INTEGRATED ENERGY PLAN

DETAILED SCENARIOS FOR LIQUID FUELS SUPPLY

DEPARTMENT OF ENERGY
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1 Section 1: Introduction

A lack of coordinated and integrated national planning for the energy sector has led to underinvestment in much needed energy infrastructure.

- There is currently inadequate supply in both the electricity and liquid fuel industries due to a lack of timely investments in new capacity.
- Electricity generation is constrained due to insufficient capacity and inadequate availability of existing infrastructure.
- There is a high dependence on import of liquid fuels as the current production capacity does not meet national and export demand. No investments have been made in new capacity since the start of the new democracy.

Planning at individual organisation level is commercially driven and therefore investments which are required in order to ensure that the policy objectives of the country have been left under invested.

The IEP aims to guide future energy infrastructure investments, identify and recommend policy development to shape the future energy landscape of the country.
The Integrated Energy Plan (IEP) considers all energy carriers, all technology options and all key national policy imperatives and proposes an energy mix and policy recommendations which ensures that the energy sector can help achieve these in the most optimal manner. It also considers the national supply and demand balance and proposes alternative capacity expansion plans based on varying sets of assumptions and constraints. While infrastructural matters are briefly discussed, the IEP does not explicitly consider supply and demand at specific geographical locations within the country, nor does it take into account infrastructure bottlenecks at specific locations. The IEP focuses on determining final demand for all forms energy and the cross linkages of different energy carriers to meet those energy needs across different sectors.

1.1 Revised Energy Planning Framework

While the IEP continues to focus on demand for all energy forms across all the economic sectors, analysis of the supply-side options has been reviewed so as to enable more in-depth analysis of the three main energy sub-sectors, namely: electricity generation; liquid fuels supply; and the gas market. This approach has been undertaken to enable the differences in each of the sectors to be analysed in detail taking into account the complexities and level of maturity of each sub-sector.

**Integrated Energy Plan (Electricity):** Planning for new electricity supply is mature and well-established globally and in South Africa; and the electricity sector is highly regulated with new supply options and prices determined through the electricity policy and legislative framework by the Department of Energy and Nersa respectively. The Integrated Resource Plan (IRP) will provide policy direction in terms of new electricity generation and will be developed as a separate sub-sector plan.

**Integrated Energy Plan (Liquid Fuels):** Planning for new liquid fuel supply options has been undertaken by individual oil companies and planning in a centralised manner through government is a new concept. The implementation of new production infrastructure is therefore to a large extent determined by market forces with minimal policy intervention. Regulation of the sector is focused on pricing, aimed at reducing volatility on petroleum products and ensuring affordability and job creation in the retail sector. Investments in new liquid fuel production infrastructure therefore do not influence final product prices, however the outlook on future prices and the concomitant refinery margins that oil industry can obtain, do influence investment decisions. The Liquid Fuels sub-sector report will explore various liquid fuel supply options and assess the impact that these options have on the economy.
**Integrated Energy Plan (Gas Development Framework):** South Africa has a Gas Policy and legislation, however this industry remains fairly small with Sasol (through the Mozambican pipeline) and PetroSA (through the GTL facility at Mossel Bay) being the dominant players in the country. Given developments in natural gas globally, and the potential for shale gas that exist within our shores, natural can become a game-changer for South Africa. However this sub-sector is not well-understood and a Gas Development Framework, which would provide a guideline of how gas can be successfully and responsibly exploited in South Africa is required. The Gas Development Framework will expand on work already done on the Gas Utilisation Masterplan and will also be developed as a separate document.

The IEP can thus be seen a framework policy which provides a basis for common assumptions and policy imperatives which impact the three main energy sub-sectors to be determined and defined. It also enables for inter-linkages between these three sub-sectors to be identified and explored so that there is alignment in policy recommendations across the entire energy sector.
This report focuses on analysing future demand for liquid fuels and also explores in more detail different scenarios for the supply of liquid fuels. The analysis also takes into account more recent macroeconomic assumptions since the development of the Draft IEP Report. This report therefore also serves as a precursor to the IEP - Liquid Fuels sub-sector report and will inform the development of the Liquid Fuels Roadmap. While some of the content is similar to that in the Draft IEP report, it takes into account additional input which has since been received by the Department.

Figure 1-2: Energy Planning Framework
2 Section 2: Energy policy considerations

One of the key elements during the energy planning process is to ensure alignment and identify synergies between various government policies. The main IEP report provides a overview of the high-impact policies and describes how they have been taken into account in the energy planning process as such they have not all been repeated here. The diagram below depicts those high-impact policies and their interaction with the IEP. The Clean Fuels 2 Regulations and the National Transport Master Plan have been expanded upon as these have the most significant impact on the liquid fuel demand and supply.

Figure 2-1: IEP within the national policy framework
2.1.1 Regulations regarding Petroleum Products Specifications and Standards ("Clean Fuels 2" Regulations)

In 2012, the Department of Energy promulgated Regulations regarding Petroleum Products Specifications and Standards ("Clean Fuels 2" Regulations). The new standards are intended to further reduce harmful pollutants and fumes as a result of combustion of Petrol and Diesel in motor vehicles. The fuel specifications were intended to come into effect in July 2017, however this was subject to local refineries receiving compensation from government for the investments which would be required to make the necessary infrastructure upgrades. Presently the issues of compensation are still under discussion and have not been resolved. Revised Draft Amendment Regulations were published for comments in June 2016 and are currently being finalised taking into account comments received from stakeholders. While the Amendment Regulations are intended to be published early in 2017, the implementation date for the CF2 fuel specifications they will make provision for the announcement of the effective date to be made on a separate date.

