert:	131000
Savanna:	532000
Woodlands:	161000
Source: NAMIBIA ENERGY REVIEW FOR THE UNFCCC, 20 July 2007	

Forest woody volume (2004) and growth estimate for bush encroached area

Region	Density m^3/ha	Volume million m^3	Area (Calc) km^2	Resource mass Tg	Contained C Tg	Growth / y million m^3	Growth / y Tg
Caprivi	21.37	30.92	14467	21.64	10.82		1.62
Erongo	0.10	0.64	63590	0.45	0.22		0.03
Hardap	0.10	1.10	109660	0.77	0.38		0.06
Karas	0.05	0.81	161080	0.56	0.28		0.04
Kavango	18.00	87.27	48483	61.09	30.54		4.56
Khomas	0.25	0.92	36860	0.65	0.32		0.05
Kunene	0.20	2.30	115155	1.61	0.81		0.12
Ohangwena	20.00	21.39	10694	14.97	7.49		1.12
Omaheke	2.00	16.89	84440	11.82	5.91		0.88
Omusati	3.22	8.54	26517	5.98	2.99		0.45
Oshana	0.90	0.78	8682	0.55	0.27		0.04
Oshikoto	11.44	44.24	38669	30.97	15.48		2.31
Otjozondjupa	3.90	41.08	105334	28.76	14.38		2.15
Total	3.12	256.86	823631	179.80	89.90	19.18	13.4
Source: Base data from NAMIBIA ENERGY REVIEW FOR THE UNFCCC, 20 July 2007, DEA				Using .7t/m^3	Using 50% C	Ex report total	Using .7t/m^3

Harvested product: (2004)

	Annual replacement million m^3 /yr	Annual harvest million m^3 /yr	Usage gap million m^3 /yr	Annual addition to resource mass Tg	Annual addition to C sink Tg
Fuel wood	16.29	1.02	15.27	10.69	5.34
Poles	2.72	0.3344	2.38	1.67	0.83
Saw timber	0.1713	0	0.1713	0.12	0.06
Totals	19.18	1.36	17.82	12.48	6.24
Source: NAMIBIA ENERGY REVIEW FOR THE UNFCCC, 20 July 2007, DEA				Using .7t/m^3	Using 50% C
Source: Using 0.7t/m3 not .8 - wood densities (dry) - from FAO web site					

In addition to providing data related to bush encroachment, the *Namibia Energy Review for the UNFCCC* provides useful data regarding traditional fuel wood and wood poles which was back adjusted to year 2000 and input into the IPCC data sheets. Data regarding charcoal production was obtained from the National Charcoal Producers Association and input into the IPCC data sheets.

Data regarding the total area/annum of conversion of forested land was obtained from the 1994 Inventory, which was still valid during year 2000. Other data required for the IPCC data sheets, such as estimated amount of biomass/ha, was obtained from the *Namibia Energy Review for the UNFCCC.* On- and off-site burning of woody biomass from cleared forested areas was assumed to be negligible. Note the low density of woody biomass (2 tons/ha) that was recently estimated for such areas in *Namibia Energy Review for the UNFCCC.*

Both the amount of non-CO_2 trace gases released by on-site burning of biomass and carbon dioxide emissions resulting from abandonment of managed lands, soil carbon, organic soils and liming were estimated to be negligible.

7. WASTE

The most important greenhouse gas produced in the Waste category is methane. The Waste category considers three main types of waste: 1) solid wastes disposed of through landfilling, recycling, incineration, or waste-to-energy; 2) treatment of liquid wastes, and; 3) waste incineration.

As societies develop their industry and economy so does their production of waste materials; the major products to be handled are 1) waste water (industrial and domestic) and 2) solid waste of variable nature, some with the potential to be recycled economically. Both may include materials that may constitute a health hazard (toxic or biological). Namibia, as a low / medium income country with a considerably poor rural society, a growing wealthy urban middle class, and significant urban drift (6% to towns from 1991 to 2001), is beginning to feel the pressure on its disposal facilities throughout the country.

