UNDP Global Project:
Capacity Development for Policy Makers
To Address Climate Change

Assessment of Investment and Financial Flows to Mitigate Climate Change in the Energy Sector in Namibia

September 2011

Capacity development for policy makers: addressing climate change in key sectors

In May 2008, the United Nations Development Program (UNDP) launched the global project, "Capacity Development for Policy Makers to Address Climate Change". The overall goals of the project are twofold:

- Increased national capacity to raise awareness and co-ordinate Ministerial and stakeholder views on climate change, leading to enhanced participation in the UNFCCC process;

- Support for long-term climate change planning and priority setting, using assessments of investment and financial flows to address climate change in key sectors, which can provide a better understanding of the magnitude and intensity of national efforts needed to tackle climate change, as well as provide more accurate estimates of the funds needed to implement mitigation and adaptation actions.

Namibia is one of the 15 countries participating in the project that undertook the assessment of investment and financial flows, using a UNDP methodology. National experts in Namibia identified two key sectors for the assessment: energy (for mitigation actions), and agriculture/land-use (for adaptation options).

This project was made possible with funding from the governments of Norway, Switzerland, and Finland, as well as UNDP and the United Nations Foundation.

Disclaimer

Acknowledgements

The author(s) gratefully acknowledge the technical comments received from Susanne Olbrisch, UNDP, and the Pan-African Start Secretariat (PASS), based in Tanzania, which operated as a regional centre of excellence under this project.

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Suggested citation
Muteyauli et al. 2011. Assessment of Investment and Financial Flows for mitigation in the energy sector in Namibia.

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Acronyms

BAU	Business As Usual
CO2	Carbon Dioxide
EU	European Union
FDI	Foreign Direct Investment
FF	Financial Flow
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IF	Investment Flow
IFF	Investment and Financial Flows
IPPR	Institute for Public Policy Research
LPG	Liquid Petroleum Gas
MET	Ministry of Environment and Tourism
MME	Ministry of Mines and Energy
MoF	Ministry of Finance
MW	Megawatt
MWh	Megawatt hour
MTI	Ministry of Trade and Industry
NDP	National Development Plan
NPV	Net Present Value
ODA	Overseas Development Assistance
OGEMP	Off-Grid Energisation Master Plan
OM	Operation and Maintenance
PED	Price Elasticity of Demand
PV	Present Value
Terawatt	Terawatt
TWh	Terawatt hour
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

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Executive Summary

The energy and agricultural sectors of Namibia are key to the country's economic growth and development. The First National Communication Report to the UNFCCC indicates that the country's Greenhouse Gas (GHG) emissions are mainly from the agriculture and energy sectors. This indicates that carbon mitigation potentials exist in the country's energy sector. The electricity generation and transport sub-sectors were chosen for this analysis.

The purpose of the present assessment is to quantify the required investments and financial flows required to mitigate the effects of climate change in Namibia's energy sector. The inclusion of additional wind power and solar power into the energy mix, together with measures to improve energy efficiency formed the basis of the additional mitigation measures evaluated for the electricity generation sub-sector; the partial replacement of petrol fuel by LPG was the additional measure considered for the transport sub-sector. It is expected that the results of this work will strengthen Namibia's negotiating position at national and international climate change forums.

Currently, Namibia's total electricity demand far exceeds local electricity supplies. Of the 3.08 TWh being supplied in 2005, some 50% is imported from neighbouring countries such as South Africa and Zimbabwe. However, Namibia's electricity demand is expected to more than triple to about 10 TWh by 2030. The total cost of investments expected in the absence of additional mitigation policies in the electricity subsector, expressed as a Present Value in 2005 US$ is estimated at US$1,147 million between 2005 to 2030. These costs are based on additional hydropower, coal and diesel investments. The hydropower investments include Ruacana's 4th turbine (95 MW) in 2012, the Orange River 1st Phase in 2013 (53 MW), the Orange River 2nd Phase (53 MW) in 2017, and the Baynes in 2019 (275 MW). Coal-fired power investments include a coal-fired plant of 250 MW, to be constructed in 2015 in Walvis Bay. Diesel investments refer to localised diesel generators to provide electrification to all rural communities, with consistent investment over the time period of analysis to provide 68 MW in 2030, as well as investment in the Anixas power plant in 2011 (22MW). These investments are what are expected under business-as-usual conditions and form the basis of the baseline scenario.

Under the mitigation scenario, where additional mitigation measures are undertaken, the energy mix incorporates significant investments in solar power and wind power, together with energy demand reductions as part of an energy efficiency programme. These investments in turn displace some of the investments expected under the baseline scenario. Solar power is expected to replace the electricity provision by local diesel generators under the mitigation scenario, the installed capacity of wind power investments are expected to be 42 MW by 2030 and energy efficiency measures are expected to decrease energy demand by 20% of the baseline figure by 2030. In addition to the benefits from reduced GHG emissions under the mitigation scenario, a reduction of energy imports from 50% to 30% of energy consumed was modelled, to provide greater self-sufficiency.

Overall, the incremental costs of the mitigation scenario in the electricity generation sub-sector (factoring in the baseline costs) are estimated to be US$1.13 billion over the time period of analysis. The costs per ton of CO2 eq. emissions reduced are estimated to be US$102 per ton.

For the transport subsector, it is expected that the passenger vehicle population would increase with the growth in GDP and human population. In practical terms, this growth is likely to lead to significant increases in GHG emissions. In order to mitigate the GHGs from the transport subsector, less carbon intensive fuels could replace conventional petrol and diesel. Our analysis of the potential for increased market penetration of LPG, given the small footprint that this technology already has in Namibia, show that this option has good mitigation potential.

Taking into account investment costs in terms of car fuel conversion and fuel station investment, Financial Flows in terms of subsidisation of conversion costs and O&M savings in terms of fuel price reductions (LPG versus conventional petrol), the incremental costs of the mitigation scenario as opposed to the baseline scenario are estimated to be US$42.4 million. This figure includes a saving of US$26 million in terms of O&M costs over the time period of analysis due to the difference in car running costs, Financial flows are estimated to be US$35 million for subsidisation of car conversion to use LPG fuel, with investment costs being US$34 million over the period of analysis. Per ton of CO2 eq. reduced by this measure, this implies a cost of US$28 per ton.

Acknowledgements

This report was funded by the UNDP, through the programme on Capacity Development for Policy Members to Address Climate Change. The authors would like to thank the various Government Ministries of Namibia that provided valuable data and expertise, without which the completion of this report would not be possible. Thanks also to Deograsias Mushi and Pius Yanda of the PASS support team, based in Tanzania and to Bhujang Dharmaji, Rebecca Carman and Susanne Olbrisch of UNDP, whose comments throughout the development of the report and creation of models were invaluable. Finally, thanks also to Detlof Von Oertzon of VO Consulting, whose technical knowledge was also very valuable throughout this process. Opinions expressed within this report should be attributed solely to the authors.

Definitions

The key terminology used in the assessment:

I. **Investment flow (IF)** is the capital cost of a new physical asset with a life of more than one year, such as the capital cost of a new power plant.

II. **Financial flow (FF)** is an ongoing expenditure on programmatic measures; financial flows encompass expenditures other than those for expansion or installation of new physical assets, e.g. expenditures for an agricultural extension program for farmers. These expenditures are operation and maintenance costs, e.g. salaries and raw materials.

III. **Investment entity** is an entity making an investment. These are the entities that decide to invest, e.g. in a wind farm. Investment entities include households, corporation and government.

IV. **Sources of I&FF funds** are the origins of the funds invested by the investment entities e.g. domestic equity, foreign debt, domestic subsidies, and foreign aid.

V. **Operation and Maintenance (O&M):** the physical assets purchased with investment flows will have operation and maintenance (O&M) costs associated with them i.e., ongoing fixed and variable costs such as salaries and raw materials.

VI. **Baseline scenario** is a reflection of the business-as-usual conditions, i.e. it is a description of what is likely to occur in the absence of new policies to address climate change.

VII. **Mitigation scenario** incorporates measures to mitigate GHG emissions, i.e. the mitigation scenario describes the expected socio-economic trends, technological changes, new measures to mitigate GHG emissions, and expected investments in the energy sector given the implementation of the various mitigation measures.

VIII. **Government** is used to indicate the Government of the Republic of Namibia

1. Introduction

Namibia’s energy sector is of key strategic importance to the country’s economy, as the availability and access to reliable and affordable sources of energy is and will remain a pre-requisite to the country’s ongoing development. All aspects of the Namibian economy rely either directly or indirectly on the availability of various forms of energy, hence the deliberate development of the country’s energy sector will, to a large degree, determine whether reasonable economic growth rates can be realised in the years to come.

Namibia’s population of some 2 million people is spread over a land area exceeding 800,000 km^2. In comparison to other developing nations, the country’s total annual per capita energy consumption of approximately 7.5 MWh (Megawatt hours) producing a gross domestic product (GDP) of some N$52 billion (US$ 8 billion), or N$26,000 (US$ 3,700) per person, is high.

Namibia’s energy intensity is attributable to various factors, including:

a) the dominant sectors are mining and agriculture, which are highly energy dependent
b) the country’s low population density coupled to high domestic energy use
c) the long transport routes between the few major centres within Namibia
d) the high reliance on imports of fuels, consumer goods and manufactured products.

All liquid, gaseous and solid fossil fuels, including petrol, diesel, heavy fuel oil, jet fuel, liquid petroleum gas and coal are imported, mainly from South Africa. Namibia’s total installed electricity generation capacity in mid-2008 was 387 MW (Megawatts), while the peak demand exceeds 500 MW (MME Annual Report 2008). Almost 50% of the country’s electricity needs are met by imports, with South Africa and Zimbabwe as the main external suppliers. In light of current energy market developments in southern Africa, this dependency is expected to remain in place for a considerable time.

The latest figures available for the country’s Greenhouse Gas (GHG) emissions are from 2000, at which time Namibia was a net carbon sink sequestering a total carbon dioxide (CO2) equivalent of some 1,400 tonnes of GHG (MET, 2002). The country’s greenhouse gas emissions were mainly from the agriculture (6,700 tonnes GHG in 2000) and energy (2,200 tonnes GHG in 2000) sectors. Land-use changes and the forestry sectors on the other hand were key in removing atmospheric CO2. Here, it is interesting to note that the single largest removal agent is an increasing density of non-indigenous bush species, the so-called invader bush, which covers some 26 million hectares of land. It is expected that considerable changes in land-use practices, the rapidly increasing use of fossil fuel-based energy, the increasing use of biomass products particularly from invader bush, and a rapidly growing need to develop local energy sources will substantially change Namibia’s overall carbon balance in years to come.

Considerable carbon mitigation potential exists in the country’s energy sector. It should however be recognised that both local and foreign investments in mitigation options and technologies will occur more frequently if the energy market is further liberalised and currency export restrictions are eased.

Namibia's technology and engineering skills base is small and generally underdeveloped. For most large-scale technology projects, the country remains highly dependent on foreign expertise. Localised economic development, mainly driven by the tourism and mining sectors, currently invigorates Namibia's economic growth. This development remains closely coupled to the availability and affordability of liquid fuels and electricity. Local fossil fuel prices are pegged internationally, which in turn exposes the Namibian energy sector, and by implication the Namibian economy, to currency fluctuations and international demand and supply forces.

