MAPS

Mitigation Action Plans & Scenarios

MODELLING DRIVERS OF EMISSIONS in the LTMS

October 2012

TECHNICAL // Drivers of Emissions

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Purpose

To provide an overview of the drivers used to project sectoral demand in the South African Long Term Mitigation Scenarios (LTMS) and in so doing provide guidance to modellers embarking on similar processes. Consideration is given to the method used by the LTMS to develop these drivers, and how inconsistencies can arise when different drivers are used for different sectors. The briefing offers an alternative hybrid approach to combat inconsistencies through the use of both a top-down and bottom-up model.

Background

Growth in total final consumption in any sector or economy is driven by an increasing demand for energy services which in turn is driven by an increase in activity in the sectors such as floor area in the commercial sector, industrial output or number of households in the residential sector. Within sectors there may be several drivers of demand, for instance in the residential sector the size of the household, household income, access to fuels, fuel prices, and number of rooms, amongst others, are all important drivers of energy services. The number of rooms may be an important determinant of demand for lighting services, and the number of people in the household may drive the demand for water heating.

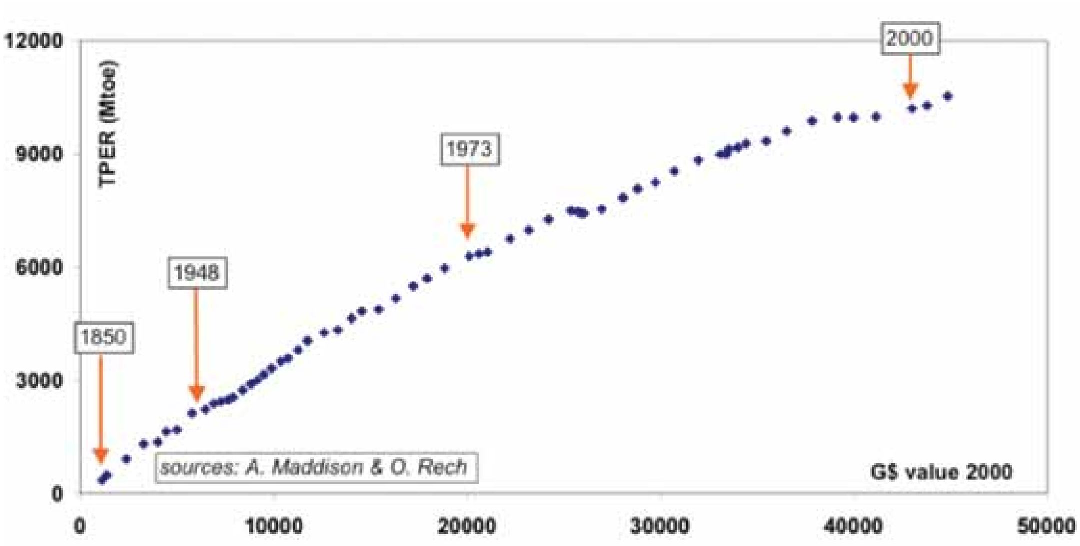
Whilst each sector has determinants of demand for energy services, at a national level economic activity and population growth are the key demand drivers. The link between economic activity and energy consumption is well established.

Figure 1 shows how over the past 150 years, global total primary energy requirements have increased as global GDP has increased. South Africa's development has followed this trend. In addition growth in population plays a role in the demand for energy services in the residential and transport sectors. Whilst there is a growth in demand for energy services as GDP and population increase, if the supply of energy services becomes more efficient, this does not necessarily translate into a growth in final energy demand. For this reason, the major drivers, GDP and population, are used to project the demand for growth in activity and demand for energy services in the sectors, and not the growth of final energy demand in the sectors.

The LTMS (for more information on LTMS see *http://www.erc.uct.ac.za/Research/LTMS/LTMS-intro.htm)* was modeled using the bottom up technology rich optimization model MARKAL. This allows demand to be modeled as a demand for energy services, often referred to as useful energy demand, and therefore it is the demand for energy services that is projected over time using the projected increase in sectoral activity. The

FIGURE 1:

WORLD TOTAL PRIMARY ENERGY REQUIREMENTS VS GDP (PPP)



Source: Maddison and Rech in WEC, 2004

demand for useful energy services is translated into final energy consumption through the use of appliances or technologies which have different efficiencies and may use different fuels allowing the energy intensity of production to change over time. The final energy demand of each sector is a model output.

Drivers of demand such as prices were not considered in the LTMS model, although this is possible to do.

