DEPARTMENT OF ENERGY

INTEGRATED ENERGY PLAN

ANNEXURE B: MACROECONOMIC ASSUMPTIONS

Table of Contents

List of Tables

List of Figures

ACRONYMS

ARV	Antiretroviral Therapy
CAPEX	Capital Expenditure
CCGT	Combined Cycle Gas Turbine
CSP	Concentrated Solar Power
CTL	Coal To Liquid Plant
DoE	RSA Department of Energy
EOCK	Economic Opportunity Cost of Capital
GDP	Gross Domestic Product
GJ	Gigajoule
GTL	Gas To Liquid Plant
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome
HSRC	Human Sciences Research Council
IEA	International Energy Agency
IEP	Integrated Energy Plan
IF"s	International Futures Model
IIASA	International Institute for Applied System Analysis
IRP	Integrated Resource Plan
ISS	Institute for Security Studies
LE	Life Expectancy
MW	Mega-Watt (1000 000 Watts)
NDP	National Development Plan
OCGT	Open Cycle Gas Turbine
OPEX	Operational Expenditure
PV	Photovoltaic
RSA	Republic of South Africa
SAM	Social Accounting Matrix
SRTP	Social Rate of Time Preference
SSA	Sub-Saharan Africa
StatsSA	Statistics South Africa
TFR	Total Fertility Rate
TWh	Terawatt hour (1000 000 000 Watt hours)
UNPD	United Nations Population Division
US$	United States dollar
WEO	World Energy Outlook

1 Background

This section details macro and socio-economic assumptions and parameters used in the IEP study. Macro-economic assumptions considered different GDP growth rates, discount rate and energy commodity price projections. Socio-economic assumptions considered are demographics; potential for localization and job creation for different electricity generation technologies; and job creation potential of the liquid fuels technologies.

The GDP growth projections were used to calculate energy demand estimates for different sectors. National Treasury provided GDP projections used in the base case to inform moderate energy demand growth projections; whilst the Green Shoots[1] GDP growth projections, developed for the IRP 2010 Update, were used as a proxy for the „high GDP growth scenario". As such the Green Shoots GDP growth was used to inform the high energy demand growth projections.

National Treasury provided the discount rate which was used in the optimization modeling process to bring costs expended in the different years to the same monetary value and to calculate the net present value of the different plans (scenarios).

Crude oil is a key commodity considered in the IEP as its price projections are used as input in estimating refined petroleum product prices. The crude oil price projections were sourced from U.S. Energy Information Administration (EIA)"s 2014 Annual Energy Outlook (AEO). This report publishes crude oil price projections up to 2040. Crude oil price projections from 2041 to 2050 were extrapolated. Natural gas price projections were sourced from IEA"s 2011 World Energy Outlook as in the Draft IEP report.

Several studies were considered to inform socio-economic assumptions. These studies were commissioned by various institutions including Institute for Security Studies providing demographic projections; McKinsey & Company providing the potential for localization and job creation of the different electricity generation technologies; and PetroSA providing job

[1] Refer to the IRP2010 Update Report published on www.doe-irp.co.za

creation potential for Crude Oil (conventional) refinery, Coal to Liquid (CTL) Plant represented by an Open Pit Coal mine with the Gas to Liquid (GTL) Plant and the development of Gas field to augment supply to the existing GTL facility.

The PetroSA study considered Greenfield conventional and CTL refineries; and a Brownfield GTL refinery located in Mosselbay. For the Brownfield GTL refinery job creation potential numbers do not give a true reflection for a construction of a new GTL therefore this numbers are not considered in the IEP process. For the CTL plant the study provides assumptions for the GTL facility and nothing for the conversion of coal to syngas process. For the purpose of IEP, new additional assumptions were created to derive numbers for job creation potential for the CTL facility. This means the total job creation potential of the CTL plant is a combination of the Greenfield GTL numbers reported in the CTL project and the open pit coal mining jobs. It was also recommended by PetroSA that numbers for the job potential of the GTL facility in the CTL be used for a Greenfield GTL plant by removing the impact of the coal supply portion of the project.

2 Macro-Economic Assumptions

2.1 GDP Growth Rate

The National Treasury‟s economic growth rate projections assume three scenarios: high, moderate and low GDP growth scenarios. These growth assumptions are based on National Treasury‟s most recent in-house estimates of growth and the underlying assumptions are described in the tables below. The high growth scenario is based on the national Development Plan (NDP) where all goals of the NDP are fulfilled. For the purpose of the IEP, only the NT‟s moderate growth scenario was used. Another growth scenario used is the Green Shoots economic growth assumptions, as used in the IRP 2010 Update.

