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DRAFT 2012 INTEGRATED ENERGY PLANNING REPORT

EXECUTIVE SUMMARY

(For Public Consultation)

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EXECUTIVE SUMMARY

1 Background

The purpose and objectives of the Integrated Energy Plan (IEP) are anchored in the National Energy Act, 2008 (Act No. 34 of 2008). Integrated energy planning is undertaken to determine the best way to meet current and future energy service needs in the most efficient and socially beneficial manner, while:

- Maintaining control over economic costs;
- Serving national imperatives such as job creation and poverty alleviation; and
- Minimising the adverse impacts of the energy sector on the environment.

Government strives to improve the lives of the people of South Africa through various programmes. This improvement is effected through policy development and the implementation of appropriate policy choices.

The IEP takes into consideration the crucial role that energy plays in the entire economy and is informed by the output of analyses founded on a solid fact base. It is a multi-faceted, long-term energy framework which has multiple objectives, some of which include:

- To guide the development of energy policies and, where relevant, set the framework for regulations in the energy sector;
- To guide the selection of appropriate technologies to meet energy demand (i.e. the types and sizes of new power plants and refineries to be built and the prices that should be charged for fuels);
- To guide investment in and the development of energy infrastructure in South Africa; and
- To propose alternative energy strategies which are informed by testing the potential impacts of various factors such as proposed policies, introduction of new technologies, and effects of exogenous macro-economic factors.

Energy is an integral part of the economy and the energy sector is a key enabler for the attainment of national policy imperatives such as those expressed in the National Development Plan and its supporting pillars which include the New Growth Path and the Industrial Policy Action Plan, amongst others. It is therefore important that a mechanism is developed to enable energy policymakers to quantify and provide feedback on the extent to which the energy sector can contribute to the attainment of these and other national policy imperatives. It is equally important to quantify and provide feedback on the extent to which policy objectives outside the energy sector may impact on the attainment of energy sector imperatives. Examples of these include objectives, targets and/or constraints set in the following policy documents:

- The Beneficiation Strategy;
- The National Climate Change Response Policy;

- The National Transport Master Plan (NATMAP 2050); and
- The proposed Carbon Tax policy

While sectoral plans look at how to ensure that energy needs are met, the IEP endeavours to provide a long-term vision of how energy can be optimally used as a mechanism for South Africa to remain competitive. Optimal use of energy may at times require a shift in the use of a particular energy resource. For example, with the challenge of carbon emissions related to the use of coal in the generation of electricity, alternative supply options such as renewable and nuclear energy should be considered, as they provide a cleaner source of energy. That said, the cost associated with these alternatives needs to be considered and investment needs to be made to promote the development of new technologies to improve the use of coal.

Today's choices about how energy is produced and used will determine the sustainability of the future energy system and consequently of socio-economic progress. Integrated energy planning involves thorough analysis of the benefits and shortcomings of integrated relationships and seeks to optimise the energy system as a whole. The benefits and advantages associated with the pursuit of a particular strategic pathway are thoroughly explored and assessed against the trade-offs of not considering other alternative pathways. Integrated energy planning is therefore not only about ensuring that South Africa's energy needs are met, but also about finding alignment and ensuring that cross-sectoral impacts are analysed in a systematic way.

As a fast emerging economy, South Africa needs to balance the competing need for continued economic growth with its social needs and the protection of the natural environment. South Africa needs to grow its energy supply to support economic expansion and in so doing, alleviate supply bottlenecks and supply-demand deficits. In addition, it is essential that all citizens are provided with clean and modern forms of energy at an affordable price. The IEP will take these and other constraints into consideration. From the myriad of factors which need to be considered and addressed during the Integrated Energy Planning process, eight key objectives were identified.

- Objective 1: Ensure the security of supply;
- Objective 2: Minimise the cost of energy;
- Objective 3: Increase access to energy;
- Objective 4: Diversify supply sources and primary sources of energy;
- Objective 5: Minimise emissions from the energy sector;
- Objective 6: Promote energy efficiency in the economy;
- Objective 7: Promote localisation and technology transfer and the creation of jobs; and
- Objective 8: Promote the conservation of water.

2 Energy Demand

Energy is a basic human need and is also a key enabler for the attainment of economic growth and other broader national imperatives. The desired structure of the economy as well as the level of activity within each of the sectors of the economy provide the starting point on which future energy requirements to support the desired economic growth can be determined. Access to modern forms of energy improves the livelihood of individuals and the growth of the population is therefore a key factor in determining future energy requirements for domestic use.

The energy planning process therefore starts with an understanding of the drivers for energy demand (with economic growth, population growth and energy prices being the three key drivers).

2.1 Macroeconomic Drivers

The National Treasury provided 20-year projections of domestic average potential economic growth for three scenarios (low growth, moderate growth and high growth) which were based on various sets of assumptions. The moderate growth assumptions assume the steady growth of the economy, with continued skills constraints and infrastructure bottlenecks in the short- to medium-term. These projections have been used in the Integrated Energy Planning process and are taken as the baseline. The GDP growth assumptions based on the National Development Plan (NDP) have been used for the high-growth scenario, but the relevant outputs have not yet been analysed.

The population growth combined with the average household size provides a good basis for determining the number of households in the future. Energy demand in the residential sector is determined by estimating the average energy consumption by different household types.

In the transport sector, GDP per capita is used to estimate future demand for passenger transportation.

Using the above-mentioned key drivers as a basis, demand projections were conducted for each of the energy demand sectors (agriculture, commerce, industry, mining, residential and transport).

- For the agricultural, commercial, industrial , mining and residential sectors, energy demand was estimated and projected for individual energy carriers (i.e. electricity, natural gas, LPG, coal, diesel, etc.); and
- For the transport sector, energy demand was projected for energy end-use (i.e. mobility measured by passenger kilometres or freight tonne kilometers) as opposed to individual fuels (i.e. petrol, diesel, jet fuel, etc).This second approach makes it possible to quantify the extent to which different fuels can be used to meet the same energy end-use/need.

The demand projections and inferred energy intensity are provided in the sections that follow.