1. Forecasting drivers of emissions in the LTMS

1.1 Approach

Common methods for forecasting demand are trend analysis and econometric forecasting. Trend analysis extrapolates past growth trends into the future while econometric forecasting correlates demand with other variables to relate future growth in demand to the growth of these variables in the future.

In the LTMS the useful demand for energy services was calculated exogenously for the commercial, industrial and agricultural sector using elasticities and intensities.

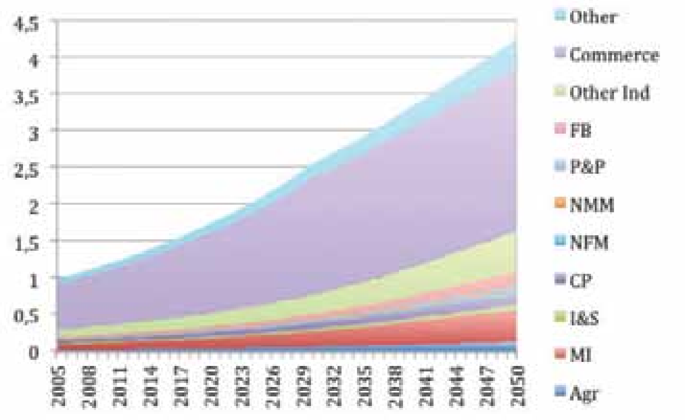
In general, elasticities indicate the responsiveness of one variable to changes in another and are calculated using historic time series data. The elasticity of subsector outputs to GDP was used to estimate the growth in the activity of each sector or sub-sector over time. Elasticities to GDP were specifically used to make projections of growth in output in terms of either value added or physical output in the industrial sub-sectors. In the commercial sector the floor area of buildings grows in relation to GDP, and in the agricultural sector, agricultural output grows in relation to GDP. In the transport sector, demand for passenger and freight transport grew with an elasticity to GDP and population and in the residential sector population growth is directly related to an increase in the number of households.

Demand for energy services over time is calculated using intensities which relate energy service demand to the projected sectoral activity e.g. useful energy required for space heating per square meter of a particular type of commercial building. The intensity of demand for energy services can be adjusted to account for factors such as improved building design, or processes i.e. the amount of useful energy services required by the sector to produce a unit of output.

Two reality checks were performed on the exogenously calculated demand for energy services, firstly, the cumulative output from industrial sectors such as mining could not exceed the economically recoverable reserves and secondly, the trend of increasing commercial share of GDP in the economy should continue.

The result is commercial sector growing faster than industrial sector as can be seen in Figure 2.

FIGURE 2:
SECTORAL CONTRIBUTION TO THE ECONOMY LTMS (2006=1)

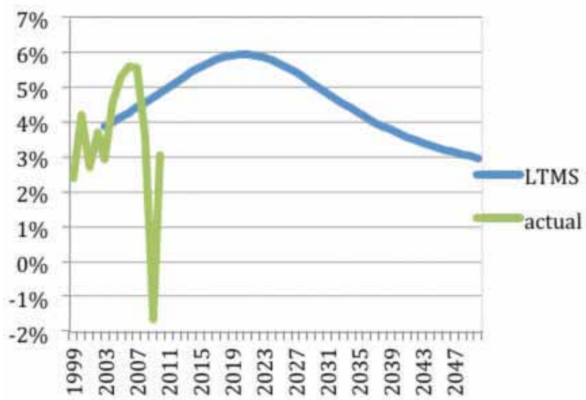


The downfall of using elasticities is that there could be a disconnect between the demand for goods from Sector A by Sector B, with insufficient growth in Sector A to supply. Also transport is dependent not only on GDP, but also on where they money is going, i.e. on income in the different income groups.

1.2 GDP Projection

Developing plausible GDP projections for any developing country is challenging. The rate of GDP growth tends to increase and then decrease as countries move along the development path. This tendency is described by the IPCC (2001) in five major stages of economic development, however the profile that this may take is uncertain and there are many factors that influence GDP growth which are not predictable. The GDP projection developed for the LTMS was based on a consensus that was arrived at during a scenario building team (SBT) meeting and as such reflected the political will at the time. The projections therefore take into account the aspirations of the Accelerated Shared Growth Initiative (ASGISA) developed by government. ASGISA laid out a growth plan for the country, where GDP growth rates between 2005 and 2009 would average 4.5% or higher, and between 2010 and 2014 would increase to an average growth rate of 6% (DOE, 2006). To reflect these aspirations the SBT agreed that the GDP growth would peak at 6% in 2020 (Winkler, 2007) and follow the peak and decline trajectory shown in Figure 3. Following the peak, GDP growth rate declines to 2.6% in 2060.