Table 2-1: National Treasury GDP growth forecast

	Short-Term				Medium-Term	Long-Term
	2014	**2015**	**2016**	**2017**	**2018-22**	**2023-50**
Low Growth	**1.5** *2.4*	**1.8** *2.5*	**2.3** *2.9*	**2.5**	**2.8** *3.1*	**3.0** *3.0*
Moderate Growth	**1.8** *3.0*	**2.7** *3.2*	**3.2** *3.5*	**3.5**	**3.7** *3.7*	**4.2** *4.0*
High Growth	**2.0** *3.3*	**3.3** *3.6*	**3.7** *4.0*	**4.0**	**4.9** *4.9*	**5.5** *5.4*

Light grey numbers indicate previous cycle forecast.
Source: National Treasury

Table 2-2 below gives the story lines underlying assumptions in the National Treasury forecast.

Table 2-2: Assumptions for GDP growth projections

SHORT-TERM	
Moderate Growth	• Growth in advance economies continue to improve, with emerging markets experiencing softer but continued growth • SA commodity export price growth subdued • Decline in strike activity, production to start normalising • Electricity supply constraint is eased as Medupi and Kusile come online • The reduction in domestic constraints result in improved confidence and fewer concerns over credit rating agency downgrades
Downside risks	• Softer emerging market growth with a hard-landing in China and SA commodity export prices decline

	• Geopolitical tensions in Middle East remain leading to higher oil prices • US eases monetary policy faster than announced • Protracted labour unrests in other sectors, production effects of mining strikes take longer to resolve • Construction of Medupi and Kusile delayed, further constraining electricity supply; increase in unplanned maintenance as exiting fleet need to run for longer • Business and consumer confidence remain low and probabilities of credit rating agency downgrades increase
Upside Risks	• Emerging market growth recovers raising demand for commodities • SA commodity export prices rise • Minimal to no strike activity with no impact on production, production returns to full capacity • Electricity supply constraint is eased as Medupi and Kusile come online • Business and consumer confidence rebound • credit rating agency downgrades do not occur
MEDIUM TERM	
Moderate Growth	• Infrastructure constraints ease as government and public corporation investment is successfully rolled out • Large reductions in business costs and bigger competitiveness gains
Downside Risks	• Continued delays in infrastructure roll-out • Infrastructure constraints worsen
Upside Risks	• Infrastructure constraints ease as government and public corporation investment is successfully rolled out • Larger reductions in business costs and bigger competitiveness gains
LONG-TERM	
Moderate Growth	• Some NDP proposals successfully implemented • Some difficulties experienced • Process moves at a slower pace than anticipated • Structural issues, such as the skills constraints persist but with some improvements

Downside Risks	• NDP proposals struggle to be implemented • Significant delays • Estimated gains achieved not achieved within time frame • Structural issues, such as the skills constraints worsen
Upside Risks	• NDP proposals successfully rolled out with estimated gains achieved within time frame • Structural issues, such as the skills constraints, resolved