2.2 Total Energy Demand

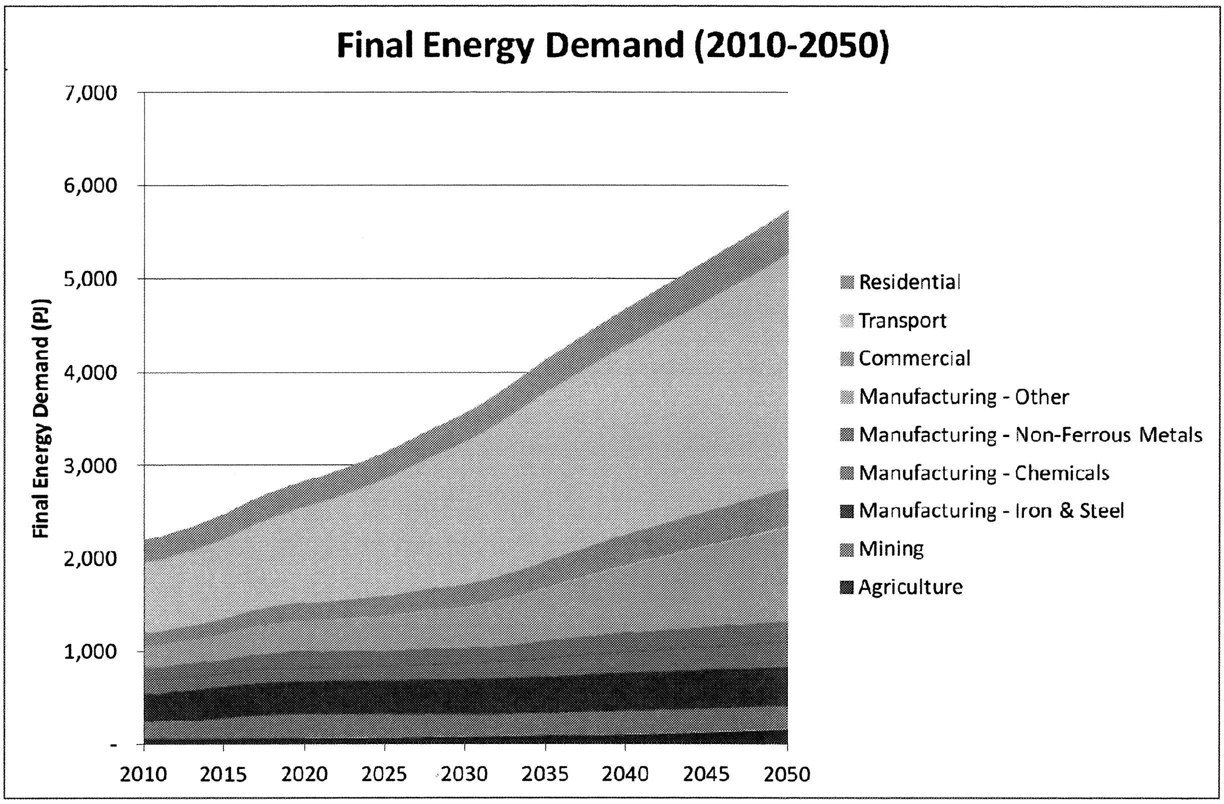


Figure 2-1: Projected energy demand for the entire economy by sector

The demand projections indicate a substantial increase in total energy demand by 2050, increasing at an average annual rate of 2% to more than double the 2010 levels.

The transport sector, comprising 34% of total energy demand in 2010, will continue to impose the most significant demand on total energy.

In line with global growth patterns, the key driver for continued passenger transport demand is linked to increased mobility which results from economic development. Disposable income levels influence the preferred mode of passenger transport with the tendency for individuals to use private passenger vehicles rather than mass public transport as income levels increase. However other factors which influence this preference include quality of roads as well as safety, efficiency and reliability of public transport systems. More recent factors that could possibly slow down the trend for people to move from public transport to private passenger vehicles include government policy interventions, which aim to accelerate the improvement of public transport by establishing integrated rapid public transport networks. These will introduce priority rail corridors and Bus Rapid Transit (BRT) systems in cities. Taxes on passenger vehicles to discourage their use, particularly in city centres, have also been introduced in efforts to reduce Greenhouse Gas (GHG) emissions. Transportation demand is largely met through liquid fuel, however the penetration of electric and hybrid vehicles could see demand shift from petroleum products to electricity for small private passenger vehicles in the future. This will see significant reduction in energy demanded relative to economic growth and an overall reduction in energy intensity for passenger transportation in the long-term.

Freight haulage, predominantly by road, has contributed the most substantially to increases in transport demand and related fuel consumption. In recent years the rail freight market lost its market share to road haulage, and presently it is estimated that 85% of total freight is hauled by road, with the remainder being transported by rail. Road freight transport, which is more reliable, flexible, accessible, and secure and provides shorter transit times by comparison with rail freight transport, is preferred by the industrial sector. However this carries with it negative externalities such as increased and rapid damage to roads, road congestion, air pollution and higher fuel/energy requirements.

Demand for freight haulage is strongly linked to the value-add of the transport sector and overall economic growth. However government has now reviewed its rail investment programme to accelerate the shift from road to rail. This will see an investment of about R63billion by Transnet in the freight rail system over the next five years. The move should result in a reduction in projected road freight haulage and resultant energy demanded and will therefore require further analysis.

Outside of the transport sector, the most significant energy demand increase is expected to be in industry (the manufacturing sector), followed by the commercial sector. The energy demand in the 'Manufacturing - Other' is largely associated with projected economic growth, while the increase in energy demand within the commercial sector is associated with the continued expansion of the tertiary sector as South Africa moves to become more of a knowledge-based economy.

Demand in the residential sector is largely driven by population growth coupled with increased urbanisation. As living standards improve, people tend to consume more energy; however, energy efficiency interventions could see this trend start to slow down in the future.

The graph below shows projected energy demand for individual energy carriers.

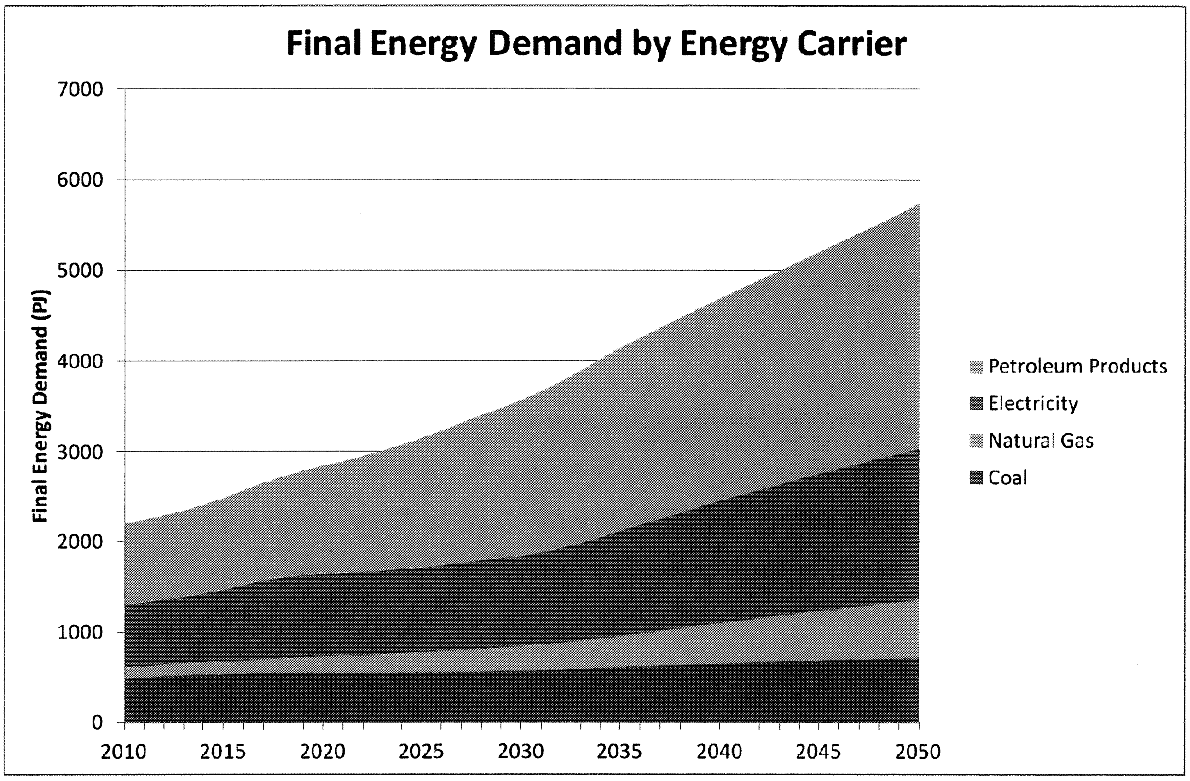


Figure 2-2: Total energy demand for different energy carriers

Demand for petroleum products increases the most significantly between 2010 and 2050 in comparison to that for other energy carriers. This is mostly attributed to the continued use of petrol and diesel vehicles to meet transportation needs into the foreseeable future with electric vehicles only beginning to make a significant contribution for passenger transport after 2030. Demand for LPG is expected to increase steadily in the residential sector and although fairly minor, ranks as the third largest increase between 2010 and 2050. Diesel consumption continues to increase in the mining sub-sector but only marginally when compared to electricity and natural gas. The use of illuminating paraffin is expected to decrease in future.