Reliable flow and COD (Chemical Oxygen Demand) data is not available for the majority of Namibia's waste water effluent plants; however, the Windhoek Gammans / Otjimuise operations, which handle the majority of the Windhoek's sewage do have good data. The plants handle approximately 27,000 m^3 of waste water per day (10 million m^3 per year). This represents approximately 75% of the NamWater input, and is equivalent to 42 m^3 per person per year. Plant managers also indicate that COD recovery is approximately 95% for Gammans / Otjimuise and 87% for the Ujams pond system (which treats mainly industrial waste). Furthermore, the Gammans / Otjimuise operations recover more than 95% of the TKN (Total Kjeldal Nitrogen).

The IPCC data sheets utilise the above data for the Windhoek population, and IPCC default values and the recommendations of the *Review of Greenhouse Gas Emission Factors* for the remainder of the urban areas.

Table 7-1 Sewage treatment types and urban populations

Region	Town	Sewage type(s)	Population 2000
Caprivi	Katima Mulilo	ponds	22,134
Erongo	Walvis Bay	activated sludge plant	43,611
Erongo	Swakopmund	activated sludge plant	23,808
Erongo	Omaruru	ponds	4761
Erongo	Arandis	ponds	3974
Erongo	Karibib	ponds	3726
Erongo	Henties Bay	ponds	3285
Erongo	Usakos	ponds	2926
Hardap	Rehoboth	ponds	21,308
Hardap	Mariental	ponds	9836
Karas	Keetmanshoop	ponds	15,778
Karas	Lüderitz	ponds	13,295
Karas	Oranjemund	ponds	4451
Karas	Karasburg	ponds	4075
Kavango	Rundu	ponds	36,964
Khomas	Windhoek	Anaerobic digesters, activated sludge and bio-filters; industrial waste ponds	233,529
Kunene	Outjo	ponds	6013
Kunene	Khorixas	ponds	5890
Kunene	Opuwo	ponds	5101

Table 7-1 (continued) Sewage treatment types and urban populations

Region	Town	Sewage type(s)	Population 2000
Ohangwena	Eenhana	ponds	2814
Omaheke	Gobabis	ponds	13,856
Omusati	Outapi	ponds	2640
Oshana	Oshakati	ponds	28,255
Oshana	Ondangwa	ponds	10,900
Oshana	Ongwediva	ponds	10,742
Oshikoto	Tsumeb	biofiltration plant	14,929
Otjozondjupa	Otjiwarongo	ponds	19,614
Otjozondjupa	Grootfontein	ponds	14,249
Otjozondjupa	Okahandja	ponds, activated sludge plant	14,039
Otjozondjupa	Otavi	ponds	3813
Otjozondjupa	Okakarara	ponds	3296
Total			**603,612**
Note: data from 2001 Population & Housing Census – table 1.2.3			

Table 7-2 Water, Toilet and Garbage Data by Region

Region	Water m3	Water m3 / head	Toilet, flush % of households	Toilet, bush % of households	Garbage collected, % of households	Number of households	Population	Numbers living in main urban areas	% living in main urban areas
Caprivi	2,622,191	33	13.3	83.4	31.5	16 839	78 785	22 134	28.1
Erongo	8,742,045	85	80.3	11.5	87.7	27 496	103 180	86 091	83.4
Hardap	3,160,883	48	49.6	34.0	58.3	15 039	66 028	31 144	47.2
Karas	3,707,581	58	57.8	26.0	76.8	15 481	64 039	37 599	58.7
Kavango	3,331,759	17	7.3	81.3	30.6	30 467	198 963	36 964	18.6
Khomas	13,130,931	54	75.3	20.2	87.9	58 580	243 585	233 529	95.9
Kunene	2,317,043	35	26.2	65.5	45.6	12 489	66 385	17 004	25.6
Ohangwena	360,097	2	3.2	88.8	45.4	35 958	226 416	2 814	1.2
Omaheke	1,092,173	16	32.9	62.2	34.5	12 590	66 779	13 856	20.7
Omusati	781,319	3	3.3	83.0	42.4	38 202	226 337	2 640	1.2
Oshana	3,478,191	22	19.2	49.2	53.3	29 557	158 181	49 897	31.5
Oshikoto	488,767	3	15.9	70.2	43.1	28 419	158 352	14 929	9.4
Otjozonjupa	3,924,677	34	47.8	42.7	64.5	25 338	116 205	55 011	47.3
Total	**47,137,656**	**27**	**34.4**	**54.2**	**42.4**	**346 455**	**1 773 235**	**603 612**	**34.0**
Urban			72.5	17.4	76.6	136 909	578 812		
Rural			9.5	78.3	20.1	209 546	1 194 423		
Namibia			34.4	54.2	42.4	346 455	1 773 235		