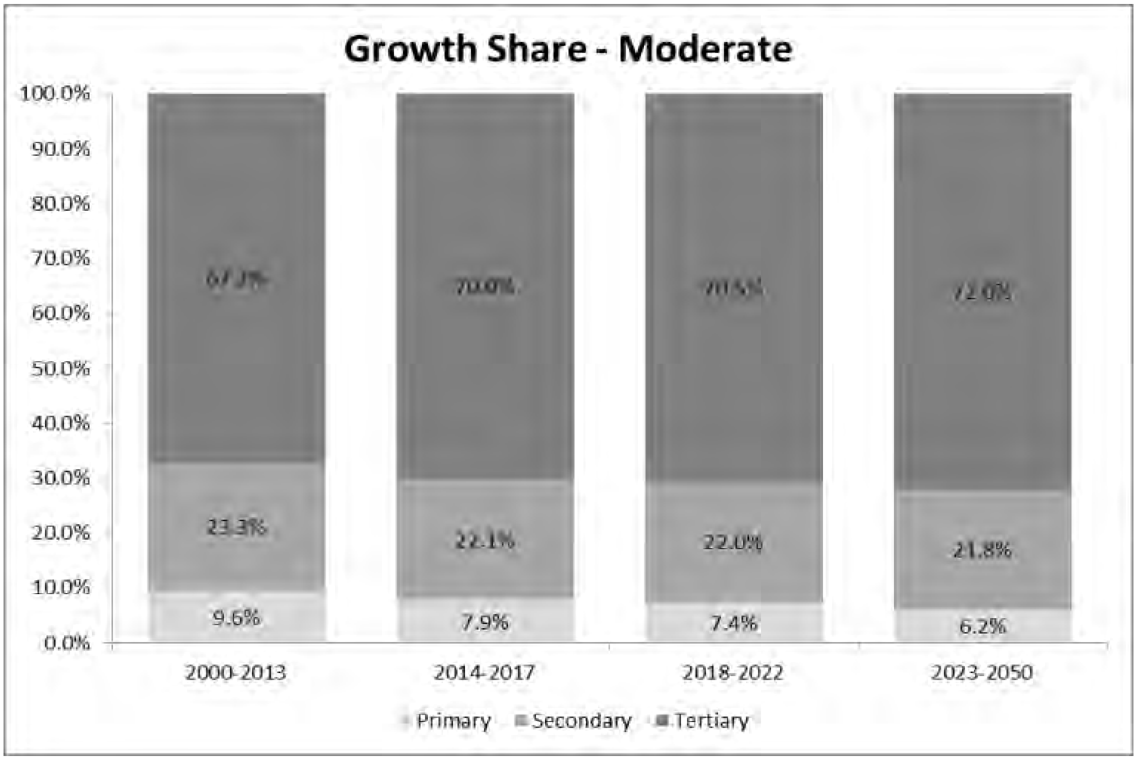
Source: National Treasury

2.1.1 Moderate Growth Scenario

The moderate growth scenario is characterised by the following:

- The sector contribution to growth will continue to transform in line with the trend of improved economic performance. Services will continue to dominate while manufacturing remains relatively unchanged and agricultural marginally declines. This does not mean that growth in primary sectors will decrease but rather that growth in other industries will be stronger;
- In the short-term, sectors will remain constrained by electricity supply although some ease is expected by 2015/16. Sectors will gradually recover from the weak growth currently experienced although infrastructure constraints remain relatively binding. It is assumed that no further labour unrest will affect production;
- Over the medium to long-term infrastructure constraints will somewhat ease, leading to reductions in the cost of doing business;
- Increase expenditure and efforts to increase the contribution of agriculture, particularly small holder development may result in stronger agriculture growth. However, increased water pricing may negatively affect production; and
- Stronger growth in mining could take place if oil and gas extraction occur and/or global commodity prices increase. Additional strike activity when wage agreements expire is a downside risk

Table 2-3: Moderate GDP Growth Sector Share



Source: National Treasury

2.1.2 Green shoots Economic Growth Projections

The Green Shoots forecast is based on National Development Plan‟s of 5.4% GDP growth till year 2030. As the GDP growth is assumed not to grow in perpetuity, this growth start tapering off post 2030. The basis for this GDP growth is that there will be a significant shift in structure of the economy, which means moving away from the classical energy intensive industries. This scenario was initially developed for the Integrated Resources Plan 2010 Update.

2.1.3 GDP per Capita

GDP per capita measures the real product or services produced by an average person in the country and in some instance it also measures the average income earned by individuals. GDP per capita is generally used as an indicator of the performance of a country‟s economy. It can be interpreted as a measure of the average living standard of a society. However, since GDP per capita does not measure the nature of income distribution in a country, a smaller wealthy population in a country can boost GDP per capita drastically despite the fact that the broader masses of the population may be relatively poor, it must be used with caution. Figure 2-1 below compares GDP per capita for moderate economic growth and for the Green Shoots scenarios.