Demand for natural gas shows the next most significant increase after that of petroleum products. Natural gas is primarily used in the industrial sector and the projected growth of the sector is a factor in this increase.

Demand for electricity continues to rise as more houses become electrified and as the tertiary sector, largely comprised of commercial and public buildings continues to expand. In the industrial sector, the increase in electricity demand is largely attributed to the manufacturing sector with the exception of the iron & steel sub-sector. The iron & steel and mining sub-sectors show very little energy demand increase from current levels.

Demand for coal will continue to grow in the industrial sector, while in the residential sector it is expected to start declining due to ongoing electrification of previously non-electrified households and improvement in household incomes.

2.3 Proportion of Final Energy Demand within Different Sectors

The share of total energy demanded across different sectors in 2010, 2030 and 2050 is provided in the table below.

Table 2-1: Proportion of current and projected final energy demand within different sectors

SECTOR	2010	2030	2050	Change
Industry (Excluding Mining)	37%	33%	34%	↓
Mining	8%	7%	4%	↓
Agriculture	3%	2%	3%	–
Commerce	7%	7%	7%	–
Residential	11%	9%	8%	↓
Transport	34%	43%	44%	↑
TOTAL	**100%**	**100%**	**100%**	

2.4 Energy Intensity

Figure 2-3 and Figure 2-4 below reflect the changes in energy intensity for the different energy demand sectors relative to 2010 levels. Using 2010 as the base year (with an energy intensity index = 1), an energy intensity index below 1 indicates an improvement or reduction in energy intensity relative to that of 2010, while an energy intensity index above 1 indicates an increase in energy intensity relative to that of 2010.

Figure 2-3 indicates an improvement in the energy intensity of the industrial, mining, commercial and transport sectors. Although energy demand increases in the tertiary sector (commerce and transport) the rate of increase is slower than projected economic growth and continues to decline throughout the planning period. The energy intensity in the mining sector increases initially (between 2010 and 2017) and starts to decline thereafter.

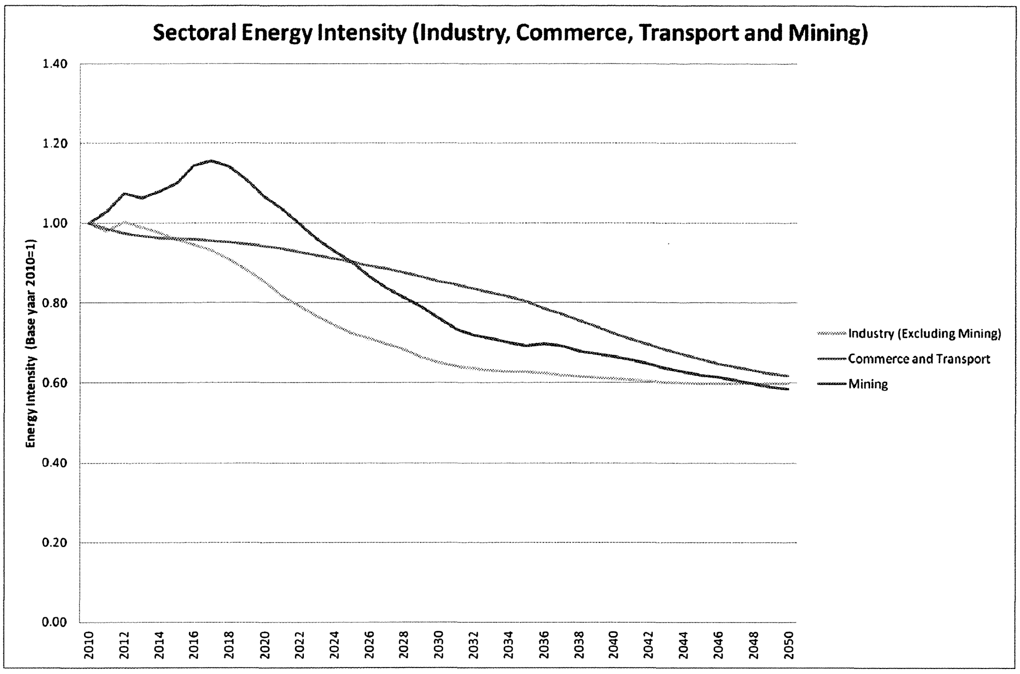


Figure 2-3: Energy Intensity Indices for the Industrial, Mining, Commercial and Transport Sectors

Unlike the sectors discussed above, energy intensity in the agricultural and residential sectors is likely to increase (See Figure 2-4). In the agricultural sector, the significant increase in energy consumption has historically been driven by the adoption of large-scale, intensive farming practices, which are assumed to continue into the foreseeable future. In the residential sector this increase will be driven by an assumed increase in the population.

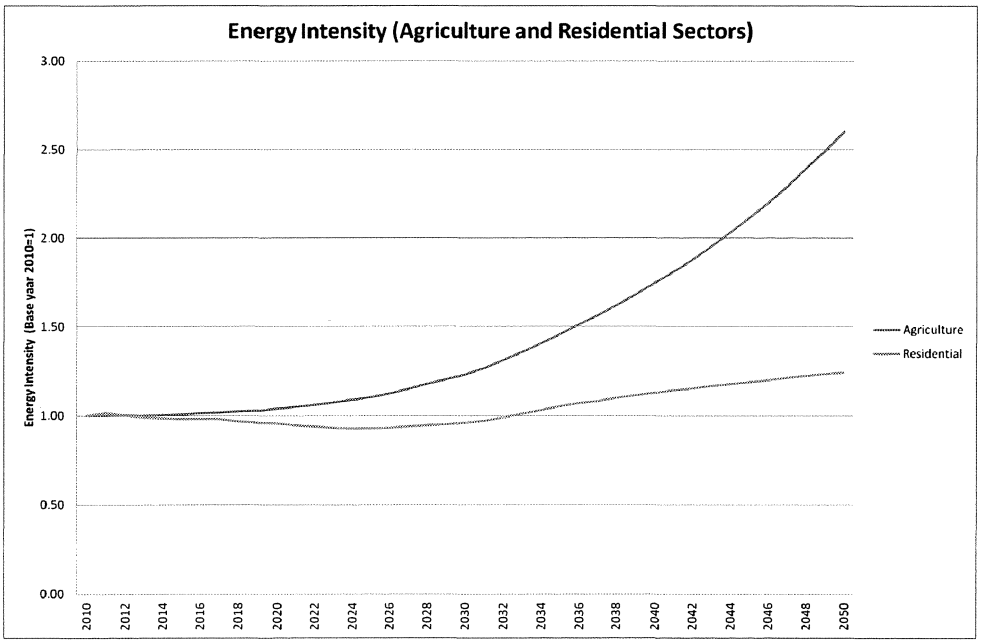


Figure 2-4: Energy intensity indices for the agriculture and residential sectors

Figure 2-5 indicates an overall reduction in the intensity of the economy. Structural changes; significant changes in the level of activity; and technological and process improvements which have taken place within each of the sectors inform the projected demand and hence the reduction in energy intensity, Further analysis is required to quantify and separate the historical impact of structural changes, activity level changes and technological changes on energy intensity. Improvements in technologies, industrial processes and practices alone can play a significant role in future efficiency improvements and government policies, such as the recently published Draft National Energy Efficiency Strategy and interventions such the financial and tax incentives for energy efficiency could materialise in further reductions of energy intensity within these sectors.