2.1.2 National Transport Master Plan

A significant portion of South Africa’s transportation needs are met through liquid fuels. Transport-related policies therefore have a significant impact on the growth in transport demand and the inherent demand for liquid fuels. The National Transport Master Plan (NATMAP 2050), which was published by the Department of Transport (DoT) in 2010, is a long-term strategy for the transportation sector which in part addresses the impact of the transport sector on various issues. The goal thereof is to develop a dynamic, long-term, sustainable land use/multi-modal transportation systems framework for the development of network infrastructure facilities, interchange terminus facilities and service delivery.

South Africa faces many challenges in instituting a practical National Transportation Plan in an environment of increasing energy demand, sustained high oil prices, regular disruptions in the energy value chain, increasing requirements for diminished GHG emissions and other environmental and social considerations. Transportation requires access to energy sources and it is therefore imperative that synergies be established between transportation planning and national energy planning. Transportation objectives must be aligned with the country’s energy supply-demand conditions and vice versa. At the same time, transportation has an environmental footprint that stretches from the global level (via international travel – trains, ships, planes), through to the national, regional and local levels (the effects of construction and operation).
Transportation in South Africa is almost totally dependent on petroleum liquids, with less than 5% of the energy used in transport being in the form of electricity. This makes the transport sector extremely vulnerable to the availability of oil and the cost of oil and therefore the cost of fuel. Almost 92% of the energy that is used in transportation is derived from oil that is imported. The balance is from fuel derived from coal (the SASOL coal to liquid process), and natural gas (the PetroSA GTL plant) (DoE, 2012).

Some of the goals of NATMAP 2050 that require a corresponding response from the energy sector are as follows:

- To minimise the impact on the environment and reduce the carbon footprint of transport (through less carbon-intensive transport fuels);
- To provide energy-efficient transport, using energy sources that are sustainable in the long term;
- To provide affordable transport to end users, operators and government; and
- To develop transport infrastructure that meets international standards and is technologically sustainable.

The IEP takes into consideration the implications of some of the goals of the NATMAP and the resultant actions or responses that are required from the energy sector. In particular, the effects that such objectives will have on the future demand for energy were assessed. Some key considerations are outlined below:

- In the short term, measures to improve fuel efficiency need to be continually explored and enhanced;
- The effect that various interventions will have on liquid fuel consumption needs to be evaluated and monitored so as to improve the understanding of their implications on future demand. These include interventions by the DoT to emphasise modes of transport where mechanical energy is used most efficiently and to advocate non-motorised transport within urban areas (short distances); and
- The effects that various interventions may have on shifting demand from liquid fuels to electricity need to be analysed. These include long-term strategies to encourage modal shifts from private passenger transportation to mass transit (most probably to rail and buses) as well as those that encourage the shift of long-distance freight off roads and onto rail.
3 Section 3: The objectives of the IEP

Taking the Energy White Paper, the National Energy Act and the various high-impact policies discussed in the previous section, the IEP takes a balanced view of the objectives of various policies. Policies which are overarching set aspirational targets and provide the context within which the IEP was developed. The impact of policies which will influence energy markets cannot be ignored, and their possible implications have been taken into consideration in order to develop long-term energy sector response strategies which are sustainable.

Based on these policies, eight key objectives were identified for the IEP and are reflected in Figure 3-1.

![8 KEY OBJECTIVES](image)

**Figure 3-1: Key IEP objectives**

These objectives are the key criteria against which the different policy alternatives and proposals made in the IEP will be evaluated. A detailed description of each of the objectives is provided in the main IEP report.

While several policies and programmes aimed at increasing access to modern forms of energy have already been developed and are currently being implemented, the IEP seeks to explore further options that can be pursued in order to address some of the challenges identified.
### 4 Section 4: Summary of Key Assumptions

This section presents a summary of assumptions for the key parameters that inform the IEP analysis, namely:

- Macroeconomic assumptions (GDP, discount rate and energy commodity prices);
- Demographic assumptions (population growth);
- Socio-economic assumptions (job and localisation potential of different technologies);
- Technology costs; and
- Externality costs.

A detailed analysis for each of these assumptions can be obtained in the annexures.

#### 4.1 Macroeconomic assumptions

**Table 4-1: Summary of macroeconomic assumptions**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Source of information</th>
<th>Unit</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>Average potential economic growth over planning period</td>
<td>National Treasury, IRP2010</td>
<td>Percentage per year</td>
<td>See Table 4-2, Green Shoots</td>
</tr>
<tr>
<td></td>
<td>Average potential economic growth over planning period</td>
<td></td>
<td>Percentage per year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discount Rate (rate at which future benefits and costs decline is important because they occur in the future. Used to express a time preference for money – money right now is preferred to money in the future)</td>
<td>National Treasury</td>
<td>Percentage per year</td>
<td>8.2%</td>
</tr>
<tr>
<td></td>
<td>Petroleum Product Prices (Price at which petroleum products are sold to the market)</td>
<td>DoE analysis (derived from crude oil price)</td>
<td>R/GJ</td>
<td>The Resource Constrained Scenario: Assumes the crude oil prices of the WEO „Current Policy Scenario”</td>
</tr>
</tbody>
</table>