FIGURE 3:
GDP GROWTH RATE IN THE LTMS

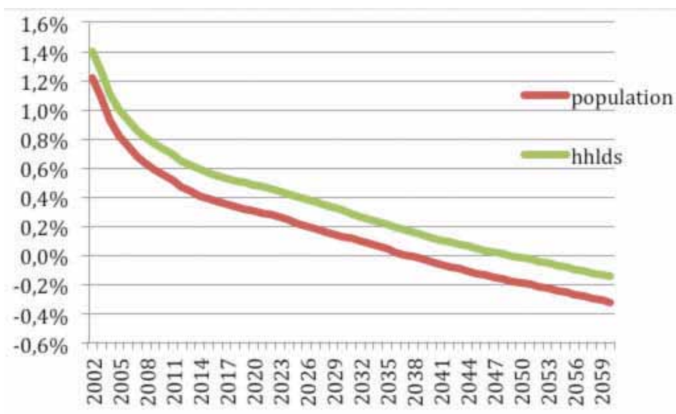


1.3 Population Projection

Population growth is impacted by many aspects related to development such as access to health care, education and age of the population. Due to the high prevalence of HIV AIDS in South Africa, which is likely to impact population growth significantly in the coming years, and other socio-demographic factors, how the population will grow over the next 3 decades is a topic of much debate, however it is unlikely that the population growth will be exponential as population growth has been decreasing over the past decade.

The Actuarial Society of South Africa (ASSA) developed a model which projects population growth in South Africa taking into account the impact of HIV AIDS. The

FIGURE 4:
GROWTH IN POPULATION AND NUMBER OF HOUSEHOLDS

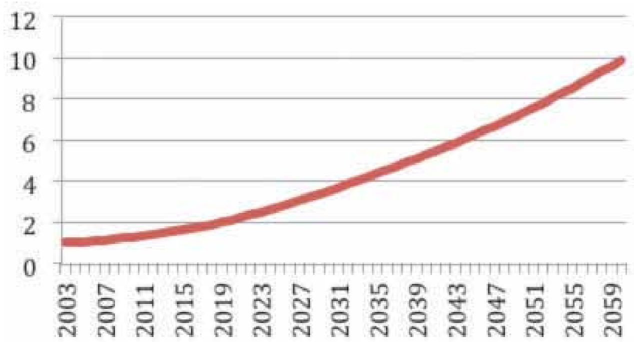


spreadsheet-based model was used to develop population projections for the LTMS. The resulting population growth is shown in Figure 4. Growth in the number of households, which is also shown in Figure 4, relates to population growth through an assumption of current and future household sizes in different income groups. The number of people per household has been decreasing however it is assumed that it ultimately remains constant.

1.4 Changing GDP per capita

South Africa has a low Gini coefficient, with many poor households. Low income households have less access to electricity and other goods and have a far lower demand for energy services than middle and high income households. In the LTMS model, GDP growth was higher than population growth, this results in an increasing GDP / Capita as shown below in Figure 5.

FIGURE 5:
AVERAGE GDP PER CAPITA (2003=1)



This has implications for energy consumption as with increasing GDP per capita one would expect the number of low income households to reduce, which would likely result in increased car ownership and use, and increasing energy consumption by households as appliance ownership increases. In order to accommodate these changes, categories of households are used, and the percentage of households in the higher and middle income categories increases over time. Effort was made to calibrate the increased GDP per capita to the assumed ratio of households in different income groups.

2 Alternative approaches to that used in the LTMS

To overcome inconsistencies in which may develop when using the method described above, a hybrid approach has been developed in South Africa. This involves using a dynamic computable general equilibrium (CGE) model to project growth in the output of the different economic sectors and to inform the household disaggregation into income groups over the modeling period.

CGE models have been used for policy-analysis in many countries, including South Africa. The premise of these models is to simulate the functioning of a market economy by modeling the interactions of producers across all sectors, households, government and the rest of the world through prices and capital flows. Their general application is to assess the impacts of a policy or project that might affect the output of one good or service on the economy as a whole across all the sectors.

Whilst the effect of developing projections of economic growth and sectoral output with the CGE model, as opposed to the method used in the LTMS, can be seen in all sectors, the most marked difference is seen in the changes in the dissagregation of the household income groups and the growing use of private vehicles in the transport sector.

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