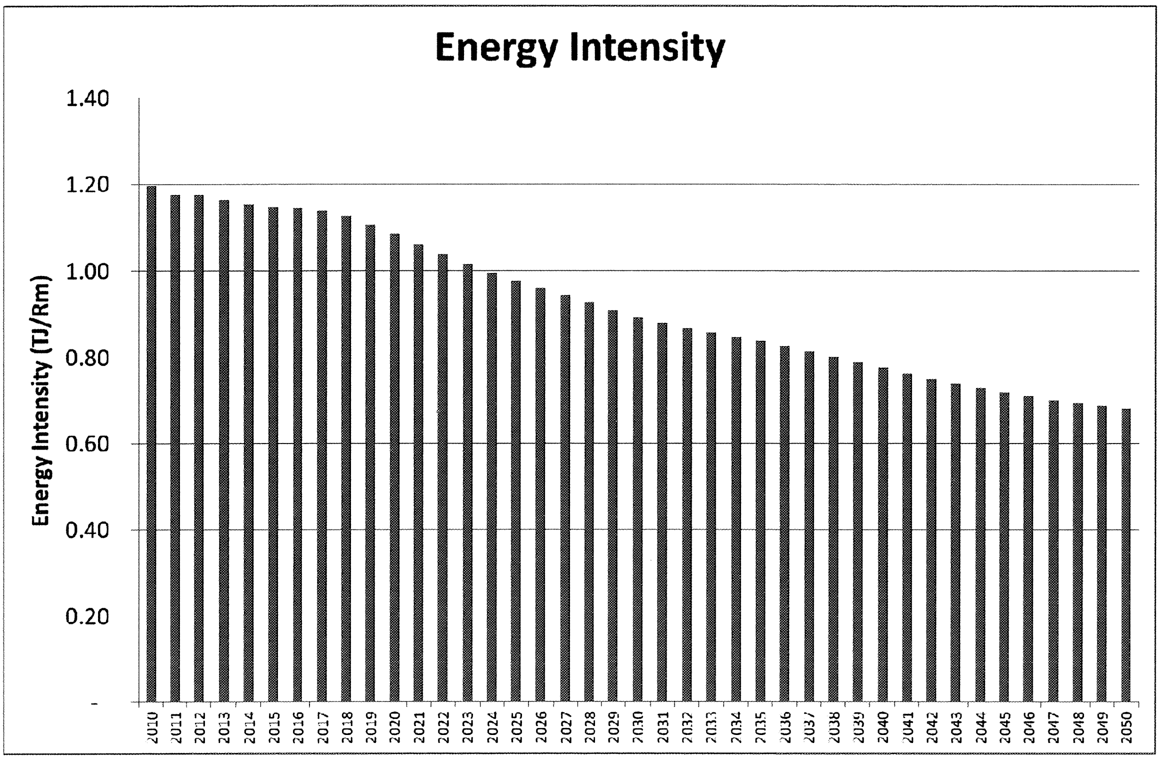


Figure 2-5: Energy intensity of the economy

3 The Base Case and Alternative Cases

The demand projections are a key input into the energy model and have a significant influence on the outcome of the Base Case and the various Test Cases. The underpinning objective is to ensure that future energy supply options meet future energy demand.

To ensure that the most appropriate supply-side options are selected, it is important to define a starting point or base against which all options are compared and analysed. This base has been defined as the 'Base Case' whilst alternative options that can be considered have been defined as 'Test Cases'.

BASE CASE

- The Base Case encapsulates the state of energy demand and supply over the planning horizon, which is most closely informed by current energy market trends; the national macroeconomic outlook; assumed energy prices; existing energy infrastructure and the existing suite of policies and government programmes. Thus, while the IEP seeks to recommend an energy roadmap or policy pathway for the energy sector, this process is not conducted in isolation and should build on energy policies, strategies and plans which have already been adopted.
- **The Base Case, is therefore not a representation of the most likely future or most likely scenario, but is rather a simplistic representation of a future outcome that could materialise in light of current policies and macroeconomic trends. It represents a Business-As-Usual or Status Quo scenario where current trends continue into the future.**

Alternative policy options or 'policy alternatives' look at different pathways that can be pursued by policymakers to achieve energy sustainability and in some instances this requires testing the impacts of competing factors. These policy alternatives are defined as 'Test Cases'.

TEST CASE

- A Test Case has been defined as a **deviation from the status quo** where current trends do not continue into the future and **deviations are as a result of specific policy interventions**. A Test Case therefore defines a set of circumstances and resultant outcomes or impacts which is informed by the possible impacts of policies and policy interventions. A Test Case does not indicate what will happen but rather tests what could happen if a particular course of action is pursued.
- While Test Cases are sometimes also referred to as scenarios, within the context of the IEP and for the purposes of common interpretation, a Test Case is specifically differentiated from a Scenario in that a **Scenario is largely influenced by exogenous forces** which the policy maker has no control over, while **a Test Case seeks to test the possible implications of active policy interventions**.

The Base Case assumes that only prevailing policies are pursued to shape the future energy pathway. The Test Cases which were also considered and modelled are described briefly below. Each Test Case has been informed by the policy imperatives of high-impact policies within the energy sector which include the Integrated Resource Plan, the National Development Plan and the National Climate Change Response White Paper.

1. **"Peak-Plateau-Decline" Emission Limit Test Case:** This Test Case assumes that the country's target (i.e. a reduction on the 'business as usual' emission level of 34% by 2020 and

of 42% by 2025) for electricity generation and liquid fuel production is met at all costs. This is achieved by setting emission limits ***on electricity generation and liquid fuel supply only*** in line with the upper bound of the "Peak-Plateau-Decline" emission trajectory, as defined in the National Climate Change Response Policy. No carbon tax is assumed. This Test Case seeks to analyse the effect of the emission limit constraints on energy supply options and costs.

2. **Emission Limit - No Nuclear Build Programme Case**: This Test Case assumes that the emission limit of the "Peak Plateau Decline" must be met as described above but that the 9,600MW Nuclear Build Programme is explicitly excluded as a supply option. This Test Case seeks to analyse the effect of embarking upon, or not embarking upon, the Nuclear Build Programme in terms of future energy security, as well as meeting the emission limit targets defined in the National Climate Change Response Policy.
3. **Renewable Energy Target Case:** No emission limit constraints are set but renewable energy options are gradually introduced into the energy mix from 2010 to 2030 such that by 2030, 10% of total energy output (electricity generation and liquid fuel production) is from renewable energy sources. From 2031 onwards, the target of 10% is maintained as a minimum. (It should be noted that given the low load factors for most renewable energy technologies, the installed capacity would effectively be much higher than 10%). This Test Case analyses the efficacy of setting renewable energy targets for reducing emissions within the energy sector.
4. **Emission Limit - Natural Gas Case:** This assumes that the emission limit of the "Peak Plateau Decline" trajectory must be met and that the Nuclear Build Programme is excluded as a supply option, as in the Test Case above. However the nuclear option is replaced by natural gas options as a policy intervention. This Test Case seeks to analyse the efficacy of including natural gas in the energy supply mix as a transitional fuel towards a low carbon economy and the implications of choosing this as a supply option over nuclear. In this context natural gas includes conventional gas, coal bed methane and shale gas.
5. **Carbon Tax Cases:** In these two Test Cases no emission limit constraints are set but the carbon tax is implemented as a test case with an upper bound of R120 per ton of CO_2-eq and a second case is implemented with a R48 per ton to simulate the 60% tax-free threshold. These test cases analyse the cost implications of a possible carbon tax on the energy sector as defined in the impending Carbon Tax Policy.

In addition, the following sensitivity analyses were conducted for the Base Case in order to test the impact of different crude oil price growth assumptions on decisions for new refining capacity:

1. **Low Crude Oil Price Case:** Assumes a low growth in the future crude oil price.
2. **High Crude Oil Price Case:** Assumes a high growth in the future crude oil price.

The model output from the Base Case and "Peak-Plateau-Decline" Emission Limit Test Case are described briefly in the two sections that follow.