Petroleum product prices were derived from the crude oil price projections mentioned above.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Source of information</th>
<th>Unit</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas Price</td>
<td>• The annual average natural gas import price</td>
<td>• International Energy Agency, 2015 World Energy Outlook (WEO)</td>
<td>• Original Units: Real 2014 US dollars per million British thermal units (MBtu)</td>
<td>• Base Case: Assumes the natural gas projections of the WEO „New Policy Scenario”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• European Natural Gas Import Prices</td>
<td>• IEP Units: R/GJ</td>
<td>• The Resource Constrained Scenario: Assumes the natural gas prices of the WEO „Current Policy Scenario”</td>
</tr>
<tr>
<td>Coal Prices</td>
<td></td>
<td>• International Energy Agency, 2015 World Energy Outlook (WEO)</td>
<td>• R/GJ</td>
<td>Assumes the coal price projections of the WEO with the Base Year calibrated to current average price of R450/ton</td>
</tr>
<tr>
<td>Shale Gas Extraction</td>
<td>• Capital costs for primary energy production</td>
<td>• PetroSA</td>
<td>• R/GJ/annum</td>
<td>Fixed R372/GJ per annum throughout the planning horizon</td>
</tr>
<tr>
<td></td>
<td>• Fixed costs for primary energy production</td>
<td>• PetroSA</td>
<td>• R/GJ/annum</td>
<td>Fixed R6/GJ per annum throughout the planning horizon</td>
</tr>
</tbody>
</table>

**Table 4-2: GDP growth projections**

<table>
<thead>
<tr>
<th></th>
<th>Short term</th>
<th>Medium term</th>
<th>Long term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Growth</td>
<td>1.3</td>
<td>0.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Moderate Growth</td>
<td>1.3</td>
<td>0.9</td>
<td>1.7</td>
</tr>
<tr>
<td>High Growth</td>
<td>2.0</td>
<td>3.3</td>
<td>3.7</td>
</tr>
</tbody>
</table>
The graph below shows different scenarios for the projected GDP per capita based on the GDP growth and population projections.

Source: DoE Analysis

**Figure 4-1: GDP growth projections**

Source: DoE Analysis

**Figure 4-2: Moderate growth and Green Shoots GDP/Capita**
4.2 Demographic assumptions

A key driver of energy demand is population size and expected growth. A detailed analysis of demographic assumptions can be obtained in ANNEXURE A.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Source of information</th>
<th>Unit</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Growth</td>
<td>Growth of the national population taking into account three key drivers: Fertility Rate, Life Expectancy and Migration</td>
<td>Institute for Security Studies</td>
<td>Million people</td>
<td>See Figure 4-3 below</td>
</tr>
</tbody>
</table>

Source: ISS (2013)

Figure 4-3: RSA population growth projections

4.3 Technology costs – Liquid Fuel Production

Table 4-3: Capital and fixed costs for liquid fuel production technologies

<table>
<thead>
<tr>
<th>Technology name</th>
<th>Capital cost</th>
<th>Fixed operating cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>New coal liquefaction</td>
<td>386.38</td>
<td>25.71</td>
</tr>
<tr>
<td>New gas to liquids</td>
<td>230.61</td>
<td>7.91</td>
</tr>
<tr>
<td>New conventional crude oil refineries</td>
<td>133.27</td>
<td>7.27</td>
</tr>
<tr>
<td>Residual coal liquefaction</td>
<td></td>
<td>25.71</td>
</tr>
<tr>
<td>Residual gas to liquids</td>
<td></td>
<td>34.94</td>
</tr>
<tr>
<td>Residual conventional crude oil refineries</td>
<td></td>
<td>0.63</td>
</tr>
</tbody>
</table>

4.4 Externality costs

An externality cost is a cost imposed on society due to the activities of a third party, resulting in social, health, environmental, degradation or other costs. Externalities may however also
be beneficial (e.g. a mine builds a fire break between its operations and the neighbouring farm from which the farmer then directly benefits in terms of safety and security).

In this IEP iteration, however, only the negative externalities of different pollutants resulting from the production of energy were costed. Examples of such factors that cause damage are: air pollution (caused by pollutants such as nitrous oxides \([\text{NOx}]\), sulphur oxides \([\text{SOx}]\), particulate matter \([\text{PM}]\) and mercury \([\text{Hg}]\)), water contamination and soil erosion. The costs of the externalities were quantified by estimating the „cost of the damage” to society caused by such pollutants (Where the overall cost to society is defined as the sum of the imputed monetary value of costs to all parties involved).

For the IEP, externality costs were estimated for four (4) categories of pollutants, namely: nitrous oxides \((\text{NOx})\), sulphur oxides \((\text{SOx})\), particulate matter \((\text{PM})\) and mercury \((\text{Hg})\). The costs have been included as part of the operating costs of different technologies and are thus the actual costs for different scenarios are influenced by the activity of particular technologies. The final values used were derived from various studies which have been conducted and are indicated in the table below. The detailed reports which informed the cost of externalities are included in the annexures.