1.1 Objectives

This assessment quantifies the required investments and financial flows (I&FF) to mitigate the effects of climate change for Namibia's energy sector. The main objective of the study is to assess the current investment in energy and to estimate the potential financial requirements needed to replace a share of the currently carbon intensive production technologies with more clean technologies in order to mitigate the effects of climate change.

The assessment of the energy sector should feed into the overall IFF assessment. This will provide an integrated and co-ordinated evaluation of Namibia's financial needs to combat climate change and hence strengthen its negotiating position at national and international platforms.

1.2 Background

1.2.1 Previous analyses used in this assessment

Several studies pertaining to the Namibian electricity sector and transport sector have been utilised in this Energy sector analysis and are discussed below. Where Namibia specific information was not available, findings from international sources were used.

Electricity sector analyses

There are a number of documents focusing on the overall electricity sector in Namibia. One of this studies was prepared by the EMCON Group in 2008 for REEECAP titled, "*Electricity Supply and Demand Management Options for Namibia - A Technical and Economic Evaluation*". The document identified and ranked different renewable energy technologies in Namibia in terms of benefit-cost-analysis as well as other parameters like technological maturity. According to the study, the use of some renewable resources is economically efficient and that within a balanced generation mix up to 20% of demand could be met by renewable energy excluding hydro power.

Another relevant study was prepared by the Institute of Public Policy Research (IPPR), entitled "*Review of Electricity Policy in Namibia*". The 2009 study assesses the present situation in Namibia's electricity sector and develops proposals on policy and planning that would help the country overcome the energy challenges it faces.

In addition to the above, the government has indicated in several policy documents such as the National Development Plans (NDPs), Vision 2030 and the White Paper on Energy Policy the necessity and commitment to shift towards renewable energy. Further, a Cabinet decision signed in 2007, approved the Off-Grid Energisation Master Plan (OGEMP), which will establish Energy Shops that will bring services and solar products closer to the communities in the rural areas. The Cabinet decision also directed that the hot water supply to all Government and parastatal buildings is to be met by solar water heaters.

Unfortunately, none of the above mentioned policy documents set specific energy production targets that could be used as a reference point for the present analysis.

Transport sector analyses

The primary source for much of the data and assumptions used in the transport analysis has been the "*Namibia Energy Review for the UNFCCC*", a report prepared for the Ministry of Environment and Tourism by Capôco, Hoveka and Heita in 2007. Much of the information regarding car numbers, fuel consumption and the LPG market in this current analysis comes from this report.

In order to assess the likely growth in car ownership in Namibia as a result of predicted increasing affluence, the findings from a study by Dargay, Gately and Sommer (2007) were adapted for Namibian circumstances. In the study, Dargay et al. describe the observed relationship between Purchasing Power Parity Income per capita and the number of vehicles per person, using country level data. They model this relationship, deriving a formula for car ownership based on income and other variables such as expected car saturation levels. This formula was then used in the present analysis to predict how car ownership levels would change into the future in Namibia, a technique also used by the International Energy Agency (IEA) in their assessments of global future fuel demand.

Another study that was used for this analysis is Espey's (1996) work on estimating the Price Elasticity of Demand (PED) for American gasoline (petrol) usage. In that study, Espey estimates a PED for gasoline of around -0.25, which has been using in this analysis in the Namibian context to estimate the impact of predicted future fuel price changes.

1.2.2 Institutional arrangements and collaborations

Namibia's Ministry of Environment and Tourism has been the main co-ordinator of this assessment. Other relevant ministries such as the Ministry of Mines and Energy, the Ministry of Trade and Industry and the Ministry of Finance also have supplied representatives for meetings and have been directly involved in all steps of the analysis.

Moreover, other institutions have also been involved in the assessment process. For instance the local office of the UNDP is contributing valuable assistance throughout the formulation of the document and the Renewable Energy and Energy Efficiency Institute have provided valuable data. VO Consulting has also provided extremely valuable technical expertise throughout this exercise.

1.2.3 Basic methodology used

The basic methodology used in the present assessment closely follows the prescribed approach for I&FF assessments, as proposed by the UNDP (UNDP, 2010).

The first steps of the assessment have been to define the sub-sectors within the energy sector, define the scope of the analyses and choose suitable mitigation measures. Once the sector was clearly defined, the relevant investment costs for the sub-sectors were projected for two scenarios: a baseline scenario, and a mitigation scenario. The baseline scenario reflects a continuation of current policies and plans, and as such reflects a future in which no new measures are taken to address climate change (this is also referred to as a "business-as-usual" scenario). The mitigation scenario (also referred to as the "climate change scenario") on the other hand includes mitigation measures over and above those that were already planned under the baseline scenario. The required investments, financial flows and operation and maintenance costs of the baseline and mitigation scenarios were then compared so as to determine the incremental costs required introducing the mitigation measures in the chosen sub-sectors.

2. Scope, data inputs and scenarios

2.1 Sectoral scope

Due to financial and time constraints, the energy (mitigation) sector group decided to concentrate on the two distinct energy sub-sectors: electricity generation and transport. Under the electricity generation sub-sector, it was agreed to consider solar, wind and energy efficiency as mitigation measures. These measures were chosen because the expected direct impacts of climate change on them will be minimal when compared to other measures, such as hydropower; and because they are measures that the Government may consider to support to strengthen Namibia's future energy mix.

Under the transport sub-sector, the working group agreed to focus only on the liquid fuels sector, and in particular on petrol-powered passenger vehicles. Liquid fuel consumption constituted over 70 percent of Namibia's total energy demand in 2006 (Capôco et al., 2007), and although diesel fuel consumption was much greater than petrol fuel consumption in 2006, the broad range of vehicle types using diesel fuel would have made the assessment very difficult to undertake. In contrast, the petrol-fuel car market is relatively homogenous, allowing assessment of particular technologies that are widely applicable. Here the main mitigation measure assessed was the introduction and use of Liquid Petroleum Gas (LPG) as an additional fuel source. The rationale for this choice was motivated by the realisation that LPG already has a small footprint in Namibia, and is a proven technology that has been adopted with success in other parts of the world.

2.2 Data inputs and scenarios

2.2.1 Assessment Period and Cost Accounting Parameters

The assessment period is the time horizon for assessment, i.e. the number of years spanned by the baseline and climate change scenarios and the associated stream of annual IF, FF and O&M costs. The baseline year used for the assessment is 2005, and the scenarios investigated were covering the period of twenty-five years up to the year 2030, thus providing a unique opportunity to assess the implications under Namibia's Vision 2030 development plan.

Where input data was unavailable for 2005, the most recent year for which such information was available was used.

In line with UNDP recommendations, all costs displayed are expressed in 2005 US$. The discount rate used to compute the Present Value (PV) was taken to be 8%, which reflects Government's long-term borrowing costs. The currency conversion between Namibian dollars (NAD) and 2005 US$ was carried out by deflating current (or otherwise as available) prices and converting these to US$. Here, the Consumer Price Index data from Bank of Namibia[1] was used, while exchange rate information was taken from the 2009 Preliminary National Accounts (MoF) where N$1 = US$6.41 in 2005.

[1] See www.bon.com.na/

Analytical approach

The selected analytical approach has been to develop Microsoft Excel spreadsheet models that describe the relevant development of each sub-sector, and the associated costs of the technologies included. As such, electricity and transport models, projecting sectoral trends, the current investment situation in the sectors (assuming no change) and an assumption of differences with the implementation of the proposed mitigation measures have been developed. Data collected included the value and quantity of the different types of energy consumption (electricity and fuel). A variety of data sources were used to make various assumptions and conclusions; these included research papers, government policy documents, Vision 2030 document, national development plans as well as interviews with key stakeholders including the private sector.

A. *Electricity Generation*

The baseline electricity generation scenario views the future as a continuation of the current electricity supply in Namibia. This implies that Namibia would continue to import some 50% of its electricity from neighbouring countries, and continues to rely on hydro-electricity as well as some coal and diesel powered plants. The model forecasts the expected local demand, between 2005 and 2030; this demand can be matched by way of systematically introducing supply (i.e. generation) facilities in future. The business-as-usual (i.e. baseline) model uses mainly additional hydroelectric plants to match the electricity demand with the various supply sources. The mitigation scenario introduces three additional generation options, namely solar; wind; and energy management practices (which reduce demand growth). The model is divided into three parts: domestic electricity consumption and generation, costs and emissions.

Domestic Electricity Consumption and Generation

Electricity consumption is projected following different assumptions (see Annex A for the list of the assumptions used in the model). For households, we assume that electricity consumption will increase following the electrification rate needed to achieve 100% electrification by 2030. For corporations, electricity consumption will grow in line with the expected average economic growth. Government is assumed to increase its consumption in line with the increase of civil servants, which we proxy by using the estimated rate of population growth. Electricity generation follows demand, with various investments proposed in order to maintain imports at 50% of the total consumption in the baseline scenario. In the mitigation scenario additional electricity generation capacity is introduced to reduce imports to 30% by 2030, increasing electricity security for the country.

Costs

We consider investment costs and operation and maintenance costs (O&M). To calculate investment costs, we first calculated the average unit costs of constructing one MW for each technology type. Then, we multiplied the unit cost per MW multiplied by the new MW installed each year (if any). We calculated operation and maintenance costs using the same technique: we obtained the average unit costs of generating one TWh for each technology and we multiplied it by the total TWh generated each year by each technology.

Note that the retail price of electricity was not been considered in this model.

Emissions

Emissions depend on both the quantity and type of electricity generated. We first calculated the tons emitted by generating one TWh of each technology, and then multiplied the estimated unit emissions by the yearly TWh generation of electricity for each technology considered.

B. Transport

The transport sub-sector focused on consumption of liquid fuels and in particular on petrol-powered passenger vehicles. Forecasting from 2005, the model computes how the consumption will change based on population growth, economic growth and expected future consumption efficiency gains. Under both the baseline and mitigation scenarios, LPG captures some of the fuel consumption demand, with users grouped as those that convert fully to LPG use, those that remain solely with petrol, and a further user group that uses 50 percent LPG and 50 percent petrol.

Under the business as usual scenario, LPG market penetration remains at relatively low levels by 2030, with market share growth by a constant proportion per annum. The mitigation scenario introduces additional LPG consumption from 2010, to displace an additional percentage of the current and future petrol demand by sedan vehicles. Sedans are operated by the Government (i.e. these are part of the Government vehicle fleet) as well as companies and households.

In common with the Electricity model, the Transport model has three main sections: a description of the sedan car market and resulting fuel demand under a baseline and mitigation scenarios; an estimation of the Investment, Financial Flow and Operations and Maintenance costs of each scenario; and the calculated climate change impact from the two scenarios.

The sedan car market

The model sets out the expected change in the sedan car market, based on assumptions regarding population, economic growth and fuel consumption. The change in fuel consumption in turn leads to differing infrastructural requirements (see Annex B for a list of the assumptions used in this model).

The growth of the market has been modelled in line with the observed relationships between income and car ownership, as used by the International Energy Agency in their predictions of fuel consumption over time. Essentially, car ownership per capita is dependent on PPP income per capita, with car ownership initially increasing rapidly at low income levels, increasing in line with medium income levels and increasing at a declining rate at higher levels of incomes until a predetermined limit of car ownership per capita (see Annex C for a fuller description of the mechanics of this model). In the transport model, fuel consumption is dependent on car numbers and consumption per car, which for both scenarios is modelled as decreasing over time due to improvements in fuel efficiency. Note that the model assumes that car usage effectively does not change under either scenario itself, but rather is a result of changes in the price of petrol.