4 Summary of Model Output

Based on the key macroeconomic, policy and technology assumptions made for the Base Case, the following section provides a summary of the total capacity for electricity generation, liquid fuel production and primary energy mix as well as estimated annual emissions and water use throughout the planning horizon.

4.1 Electricity Generation

The technology options for electricity generation for the High Oil Price and the Low Oil Price Test Cases remains the same as the Base Case as changes in crude oil price have little impact on electricity generation options.

- Coal technologies continue to play a role in the Base Case and all Test Cases however this is reduced significantly by 2030 as the existing fleet of coal technologies starts to be retired. The role of coal technologies continues to decline in the three Test Cases within emissions limits as no new coal power plants (besides Medupi and Kusile) are brought onstream. However in the Base Case and the Renewable Energy Target Cases new coal technologies continue to contribute to electricity supply (approximately an additional 50GW by 2050 in the Base Case and 30GW in the Renewable Energy Target Case).

- Solar plays a significant role in the Base Case and all Test Cases as the cost of solar technologies is projected to continue declining in the foreseeable future. Solar shows the biggest increase in contribution to the total energy mix in the Base Case and all Test Cases.

- The contribution of wind technologies is reduced in the Base Case as other options are more cost effective than wind technologies in the absence of emissions limits or renewable energy targets. However wind does play a significant role in the Emissions Limit and Renewable Energy Target Test Cases. Wind shows the second biggest increase in contribution in all Test Cases with emissions limits.

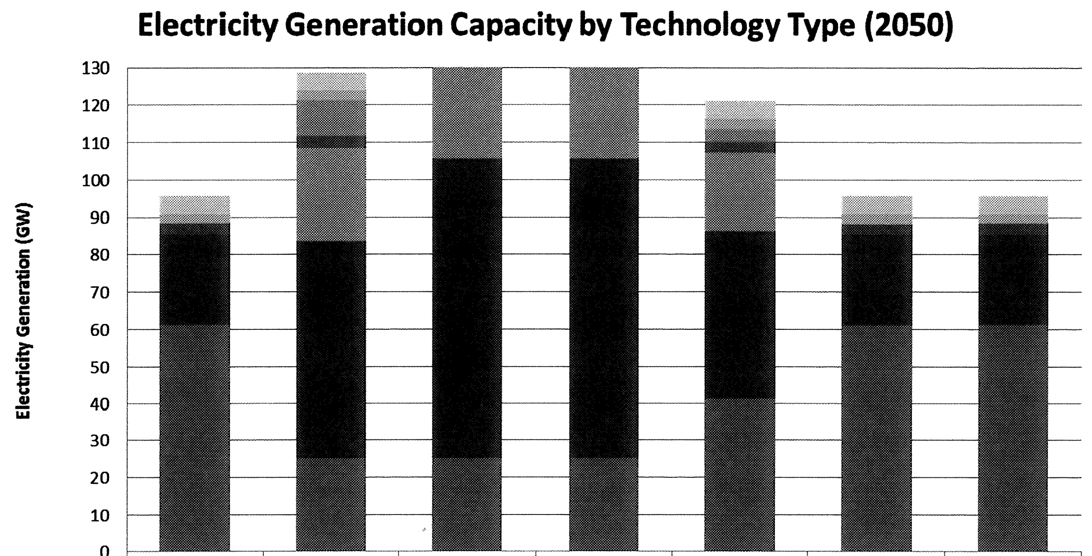
- A new nuclear plant is selected by the model in the Emissions Limit Case with no explicit exclusion of nuclear. Nuclear, together with Renewable Energy technologies are therefore viable options in reducing emissions in the Emissions Limit Test Cases. Nuclear does not feature in the Renewable Energy Target Case as preference is given to renewable energy technologies in this Test Case.

- Biomass only features in the Renewable Energy Target Test Case in order to ensure that the renewable energy targets are met.

- Besides the natural gas options included as part of the ministerial determinations, new natural gas options do not feature prominently in the Base Case or any of the Test Cases. New natural gas only features in the Test Case where Natural Gas options are explicitly enforced.

- While coal-fired power plants with Carbon Capture and Storage (CCS) technologies were considered as an option, due to their relatively high cost the model does not select any CCS technologies in the Test Cases with emissions limits as other cheaper alternatives (i.e. Wind and Solar technologies) are available.

Figure 4-1 presents the electricity generation capacity for different technologies by 2050.



	Base Case	Emissions Limit Case	Emissions Limit - No Nuclear Case	Emissions Limit - Natural Gas Case	Renewable Energy Target Case	High Oil Price Case	Low Oil Price Case
Other *	4.9	4.9	4.9	4.9	4.91	4.9	4.9
Gas	0.2	0.2		4	0.237	0.2	0.2
Petroleum	2.4	2.4	2.4	2.4	2.415	2.4	2.4
Nuclear		9.6					
Biomass					3.417120576		
Hydro	3.1	3.1	3.1	3.1	3.109	3.1	3.1
Wind		25	25	25	20.90722329		
Solar	24	58.1	80.1	80.1	44.99309098	24	24
Coal	61.2	25.4	25.4	25.4	41.20415853	61.1	61.2

Figure 4-1: Electricity generation capacity by technology type (2050)

4.2 Liquid Fuel Production

The exclusion of nuclear energy (i.e. Emissions Limit – No Nuclear Case) has no significant impact on the liquid fuels sector in comparison to the Emissions limit case. Likewise the enforcement of natural gas as a supply option (i.e. Emissions Limit – Natural Gas Case) also has no significant impact on the liquid fuel sector. The output from these two test cases therefore requires no further analysis in this section as the output is the same as that for the Emissions Limit Test Case.

- In the Base Case and all Test Cases, the model selects new refining capacity to meet future liquid fuel demand from as early as 2020. Total liquid fuel production slows down by 2034 and plateaus to 2040 after which it declines as a result of electric vehicle penetration in all Test Cases.