Note: Water data from NamWater - some urban areas have own systems (i.e. Tsumeb / Grootfontein) - thus not included

Note: Population, garbage, toilet and urban distribution all from 2001 Population and Housing Census

Note: Collected garbage is sum of regular, irregular collection plus roadside dumping (usually skip collection)

Information regarding the percentage make-up of typical contents in solid waste and the typical amounts\ per capita was difficult to identify. However, some data on the content of waste based on a 2004 study is shown below. The contractor for the Kupferberg landfill site (Windhoek) provided recent, but very limited data; this would indicate that about 40Gg of waste is produced per annum in Windhoek (present rates). Discounting this back (-5% per annum) to 2000 and using the Windhoek population at that time indicates that a town dweller would dispose on average 0.35 kg of solid waste per day. When compared with an estimate of the average per capita solid waste disposal in the USA of 0.85 kg/day (Source: Mexico Emissions Inventory Program Manuals, Volume V - Area Source Inventory Development, Final, March 31, 1997), the value for Windhoek would appear reasonable. 0.35 kg/day was therefore used.

It should be noted that refuse is regularly burned at dumps located throughout Namibia as a way to reduce volumes. However, not all towns follow this practice, so it would not be practical to estimate the amount of refuse burned annually in Namibia.

Table 7-3 Typical Contents of Solid Waste in Windhoek

Analysis of general waste.	% weight	% volume	kg/day/town dwellers	Gg / y
Metal	4	6	10498	3.8
Glass	14	7	36742	13.4
Ceramics	0	0	0	0.0
Non-biodegradable	18	13	47239	17.2
Plastic (containers)	4	14	10498	3.8
Plastic (soft)	7	14	18371	6.7
UV degradable	11	28	28868	10.5
Organic food products	15	7	39366	14.4
Garden refuse	32	16	83981	30.7
Wood / timber	1	1	2624	1.0
Biodegradable organics	48	24	125971	46.0
Paper (plain)	9	14	23620	8.6
Paper (Carton)	6	15	15746	5.7
Biodegradable paper	15	29	39366	14.4
Total	92	94	241445	88.1

Source: Nature of General Waste graphic - Kupferberg, study of October - November 2004 (From Windhoek City Engineers)

Total based on 0.4 kg / day / urban dweller then material distribution back calculated.

Table 7-4 Recent Monthly Amounts of Solid Waste in Windhoek

Analysis of Kupferberg inputs	**Apr-07 (m3)**	**May-07 (m3)**	**Jun-07 (m3)**	**% by volume**
1. General waste	5064	4958	5562	91
2. Garden waste	1	1	1	0
3. Builders rubble	76	5	11	1
4. Hazardous waste	459	452	490	8
Total	**5600**	**5416**	**6064**	**100**
Mass estimates				**% by weight**
1. General waste @ .5 t/m3	2532	2479	2781	46
2. Garden waste @ .3 t/m3	0.3	0.3	0.3	0
3. Builders rubble @ 2.0t / m3	152	10	22	1
4. Hazardous waste @ 2.0 t/m3	918	904	980	16
Total	**3602**	**3393**	**3783**	**100**

Source: EnviroFill contractors data from City Engineer

8. RECOMMENDATIONS

A few detailed recommendations have been formulated that both would improve future greenhouse gas inventories, and would provide cross-cutting benefits related to carbon credit applications, promotion of renewable energy, and finding solutions to the bush encroachment problem. Some of the recommendations are supported by previous recommendations made in the *Year 1994 Inventory* and in the 2005 *Review of Greenhouse Gas Emission Factors in Namibia.* The following are the recommendations:

Recommendation 1:

Establish a greenhouse gas data collection unit within a Government body such as the National Planning Commission Central Bureau of Statistics or the Ministry of Environment and Tourism – Department of Environmental Affairs.