The model shows an in-built sensitivity to differing expectations with regards to changes in petrol price, with a price elasticity of demand equal to -0.25 (based on Espey, 1996). Four pricing scenarios are introduced: a no real price change, a low real price change, a medium real price change and a high real price change (an average impact is taken for costing purposes). The model also takes into account the effect of the cheaper cost of LPG fuel (assumed consistent at 20% cheaper than petrol) on consumption, as well as the lower energy density of LPG compared to petrol (hence additional consumption per km).

Investment, and Operation and Maintenance Costs

Costs are broken down into those falling on Households, Corporations and Government. For all three entities, the costs of switching to LPG vehicles have been calculated in terms of conversion of personal vehicles and corporation and Government fleets. The other investment costs refer to those falling on corporations running fuelling stations, as both the differing LPG and petrol costs of installation and the number of pumps differs under each scenario.

The only Financial Flows that are applicable refer to the costs accruing to Government, where it is assumed that conversion to LPG is subsidised so as to encourage the rapid technology migration to achieve GHG reductions stemming from the transport sector.

Operation and maintenance costs relate to the price of fuel and the litres consumed. As indicted above, the average cost associated with the four fuel price scenarios has been calculated.

Estimated Climate Change Impact

Carbon dioxide accounts for up to 95% of the greenhouse gases emitted from vehicles. Total carbon dioxide emissions were estimated using the IPCC Tier 1 method. The two models allow for the calculation of emissions from vehicles. Over the time period of analysis, it was found that the baseline scenario has higher emissions at 33,961,103 tons of CO2 equivalent, compared to 32,756,311 tons CO2 equivalent for the mitigation scenario, i.e. about a 3.6 percent reduction compared to the baseline. This reduction may seems small, but takes into account the impact of the price differential between LPG and petrol fuel and the different consumption figures of each (LPG cars consume more litres per km, due to differences in fuel energy density).

2.2.2 Historical IF, FF, and O&M Data and Subsidies

A. Electricity Generation

In the base year there were no investments or financial flows associated with energy generation (see Table 1). Operation and maintenance of the existing hydropower, diesel and coal plant in 2005 amounted to around US$11.83 million, most of which related to the running of the large Ruacana hydro plant.

Table 1. Electricity Base Year IF & FF Data, By Investment Type, Investment Entity, and Funding Source (million 2005 US$)

	Hydro			Diesel			Coal		
Investment Entity Category/Source of Funds	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
Households									
Domestic									
Equity & debt									
Total Household Funds	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Corporations									
Domestic									
Domestic equity									
Domestic borrowing									
Total Domestic Sources	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Foreign									
FDI									
Foreign borrowing									
ODA									
Total Foreign Sources	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Total Corporation Funds	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Government									
Domestic									
Domestic funds	0,00		11,52	0,00		0,11	0,00		0,25
Foreign									
Foreign borrowing	0,00		0,00	0,00		0,00	0,00		0,00
Bilateral ODA	0,00		0,00	0,00		0,00	0,00		0,00
Multilateral ODA	0,00		0,00	0,00		0,00	0,00		0,00
Total Foreign Sources	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Total Government Funds	**0,00**	**0,00**	**11,52**	**0,00**	**0,00**	**0,11**	**0,00**	**0,00**	**0,25**
Total Funds	**0,00**	**0,00**	**11,52**	**0,00**	**0,00**	**0,11**	**0,00**	**0,00**	**0,25**

Data Sources: Based on model calculations using data from various sources

B. Transport

Table 2 shows the base year costs associated with the sedan car market. For all entities there are significant investment costs expected, in terms of the costs of conversion of cars to LPG, but also in terms of the costs of replacement petrol vehicles. Investment costs for Corporations also include investment in additional service stations/pumps, which is required to match the continuing growth in car numbers and in terms of replacement of current architecture. Operation and maintenance costs refer to the running of car fleets and petrol stations (for corporations). Households share the majority of both the investment and O&M costs (US$458 million and US$141 million), followed by Corporations (US$167 million and US$512 million) and the Government (US$32 million and US$10 million).

Table 2. Transport Base Year IF & FF Data, By Investment Type, Investment Entity, and Funding Source

2005			
	LPG		
Investment Entity Category/Source of Funds	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
Households			
Domestic			
Equity & debt	458.13		141.50
Total Household Funds	**458.13**	**0.00**	**141.50**
Corporations			
Domestic			
Domestic equity	50.23		15.51
Domestic borrowing	117.19		36.19
Total Domestic Sources	**167.42**	**0.00**	**51.70**
Foreign			
FDI	0.00		
Foreign borrowing	0.00		
ODA	0.00		
Total Foreign Sources	**0.00**	**0.00**	**0.00**
Total Corporation Funds	**167.42**	**0.00**	**51.70**
Government			
Domestic			
Domestic funds	22.44		7.07
Foreign			
Foreign borrowing	0.00		0.00
Bilateral ODA	9.62		3.03
Multilateral ODA	0.00		0.00
Total Foreign Sources	**9.62**		**3.03**
Total Government Funds	**32.06**	**0.00**	**10.11**
Total Funds	**657.60**	**0.00**	**203.30**

Data Sources: Based on model calculations using data from various sources

2.2.4 Baseline scenario

A. Electricity Generation

Scenario description
In 2005, Namibia's electricity demand was 3.08 TWh. Namibia imports about 50% from the neighbouring countries (South Africa & Zimbabwe). The use of renewable energy technologies to contribute to Namibia's energy supply mix is negligible.

Although Namibia is classified as a middle income country, according to 2005 Rural Electrification Master Plan, only 1/3 of Namibia's population had access to electricity (67% for urban areas and 10% of rural areas). Of Namibia's 2,855 rural settlements (some 260,000 households) around 2,400 such settlements are not electrified. Some settlements are officially designated as off-grid, which means that some households will not have access to national grid for about 20 years.

The growing need for power for lighting, refrigeration and cooking is currently not being met using grid electricity. About 213,000 households in Namibia use wood for cooking and lighting. Subsistence consumption of fuel-wood is estimated at 520,000 tons per year *(Wood Fuel Review and Assessment: Namibia Country Report, MET, 2000).* Under the baseline scenario it is assumed that provision of power to supply electricity to all households is done through off-grid diesel generation.

Namibia's total domestic electricity generation in 2005 was 1.66 TWh, while some 3.1 TWh of electrical energy was consumed. Namibia has a total domestic generating capacity of 393 MW, although reaching full capacity depends significantly on the water levels at Ruacana which represents 63.4% of Namibia's total domestic generation capacity. In addition, 30.5% of Namibia's generation capacity is contributed by the Van Eck coal–fired station, and 6.1% is generated by the Walvis Bay heavy fuel oil thermal power plant (NamPower Annual Report, 2005).

Namibia has not benefitted from significant energy or electricity generation infrastructure developments in the past decades, other than the considerable expansion of its electricity transmission and distribution systems since 2005. Over 50% of the country's electricity needs are met by imports, with South Africa (Escom) and Zimbabwe (Zesco) as the main external suppliers. In light of the current energy market developments in southern Africa, this dependency is expected to remain in place for a considerable time until additional local generation plants are realised. Considerable carbon mitigation potentials exist in the country's energy sector.

Baseline Scenario IF, FF, O&M Costs, and Subsidy Costs
The costs shown in Table 3 illustrate that rural households are expected to purchase their own diesel generators for US$98 million under the baseline scenario, with operation and maintenance costs of US$ 1,024 million. Investment costs to Government are US$43 million on diesel, with operating and maintenance costs on larger diesel electricity generation estimated to be US$11.2 million.

Other Government investments anticipated in the baseline scenario relate to capital investments in both hydro and coal (US$786 million and US$232 million respectively). Operation and maintenance costs are estimated to cost the Government US$205 million for hydro and US$99m million for coal, which is a reflection of the greater installed hydro capacity (indeed, hydro power is estimated to be greater than 9 times cheaper to run than coal power). Under the baseline scenario, there are no expected costs falling on Corporations.

Table 3. Electricity Baseline Scenario: Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source (million 2005 US$)

Investment Entity Category/Source of Funds	Hydro			Diesel			Coal		
	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
Households									
Domestic									
Equity & debt				97.69	0.00	1,024.82			
Total Household Funds	**0.00**	**0.00**	**0.00**	**97.69**	**0.00**	**1,024.82**	**0.00**	**0.00**	**0.00**
Corporations									
Domestic									
Domestic equity									
Domestic borrowing									
Total Domestic Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Foreign									
FDI									
Foreign borrowing									
ODA									
Total Foreign Sources	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Corporation Funds	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Government									
Domestic									
Domestic funds	550.26		204.65	22.29		11.21	162.12		98.94
Foreign									
Foreign borrowing	0.00		0.00	0.00		0.00	0.00		0.00
Bilateral ODA	235.82		0.00	9.55		0.00	69.48		0.00
Multilateral ODA	0.00		0.00	0.00		0.00	0.00		0.00
Total Foreign Sources	**235.82**	**0.00**	**0.00**	**9.55**	**0.00**	**0.00**	**69.48**	**0.00**	**0.00**
Total Government Funds	**786.08**	**0.00**	**204.65**	**31.84**	**0.00**	**11.21**	**231.60**	**0.00**	**98.94**
Total Funds	**786.08**	**0.00**	**204.65**	**129.53**	**0.00**	**1,036.02**	**231.60**	**0.00**	**98.94**

Data Sources: Based on model calculations using data from various sources

Table 4. Electricity Baseline Scenario: Annual IF, FF and O&M Estimates by Investment Type (million 2005 US$)

Year	Hydro			Diesel			Coal			All investments		
	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
2005	0		11.52	-		0.11	-		0.25	-		11.88
2006	0		9.74	-		1.04	-		6.49	-		17.28
2007	0		9.20	-		0.29	-		2.22	-		11.71
2008	0		7.70	-		0.89	-		11.07	-		19.67
2009	0		7.21	-		0.25	-		4.79	-		12.24
2010	0		7.23	3.40		7.84	-		4.18	3.40		19.25
2011	0		6.69	32.64		9.41	-		3.87	32.64		19.98
2012	214.72		8.49	0.93		10.75	-		2.69	215.65		21.93
2013	113.46		9.07	1.08		12.32	-		2.49	114.54		23.88
2014	0		8.40	1.26		14.16	-		1.54	1.26		24.09
2015	0		7.78	1.46		16.30	231.60		7.35	233.05		31.43
2016	0		7.20	1.69		18.81	-		6.15	1.69		32.15
2017	83.39		7.56	1.97		21.72	-		5.69	85.36		34.97
2018	0		7.00	2.29		25.12	-		4.71	2.29		36.82
2019	374.51		11.04	2.66		29.08	-		4.36	377.16		44.48
2020	0		10.22	3.09		33.68	-		4.03	3.09		47.94
2021	0		9.47	3.58		39.04	-		3.74	3.58		52.24
2022	0		8.77	4.16		45.26	-		3.46	4.16		57.49
2023	0		8.12	4.84		52.51	-		3.20	4.84		63.83
2024	0		7.52	5.62		60.92	-		2.97	5.62		71.41
2025	0		6.96	6.53		70.71	-		2.75	6.53		80.42
2026	0		6.44	7.59		82.08	-		2.54	7.59		91.07
2027	0		5.97	8.81		95.30	-		2.35	8.81		103.62
2028	0		5.52	10.24		110.66	-		2.18	10.24		118.37
2029	0		5.11	11.89		128.51	-		2.02	11.89		135.64
2030	0		4.74	13.82		149.25	-		1.87	13.82		155.85

Data Sources: Based on model calculations using data from various sources

The same costs shown over time (Table 4) show that that the total annual O&M estimates that hydro, diesel and coal cost Namibia an amount of US$12 million in 2005, and will increase to US$156 million (discounted at 8%) by 2030.