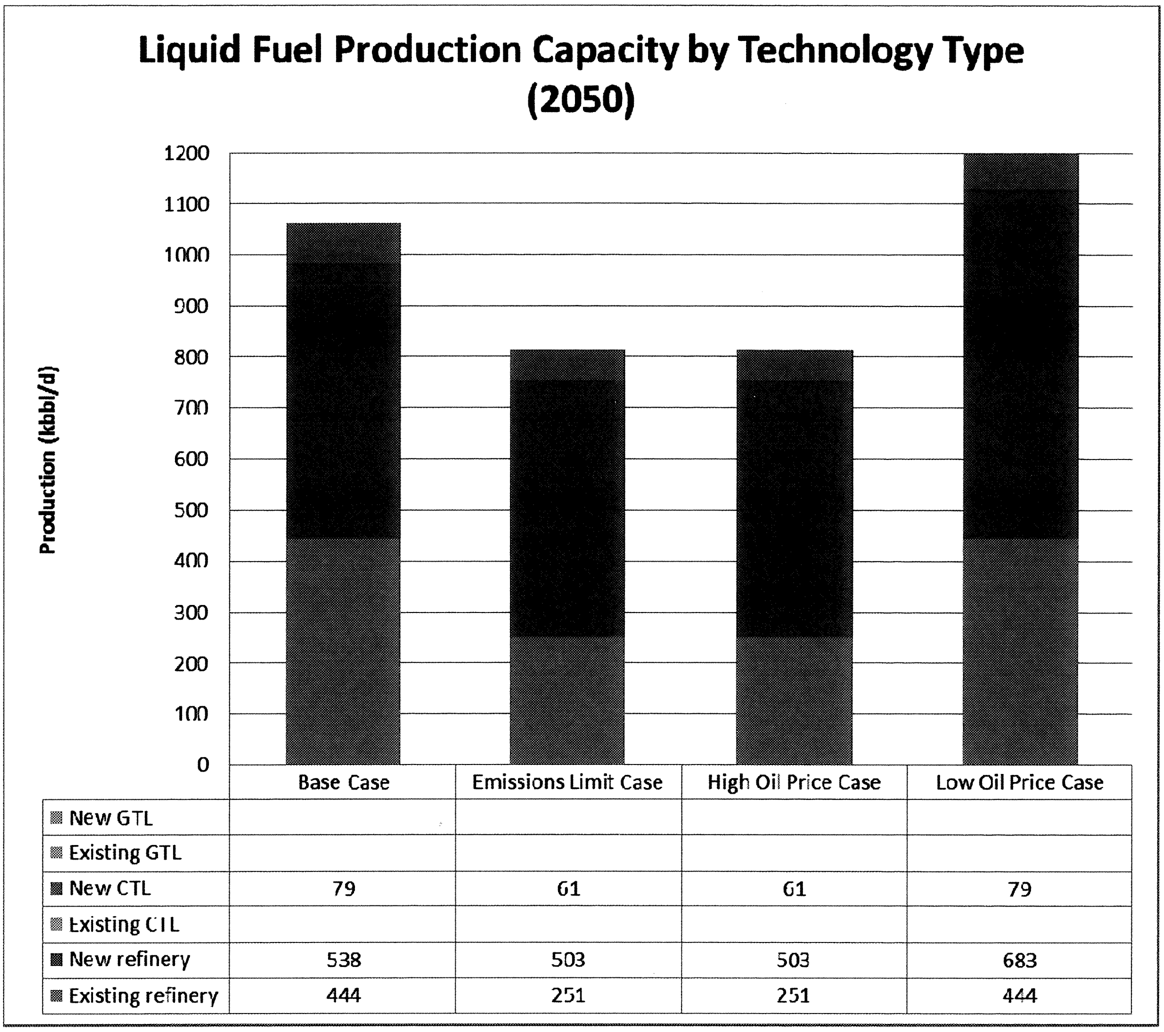
- New conventional crude oil refineries are a viable option in the Base Case and all Test Cases however additional capacity in the outer years is reduced for the Emission Limit Test Cases. It is assumed that existing conventional refineries are not retired within the modelling period and that their operational life is extended through continued maintenance, occasional upgrades (usually related to fuel specifications) and the low cost of maintaining the existing refineries relative to the cost of crude oil processed.

- In the Base Case and test cases without emissions limits, the cost of producing liquid fuels from coal is lower than that for both conventional refineries and gas to liquid plants as presented in the assumptions. In these test cases a coal-to-liquid plant is built to the maximum constraint set in the input parameters of 80 000 barrels per day, after which conventional refineries are selected to provide for the increasing liquid fuels demand. In the Emissions Limit Test Case, the selection of a new coal-to-liquid plant is restricted as a consequence of the high associated carbon emissions. A new plant does however feature only after 2040 when the existing coal to liquids plant is decommissioned and the use of electric vehicles reduces overall emissions below the emissions limits therefore providing scope for the more cost-effective coal to liquid plant. In the absence of a carbon tax, the total discounted cost of producing liquid fuels from coal-to-liquid plants is lower than that for both conventional refineries and gas to liquids.

- No new Gas-to-Liquid (GTL) plants are selected by the model. This is partially informed by the relative costs of new GTL plants as compared to conventional crude oil refineries as well as projected natural gas prices.

- In the absence of emissions limit constraints, the model output shows sensitivity to new capacity for different crude oil price assumptions. The capacity of new conventional refineries is highest in the Low Oil Price Case as compared to the Base Case and all the other Test Cases. On the contrary, the capacity of new conventional refineries in the High Oil Price Case is lower than that of the Base Case but is comparable to that of new capacity in the Emissions Limit Case.

- All supply shortfalls are met via imports in all Test Cases. Imports are especially high in the High Oil Price Case and the test cases which set limits on carbon emissions.



	Base Case	Emissions Limit Case	High Oil Price Case	Low Oil Price Case
New GTL				
Existing GTL				
New CTL	79	61	61	79
Existing CTL				
New refinery	538	503	503	683
Existing refinery	444	251	251	444

Figure 4-2: Liquid fuel production by technology type (2050)

4.3 Primary Energy Supply

- Coal loses its share in the primary energy mix in the Base Case and all three Test Cases however this is pronounced in the Emissions Limit Cases.

- New nuclear only features in the Emission Limit Test Case without technology constraints.

- Solar technologies are viable and play a prominent role in all Test Cases however the share contribution is reduced in the Renewable Energy Target Case as Wind – which is included earlier in this Test Case reduces the requirements for new renewable energy technologies in the outer years.

- New biomass only features when a renewable energy target is set.

- Transport demand continues to increase which results in an increase in the demand for liquid fuel. In the Base Case and the Test Cases without emissions limits, this demand is met through local production (primarily crude oil refining and limited production of synfuels from coal and gas). The share of crude oil in the primary energy mix therefore increases in these Test Cases.

- In the Emissions Limit Test Cases, local production of liquid fuel is displaced with imports and this sees an increase in the share of petroleum products in the primary energy mix. In the High Crude Oil Price Case, the import of final product surpasses crude oil imports and the inverse is the case in the Low Crude Oil Price Case.

- Imported natural gas plays an increasing role in all Test Cases throughout the planning period; however this is not prominent in comparison to other primary energy sources.

4.4 Discounted Cost

The total discounted cost represents all the costs of the energy system discounted to a single number for comparison purposes. It is the main variable used to compare the policy interventions which inform the various test cases which have been defined.

A large dependence on imported energy (crude oil and liquid fuels) in all test cases can be observed from an analysis of costs related to the energy system as presented in Figure 4-3. Imports increase from about 70% to 80% of the total energy supply costs for the Base Case between 2010 and 2050; from 80% to 90% in the Emissions Limit Case and the No Nuclear Case; from 70% to 80% in the Renewable Energy Target Case.

The total discounted costs for the Emissions Limit Case and the No Nuclear Case are both 4.8% more than that for the Base Case; and that for the Renewable Energy Target Case is 1% more than that for the Base Case. The higher costs are due to an increase in the share of imported energy and the use of technologies which are less carbon intensive in the test cases with emissions limits.