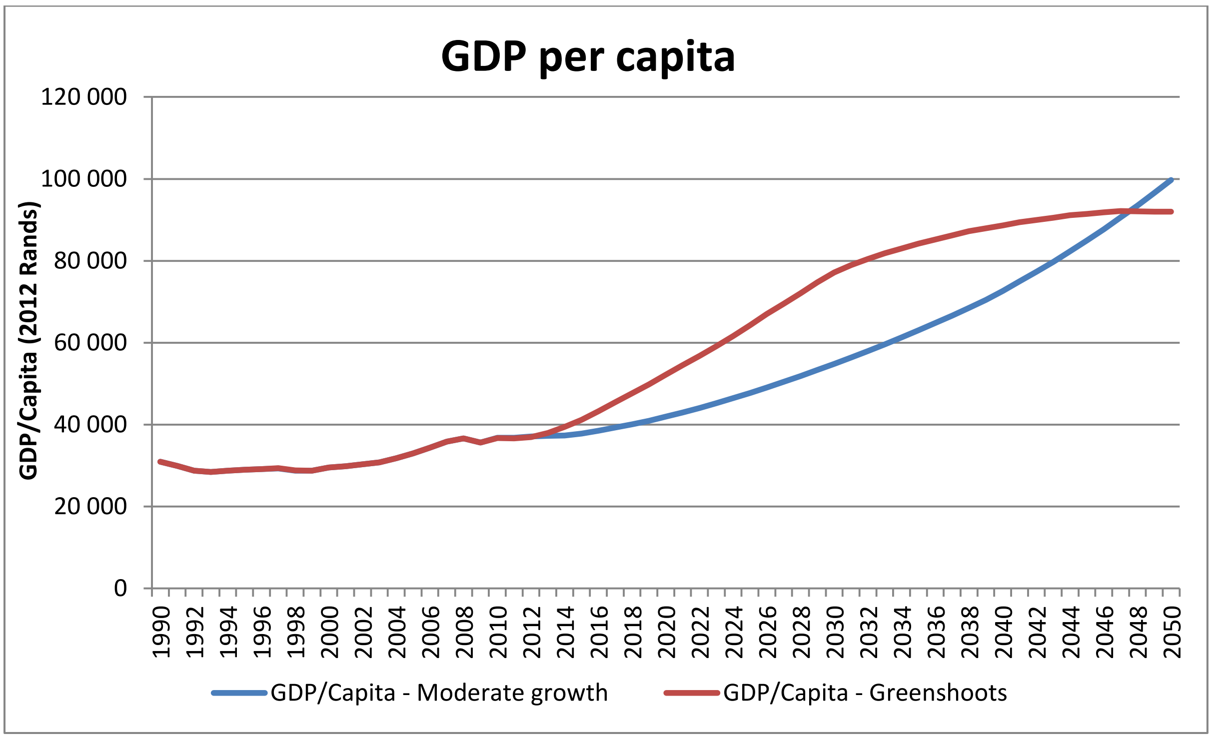


Figure 2-1: GDP per capita for the moderate and green shoots economic growth

Source: DoE Analysis, 2015

Figure 2-2 below, compares GDP per capita on a purchasing power parity basis across the BRICS countries. Among the BRICS countries, Russia and China consistently outperform the other members of the group in terms of GDP per capita, and appear to be experiencing faster levels of social progress. South Africa on the other hand only begins to outperform

Brazil in the period 2040 to 2050. India‟s GDP per capita is the lowest among the group and is forecast to grow at a pace similar to that of South Africa, particularly in the period between 2030 and 2050.