**Table 4-4: Externalities costs**

<table>
<thead>
<tr>
<th>Externality</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{SO}_2)</td>
<td>Sulphur dioxide</td>
<td>7.60</td>
<td>2012 Rand/kg</td>
<td>ANNEXURE C2: FRIDGE Study (2003)</td>
</tr>
<tr>
<td>(\text{NO}_x)</td>
<td>Nitrous oxide</td>
<td>4.50</td>
<td>2012 Rand/kg</td>
<td>ANNEXURE C2: FRIDGE Study (2003)</td>
</tr>
<tr>
<td>(\text{Hg})</td>
<td>Mercury</td>
<td>41484.00</td>
<td>2012 Rand/kg</td>
<td>ANNEXURE C3: Cukrowska (2011)</td>
</tr>
<tr>
<td>(\text{PM})</td>
<td>Particulate matter</td>
<td>11.30</td>
<td>2012 Rand/kg</td>
<td>ANNEXURE C2: FRIDGE Study (2003)</td>
</tr>
<tr>
<td>(\text{PM}_{\text{transport}})</td>
<td>Particulates in transport sector</td>
<td>280.70</td>
<td>2012 Rand/kg</td>
<td>ANNEXURE C2: FRIDGE Study (2003)</td>
</tr>
</tbody>
</table>
5 Section 5: Scenarios Considered

5.1 Base Case Assumptions

The Base Case can be referred to as the „Business as Usual“ scenario. It is assumed that all existing and appropriate government policies relevant to the energy sector have shaped the energy sector landscape and will continue to do so in the future.

This section provides the assumptions about key policies, costs and other factors which have an influence on energy supply options; and which can be represented and simulated by energy models. While many real world phenomena (physical, financial and economic) have an impact on the future optimal supply options, the selected models and modelling approaches simplify reality by considering only a subset of parameters which have a significant impact. Furthermore, only those assumptions (about real world phenomena) which can be translated into model parameters and quantified as parameter values need mention. This section is therefore limited in scope to those assumptions which inform the final values of the model parameters for the Base Case and the various Test Cases which were modelled.

The demand projections are a key input into the energy model and inform the required supply capacity. The underpinning objective of the energy planning process is to ensure that future energy supply options meet future energy demand. However in order to ensure a balanced consideration of all the eight objectives, different supply-side energy options are explored based on different sets of assumptions and constraints. As a starting point, the „Base Case“ is defined and serves as a basis to measure the extent to which current interventions within the energy sector can meet the constraints and targets set by various policies.

From this base, policy options which enable policymakers to consider alternative energy pathways that can be pursued are identified and evaluated. During the integrated energy planning process, various policy options (referred to as Test Cases) were identified and modelled. These Test Cases were informed by national government policies which are considered to be high-impact policies for the energy sector, and include the Integrated Resource Plan, National Development Plan, the National Climate Change Response Policy and the impending Carbon Tax Policy.

5.1.1 Economic Structure and Growth

Economic growth is perceived to be increasing at moderate rate in line with the moderate National Treasury GDP projections described earlier. As a consequence immigration
increases at a moderate rate. In line with prospects within the economy, the unemployment rate continues at the current rate as there are no perceived changes in the structure of the economy.

5.1.2 Energy Efficiency
Motor vehicles and light delivery truck fuel efficiency improves moderately at an annual average rate of 1.1% whilst trucks and buses improve their fuel efficiency at an annual average of 0.8%. Electric vehicles do enter the market, however as this is not policy-driven they are assumed to have a maximum 20% penetration rate by 2050.

5.1.3 Commodity Prices
Global crude oil prices continue to increase at the current (moderate) growth rate which then translates to moderate price increases for refined petroleum prices. Efforts to develop co-operation regionally do not show much improvement and as such the import of primary energy (i.e. natural gas) and power imports continue at the current rates. Natural gas prices and coal prices are also assumed to growth at a moderate rate.

5.1.4 Climate Change
The mitigation of climate change remains one of the primary policy imperatives and the Peak-Plateau-Decline emission limits are adopted as the norm. The national emission reduction targets are translated across all economic sectors and all externality costs associated with carbon emissions and other pollutants are accounted for. Although no carbon tax is assumed, the externality cost of carbon is calculated based on the carbon tax rate advocated in the proposed Carbon Tax Policy. In the Base Case, the upper bound of the so-called “Peak, Plateau, Decline” emissions limit trajectory as espoused in the National Climate Change Policy are imposed for electricity generation and liquid fuel supply sectors.
5.1.5 Air Quality and Other Environmental Considerations

The Air Quality Standards are imposed on existing Eskom fleet as per the timeframes agreed upon between Eskom and the Minister of Environmental Affairs.

5.1.6 Clean Fuels 2 Standards

Compliance to the Clean Fuels 2 standards requires an effective compensation mechanism to existing refineries as significant upgrades would need to be done on existing facilities. The Base Case assumes that a compensation mechanism is not established and that the current standards remain the minimum for South Africa. However introduction of new fuel grades happens slowly through imports and only for new refineries.
## Table 5-1: Summary of Key IEP Base Case Assumptions