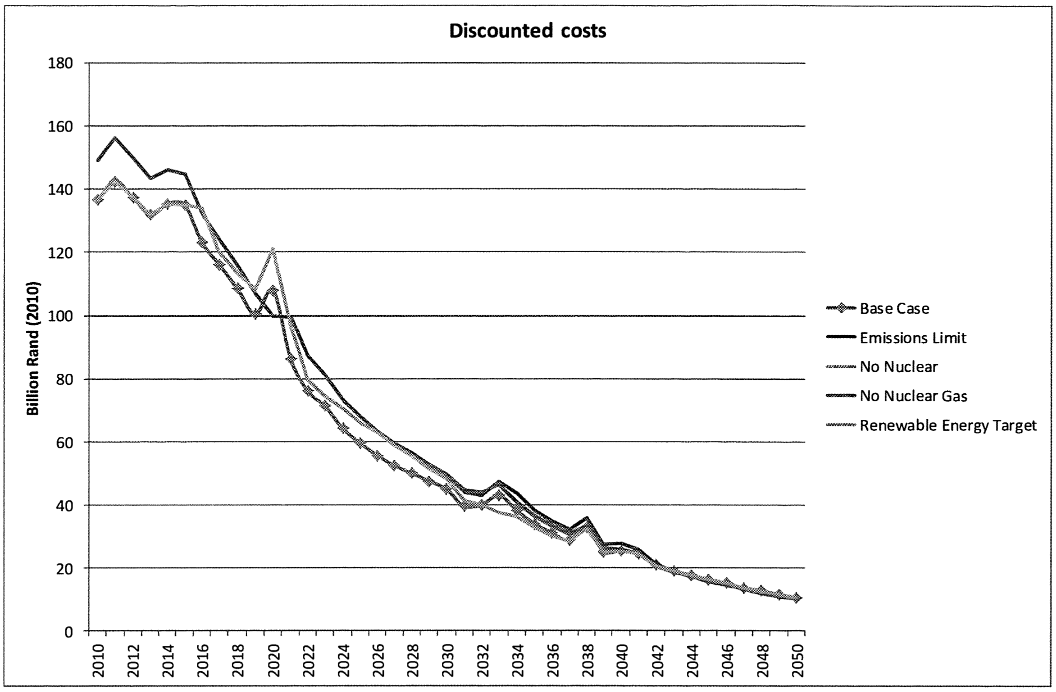


Figure 4-3: Discounted costs for all Test Cases

4.5 Emissions

Carbon dioxide emissions for the Base Case and test cases are presented in Figure 4-4. These emissions are primarily driven by the use of coal for electricity generation and liquid fuel production; however a considerable amount of coal is also used in other parts of the economy and is not included here. The abatement cost for meeting the emissions limit for the Emissions Limit Test Case and the No Nuclear Test Case is calculated at R41/t (in 2010 Rand). Setting emissions limits on energy production (i.e. refineries and electricity generation) without setting emissions constraints or emissions penalties on energy end-use (i.e. demand-side emissions controls) results in greater use of imported energy. Emissions resulting from energy end-use therefore continue growing unconstrained. Therefore national emissions limits cannot be met without addressing final demand for energy carriers.

Fuel switching between final energy carriers was only modelled for the transport sector and this allows for the switching from fuel-powered vehicles to hybrid and electric vehicles which results in reduced emissions in the transport sector when constraints are set.

In summary:

- Emissions in the Base Case continue to increase.
- Emissions are reduced for the Renewable Energy Target Test Case however the reduction is not significant enough for them to be below the levels required by the "Peak Plateau Decline" Emissions Trajectory.

- The carbon emissions associated with energy supply (electricity generation and liquid fuel production) for all the test cases with emissions limits are within the "Peak Plateau Decline" Emissions Trajectory as this is set as a constraint. The reduction in the use of coal has the most significant impact on this reduction and the emissions constraints resulted in a 7.5 billion tonnes (or 31%) reduction in carbon dioxide emissions over the 40 year period as compared to the Base Case.

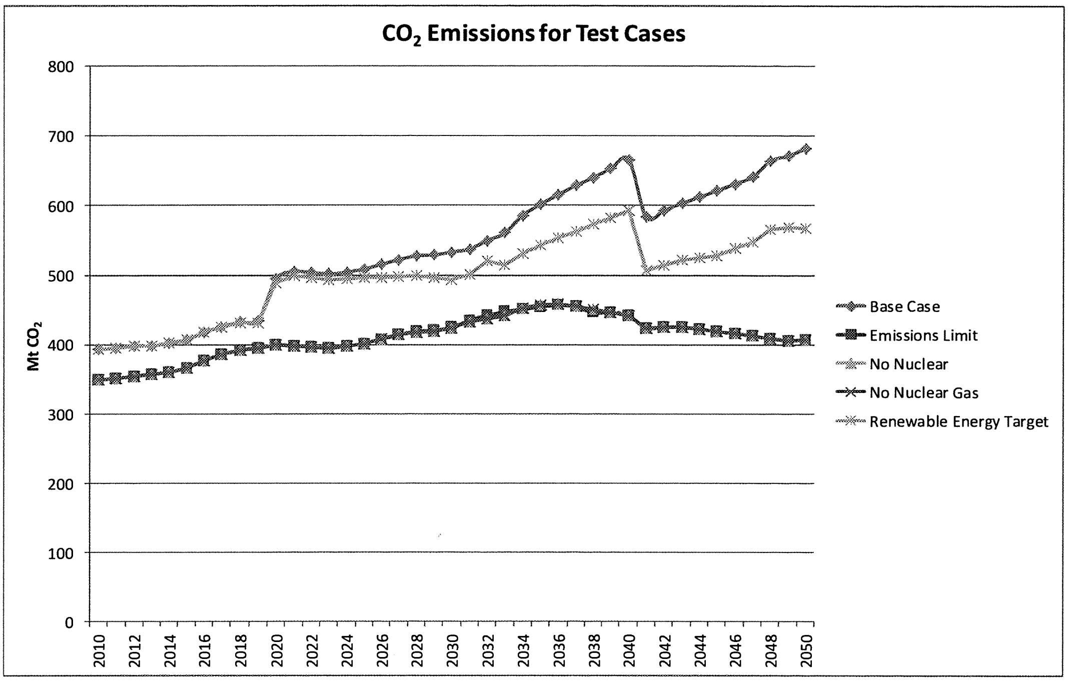


Figure 4-4: CO_2 emissions for all Test Cases

4.6 Water Use

Water use in the various test cases is shown in Figure 4-5. Coal-to-liquid plants use large quantities of water - this is evident by comparing the water consumption of the Base Case (which includes a new coal-to-liquid plant) with that of the Emissions Limit case (all of which exclude a new coal-to-liquid plant). There is very little difference in water consumption for the Emissions Limit case and the No Nuclear case. The small difference is because nuclear (which is selected by the model in the Emissions Limit Test Case) is assumed to use sea water whereas the CSP technologies (which are selected by the model partially in place of nuclear in the Emissions Limit – No Nuclear Test Case) use fresh water. In general the test cases which have limited or no production from coal-to-liquid plants have a reduced demand for water in comparison to those that have significant production. In the latter years, water demand is also reduced as dry-cooled plants replace wet-cooled plants for electricity generation and renewable energy technologies which use less water start to play a more prominent role in the energy mix.

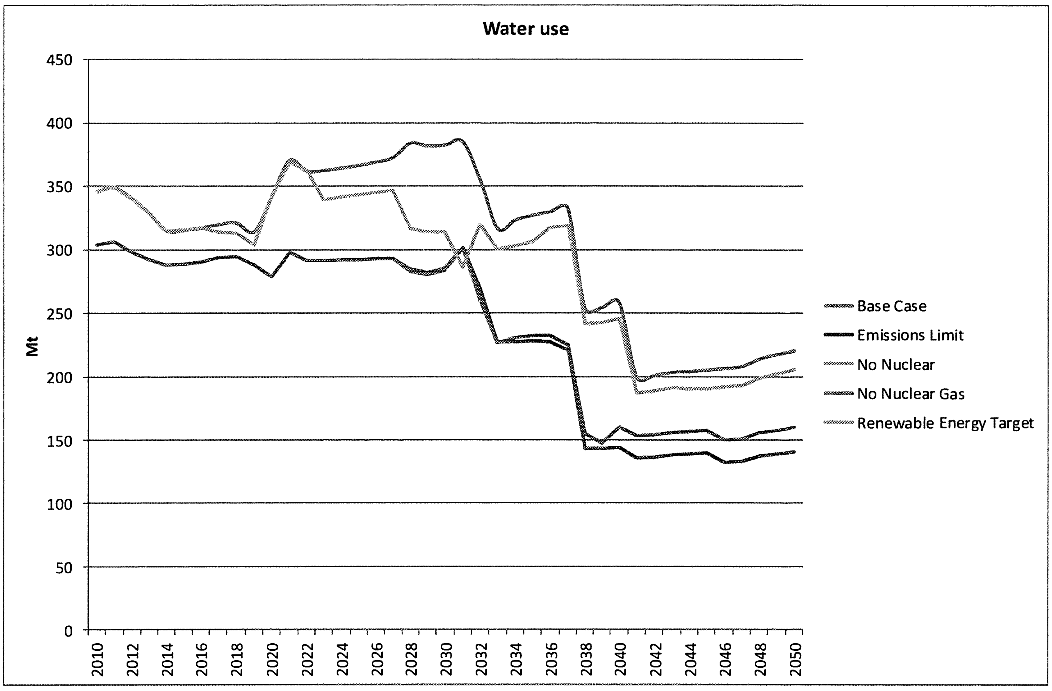


Figure 4-5: Water use for the test case

5 Way Forward

The energy planning process entails quantitative analysis as well as qualitative analysis or value judgement. The key inputs into the energy models and the underpinning assumptions which inform that input are therefore critical and need to be well communicated. The demand projections are largely informed by the macroeconomic and demographic assumptions which have been made, and in the case of the transport sector assumptions about energy end-use technologies (or vehicles). The final output from the energy models is greatly influenced by the projected demand, together with assumptions made about the impact of policies, energy supply technologies as well technological developments.