The investments shown in Table 4 for hydro refer to Ruacana 4th turbine (95 MW) in 2012 (US$215 million), Orange River 1st Phase (53 MW) in 2013 (US$114 million), Orange River 2nd Phase (53 MW) in 2017 (US$83 million) and US$ 500 million in 2019 for Baynes, which we assume will have a total capacity of 550 MW and will be shared on an equal basis with Angola. The largest single year for investment is 2019, as a result of the construction of Baynes. There is investment planned in a Diesel power plant in 2011 (Anixas Power station), estimated to generate 21.5 MW at a cost of US$51 million, and an investment of a coal-fired station in 2015 of US$ 500 million in the Walvis Bay.

NamPower has almost completed the construction of another high-capacity transmission intreconnector line to Zambia and Zimbabwe, which will ease the pressure on the transmission system to South Africa. However, it is noted that this investment will not assist in improving Namibia's energy self-sufficiency, rather this investment is required to maintain the status quo of imports from South Africa and Namibia's northerly neighbours.

B. Transport

Scenario description

Transport fuel consumption is estimated to constitute more than 70% of the total energy demand of Namibia. This presents a high mitigation potential from this fuel source alone. Of the 880 million litres of liquid fuel consumed in 2005, around 36 percent was in the form of petrol, 55 percent diesel and the remainder shared between dual purpose kerosene and heavy fuel oil (Capôco et al., 2007). Petrol is almost exclusively demanded for passenger road transport, in particular for sedan-type cars, which in general consume petrol rather than diesel fuel. Petrol consumption is based on vehicle numbers, vehicle efficiency and car usage (i.e. km travelled).

Based on figures obtained from the National Planning Commission, it is estimated that the Namibian population is expected to grow from 2 million in 2005 to about three million by the year 2030. At the same time, economic growth is expected to continue at around 4% per annum, which is in line with the predicted economic growth path necessary to achieve the goals of Vision 2030. Together, these two factors are expected to increase the total vehicle population significantly from 2005 to 2030, from 220,000 vehicles to 770,000.

In 2005, petrol driven vehicles constituted a significant share (88%) of the gross vehicle population (Capaco et al, 2007). This share is expected to remain constant until 2030. Of all the petrol vehicles, the majority share of ownership is for households. It is anticipated that over time, the number of vehicles running on LPG or running on a mix of LPG and petrol will gradually increase to 20% and 10% of the total sedan population respectively by 2030, based on current market growth rates.[2] At present the cost of converting cars to LPG is

[2] Other Technologies, such as hydrogen fuel cars may also begin to erode petrol engine market share. However, these technologies do not have a market presence in Namibia as yet, and have therefore not been considered in the present assessment.

around N$6,000 (US$ 833) and can be carried out by one company, Autogas plc. It is assumed that the conversion of cars will be a gradual process up until 2030, with the costs of conversion declining (at 2005 prices) to N$3,000 as supply and competition increases and the vehicle stock becomes newer.

Cars that run on LPG consume around 15% more fuel than cars running on petrol for a given km travelled, due to differing energy densities for the fuels. At the same time, the difference in price between running an LPG car versus a petrol car (around 20% cheaper; Capaco et al, 2007) means that there is a further impact on km travelled, based on the price elasticity of demand of –0.25 (Espey, 1996). This price impact is somewhat reduced however due to the additional consumption requirements per km. As such, it is assumed that the petrol consumption figures are 15% greater per km and km travelled are 5% greater for LPG cars.

Based on data from the Oil Industry, the majority of sedan passenger vehicles on the road in Namibia in 2006 were older than 8 years (68.2 percent). This age profile is expected to change as the demand for vehicles continues to grow, with the average age of vehicles reducing over time.

Based on data from the USA, from 1980 to 2005, average fuel efficiency of passenger vehicles has increased by 38 percent (RITA, 2010), although it is perhaps unlikely that such a significant change will occur in fuel efficiency using current technology types for the next 25 years. For the purposes of this assessment it was assumed that average fuel efficiency will increase by 20 percent over the time period considered. The change in fuel consumption per car as a result of this change is expected to be somewhat less due to the empirically observed rebound effect. Essentially the rebound effect suggests that any change in the efficiency of technology, changes the effective price of its use. Improved efficiency implies a cheaper price, which in turn suggests additional usage. For the purposes of this exercise, the impact of improved efficiency is estimated to be a 5 percent reduction in fuel use per car.

Additionally, there are an estimated 220 service stations in Namibia (BP website[3], accessed March 2010). Increases in petrol consumption therefore imply increasing numbers of service stations to provide petrol. However, based on a standard petrol station having six car pumps for petrol, we assume that the growth rate in service stations be a less than that of petrol consumption. It is assumed that 50% of the growth in petrol pumps is provided through additional stations, with the remaining 50% provided by expansion of existing stations. Through the model, this implies an increase in the number of pumps from 1,320 in 2005 to 3,383 in 2030.

Baseline Scenario IF, FF, O&M Costs, and Subsidy Costs

Table 5 shows the cumulative discounted IF, FF and O&M estimates by investment types, investment entities and funding sources for the analysed transport sector. The cumulative discounted IF for Households is estimated to be US$8,416 million, and the O&M costs are estimated at US$2,866 million. These investment costs reflect both the costs of car conversion to LPG and the cost of new and replacement cars.

[3] http://www.bp.com/genericarticle.do?categoryId=16003471&contentId=7020758

For Corporations, the total cumulative discounted IF is US$3,104 million, of which US$931 million is funded by domestic equity and US$2,173 million funded by domestic borrowing. The total cumulative discounted O&M costs for corporations amount to US$1,026 million, of which US$308 million funded by domestic equity and US$718 million funded by domestic borrowing. Investment costs reflect both the costs for business fleets and the costs associated with fuel stations.

Government costs under the baseline scenario are estimated to be US$566 million, US$414 million of which are investments and US$152 million of which are O&M costs. Around US$170 million of these costs are expected to be funded by Bilateral ODA, with the remainder provided through domestic funding.

Table 5. Transport Baseline Scenario: Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source

	LPG		
Investment Entity Category/Source of Funds	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
Households			
Domestic			
Equity & debt	8,415.68		2,865.98
Total Household Funds	**8,415.68**	**0.00**	**2,865.98**
Corporations			
Domestic			
Domestic equity	931.15		307.89
Domestic borrowing	2,172.68		718.40
Total Domestic Sources	**3,103.83**	**0.00**	**1,026.29**
Foreign			
FDI	0.00		
Foreign borrowing	0.00		
ODA	0.00		
Total Foreign Sources	**0.00**	**0.00**	**0.00**
Total Corporation Funds	**3,103.83**	**0.00**	**1,026.29**
Government			
Domestic			
Domestic funds	289.57		106.44
Foreign			
Foreign borrowing	0.00		0.00
Bilateral ODA	124.10		45.62
Multilateral ODA	0.00		0.00
Total Foreign Sources	**124.10**		**45.62**
Total Government Funds	**413.67**	**0.00**	**152.06**
Total Funds	**11,933.18**	**0.00**	**4,044.34**

Data Sources: Based on model calculations using data from various sources

Table 6 shows the annual costs for the transport sector under the baseline scenario. Under this scenario there is no training or information provision regarding LPG by the Government, and hence there are no expected Financial Flows.

Investment costs, which include the costs of purchasing new vehicles, and converting a portion of those cars to run on LPG decrease each year due to cost discounting. In non-discounted terms, these costs are increasing year on year, due to the increasing number of cars in the country. Likewise the O&M costs decrease per annum from US$203 million in 2005 to US$131 million in 2030 due to PV calculation, whereas in non-discounted terms these costs rise year on year.

Table 6. Transport Baseline Scenario: Annual IF, FF and O&M Estimates by Investment Type

Year	LPG		
	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
2005	494.21		203.30
2006	474.73		195.13
2007	455.69		188.02
2008	437.19		181.86
2009	419.30		176.49
2010	408.79		171.49
2011	386.64		167.36
2012	370.94		163.77
2013	355.86		160.59
2014	377.97		157.78
2015	369.54		155.28
2016	360.87		153.04
2017	351.95		151.02
2018	343.17		149.15
2019	337.31		147.45
2020	326.07		145.83
2021	317.42		144.30
2022	308.89		142.81
2023	318.75		141.37
2024	312.96		139.93
2025	307.15		138.49
2026	301.04		137.04
2027	294.63		135.55
2028	289.76		134.02
2029	281.51		132.45
2030	274.57		130.81

Data Sources: Based on model calculations using data from various sources

2.2.5 Mitigation Scenario

A. Electricity Generation

Scenario description

Under the mitigation scenario, the analysis looked at the types of energy technologies that would have to be introduced to replace those used under the baseline scenario. Here, solar power, wind power and energy efficiency measures are the energy generation and energy reduction options that were introduced and produce a reduction of GHG emissions.[4]

[4] Solar Water heaters, solar cookers and other forms of solar lighting devices do not generate electricity and therefore are not included as solar generation of electricity. Instead, since they replace electricity consumption they are considered within the energy efficiency category.

The following energy supply options have been considered, which would satisfy the country's economic growth requirements and at the same time lead to a more carbon-constrained national electricity generation portfolio:

Solar power
Namibia has one of the best solar regimes in the world, with an average high direct insulation of 2200kWh /m²/year with minimal cloud cover. Solar power is particularly suitable for off-grid power generation, with low O&M costs and no CO2 emissions associated with its generation.

Wind energy generation
Wind resources along the Namibian coast are considerable, and several on-shore wind farms of 20 to 50 MW capacities each seem possible, yielding some 0.12 TWh per annum per 50 MW installed capacity at several coastal sites. Off-shore sites may add considerably to such capacity, but would also increase the cost of such supply.

Energy Efficiency
The cost of saving energy through the particularly large, untapped demand–side energy efficiency potential in Namibia is often cheaper than the cost of adding new supply capacities. As Namibia faces a 5% growth in energy demand per year, energy efficiency in Government buildings, parastatals and residential properties could lead to lower energy use. As indicated in the model, the practice of energy efficiency through the use of efficient devices can reduce both energy consumption and demand. One such investment made by households to save energy requirements will be efficient lighting (replacement of incandescent bulbs with compact fluorescent lamps -CFLs). The cost of a bundle of energy efficiency measures has been based on the associated price of electricity and the savings associated with the measures. As a simplifying assumption, the cost of the measures are assumed to be half the value of the saving in energy consumption (e.g. if 1TWh cost 100 units and the energy efficiency measure saved 1Twh, the cost is assumed to be 50 units).