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
<th>ASSUMPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEP Planning Horizon</td>
<td>The period over which key assumptions which inform demand projections and supply options are made</td>
<td>2015-2050</td>
</tr>
<tr>
<td>Base Year</td>
<td>The starting year on which projections are made. Any values/data prior to and including the base year are based on actuals. While any values/data after the base year are projections.</td>
<td>2015</td>
</tr>
<tr>
<td>Annual Emission Limit</td>
<td>This sets annual limits on allowable emissions</td>
<td>Emission limits are defined as per the “Peak-Plateau-Decline” trajectory in the National Climate Change Response White Paper</td>
</tr>
</tbody>
</table>
| Externality Costs             | The damage cost associated with different pollutants have been included in the Base Case as specified in table 3-5 in the previous section. Six pollutants were considered | SO₂ (7.60 R/kg)  
NOx (4.50 R/kg)  
Hg (41484 R/kg)  
PM (11.30 R/kg)  
PM\text{transport} (280.70 R/kg) |
| Liquid Fuel Production        | No constraints are defined for liquid fuel production                       | All technologies are considered and there are no model constraints on energy supply options |
| Technology Options            |                                                                             |                                                 |

### 5.2 Core Scenarios

Market activity alone does not deliver optimal solutions to the challenges faced by the energy sector, such as the guarantee of energy security, the reduction of GHG emissions, the reduction in energy intensity, or increasing energy efficiency within the economy. Thus, in some instances government intervention – through policy and regulation – is necessary to ensure the delivery of certain services to the public and the attainment of certain policy objectives.

In section 1 several policies, identified and described as “high-impact” policies, were discussed. These “high-impact” policies have a significant impact and influence on the development of energy policies as they require some level of intervention or deviation from the status quo from the energy sector. Therefore while the Base Case largely assumes that only prevailing policies are pursued to shape the future energy pathway, the effects of these
“high-impact” policies on the future energy landscape is considered and the concept of different scenarios to explore these possible policy impacts is introduced. This section describes how the different policy elements have informed the various scenarios.

Five core scenarios (Base Case, Green Shoots, Cleaner Pastures, Resource Constrained, and Security of Supply) were considered during the planning process. While the objective was to develop and analyse a set of scenarios that would be as mutually exclusive as possible, there may be some level of interdependency within the key underpinning assumptions which form the basis of the scenarios. Although the scenarios themselves are not intended to test the impact of specific policy interventions, they are characterised by an environment in which certain national policy imperatives are dominant and shape the future economic landscape.

5.2.1 Base Case

The Base Case provides a basis on which the impact of various policy interventions can be evaluated. In this scenario it is assumed that all existing policies are implemented and will continue to shape the energy sector landscape going forward. The impact of policies that are already well-developed and entrenched is assumed to be embedded into society.

5.2.2 Green shoots

The Green Shoots scenario is characterised by the high economic growth outlook and significant structural changes envisaged in the National Development Plan (NDP)'s scenario of “A diversified dynamic economy” on which the NDP itself is based. The economy is assumed to grow at an annual average rate of 5.7% to 2030, with a slight and steady slowdown from then until 2050. The structure of the economy shifts from a resource-driven to a high value-add manufacturing- and a services-driven economy as the “re-industrialisation” objectives of the country materialise. This results in higher demand for energy in these two sectors as compared to other scenarios.

In the energy sector, there is a more aggressive uptake of alternative energy sources such as solar water heaters, rooftop PV panels and electric vehicles by individual consumers, which are made possible by the higher average household income levels envisaged in this scenario. While awareness of climate change is a key policy imperative in this scenario, this is balanced with stimulating the growth of the economy.
Table 5-2: Changes in Economic Structure from 2010 to 2030 in the “A Diversified Dynamic Economy” NDP Scenario

5.2.3 Cleaner Pastures

In this scenario there is greater awareness and a more concerted effort to reduce greenhouse gases than in other scenarios. More countries at a global level adopt policies that aim to achieve the emission reduction targets that seek to keep the average annual temperature increases below the 2°C threshold. For South Africa this means that there are more aggressive interventions to curb the effects of climate change and the lower Peak-Plateau-Decline emission limits become the order of the day. A higher cost is placed on externalities associated with carbon, with the cost placed at R270/ton.

Individual consumers pursue alternative sources of energy and there is an increased uptake of solar water heaters, primarily in new houses.
This scenario considers what moving to a lower carbon economy by following the “required by science would have on the energy sector. All the assumptions in this scenario are the same as those of the Base Case with the exception that a lower emission limit is placed. For the electricity sector, start declining until they reach an average of 170Mt/annum and stay at that level until 2035, thereafter they continue to decline in absolute terms until reaching the low level of 90Mt/annum by 2050. For the petroleum sector, emissions start declining down to an average of 36Mt/annum up to 2035, thereafter they continue to decline until reaching the low level of 19Mt/annum by 2050.

![Emission Limits](image)

**Figure 5-2: National CO2 emissions limits for Peak-Plateau-Decline**

### 5.2.4 Resource constrained

South Africa is a price taker, mainly for crude oil and natural gas and is thus exposed to fluctuations and unpredictability of global prices and exchange rate. The main characteristics of this scenario are high commodity prices, in particular those of crude oil and natural gas. High crude oil prices lead to higher than usual increases in petroleum product prices which have an impact on inflation. Domestic economic growth is then severely impacted and remains lower than expected. Higher prices of imported products also have an impact on the Balance of Payments.
5.2.5 Security of Supply

The Security of Supply takes a closer look at the impact of policies driven primarily by ensuring energy security mainly for imported commodities such as crude oil, of which South Africa has very scarce resources. Another important factor which is deemed to be critical for security of supply is that of increasing local manufacturing capacity.