As mentioned in Section 1.2, the process of contacting individuals and organisations during the data collection process is extensive and time consuming. The data to be collected is more than five years old and typically stored away in archive files. Furthermore, there is limited disaggregated data available in since key stakeholder institutions are not encouraged and monitored by any Government body to improve and communicate their record keeping of greenhouse gas data. The situation could be significantly improved if a government body was delegated with the responsibility of collecting relevant data and communicating with key stakeholder institutions on a continuous basis. In addition to being necessary for Namibia's greenhouse gas inventories, reliable and comprehensive greenhouse gas data will be critically important for the future preparation of carbon credit funding applications for projects and programmes that could prove highly beneficial for Namibia. It is important that the mission of the future greenhouse gas data collection unit include both of these objectives: improved greenhouse gas inventories, and optimal technical support of carbon credit applications.

DEA and the Namibia Committee on Climate Change (NCCC) should take the lead in identifying the ideal institutional body to host the greenhouse gas data collection unit. DEA and NCCC should then discuss the need for the data collection unit with the leaders of the potential host institution, propose the number of staff required and the annual budget required.

Recommendation 2:

Conduct scientific studies that will significantly improve our understanding of the impact of invader bush encroachment on Namibia's greenhouse gas profile.

Bush encroachment is the single most significant factor in determining Namibia's greenhouse gas profile, yet the available data regarding the total area, mass density, and growth rate, is based largely on rough estimates performed by local experts. The vast potential of invader bush as a commercial resource for the electricity, liquid fuel, and cooking fuel sectors also warrants the funding of comprehensive scientific studies. Furthermore, the disastrous consequences that bush encroachment has had on the agriculture sector have prompted numerous stakeholders to call for wide-scale elimination of invader bush. It is important that future studies establish a better understanding and consensus of the pros and cons of large-scale bush harvesting and the underlying sustainability criteria. Similar to Recommendation 1, it is important that the funding and implementation of this recommendation be focused on more than just supporting the better greenhouse gas inventories in the future. There are other important economic and environmental objectives and benefits to be achieved simultaneously.

DEA and NCCC should work with experts within MET and MAWF to determine the type of studies (remote sensing, field tests) that should be performed to obtain data required for improved greenhouse gas inventories and environmental management. DEA, NCCC and the newly established Designated National Authority should meet with leaders of MAWF and MME, and other informed stakeholders, to identify and obtain consensus about the cross-cutting objectives of invader bush study and the funding required for such a study.

Recommendation 3:

Clarify the details of pre-anthropogenic baseline ecological conditions in Namibia.

A number of questions were raised at the stakeholder workshop regarding what are the baseline ecological conditions that define anthropogenic influence. Some examples of the questions raised include:

- To what extent can game numbers be increased on Namibian game farms before the impact is considered an anthropogenic factor to be quantified and recorded in the greenhouse gas inventory?
- What is the defining year and corresponding vegetative conditions after which the growth of invader bush is considered an anthropogenic influence?
- Have termite populations increased as result of anthropogenic factors?

It is recommended that the baseline ecological conditions that define the starting point of anthropogenic influences be better defined, and that selected issues such as the one related to termites be given more review and evaluation. This will help to ensure that the fundamental environmental principles that underlie Namibia's greenhouse gas inventory process are better understood by Namibia's environmental stakeholders and that there is consensus around those principles.

DEA and NCCC should approach UNDP, UNGEF or UNFCCC to provide funding for a short study that would address the issues raised above.

Recommendation 4:

A review similar to the 2005 *Review of Emission Factors for Namibia* should be performed on the 2000 Inventory.

The 1994 Inventory received a thorough review in the 2005 *Review of Emission Factors for Namibia*; and this 2000 Inventory requires a similar, independent in-depth review. The review should in particular focus on how Source Categories Approach in the Energy Sector could be improved and become more independent of the Caltex Wholesaler's database upon which the Reference Approach is largely based. The review could also resolve potentially conflicting recommendations made in the 2005 Review and by the independent UNDP reviewer for this inventory regarding the need and significance of calculating emissions for manure in the Agriculture Sector.

DEA and NCCC should approach UNDP, UNGEF or UNFCCC to provide funding for a such review.