Mitigation Scenario IF, FF, O&M Costs, and Subsidy Costs

Table 7 illustrates the cumulative discounted IF and FF and operational and maintenance cost estimates by investment types, entity and funding sources.

For hydroelectricity generation, investment costs of US$786 million are expected, all of which investment is assumed to originate from Government. Operating costs of US$205 million will likewise fall on the Government for the provision of hydropower. Diesel generation is likewise expected to be carried out by Government alone under the mitigation scenario, with US$32 million in investment costs and US$10 million in O&M costs. There are no expected investments required for coal power generation, as other sources of electricity generation replace coal power generation under this scenario. O&M costs of US$36 million are required for the Van Eck power station, prior to its decommissioning in 2018.

The costs associated with the technologies considered in the mitigation scenario, but not in the baseline scenario, are significant. To replace the diesel generators as assumed to exist under the baseline scenario, households would need to invest US$1,099 million in solar technologies, with some US$ 2 million expected for operation and maintenance costs. To replace the electricity provided by the new coal power station under the baseline scenario, Corporations are expected to spend US$70 million to invest in wind power, with another US$6 million for the operational and maintenance cost of the wind power. Finally, the costs associated with energy efficiency are around US$1,363 million, US$1,339 of which are costs in terms of investments and US$24 of which are O&M costs.

Table 8 illustrates the mitigation scenario annual IF, FF and O&M estimates by investment type in millions at 2005 U$ value. Aside from investments planned in 2011 for the Anixas Diesel Power station, there are no planned investments for Diesel and coal power; indeed from 2018 there is no coal power production planned after the Van Eck power station is decommissioned. Investment in solar power is expected to grow over the time period shown, which given the fact that the figures contained in the table are in PV terms, illustrates the magnitude of annual investments required by Households to replace locally provided Diesel power under the baseline scenario.

Table 7. Electricity Mitigation Scenario: Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source (million 2005 US$)

	Hydro			**Diesel**			**Coal**			**Solar**			**Wind**			**Energy Efficiency**		
Investment Entity Category/Source of Funds	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
Households																		
Domestic																		
Equity & debt										1.099		4				618		11
Total Household Funds	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.099**	**0**	**4**	**0**	**0**	**0**	**618**	**0**	**11**
Corporations																		
Domestic																		
Domestic equity													28		6	256		12
Domestic borrowing													21		0	192		0
Total Domestic Sources	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**49**	**0**	**6**	**448**	**0**	**12**
Foreign																		
FDI													0		0	0		0
Foreign borrowing													21		0	192		0
ODA													0		0	0		0
Total Foreign Sources	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**21**	**0**	**0**	**192**	**0**	**0**
Total Corporation Funds	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**70**	**0**	**6**	**639**	**0**	**12**
Government																		
Domestic																		
Domestic funds	550		205	22		10	0		42							57		1
Foreign																		
Foreign borrowing	0		0	0		0	0		0							0		0
Bilateral ODA	236		0	10		0	0		0							25		0
Multilateral ODA	0		0	0		0	0		0							0		0
Total Foreign Sources	**236**	**0**	**0**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**25**	**0**	**0**
Total Government Funds	**786**	**0**	**205**	**32**	**0**	**10**	**0**	**0**	**42**	**0**	**0**	**0**	**0**	**0**	**0**	**82**	**0**	**1**
Total Funds	**786**	**0**	**205**	**32**	**0**	**10**	**0**	**0**	**42**	**1.099**	**0**	**4**	**70**	**0**	**6**	**1.339**	**0**	**24**

Data Sources: Based on model calculations using data from various sources

Table 8. Electricity Mitigation Scenario: Annual IF, FF and O&M Estimates by Investment Type (million 2005 US$)																					
	Hydro			Diesel			Coal			Solar			Wind			Energy Efficiency			All investments		
Year	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
2005	-		11.52	-		0.11	-		0.25	-		-	-		-	-		-	-		11.88
2006	-		9.74	-		1.04	-		6.49	-		-	-		-	-		-	-		17.28
2007	-		9.20	-		0.29	-		2.22	-		-	-		-	-		-	-		11.71
2008	-		7.70	-		0.89	-		11.07	-		-	-		-	-		-	-		19.67
2009	-		7.21	-		0.25	-		4.79	-		-	-		-	-		-	-		12.24
2010	-		7.23	-		0.40	-		4.18	38.20		0.03	-		-	123.76		0.27	161.96		12.11
2011	-		6.69	31.84		0.77	-		3.87	9.01		0.03	-		-	114.60		0.50	155.44		11.88
2012	214.72		8.49	-		0.72	-		2.69	10.46		0.04	-		-	106.11		0.70	331.30		12.63
2013	113.46		9.07	-		0.66	-		2.49	12.16		0.05	-		-	98.25		0.86	223.86		13.13
2014	-		8.40	-		0.61	-		1.54	14.12		0.05	-		-	90.97		1.00	105.09		11.60
2015	-		7.78	-		0.57	-		1.42	16.41		0.06	69.99		0.61	84.23		1.11	170.63		11.55
2016	-		7.20	-		0.53	-		0.66	19.06		0.07	-		0.57	77.99		1.20	97.05		10.22
2017	83.39		7.56	-		0.49	-		0.61	22.14		0.08	-		0.53	72.22		1.27	177.75		10.53
2018	-		7.00	-		0.45	-		-	25.72		0.10	-		0.49	66.87		1.32	92.59		9.35
2019	374.51		11.04	-		0.42	-		-	29.88		0.11	-		0.45	61.91		1.36	466.30		13.38
2020	-		10.22	-		0.20	-		-	34.71		0.13	-		0.42	57.33		1.38	92.04		12.36
2021	-		9.47	-		0.19	-		-	40.33		0.15	-		0.39	53.08		1.39	93.41		11.59
2022	-		8.77	-		0.17	-		-	46.85		0.18	-		0.36	49.15		1.40	96.00		10.87
2023	-		8.12	-		0.16	-		-	54.43		0.21	-		0.33	45.51		1.40	99.93		10.21
2024	-		7.52	-		0.15	-		-	63.23		0.24	-		0.31	42.14		1.38	105.36		9.60
2025	-		6.96	-		0.14	-		-	73.45		0.28	-		0.28	39.02		1.37	112.47		9.03
2026	-		6.44	-		0.13	-		-	85.33		0.33	-		0.26	36.13		1.34	121.46		8.51
2027	-		5.97	-		0.12	-		-	99.13		0.38	-		0.24	33.45		1.32	132.58		8.03
2028	-		5.52	-		0.11	-		-	115.17		0.44	-		0.23	30.97		1.29	146.14		7.59
2029	-		5.11	-		0.10	-		-	133.79		0.51	-		0.21	28.68		1.26	162.47		7.19
2030	-		4.74	-		0.09	-		-	155.43		0.60	-		0.19	26.55		1.22	181.98		6.84

Data Sources: Based on model calculations using data from various sources

B. Transport

Scenario description
Under the mitigation scenario, a far greater proportion of owners of sedan cars will be using LPG as the main fuel source, in contrast to using petrol as assumed to be the case in the baseline scenario. It is assumed that by 2030, 40 percent of sedan cars will use LPG as their principal fuel source, with another 40 percent of fuel users using LPG 50 percent of the time and petrol 50 percent of the time. Overall car numbers are assumed to be the same as under the baseline scenario.

The cost of running a car on LPG is estimated to be around 20 percent less than the costs of running on petrol alone (Capôco et al., 2007). However, based on the energy density per litre of LPG versus petrol, it is assumed that the same car travelling the same distance will consume 15% more LPG in volume than petrol.

In order to meet the demand for LPG, investment in downstream fuel supply will have to take place, both at service stations and in importing the fuel through Walvis Bay. In common with the baseline scenario it is assumed that 50% of the growth in pumps is provided through additional stations, with the remaining 50% provided by expansion of existing stations. Due to the differences in the energy density per litre of LPG versus petrol, a greater demand for LPG under the mitigation scenario implies a greater number of pumps required to satisfy demand. Note that for simplification, it is assumed that the costs of any additional infrastructure are the same under both scenarios.

It is assumed that economic growth and population growth will be unchanged from the baseline scenario. In order to achieve the assumed levels of LPG penetration and the associated reduction in GHG emissions, favourable Government policies will need to be enacted. It particular, subsidisation of LPG conversion will be needed to boost demand, which is assumed to begin at N$2,000 per conversion until 2015, when it is assumed to decline to N$1000 in 2030.

Mitigation Scenario IF, FF, O&M Costs, and Subsidy Costs

Under the mitigation scenario, investment by households in the sedan car market is estimated to be US$ 8,430 million, with O&M costs to Households being US$2,850 million. Note that these O&M costs reflect the running costs of all sedan car ownership and are based on the average costs given the four fuel price scenarios.

For the corporate sector the IF funded by domestic equity stands at US$936 million with associated O$M costs of US$ 306 million. IF that are expected to be paid for through domestic borrowing are estimated to be US$2,185 million with US$713 million as O&M costs funded in this way.

The government is expected to face investment costs of US$416 million, with O&M costs expected of US$150 million. There are also costs in terms of Financial Flows expected for Government, in the form of subsidisation of LPG conversion.

All in all, the total capital required for the mitigation scenario in the transport sector is summed expected to be US$11,967 million for IF, US$35 million for FF and US$4,018 million for OM costs. Of these cost requirements, Household costs account for 70% of the total capital followed by corporation with 26% with Government accounting for the remainder of 4%.

Table 9. Transport Mitigation Scenario: Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source

	LPG		
Investment Entity Category/Source of Funds	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
Households			
Domestic			
Equity & debt	8,430.04		2,849.79
Total Household Funds	**8,430.04**	**0.00**	**2,849.79**
Corporations			
Domestic			
Domestic equity	936.24		305.53
Domestic borrowing	2,184.57		712.90
Total Domestic Sources	**3,120.81**	**0.00**	**1,018.42**
Foreign			
FDI	0.00		
Foreign borrowing	0.00		
ODA	0.00		
Total Foreign Sources	**0.00**	**0.00**	**0.00**
Total Corporation Funds	**3,120.81**	**0.00**	**1,018.42**
Government			
Domestic			
Domestic funds	291.35	24.25	104.97
Foreign			
Foreign borrowing	0.00	0.00	0.00
Bilateral ODA	124.86	10.39	44.99
Multilateral ODA	0.00	0.00	0.00
Total Foreign Sources	**124.86**	**10.39**	**44.99**
Total Government Funds	**416.21**	**34.64**	**149.96**
Total Funds	**11,967.07**	**34.64**	**4,018.17**

Data Sources: Based on model calculations using data from various sources

Table 10 provides the costs associated with the mitigation scenario in the transport subsector annually. The apparent decline in annual costs from 2005 to 2030 is a reflection of discounting; in non-discounted terms costs are actually increasing per annum. It is interesting to note that Financial Flows are expected to increase substantially year on year, reflecting the increasing uptake of LPG, despite the reduction in subsidisation assumed to be in place in this timeframe.