This scenario imposes the construction of a new crude oil refinery with a capacity of 250 000 bbl/day. Further sensitivity analyses are conducted for refineries with capacities of 300 000 bbl/day and 360 000 bbl/day.
### Table 5-3: Key Assumptions for Core Scenarios

<table>
<thead>
<tr>
<th>INDICATORS</th>
<th>BASE CASE</th>
<th>GREEN SHOOTS</th>
<th>CLEANER PASTURES</th>
<th>RESOURCES CONSTRAINED</th>
<th>SECURITY OF SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Constraints</td>
<td>Minimum production constraints on crude oil refineries</td>
<td>Same as Base Case</td>
<td></td>
<td>New crude oil refinery enforced (250 000 bbl/day)</td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>Moderate GDP Growth</td>
<td>High GDP Growth</td>
<td></td>
<td>Same as Base Case</td>
<td></td>
</tr>
</tbody>
</table>

#### VEHICLE EFFICIENCY IMPROVEMENT FOR NEW VEHICLES PER ANNUM

<table>
<thead>
<tr>
<th>Category</th>
<th>Base Case</th>
<th>Green Shoots</th>
<th>Cleaner Pastures</th>
<th>Resources Constrained</th>
<th>Security of Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars and SUVs</td>
<td>1.1%</td>
<td>2.50%</td>
<td>Same as Base Case</td>
<td>Same as Base Case</td>
<td></td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>0.8%</td>
<td>1.00%</td>
<td>Same as Base Case</td>
<td>Same as Base Case</td>
<td></td>
</tr>
<tr>
<td>New Electric vehicle penetration</td>
<td>20% annual rate</td>
<td>40% annual rate</td>
<td>Same as Base Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prices of Energy Commodities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate commodity prices</td>
<td>Same as Base Case</td>
<td>High commodity prices</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shale gas available after 2026</td>
<td></td>
<td>Extraction of shale gas uneconomical</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### ENVIRONMENTAL CONSIDERATIONS

<table>
<thead>
<tr>
<th>Category</th>
<th>Base Case</th>
<th>Green Shoots</th>
<th>Cleaner Pastures</th>
<th>Resources Constrained</th>
<th>Security of Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emissions limits</td>
<td>PPD Upper limit</td>
<td>Same as Base Case</td>
<td>PPD Lower limit</td>
<td>Same as Base Case</td>
<td></td>
</tr>
<tr>
<td>Compliance to Clean Fuels 2 (CF2) Standards and Specifications</td>
<td>All new refineries are CF2 compliant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total refining yield is reduced as a result of CF2 implementation on existing refineries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compensation to the Oil Industry in order to upgrade existing refineries to be CF2 complaint has not been factored</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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1 While it is acknowledged that implementation of CF2 has many benefits, including health, environmental and also to the motor industry, the oil industry have raised concern that in order for existing refineries to comply, significant capital outlay will be required in order to upgrade the
### Existing refineries

- All the crude oil refineries (Chevref, Enref, Natref and Sapref) continue to operate throughout the planning horizon (the closure of some of the older refineries are explored in more detailed scenarios)
- The PetroSA Mossel Bay gas-to-liquid plant ceases production after 2023 as a result of depleting gas feedstocks
- The Sasol Secunda coal-to-liquid plant continues to operate until 2040

South African Petroleum Industry Association (SAPIA) estimates the total costs to the entire local refining industry at $4.4m or ~R70 bn. SAPIA has also indicated that given the fact that the industry is currently regulated (diesel wholesale prices and petrol retail prices), the industry will be unable to recoup the relevant capital costs which would be required to upgrade. SAPIA has therefore approached the Department of Energy to establish mechanisms for the industry to recover their costs. A Joint Task Team comprised of the Department of Energy, Department of Environmental Affairs and SAPIA and its members has been established to determine the exact impact and explore various mechanisms of providing support to SAPIA. A cost-benefit analysis, which seeks to determine i) whether compensation is required; ii) what the magnitude of that compensation should be; and iii) what mechanisms should be used to compensate the industry will be commissioned early in 2017. SAPIA has not yet provided the Department with the detailed estimated costs of upgrades per refinery the IEP analyses has thus used detailed estimations which were provided 2011.
6 Section 6: Analysis of future demand

This section provides projections of future demand for liquid fuel. While there is some level of
final liquid fuel product consumption in all sectors, the focus has been on the transport sector
given that this is the sector which has the biggest impact on demand and will continue to do
so into the foreseeable future.

6.1 Break-down of Energy End-Use across all Sectors

![Agricultural Energy End-Use](image)

Source: DoE Analysis

Figure 6-1: Energy end-use within the agricultural sector
Figure 6-2: Energy end-use within the commercial sector

Figure 6-3: Energy end-use within the industrial sector
Figures 6-1 to 6-4 above indicate energy end-use in the agricultural, commercial, industrial and residential demand sectors. Understanding energy end-use assists in understanding the different forms of energy or types of fuels that can be used to meet a particular energy need. This also assists in determining energy end-uses for which switching fuels is possible and thus assists in testing the efficacy of fuel-switching policy interventions.
Figure 6-5 indicates the breakdown of fuel use within the transport sector.