The Draft Integrated Energy Planning Report presents the energy planning approach followed, including the methodologies used to estimate energy demand projections in light of the data scarcity issues encountered. It also presents the model output and analysis for the Base Case and the test cases which were modelled.

This document therefore does not seek to make recommendations but provides the preliminary model output and a basis from which stakeholder input can be obtained. Once published various stakeholder consultations will take place over a period of approximately four (4) months. During the stakeholder consultation process, it is anticipated that various inputs will be received which will provide information to guide further analysis. Some of the assumptions, (for example GDP growth rates) may need to be revised based on the latest national forecasts. Areas which require further analysis include the following:

- Assess the impact of Transnet Freight Rail's expansion plan on displacement of freight haulage from road to rail and the impact that this may have on projected demand;
- Conduct further analysis of the constraints that natural gas infrastructure may have in meeting projected demand for natural gas, particularly in the industrial and commercial sectors;
- Explore options for natural gas imports and analyse the potential impact on projected natural gas import prices including imports from Mozambique and other countries within the region;
- Obtain more data and information to explore regional options such as the Northern Mozambique Power Development Programme and the Grand Inga Hydropower Scheme;
- Gain a better understanding of the land limitations which may constrain growth in the agricultural sector and in particular the projected demand for diesel, which is primarily used by tractors for ploughing; and
- Assess in more detail and better quantify the impact of technological advancements and process improvements which could result in further energy efficiency gains in the industrial and commercial sectors.

The input obtained from the stakeholder engagement process may result in the revision of some of the key planning assumptions. Such revisions may also result in changes to the demand projections and subsequently outputs from the Base Case and test cases.

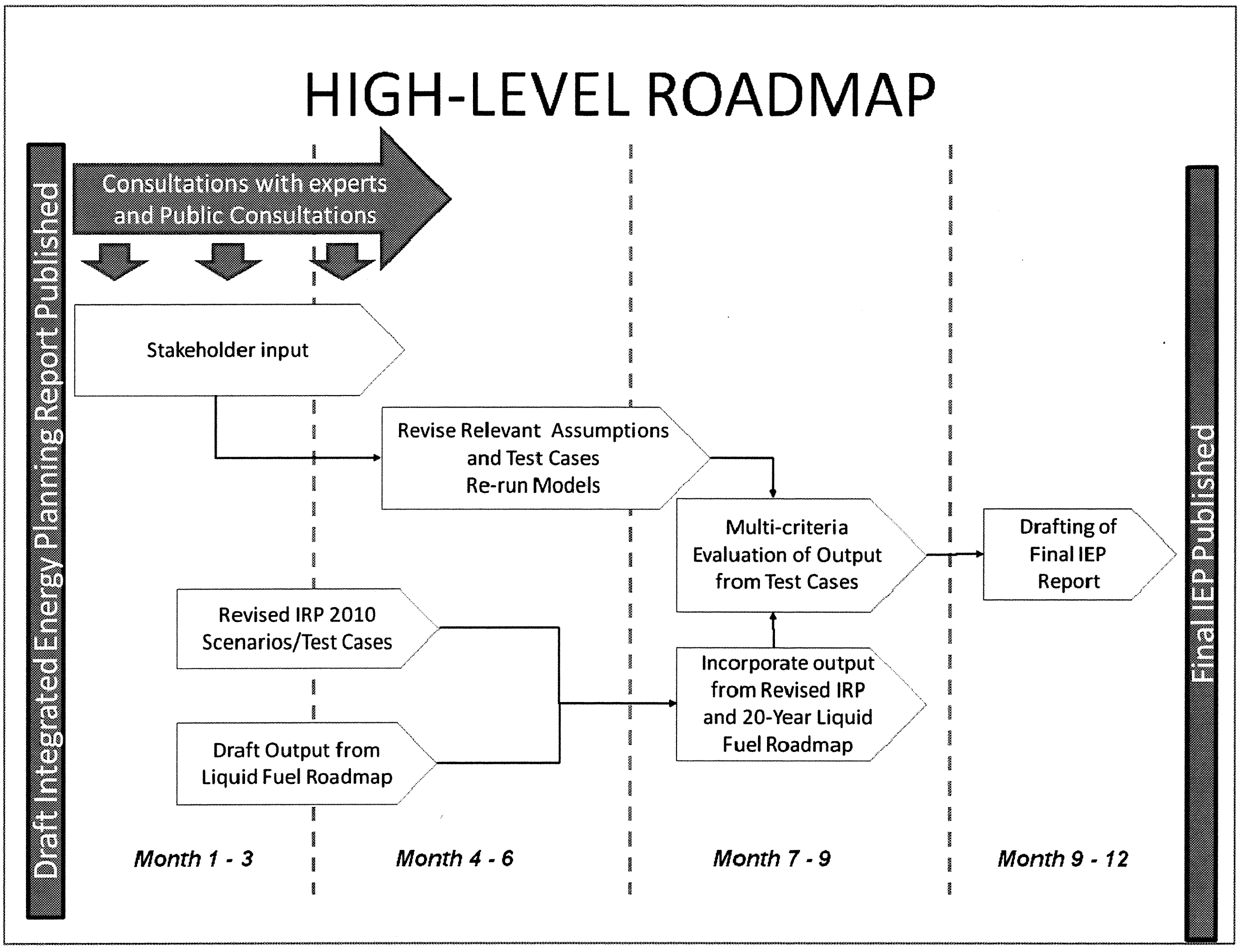


Figure 5-1: High-level roadmap

After the stakeholder engagement process, the final set of outputs will be evaluated using a Multi-Criteria Decision Analysis (MCDA) technique. The outcome from this process will inform the final IEP.

6 Document Structure

- Section 1 presents the main introduction of the report and defines the scope of the IEP. It also covers the high-level integrated energy planning approach and sets the scene for the remainder of the document.
- Section 2 provides a discussion on the key policies which have informed the Integrated Energy Planning process, including those policies outside of the energy sector which are considered to have a high impact on the energy sector. The eight (8) competing objectives that the Integrated Energy Planning process seeks to balance are discussed.
- Section 3 provides an overview of the South African energy sector, including an overview of primary energy sources and their potential future role in the energy mix.
- Section 4 provides the key macroeconomic assumptions including the detailed write-up and values with supporting calculations and tables where relevant.

- Section 5 provides an analysis of the projected energy demand by sectors. In each instance the key assumed drivers for demand are discussed.
- Section 6 provides the detailed write-up of the Base Case policy assumptions and Test Cases which were modelled.
- Section 7 provides analyses of the model output for the Base Case and all the Test Cases.
- Lastly, Section 8 presents the way forward, including the stakeholder consultation process and timelines and how input will be incorporated into the final IEP Report. This section also outlines how the Multi-Criteria-Decision-Making (MCDA) technique will be used to evaluate all model outputs and make final recommendations based on the key objectives of the IEP. The MCDA technique is also described in detail in Appendix 1.