Table 10. Transport Mitigation Scenario: Annual IF, FF and O&M Estimates by Investment Type

Year	LPG		
	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
2005	657.60	0.00	203.30
2006	630.96	0.00	195.13
2007	604.80	0.00	188.02
2008	579.27	0.00	181.86
2009	554.46	0.00	176.49
2010	539.41	5.25	171.31
2011	509.00	0.93	167.15
2012	486.90	1.11	163.51
2013	465.63	1.31	160.29
2014	493.90	1.56	157.43
2015	481.42	1.85	154.87
2016	468.60	2.13	152.56
2017	455.57	2.45	150.46
2018	442.45	2.82	148.51
2019	429.77	7.79	146.70
2020	416.44	4.51	144.97
2021	403.57	5.18	143.30
2022	390.89	5.94	141.66
2023	402.78	6.80	140.03
2024	394.11	7.79	138.38
2025	385.06	8.91	136.69
2026	375.28	10.19	134.96
2027	365.19	11.62	133.14
2028	355.12	16.21	131.22
2029	344.64	15.54	129.19
2030	334.24	17.61	127.02

Data Sources: Based on model calculations using data from various sources

3. Results

3.1 Incremental Changes in IF, FF, O&M Costs, and Subsidy costs

A. Electricity Generation

Table 11. Summary of Baseline Total Estimated Consumption/Demand (TWh), Total supply (TWh) and Total Investment cost

	2005	2030 Base Line	2030 Mitigation	% change between the baseline and mitigation scenarios
Demand TWh	3.08	9.97	9.97	0.0%
Energy Efficiency	0.00	0.00	-1.20	
Total consumption	3.08	9.97	8.76	-12.1%
Installed capacity MW	389	1,347.52	1,652.46	22.6%
Hydro	249	721	721	0.0%
Diesel	20	376.5	21.5	-94.3%
Coal	120	250	0	-100.0%
Solar	0	0	837.6	
Wind	0	0	72.4	
Effective generation				
Hydro	1.656	4.66	4.66	0.0%
Diesel	0.001	1.48	0.006	-99.6%
Coal	0.003	0.15	0.00	-100.0%
Solar	0	0.00	1.47	
Wind	0	0.00	0.16	
Total Domestic supply TWh	1.66	6.29	6.29	0.0%
Imports TWh	1.42	3.67	2.47	-32.7%
Total supply TWh	3.08	9.97	8.76	-12.1%
Imports as % of total Supply	46.0%	36.9%	28.2%	-23.5%
CO2 emissions, tonnes	4,200	1,927,270	6,780	-99.6%
Accumulated CO2 emissions, Tons		11,690,220	566,597	-95.2%
PV of Investment costs (million USD)		1,147.21	3,325.81	189.9%
PV of O&M costs (million USD)		1,339.62	290.97	-78.3%
PV of total costs (million USD)		2,486.82	3,616.78	45.4%

Data Sources: Based on model calculations using data from various sources

Table 11 shows a summarised total electricity consumption in TWh, total supply and the total Present Value of total costs in US$ million (using 2005 prices). From an initial electricity consumption of 3.08 TWh in 2005, under the baseline scenario it is estimated that this will rise to 9.97 TWh in 2030. Total consumption would be around 12% less under the mitigation scenario in 2030, as a result of energy efficiency measures. Under both scenarios, imports are expected to decline as a proportion of total supply, which in part reflects the increase in rural off-grid electrification. The overall difference in costs, in PV terms, between the two scenarios is US$1,129 million. Given an expected difference of around 11 million tonnes of CO2 between the two scenarios, this implies a cost of US$102 per ton of CO2 eq.

Table 12 shows the incremental cumulative discounted investment and operational and maintenance costs of implementing the mitigation scenario as opposed to the baseline scenario. The table indicates that there would be no additional costs for hydro projects, because we consider the same investments and levels of operations in both scenarios.

With regards to diesel and coal, there will be significant savings in the mitigation scenario. Diesel in this sense refers to both large power plants and diesel generators for rural areas. The table indicates that in the mitigation scenario, households would save US$1,124 million on diesel when solar power generators are introduced to replace all diesel generators. The vast majority of these savings accrue as a result of O&M cost savings. However, expenditure of US$1,103 million is expected in relation to the replacing solar technologies, with the vast majority of costs relating to upfront investment rather than O&M costs. The reader should bear in mind that these costs refer to full electrification of all households in Namibia, which is an ambitious target. However, it is interesting to note that the costs of mitigation (using solar power) are expected to be marginally less than those faced under the BAU (using local Diesel generators).

Similarly, as regards to coal, Government would save US$288 million in the mitigation scenario by not building the 250 MW Walvis Bay coal plant as assumed under the baseline scenario. But, on the other hand, it would cost Namibia as a whole US$1,439 million to replace that generation (and reduce imports) by using wind and energy efficiency technologies.

All in all, to achieve the mitigation scenario with lower CO2 emissions and increased energy self-sufficiency, Namibia will need an additional US$1,649 million.

Table 13, presents the Incremental Annual Investment Flow, FF and Operation and Maintenance cost Estimates by investment type. As mentioned in Table 12 above, the baseline scenario considers that rural areas obtain electricity via diesel generators- whose operational costs are prohibitive. Since the mitigation scenario considers that diesel generators will be replaced by solar technologies, the yearly O&M savings in diesel are significant.

Similarly, for coal we observe the savings in 2015 resulting from not building the Walvis Bay coal power plant. In turn, this results in a US$12.8 million yearly savings in the O&M costs that would have been derived from that plant. Nonetheless, to replace the Walvis Bay station, we consider that we will construct a wind farm, which will need US$151 million and will have US$1.32 million in yearly O&M costs.

With regards to energy efficiency, it is projected that US$182 million will be needed every year to install the efficient technologies, that will reduce demand for electricity to a level corresponding with the target of reducing imports from 50% to 30% of total consumption of electricity. However, with the introduction of new power generation plants (solar, wind and hydro), the electricity operation and maintenance will decrease substantially.

It is estimated though that consumption/demand of electricity will increase to 9.97 TWh by 2030, mainly as a result of industrial activities and population growth. In order to meet the national energy demand, the Government should invest into new local power generation plants that are renewable and reliable, and continue importing some <30% electricity from other countries when necessary.

Table 12. Electricity Incremental Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source (million 2005 US$)

Investment Entity Category/Source of Funds	Hydro			Diesel			Coal			Solar			Wind			Energy Efficiency			All investment types		
	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
Households																					
Domestic																					
Equity & debt	-		-	-97.7		-1,024.8	-		-	1,099.0		4.1	-		-	617.8		11.2	1,619.1		-492.6
Total Household Funds	**-**		**-**	**-97.7**		**-1,024.8**	**-**		**-**	**1,099.0**		**4.1**	**-**		**-**	**617.8**		**11.2**	**1,619.1**		**-492.6**
Corporations																			-		-
Domestic																			-		-
Domestic equity	-		-	-		-	-		-	-		-	28.0		5.9	255.7		11.6	283.7		17.5
Domestic borrowing	-		-	-		-	-		-	-		-	21.0		-	191.8		-	212.8		-
Total Domestic Sources	**-**		**-**	**-**		**-**	**-**		**-**	**-**		**-**	**49.0**		**5.9**	**447.5**		**11.6**	496.5		17.5
Foreign																			-		-
FDI	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Foreign borrowing	-		-	-		-	-		-	-		-	21.0		-	191.8		-	212.8		-
ODA	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Total Foreign Sources	**-**		**-**	**-**		**-**	**-**		**-**	**-**		**-**	**21.0**		**-**	**191.8**		**-**	212.8		-
Total Corporation Funds	**-**		**-**	**-**		**-**	**-**		**-**	**-**		**-**	**70.0**		**5.9**	**639.3**		**11.6**	**709.3**		**17.5**
Government																			-		-
Domestic																			-		-
Domestic funds	-		-	-		-1.4	-162.1		-56.7	-		-	-		-	57.2		1.5	-104.9		-56.6
Foreign																			-		-
Foreign borrowing	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Bilateral ODA	-		-	-		-	-69.5		-	-		-	-		-	24.5		-	-44.9		-
Multilateral ODA	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Total Foreign Sources	**-**		**-**	**-**		**-**	**-69.5**		**-**	**-**		**-**	**-**		**-**	**24.5**		**-**	-44.9		-
Total Government Funds	**-**		**-**	**-**		**-1.4**	**-231.6**		**-56.7**	**-**		**-**	**-**		**-**	**81.8**		**1.5**	**-149.8**		**-56.6**
Total Funds	**-**		**-**	**-97.7**		**-1,026.3**	**-231.6**		**-56.7**	**1,099.0**		**4.1**	**70.0**		**5.9**	**1,338.9**		**24.3**	**2,178.6**		**-531.8**

Data Sources: Based on model calculations using data from various sources

Table 13. Electricity Incremental Annual IF, FF and O&M Estimates by Investment Type (million 2005 US$)

	Hydro			Diesel			Coal			Solar			Wind			Energy Efficiency			All investments		
Year	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs	IF	FF	O&M Costs
2005	-		-	-		-	-		-	-		-	-		-	-		-	-		-
2006	-		-	-		-	-		-	-		-	-		-	-		-	-		-
2007	-		-	-		-	-		-	-		-	-		-	-		-	-		-
2008	-		-	-		-	-		-	-		-	-		-	-		-	-		-
2009	-		-	-		-	-		-	-		-	-		-	-		-	-		-
2010	-		-	-3.40		-7.44	-		-	38.20		0.03	-		-	123.76		0.27	158.57		-7.13
2011	-		-	-0.80		-8.64	-		-	9.01		0.03	-		-	114.60		0.50	122.80		-8.10
2012	-		-	-0.93		-10.04	-		-	10.46		0.04	-		-	106.11		0.70	115.64		-9.30
2013	-		-	-1.08		-11.66	-		-	12.16		0.05	-		-	98.25		0.86	109.32		-10.75
2014	-		-	-1.26		-13.54	-		-	14.12		0.05	-		-	90.97		1.00	103.84		-12.49
2015	-		-	-1.46		-15.73	-231.60		-5.93	16.41		0.06	69.99		0.61	84.23		1.11	-62.43		-19.88
2016	-		-	-1.69		-18.28	-		-5.49	19.06		0.07	-		0.57	77.99		1.20	95.36		-21.93
2017	-		-	-1.97		-21.23	-		-5.08	22.14		0.08	-		0.53	72.22		1.27	92.39		-24.44
2018	-		-	-2.29		-24.67	-		-4.71	25.72		0.10	-		0.49	66.87		1.32	90.30		-27.47
2019	-		-	-2.66		-28.66	-		-4.36	29.88		0.11	-		0.45	61.91		1.36	89.14		-31.09
2020	-		-	-3.09		-33.48	-		-4.03	34.71		0.13	-		0.42	57.33		1.38	88.95		-35.58
2021	-		-	-3.58		-38.85	-		-3.74	40.33		0.15	-		0.39	53.08		1.39	89.82		-40.65
2022	-		-	-4.16		-45.09	-		-3.46	46.85		0.18	-		0.36	49.15		1.40	91.83		-46.61
2023	-		-	-4.84		-52.35	-		-3.20	54.43		0.21	-		0.33	45.51		1.40	95.10		-53.61
2024	-		-	-5.62		-60.78	-		-2.97	63.23		0.24	-		0.31	42.14		1.38	99.74		-61.81
2025	-		-	-6.53		-70.57	-		-2.75	73.45		0.28	-		0.28	39.02		1.37	105.94		-71.39
2026	-		-	-7.59		-81.96	-		-2.54	85.33		0.33	-		0.26	36.13		1.34	113.87		-82.57
2027	-		-	-8.81		-95.18	-		-2.35	99.13		0.38	-		0.24	33.45		1.32	123.77		-95.60
2028	-		-	-10.24		-110.55	-		-2.18	115.17		0.44	-		0.23	30.97		1.29	135.90		-110.78
2029	-		-	-11.89		-128.41	-		-2.02	133.79		0.51	-		0.21	28.68		1.26	150.58		-128.45
2030	-		-	-13.82		-149.15	-		-1.87	155.43		0.60	-		0.19	26.55		1.22	168.16		-149.01

Data Sources: Based on model calculations using data from various sources

B. Transport

As shown in Table 14, the IF by households, in terms of equity and debt, stands at US$14 million, while the OM costs stands at minus US$ 16 million. The savings on O&M costs refer to the cheaper running costs of LPG cars versus conventional petrol-powered sedans. Indeed, with the subsidisation of conversion provided by Government under the mitigation scenario, it is cost-effective for such a level of conversion to take place.