### 6.2 Total Fuel Demand in All Sectors

![Fuel Demand across All Sectors](image)

Figure 6-6: Projected fuel demand within different sectors (Base Case)

Figure 6-6 above provides fuel demand across all economic sectors. Petroleum products are consumed across most economic sectors and households however the transport sector has and will continue to take up the highest demand on petrol and diesel.

- Illuminating paraffin is almost exclusively used in households while there are traces of its use in industry and commerce
- LPG is primarily used in industry and commerce, followed by households
- Petrol is almost exclusively used in road transport
- Diesel is by far the most dominantly used fuel. Outside of the transport sector, it is also used in mining (for heavy vehicles and machinery) and agriculture (for tractors)
Going forward:

- Diesel will continue to dominate consumption of liquid fuel, with most growth taking place in the transport sector. However, its use in the mining and agriculture sector is also expected to grow aligned with the assumed economic growth.
- Petrol demand will also continue to grow in the transport sector.
- While demand for other petroleum products will also increase, it is the growth in diesel and petrol demand which have the biggest impact on the future oil supply industry. Demand for these two transport fuels therefore has a significant impact on future required supply and hence influences justification for local production versus other alternatives such as imports.

### 6.3 Fuel Demand in the Transport Sector

The graph above indicates that future transport fuel demand will be dominated by diesel, followed by petrol and jet fuel and this is consistent across all scenarios.

**Figure 6-7: Transport Sector Fuel Demand by Vehicle Category**
While it is envisaged that electric vehicles will penetrate the local passenger transport market, petroleum vehicles will continue to dominate the passenger transport market while diesel will continue to be used for larger vehicles such as trucks.

While the current proportion of petrol consumption against that of diesel consumption is slightly higher across the entire transport sector, this will equalise over the next ten years, with future consumption in diesel surpassing that of petrol in the longer term. This will be primarily driven by increase in trucks for freight transport which is influenced by the envisaged economic growth.

The improvement in the fuel economy of vehicles (i.e. vehicle technology efficiency) combined with fuel quality improvement, will improve general vehicle fuel consumption and has the most significant downward impact on projected fuel demand (as evidenced in the Green Shoots scenario which assumes rapid improvement in vehicle technologies resulting in better fuel efficiency).

For passenger transportation, policies to encourage the use of mass transport (buses and trains) and non-motorised transport should continue to be promoted.

For freight transport, the growth in road freight haulage can be minimised by investments in additional rail fleet and other infrastructure to improve the rail network. High penalties should be imposed on heavy vehicles transporting goods as a means to encourage the use of rail for long distance haulage.
7 Liquid Fuel Supply Options to meet Future Demand

Given the future liquid fuel demand scenarios presented in the previous section, various supply-side options were modelled.

7.1 Local Production versus Imports

The proportion of imports against local production will continue to increase as demand for petroleum products (in particular motor fuels) increases.

In the short-term no new production capacity comes online for two primary reasons:
- The average lead time for a new refinery is assumed to be eight years
- No availability of indigenous gas before 2025

The model results indicate that a combined strategy for the supply of liquid fuels should be adopted, where some of the future demand is met by local production and the balance through imports.
As can be seen from Figure 7-2 above, the availability of gas at favourable prices indicates that gas-to-liquid can be a viable option for South Africa as new gas-to-liquid plants appear in all scenarios modelled.

It is also worth noting that while emission limits put a constraint on new coal-to-liquid plant, a new coal-to-liquid only becomes viable and maintains emissions below the stipulated targets for the liquid fuel sector after the current coal-to-liquid plant has reached its end of life. Therefore only one coal-to-liquid plant can be accommodated at a time in order to ensure that the petroleum sector remains within the country’s emission reduction targets.

In the Cleaner Pastures scenario, which has lower and more stringent emission limits, no new coal-to-liquid plant is chosen as this would result in a violation of the emission reduction targets.

Further analysis will be conducted to determine the impacts of a carbon tax and carbon budgets as policy instruments to reduce emissions within the sector.

The only scenario in which a new crude oil refinery appears is the Security of Supply scenario wherein a new 250 000 barrel per day (bbl/day) refinery is imposed. This new crude oil refinery is built in addition to the new gas-to-liquid and coal-to-liquid plants.
Figure 7-3: Production by new refineries by scenario

Figure 7-4: Total liquid fuel supply options to meet future demand
As indicated previously in Figure 7-1, the balance of the country’s liquid fuel requirements not met through local production will be met through imports. As expected, the composition of imported products is dominated by diesel, followed by petrol and jet fuel aligned with projected demand.

Imports are lowest in the Security of Supply scenario due to the additional production capacity from the crude oil refinery.

There is a trade-off between constructing new local refining capacity to increase local production against that of constructing new port infrastructure to meet increasing imports. Both options have their advantages and disadvantages.