Appendix 1

List of Contacts for Data

Organisation	Contact's surname	Contact's name	Tel.No	Fax No	email	Comments	Sector
Barlows (paint)		Robert	280 4200			Paint consumption estimate	Solvents
Bokomo Mills	Hite	Eugene	264466			Flour milling	Industrial
Caltex Fuel Database	Peens	AP	27214037296		ajpeens@absamail.co.za	Prime source of liquid fuel data	Fuel
City of Windhoek (Engineering)	Cronje	Gerhard	290 2103	2902404	glc@windhoekcc.org.na	Section Engineer Waste water	Waste
City of Windhoek (Engineering)	Menges	Jurgen	290 3450			Microbiologist	Waste
City of Windhoek (Engineering)	Beukes	Jaco	290 2755			Section Engineer Solid Waste	Waste
CRIIA	du Plessis	Pierre	254766 / 220117			Advice on IPCC system	General
Etosha Fisheries		Grizzel	064 215600			Fishing and fuel info	Industrial
Independent	Bester	Bessie	251956			Bush - wide experience, good source	Land
Luxembourg Cooperation (NPC)	Verlinden	Alex	238 2042	239376	alex.verlinden@	GIS / vegetaition and bush fires	Land
Meat Board	Schutz	Willie	275 830		willie@nammic.com.na	Excellent stock and slaughter data	Agriculture
MeatCo (Okahandja)	du Preez	Hannes	062 501061			Abattoir fuel usage	Fuel
MeatCo (Windhoek)+A22	Hobling	Tony	321 6000			Abattoir fuel usage	Fuel
Ministry of Agriculture, Water and Forestry	Bamhare		208 7505			Contacted - stock info source elsewhere.	Agriculture
Ministry of Agriculture, Water and Forestry	Coetzee	Marina	2087111 / 2529 ?			GIS land use - agricultural classification	Land
Ministry of Agriculture, Water and Forestry	Hailwa	Joseph	208 7330 / 7663			Background information and contacts	Land
Ministry of Agriculture, Water and Forestry	Espach	Celeste	208 7070			GIS expert	Land
Ministry of Agriculture, Water and Forestry (Katima)	Beatty	Robin			robin.bt@gmail.com	Fire management	Land
Ministry of Environment and Tourism	le Roux	Johann	271281			GIS data to 2004	Land
Ministry of Environment and Tourism (DEA)	Nghitila	Te	284 2751			Background information and contacts	General
Ministry of Environment and Tourism	Lindeque	Malan	284 2333			Now PS MTI	General
Ministry of Environment and Tourism	Griffin	Mike	237553			Background information and contacts	General
Ministry of Mines and Energy	Nghishoola	Emmanual	2848322			Fuel statistics	Fuel
Ministry of Mines and Energy	Iiita	Joseph	284 8312			Background information and contacts	General
Ministry of Mines and Energy	Uutoni	Selma	284 8322			Director Energy, background information and contacts	General
Ministry of Works, Transport and Communication (Civil Aviation)	Gunzel	Tobias	702215			Civil aviation - real time TLA data	Fuel
Namibia Agronomic Board	Brock	Christof	379 500			Excellent source on grains and horticulture	Agriculture
Namibia Agronomic Board	Nel	Madeline	379506			Flour and grain info.	Industrial
Namibia Breweries	Lukashic	Rolf	320 4999			Brewery fual and output data	Industrial