When it comes to the corporate sector, the IF in terms of domestic equity stands at US$5 million with an associated OM costs of minus US$3 million. The IF in terms of domestic borrowing stands at US$12 million with the minus US$6 million as OM costs.

On the Government side, costs for investment IF stand at US$3 million, for FF US$35 million and for O&M minus US$ 2 million. US$ 1.8 million of IF come from domestic funds, with US$0.8 million coming from bilateral ODA. For FF, US$24 million of the overall costs come from domestic funding, with US$10 million coming from bilateral aid. The greatest savings for O&M costs fall on domestic funds (US$2 million), with a further US$0.6 million coming from reduced ODA assistance.

Overall therefore, the total costs of the LPG mitigation measure is estimated to be US$42 million, for an associated reduction in 1.2 million tons of CO2 eq., which equates to US$28 per ton CO2 eq. reduced.

Table 14. Transport Incremental Cumulative Discounted IF, FF and O&M Estimates by Investment Type, Investment Entity and Funding Source

	LPG		
Investment Entity Category/Source of Funds	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
Households			
Domestic			
Equity & debt	14.36	0.00	-16.20
Total Household Funds	**14.36**	**0.00**	**-16.20**
Corporations	0.00	0.00	0.00
Domestic	0.00	0.00	0.00
Domestic equity	5.09	0.00	-2.36
Domestic borrowing	11.89	0.00	-5.51
Total Domestic Sources	16.98	0.00	-7.87
Foreign	0.00	0.00	0.00
FDI	0.00	0.00	0.00
Foreign borrowing	0.00	0.00	0.00
ODA	0.00	0.00	0.00
Total Foreign Sources	0.00	0.00	0.00
Total Corporation Funds	**16.98**	**0.00**	**-7.87**
Government	0.00	0.00	0.00
Domestic	0.00	0.00	0.00
Domestic funds	1.78	24.25	-1.47
Foreign	0.00	0.00	0.00
Foreign borrowing	0.00	0.00	0.00

Bilateral ODA	0.76	10.39	-0.63
Multilateral ODA	0.00	0.00	0.00
Total Foreign Sources	0.76	10.39	-0.63
Total Government Funds	**2.54**	**34.64**	**-2.10**
Total Funds	**33.89**	**34.64**	**-26.16**

Data Sources: Based on model calculations using data from various sources

Table 15 disaggregates the figures listed in Table 15 in terms of incremental annual IF, FF and OM. As indicated in this table, the IF would decrease from US$163 million in 2005 to about US$60 million by the year 2030 per annum. The annual the FF would increase from about US$5 million in 2010 to about US$18 million per annum during the same period as above. In a similar fashion, the OM will decrease from about US$0.0 million from the year 2005 to minus US$ 4 million by the year 2030 per annum. Note that the changes that occur in costs do not do so along a smooth trajectory over time.

Table 15. Transport Incremental Annual IF, FF and O&M Estimates by Investment Type

	LPG		
Year	IF (million 2005 US$)	FF (million 2005 US$)	O&M Costs (million 2005 US$)
2005	163.39	0.00	0.00
2006	156.23	0.00	0.00
2007	149.11	0.00	0.00
2008	142.08	0.00	0.00
2009	135.16	0.00	0.00
2010	130.62	5.25	-0.17
2011	122.36	0.93	-0.21
2012	115.96	1.11	-0.25
2013	109.77	1.31	-0.30
2014	115.93	1.56	-0.35
2015	111.88	1.85	-0.41
2016	107.73	2.13	-0.48
2017	103.62	2.45	-0.55
2018	99.28	2.82	-0.64
2019	92.46	7.79	-0.74
2020	90.36	4.51	-0.86
2021	86.14	5.18	-1.00
2022	82.00	5.94	-1.15
2023	84.03	6.80	-1.34
2024	81.15	7.79	-1.55
2025	77.91	8.91	-1.80
2026	74.24	10.19	-2.08
2027	70.56	11.62	-2.42
2028	65.36	16.21	-2.80
2029	63.13	15.54	-3.26
2030	59.67	17.61	-3.79

Data Sources: Based on model calculations using data from various sources

3.2 Policy Implications

As a UNFCCC signatory developing country, Namibia does not currently have any obligations to reduce its GHG emissions. This is based on both the responsibility for climate change and the costs associated with tackling the issue. In terms of responsibility, the current and historical GHG emissions from Namibia are minuscule compared to other “developed” countries. In terms of the cost, as a developing country, Namibia has relatively limited means with which to tackle the issue. At the same time, there are many other issues, such as poverty alleviation, that take precedence over the short term.

However, as part of the global community, Namibia should be prepared to search for opportunities to reduce emissions, in terms of “win-win” mitigation efforts and in terms of potential areas where such reductions could be financed from abroad under the many developing climate change mechanisms. Tackling climate change requires a global effort on both mitigation and adaptation; divorcing the cause from the effect can surely only lead to procrastination.

This assessment of the mitigation potential and the costs of such mitigation are not radical in design. On energy generation, the use of increased levels of renewable sources in the energy mix is based on current technological solutions; likewise for transport the use of LPG can been seen across the world, with a small footprint developing in Namibia already. In a sense, the costs and mitigation potential of the measures evaluated can be seen to be an overestimate and underestimate respectively, given the relative infancy of the technologies themselves. However, this analysis is based on current technology levels, to enable long term planning with regards to some of the potential mitigation options available to Namibia in the Energy sector.

For the electricity generation sub-sector, three key mitigation measures have been assessed: solar power, wind power and energy efficiency (hydropower is already part of the Namibian current and future energy mix). Each of the technologies assessed take into account capacity factors, but does not assess the impact on consumer energy prices.

- Solar power. As previously mentioned, Namibian conditions are very suitable for the use of solar power, both in terms of large-scale generation and localised generation. The technology is costly however, requiring large levels of up-front capital financing. In contrast, O&M costs are very low, as is the GHG reduction potential (including the life-cycle costs of assembly and disposal).

  This analysis has focused on localised generation solutions for off-grid households, representing an effective generation of 1.5 TWh per annum in 2030. The costs of providing electricity to those off-grid households is estimated at US$1.1 billion over the 25 year time period until 2030, which is substantial. The alternative, considered under the baseline scenario, would be for localised diesel generation, which would cost around US$1.12 billion, greater than 90 percent of which would be in running costs. The difference in GHG emissions over the 25-year time period would be approximately 8.7 million tons. It is important to note that alternative baseline scenario solutions for household electricity provision have not been considered, which may indeed be cheaper than small scale diesel generation. In particular the costs of providing all households with grid provided electricity have not been considered.

- Wind power. With its long and windswept coastline, Namibia also has significant wind power potential. As with solar power, the costs of wind power are mainly in terms of large capital costs, although O&M costs are not insignificant.

  Investment in wind power in our analysis is assessed in terms of the replacement of other power generation technologies in the energy mix and in terms of reducing Namibia's reliance on foreign energy supplies (to 30 percent of total supply, as opposed to 50 percent of total supply). Investment in wind farms with an installed capacity of 72 MW (effective generation 0.16 TWh) under the mitigation scenario are estimated to cost US$70 million, with associated O&M costs of US$6 million. If this energy generation replaced the equivalent generation by a coal powered plant, this would represent a saving of 2.8 million tons of GHG over the 2010 to 2030 wind farm lifecycle.

- Energy efficiency. Improving energy efficiency can be seen as the most cost-effective option available to reduce global GHG emissions: indeed many energy efficiency measures are themselves cost reducing (win-win solutions) (see, for example, Stern, 2006). Based on a basket of energy efficiency measures including installation of CFLs, the introduction of newer appliances etc., which reduce energy consumption by households by 20 percent and by government and businesses by 10 percent, the costs are estimated to be US$1.4 billion, US$24 million of which occurs in O&M costs. From a start date of 2010 until 2030, this implies a saving of 13.2 TWh, which based on the baseline energy mix in 2030 implies a saving of 4 million tons of GHG. It should be noted that this measure also reduces the need for investment in additional energy sources, a benefit captured in the current analysis through the costs relating to other technologies.

Based on this assessment, the incremental costs of these three measures are significant at US$3.6 billion over the period of analysis, implying a cost of US$101 per ton of CO_2 eq.

For the transport sub-sector, the greater use of LPG as opposed to petrol has been assessed as a mitigation measure.

- LPG. GHG emissions from a litre of LPG consumed are estimated to be around 35 percent less than the emissions from petrol consumption, although due to the difference in energy content of the two fuels, the emissions per km travelled is around 20 percent less for LPG travel.

  However, the impact of cheaper fuel prices for LPG on fuel demand means that drivers would be expected to travel further on switching to LPG powered vehicles. As such, the overall saving in emissions as part of a programme to increase LPG usage is estimated to be around 1.2 million tons of GHG over the time period of analysis.

The incremental costs of a programme to increase LPG usage are estimated to be around US$42 million, which includes the costs of car conversion to LPG use, petrol station infrastructure, Government subsidisation of conversion costs and costs of O&M[5].

Based on the analysis performed, the incremental costs imply an average cost per kg of CO2 equivalent of US$28 per ton (of US$56 per ton, if the O&M savings are excluded).

3.3 Key Uncertainties and Methodological Limitations

A. Electricity Generation

The major limitation of the model is the reliability of data, as significant proportions of input data used had to be estimated. Besides, the model focuses on future years and therefore there is an inevitable level of uncertainty regarding the projections.

Given the continuous improvements in technology, there is a real possibility that the unit costs of different technologies will change overtime, affecting the funding requirements derived from the model.

Another challenge is the unavailability of information on the funding sources of the various mitigation options considered. Companies (even State Owned Enterprises) are reluctant to provide detailed information on projected funding requirements and sources. But even if they were willing to provide such information, raising funds depends on a number of factors such as available capital in the country, willingness of domestic investors to lend, domestic interest rates vis-à-vis foreign interest or foreign exchange rates. In this case, it is almost impossible to know with certainty the origin of financing beyond a one year span.

Aside from the challenges experienced with model input data, the need to ensure comparability in the baseline and mitigation scenarios meant that we had to reach the same total figures for the main variables such as demand or the electrification rate.