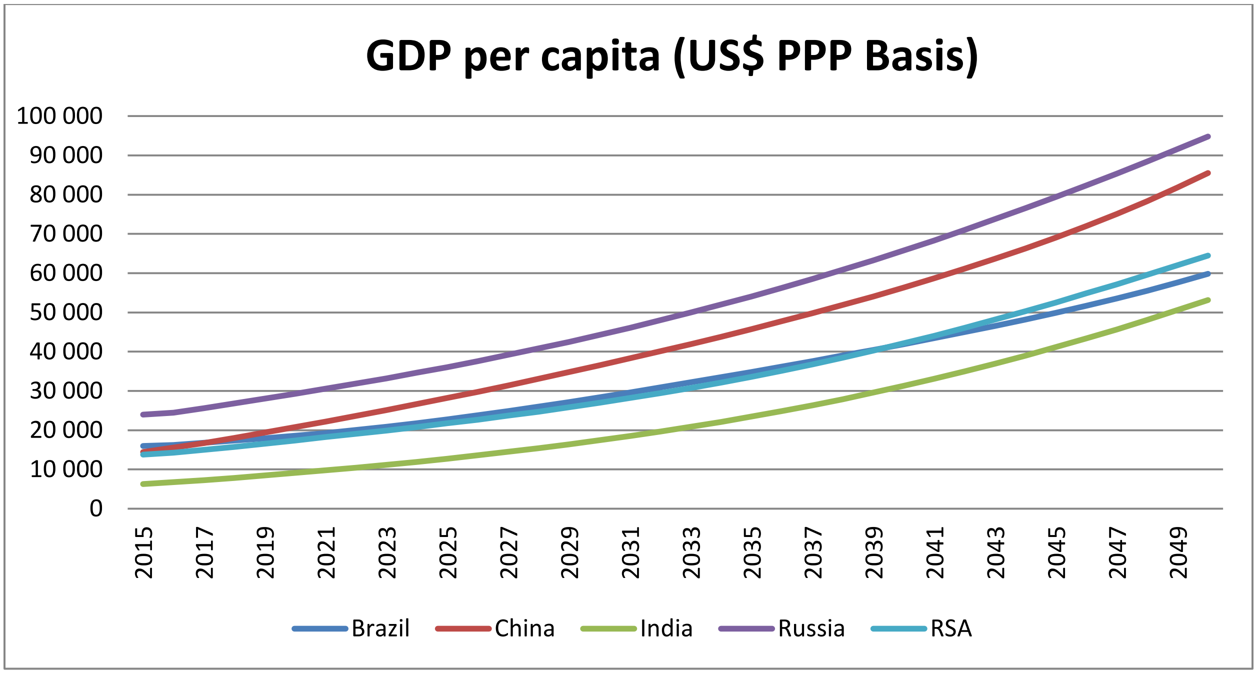


Figure 2-2: GDP per capita for BRICS Countries

Source: Economist Intelligence Unit

2.2 Social Discount Rate

The social discount rate is an economic indicator for discounting future costs and benefits in economic cost benefit analysis. This discount rate is used to compute the value of funds spent on social projects. It is a reflection of society‟s relative valuation of today‟s well-being versus well-being in the future. It therefore also represents the opportunity cost of those funds spent in present day against other alternatives that Government could have considered with those same funds. This is the case as funds are not unlimited. There are a number of qualitative differences between social and corporate discount rates and the valuation of projects associated with them. The governance of social project funding is different because estimating the benefits of social projects requires making ethically subtle choice about the benefits to society in question.

There is a vast diversity in the application of social discount rates for economies which are more developed as compared to those that are still in the developmental stage. Typically the former‟s social discount rates would be in the region 3-7% whilst the latter 8-15%. Since the social discount rate measures the opportunity cost of scarce/limited resources and in particular available finances (Government fiscal balance), the following are some of the reasons why a higher discount rate is expected for developing economies:

- Developing countries require projects that provide essential delivery services to citizens or constraint unlocking projects which have higher social returns than projects in more developed economies, e.g. the impact of schools where educational attainment and the social gains from the investment are high;
- Due to the risks associated with the inherently uncertain nature of projecting what economic conditions might be like in a few years‟ time (or demand for a particular project) in a developing country; one needs to discount heavily the promised future benefits of a particular project. This is due to conditions that might have changed in 15-20 years‟ time and the benefits might not materialise;
- Developing economies tend to emphasise investing in quicker short term projects where the benefits are better understood, achieved faster, and address needs that are known at this instant. Therefore higher social discounts rate are used in planning to reward such behaviour; and
- High social discount rates are also reflected both in the general nature of people‟s saving habits (time value of money), and how capital is used generally in the economy (typical market returns).

Table 2-4: Examples of social discount rates across the globe

Social Discount Rate			
Country	*Rate*	*Country/Institution*	*Rate*
Developed		***Developed***	
Austria[1]	3%	United States (OBM) - 1992 [2]	10%
Belgium[1]	6.5%	United States (OBM) - now [2]	7%
Czech Republic[1]	6-7%	Canada - 1970 -2007 [2]	10%
Denmark[1]	6%	Canada - 2008 [2]	8%
Estonia[1]	6%	***Developing***	
France 1985-2005[2]	8%	Phillipines [2]	15%
France[2]	4%	India [2]	12%
Germany[1]	3%	Pakistan[2]	12%
Ireland[1]	5%	China[2]	8%
Italy[1]	4-6%	Mexico [3]	10%
Netherlands[1]	4%	Argentina [3]	11%
Poland[1]	6%	Uruguay [3]	11%
Slovenia[1]	8%	Colombia[4]	8.5%
Spain[1]	6%	Chile[4]	9%
UK - 1969-78[2]	10%	***Multilateral***	
UK - from 2003[2]	3.5%	EU (2001-2006)[2]	6%
Australia [2]	3-7%	World Bank[2]	10-12%
New Zealand - 1982-2008[2]	10%	Inter-American Development Bank[2]	10-12%
New Zealand - now[2]	8%	European bank for reconstruction & development[2]	10%
		African Development Bank[2]	10-12%

Source 1: OECD 2012, Hoeller & Journard Options for benchmarking Infrastructure Performance

Source 2: Australian Government Productivity Commission, Harris 2010, Valuing the Future