Organisation	Contact's surname	Contact's name	Tel.No	Fax No	email	Comments	Sector
Namibia Dairies	Krier	Llewellyn	299 4734			Confrmation of dairy data	Agriculture
Namibian Agricultural Union	Margraff	Harald	237838			Dairy cattle information	Agriculture
Namibian Charcoal Producers Association (Grootfontein)	Enslin	Willem	067 306225 / 240084			Producer and good source	Land
Namibian Charcoal Producers Association (Otjiwarongo)	Coetzee	Desmond	062 503838			Producer information	Land
Namibian Manufacturers Association	Fourie	Hennie	299 5000	2995271	nmc@ppnam.com	Background information and contacts	Industrial
NamPower	Carstens	Rinus	205 2331		Rinas.Carstens@nampower.com.na	Backgroud information	Energy
NamPower	Kasai	Eli	2052216			Power data	Energy
NamPower	Langehoven	Piet	2052111			van Eck power station	Energy
Namwater	Enslin		71000			Closed cement plant information	Industrial
Namwater	Muisoor	Hendrik	712061		muisoorh@namwater.com.na	National water statistics	Waste
National Botanical Institute	Strobach	Ben	202 2040			GIS / vegetaition	Land
National Planning Commission	Sindano		283 4111			Limited power statistics	Energy
National Remote Sensing Centre (MAWF)	Shapala		208 7331	222830		GIS / vegetation info	Land
NATIS	Brock	Wilfred	284 7203			Registered vehicle data	Fuel
Petroleum Wholesaler's Association	Schmidt	Harald	228839			Taxed fuel data - confirmation provision	Fuel
Polytechnic (REEEI) and AMUSHA cc	Schutt	Harald	232333	237823	REEEI@polytechnic.edu.na	Informed on renewables	Energy
RAISON	Mendelson	John	254962			not contacted but has broad data	Land
TransNamib	Dempsey	Jack	298 2022	2982710	Jack.Dempsey@TransNamib.com.na	Bulk freight statistics	Fuel
TransNamib	Englebrecht	Sakkie	2982606			Now retired - referred Wessels Swanepool for loco data	Fuel
United Fisheries	Pronk	Willie	064 217500			Fishing and fuel info	Fuel
Weatherly Mining and Smelting	Nolte	Hans	081 122 8505			Smelter fuel use	Fuel

Appendix 2

IPCC Data Sheets

Appendix 3

EVALUATION OF POTENTIAL GREENHOUSE GAS BENEFITS RESULTING FROM FUTURE RAILROAD DEVELOPMENT IN NAMIBIA'S NORTHERN REGIONS

EVALUATION OF POTENTIAL GREENHOUSE GAS BENEFITS RESULTING FROM FUTURE RAILROAD DEVELOPMENT IN NAMIBIA'S NORTHERN REGIONS

Question to be answered: Would expanded railway use (passenger & freight) in the northern part of Namibia result in reduced greenhouse gas emissions?

Recent political activity has pushed matters relating to the northern extension into the spotlight. It is common knowledge that the passenger train broke down some months ago; contacts indicate that the amount of freight carried at present is small although on the increase. Thus costs and comparative benefits cannot be calculated on real data – and it would be unwise to speculate on past reports or hypothetical scenarios. The road industry is equally hesitant to release specific movement or cost data for commercial reasons. Their opinion is that the bulk of goods going north is transported by truck and, apart from bulk materials (fuel, coal, cement, fertiliser), this situation is likely to remain as customers regard road transport as cost effective, predictable and reliable. Several contacts indicated that TransNamib tariffs are often double that of road transport (charcoal transport is a good example). Customers will put their money where it provides the service they need. TransNamib contacts indicated that their prime business remains the bulk side of the market and foresaw little change in this unless the final linkup to Angola was matched with further rail linkups within Angola. However, containerised through traffic to Angola is currently operating at 250 t/day (average) and increasing – presently transhipped by road to the Oshikango border.

Thus, the answer to the question has to remain at a simple level – that of a straight comparison of specific fuel consumption, ml fuel/tonne/km. Both rail and road transport utilise diesel fuel; and both produce similar greenhouse gas emissions per unit of fuel. The new Chinese Cummings powered locomotives are fully environmentally compliant, as are modern truck engines.

A comparison of specific fuel consumption:

	Units	Train	Truck
Fuel consumption	litre / km	6.40	0.30
Engine rating	kW	3300	368
Cargo load	t	800	36
Specific fuel consumption	mg / t / km	6.4	6.7

Train based on twin Chinese locos hauling 1800t gross inc. engines
Truck based on interlink with 3 6m containers.

The data above was sourced from TransNamib and confirmed by a large road haulage operator. It is evident from the above that fuel consumption and pollution levels for both forms of motive power are very similar. If the additional handling and "to site" transportation of containers required for rail transport is taken into account, the difference between the two types of transportation becomes insignificant.

In conclusion, it appears that expansion of the railway in the northern parts of Namibia would not result in less greenhouse gas emissions than road transport.