The need to equate demand in both scenarios meant that there was no room for scaling up energy efficiency in the mitigation scenario. To solve this, we decided to create a variable for demand and another variable for total consumption, with demand being the amount of electricity wanted by consumers and consumption being the effective amount of electricity that

[5] Note that the incremental O&M costs are estimated to be negative (minus US$26 million), based on the price of fuel. Essentially this saving (a benefit to consumers) can be seen as a cost to Government however, in terms of reduced taxation revenue (effectively a transfer from Government to car users, assuming the price differential reflects differing taxation regimes). Should the price differential between the fuels not be maintained, this saving to car users would not be present.

needs to be delivered to the consumers to satisfy their demand given the introduction of energy saving measures.

Similarly, the need to equate the share of people with access to electricity (the electrification rate) in both scenarios had a severe methodological complication. Namibia's low population density renders 100% on grid-electrification unfeasible. In the business as usual scenario this would have meant that a share of the population would have remained without access to electricity. However, since in the mitigation scenario we were targeting 100% electrification via solar technology, we also had to consider 100% electrification in the business as usual scenario. In this case, the only theoretical option was diesel generators, whose operation and maintenance costs cause them to be unworkable in practical terms. By having to include as a mere theoretical alternative such costly generators, the costs in the business as usual scenario are artificially ballooned, consequently artificially reducing the additional funds needed by the country to attain the mitigation scenario. However, it is interesting to note that the costs of providing 100% electrification are very similar under both scenarios: if this is not a policy that is followed, the overall incremental costs would not be substantially different.

B. Transport

The model is an attempt to depict changes in the sedan car market in Namibia, and the potential costs of policy changes to incentivise LPG market penetration due to the mitigation potential of the technology. In predicting future market situations, especially when concerning a technology that still has little market penetration in Namibia, it is somewhat inevitable that there are many uncertainties that are inherent to the model.

Despite this however, some of the assumptions underlying the development of the sector over time could be explored in further depth in future to improve the robustness of the model.

For example, economic growth rates play an important role in the model, impacting car numbers and hence overall fuel consumption. At present, the model does not allow for growth rate fluctuations or have any in-built sensitivity analysis, both of which would improve confidence in the model. Likewise, LPG market penetration rates, which are extremely uncertain, have no in-built sensitivity analysis in the model. Given that LPG penetration is vital to assessing the costs of mitigation, further research into these assumptions under the baseline and mitigation scenarios would be welcome.

In other areas of the model, consistency has been assumed throughout time. For example, the difference in running costs between LPG and petrol cars is consistent, irrespective of the price of fuel. Likewise the price elasticity of demand for car usage is assumed to be consistent, as is the share of cost born by debt and equity by each of the three actors (government, business and actors) considered.

One further simplification in the model that should be mentioned is the infrastructural costs relating to LPG and petrol fuel. For simplicity, it has been assumed that non-fuel station infrastructure, such as fuel storage tanks or transportation vehicles, are equally as costly for petrol fuel and LPG. Given that any actual difference in costs could have large overall cost implications, potentially limiting the further expansion of the LPG market, further work into this issue is recommended.

Aside from investigating some of the assumptions further, the scope of the model itself is perhaps a limiting factor in reflecting the cost of climate change within the transport sector in the future. Whilst focussing on the expansion of LPG to the exclusion of all other measures provides a clear estimate of the costs of the policy options related to LPG, this narrow scope perhaps does not reflect the reality of the various policy solutions available for reducing emissions in the sector. In particular, further model developments could focus on the costs related to expansion of public transport, with the interactions between the policies measures providing valuable further insight into the costs of mitigation.

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Annexes

Annex A – Assumptions used for the Electricity Model

Assumption		Reference/Basis	Further details
Population growth rate per annum	1.7% average	National Planning Commission personal communication	
Estimated GDP growth per annum	4% average	World Development Indicators Database – World Bank	Average of growth rates 2000-2005
Discount rate	8%		Based on the return on Long Term Government bonds
N$/US$, 2005	6.41	www.oanda.com	Average annual rate
Composition of electricity demand, 2009	• Households – 25% • Corporations – 60% • Government – 15%		Estimate, based on City of Windhoek figures (no precise figures available)
Share of households that have electricity, 2005	• 36.4%	Namibia Household Income and Expenditure Survey 2003/2004, 2006	
Share of households that will have electricity by 2030	• 100%		
Growth of electricity demand, 2005 –2030	• Households – 5.74% • Corporations – 4% • Government – 1.7%		Household rate based on the growth rate required to supply all households Corporation growth rate based on GDP growth Government growth rate based on growth of the number of civil servants (population growth a proxy)
Average annual growth rate of electricity demand	• 5% average		Estimated growth required based on GDP growth per annum figures
Transmission loses (of total production)	• 10%		Simplification, based on discussions with VO Consulting
Capacity factors by power station type	• Hydropower (Ruacana) – 70% • Hydropower (Baynes) – 80% • Solar panel – 20% • Wind – 25% • Diesel – 3% • Coal – 7% • Local rural generation – 50%		Approximations, based on VO Consulting knowledge
Installation costs by power type, 2005 US$ million per MW	• Solar – 5.22 • Wind – 2.09 • Hydropower – 4 • Diesel – 2	REEECAP (REEEI, 2007)	

	• Coal – 2 • Diesel remote – 1.4 • Solar remote – 6.3		
Operation and Maintenance costs by power type, 2005 US$ cents per KWh	• Solar – 0.0028 • Wind – 0.0083 • Hydropower – 0.007 • Diesel – 0.1127 • Coal – 0.0835 • Diesel remote – 0.6957 • Solar remote – 0.0028	REEECAP (REEEI, 2007)	
Tons of CO_2 per KWh by power source	• Solar – 0 • Wind – 0 • Hydropower – 0 • Diesel – 0.0012 • Coal – 0.001		
Percentage of costs paid by each agent	• Household 100% - Rural Diesel/Solar • Corporations 100% - Wind • Government 100% - Hydro, Diesel and Coal		

Funding sources – IF	• Household:
	  • Domestic equity – 100%
	• Corporations:
	  • Domestic equity – 40%
	  • Domestic borrowing – 30%
	  • Foreign borrowing – 30%
	• Government :
	  • Domestic funds – 70%
	  • Bilateral ODA – 30%		

Funding sources – O&M	• Household:
	  • Domestic equity – 100%
	• Corporations:
	  • Domestic equity – 100%
	• Government :
	  • Domestic funds – 100%		

Annex B – Assumptions used for the Transport Model

Assumption		Reference/Basis	Further details
Population growth rate per annum	1.7% average	National Planning Commission personal communication	
Estimated GDP growth per annum	4% average	World Development Indicators Database – World Bank	Average of growth rates 2000-2005
Discount rate	8%		Based on the return on Long Term Government bonds
N$/US$, 2005	6.41	www.oanda.com	Average annual rate
Vehicles per 1000 population	See Annex C		
Average life of a car	• 8 years		
Real fuel price change sensitivity levels, 2005 to 2030	• No change • Low change – 10% increase • Med change – 50% increase • High change – 100% increase		Sensitivity analsysi
Share of total vehicle population that are sedan or light load vehicles, 2005	• 88%	Capôco et al, 2007	Assumed fixed over time for simplicity
Share of sedan and light load vehicles using petrol	• 100%	Capôco et al., 2007	Stated that sedan and light load vehicles predominantly use petrol, assumption for simplicity
Change in fuel consumption of an average petrol and LPG car, 2005-2030	• 5% reduction		Taking into account rebound effect on petrol consumption
Average number of petrol pumps per service station	• 6		Estimate
Share of sedan and light load vehicles using petrol, 2005-2010	• 100%	Capôco et al., 2007	
Baseline share of sedan and light load vehicles using LPG only, 2005-2010	• Household – 10% • Corporation – 10% • Government – 10%		Estimate
Baseline share of sedan and light load vehicles using LPG and petrol, 2005-2010	• Household – 20% • Corporation – 20% • Government – 20%		Estimate
Mitigation share of sedan and light load vehicles using LPG only, 2005-2010	• Corporation – 40% • Government – 100%		Estimate
Mitigation share of sedan and light load vehicles using LPG and petrol, 2005-2010	• Corporation – 40% • Government – 40%		Estimate
Cost of conversion petrol to LPG / additional cost of purchasing a car already converted	• 2005 – N$6000 • 2030 – N$3000	2005 figures Autogas plc	
Cost saving from running an LPG versus petrol car, fixed	• 20%	Capôco et al, 2007	Based on both the price of fuel and O&M costs This saving is assumed to lead to an

			increase in the average millage covered when a switch is made to LPG
Price elasticity of demand for petrol	• -0.25	Espey, 1996	
Station infrastructure replaced	• Every 6 years		Estimate
Cost of replacing a petrol pump, 2005 N$	• 34,920	Namcor	Figures extrapolated from personal communication
Cost per additional petrol pump (expanding stations), 2005 N$	• 160,231	Namcor	Figures extrapolated from personal communication
Cost per additional petrol pump (new stations), 2005 N$	• 1,629,590	Namcor	Figures extrapolated from personal communication
Share of pumps that are in new stations rather than expanded stations	• 50%		
Cost of replacing an LPG pump, 2005 N$	• 58,043	Autogas	Figures extrapolated from personal communication
Cost per additional LPG pump (expanding stations), 2005 N$	• 267,000	Autogas	Figures extrapolated from personal communication
Cost per additional LPG pump (new stations), 2005 N$	• 1,891,782	Autogas	Figures extrapolated from personal communication
Share of pumps that are in new stations rather than expanded stations	• 50%		Estimate
O&M costs assumed the same for LPG and petrol pumps	• N$16,667	Namcor (figure for petrol)	

Funding sources – IF	• Household:
	  • Domestic equity – 100%
	• Corporations:
	  • Domestic equity – 40%
	  • Domestic borrowing – 30%
	  • Foreign borrowing – 30%
	• Government :
	  • Domestic funds – 70%
	  • Bilateral ODA – 30%		

Funding sources – O&M	• Household:
	  • Domestic equity – 100%
	• Corporations:
	  • Domestic equity – 100%
	• Government :
	  • Domestic funds – 100%		

Annex C – Derivation of vehicle ownership growth rates

Vehicle ownership per 1000 members of population is based on analysis by Dargay et al. (2007) on the relationship between vehicle ownership and Purchasing Power Parity GDP levels. The formula below describes the relationship as observed for number countries across the world:

V = (a*b*exp^c*exp^d*GDP) + (1-b)V(t-1)

Where V = vehicles per 1000 population
a = saturation level (maximum no of vehicles per population)
b = the speed of adjustment to income changes
c = determinant of the income level of saturation
d = maximum income elasticity of income ownership rates
GDP = PPP income US$ 1995

For Namibia, V is known at 115 vehicles per 1000 population in 2005. B is fixed for all countries at 0.095, as is c, fixed at - 5,897. The saturation level chosen for Namibia is the figure selected by Dargay et al. for Australia, a similarly large and uninhabited country as Namibia. In order to match V to Nambia's situation, a figure for d must be calculated: -0.20013 is calculated, which is similar to other figures used for the analysis by Dargay et al.

Based on expected growth rates (taken as a proxy for PPP growth) and population growth rates, Namibia will not reach saturation levels until much later than the period of analysis (see Chart 1).