**Increased local refining**

- **Advantages**
  - Increase in potential job creation for new plants that are constructed
  - Reduced exposure of the petroleum industry to global price fluctuations if indigenous sources (such as gas – if available or coal) are used as feedstock for petroleum production

- **Disadvantages**
  - As refineries are built and configured in accordance to prevailing fuel standards and specifications, there is potential inflexibility of these plants to produce future fuel specifications should these change substantially. Any reconfiguration or upgrades to meet future standards are likely to come with high capital costs. This could cause delays in South Africa adopting global fuel standards with the concomitant impact on the motor industry

**Increased imports**

- **Advantages**
  - Ability for the local market to respond rapidly to global changes in fuel standards

- **Disadvantages**
  - Potential port constraints if port expansion plans are not implemented timeously
  - Negative impact on the Balance of Payments

### 7.2 Alignment with Transnet Port Expansion Plans

The table below indicates projected annual fuel imports and the estimated port capacity. The port capacity expansion plans will be able to accommodate project future imports.
Table 7-1: Comparison of Annual Import Requirements against Transnet Port Expansion Plans

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Import Requirements (Billion litres)</th>
<th>Annual Port Capacity² (Billion Litres)</th>
<th>Potential Capacity Constraint?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>9</td>
<td>10</td>
<td>No</td>
</tr>
<tr>
<td>2020</td>
<td>10</td>
<td>18</td>
<td>Potentially constraints in the Green Shoots scenario</td>
</tr>
<tr>
<td>2025</td>
<td>13</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>16</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>2035</td>
<td>21</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td>25</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>2045</td>
<td>28</td>
<td>35</td>
<td>No</td>
</tr>
<tr>
<td>2050</td>
<td>38</td>
<td>35</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Based on table 7-1 above, it appears that the planned port expansion plans would be able to absorb the additional imports resulting from the increased imports in all scenarios except the Green Shoots scenario as envisaged in the National development Plan. However the full macroeconomic implications of this have not yet been assessed in full detail.

² Port capacity aligned with port expansion plans in Transnet Master Plan
7.3 Impact of Refinery Closures and Clean Fuels 2

It is widely acknowledged that implementation of CF2 results in a reduction of harmful emissions from motor vehicles and thus has health and environmental benefits. The implementation of CF2 will also benefit the motor industry as new vehicles which are compatible with the cleaner Euro 5 standards can be imported into the country thus stimulating growth in this market. The oil industry, through South African Petroleum Industry Association (SAPIA), has raised concern that in order for existing refineries to comply, significant capital outlay will be required in order to upgrade the refineries. SAPIA estimates the total costs to the entire local refining industry at $4.5bn or ~R70bn. SAPIA has also indicated that due to the fact that the industry is currently regulated (diesel wholesale prices and petrol retail prices), the industry will be unable to recoup the relevant capital costs which would be required to make the necessary upgrades. SAPIA have also expressed concern that some of the older refineries will be forced to shut down, should the new fuel specifications come into force without the requisite compensation from government. The implications for the country are increased imports which would be required to meet the shortfall from the refinery closures.

In order to assess the high-level impact of implementation of Clean Fuel 2 by the existing refineries, various additional scenarios were developed from these core scenarios to enable further exploration of the model output. These are described below:

**CF2_Two Crude Oil Refinery Closures (CF2_2C):** This scenario uses the Base Case as reference. The key assumption in this scenario is that the implementation of CF2 in 2022, with no cost recovery mechanism being instituted. This then leads to the closure of two existing crude oil refineries. A further assumption is that no new build commitments are undertaken.

**CF2_Three Crude Oil Refinery Closures (CF2_3C):** This scenario used the Base Case as reference. The key assumption in this scenario is that the implementation of CF2 in 2022, with no cost recovery mechanism being instituted. This then leads to the closure of three existing crude oil refineries. A further assumption is that no new build commitments are undertaken.
Figure 7-6: Total liquid fuel supply options to meet future demand

Figure 7-7: Liquid Fuel Imports
As can be seen in the two graphs above, as no new capacity is imposed in the two scenarios where there are refinery closures, the shortfall in local production is met through increased imports. The graph below indicates that the current port capacity expansion plans may be inadequate to meet the increased imports in the scenarios where there are two or more refinery shut downs.

Figure 7-8: Port Capacity to meet Liquid Fuel Imports
8 SECTIO 8: Way Forward

The above preliminary analysis presents the first set of scenarios which were conducted to evaluate different liquid fuels supply options. Further areas of analysis are on-going, the outputs of which will be incorporated into the final IEP - Liquid Fuels sub-sector report.

1. Further analysis will be conducted to determine the impact of implementing the new fuel specifications (Cleaner Fuels 2) - both the demand-side impact as well as the supply-side impacts. Further to this, the Department continues to work with the oil industry to better understand the economic benefits of CF2. A cost-benefit study aimed at determining the following amongst other factors is planned to commence early in 2017:
   i. The magnitude and types of investments required by individual refineries in order to upgrade to be CF2 compliant
   ii. Whether government support would be required in order to support investments made by oil companies in such upgrades;
   iii. The level of support required (if determined to be required)
   iv. The impact of upgrading refineries to comply to CF2 specifications on their ability to comply to other legislation such as the Air Quality Act emissions standards

2. Alignment with Transnet Master plans, in particular the Pipelines, Ports and Rail expansion plans is critical, the Department continues to engage with Transnet in this regard.

3. A study to determine the macroeconomic impact of liquid fuel imports – in particular considering the impact on the Balance of Payment is currently underway.

4. A study to assess and quantify the job creation and localisation potential of liquid fuel infrastructure investments (with particular focus on new refineries – crude oil, gas and coal) will be conducted during 2017.

5. A study to determine the average construction, operating and maintenance costs for liquid fuel production infrastructure from different energy carriers will also be conducted during 2017. This study will also include performance characteristics associated with such infrastructure. Data and information collected from this study will support much of the further analysis on liquid fuel supply options.

6. The potential impact and incorporation of biofuels framework implementation will also be considered.