Source 3: Rodriguez 2013 The Economic Opportunity Cost of Capital for Mexico

Source 4: Marquez, D. (2013). "Actualización de la Tasa Social de Descuento en el Marco del Sistema Nacional de Inversiones de Chile

2.2.1 Methodology for calculating social discount rate

National Treasury evaluated two methodologies for calculating RSA appropriate social discount rate for use in long term energy planning. The two methodologies were due to the debate in economics literature, whether rates should reflect the social rate of time preference (SRTP) or the opportunity cost of capital (EOCK). The SRTP is the rate at which individuals are willing to trade off present for future consumption. Below, the two methodologies are described briefly:

2.2.1.1 Ethical Considerations Approach

This approach is based on the Stern report and is largely applied to environmental projects where there are intergenerational (equity) considerations. One of the main criticisms of this method is that it mixes efficiency and equity considerations. For RSA a social discount rate of 1.4% is used in the Stern Report.

2.2.1.2 Economic opportunity Cost of Capital (EOCK)

The economic opportunity cost of capital or the social discount rate is defined as the minimum economic rate of return that either a private or public sector investment must earn if it is to contribute positively to the growth of the economy. In a closed economy in terms of foreign borrowing or lending, there are two principal sources of diverted funds and they include the following:

- Those invested in other investment activities either displaced or postponed; and
- Those spent on private consumption foregone due to the stimulation of domestic savings.

The economic cost of capital (EOCK) can be measured as a weighted average of the rate of return on displaced investment, and the rate of time preference to savers re-shifted out of the capital market. The National Treasury recommends the use of the Economic Opportunity Cost of Capital approach for RSA social discount rate in the IEP process as the IEP discounts future costs and does not calculate the cost benefit or Net Present Value (NPV).

For the past 40 years, the average real rate of return on investment in South Africa has been about 19.71% in 1961-70, 17.21% in 1971-80, 15.22% in 1981-90, and 15.70% in 1991- 2000. The rate of return was relatively high in early years because of monopolies and high profitability in certain sectors such as mining. In the last two decades, the rate of return on capital has been somewhat reduced. As the economy becomes more open and capital becomes more internationally mobile, one would expect the rate of return on capital to decline over time.

2.2.2 Results

The following are the observations from the calculation of the EOCK:

- Generally the EOCK has been falling, as capital has become less constrained, and economic returns have matured
- However during the boom with higher returns, and expensive coupon rates from international sources – the EOCK rate was high – which increased the rate recently
- Over the entire period of SA‟s modern democracy the real after tax EOCK is estimated at 8.4%.

Table 2-5: Calculated Annual EOCK for Modern RSA

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Annual EOCK (%)	7.5	7.5	8.1	9	8.6	7.5	8.1	8.9	8.5	7.8	7.5	8.9	16.9	11.1	9.7	6.1	4.5	6.2	7

Source: National Treasury

Table 2-6: Average EOCK

Period	Average EOCK (%)
1995-1999	8.1
2000-2006	8.1
2007-2013	8.8
1995-2013	8.4
2000-2013	8.5

Source: National Treasury

2.3 Energy Commodity Price Projections

2.3.1 Crude oil

Crude oil prices used in this report are sourced from U.S. Energy Information Administration (EIA)"s 2014 Annual Energy Outlook (AEO). According to AEO, 2014 oil prices are influenced by several factors, such as expectations about future world demand for petroleum and other liquids and production decisions by the Organization of the Petroleum Exporting Countries (OPEC), which can affect prices over the longer term (AEO, 2014). Supply and demand in the world oil market are balanced through responses to price movements, with considerable complexity in the evolution of underlying supply and demand expectations (AEO, 2014).

Two oil price scenarios are used in the report, namely the Reference Case and the High Oil Price Case. The reference case is used to inform the IEP moderate crude oil price projections, while the high oil price case is used to inform the IEP high crude oil price projections. Key assumptions driving global crude oil markets in AEO 2014 in the reference case over the projected period includes the following:

- Average economic growth of 1.9% per year for major U.S. trading partners; and
- Average economic growth of 4.0% per year for other U.S. trading partners.

Growth in petroleum and other liquids use occurs almost exclusively outside the Organization for Economic Cooperation and Development (OECD) member countries, with 1.8% average annual growth in petroleum and other liquids consumption by non-OECD countries, including significantly higher average annual consumption growth in both China and India. The crude oil price projected for the reference case and the High oil price case as published in the AEO, 2014 are shown in Figure 2-3 below.

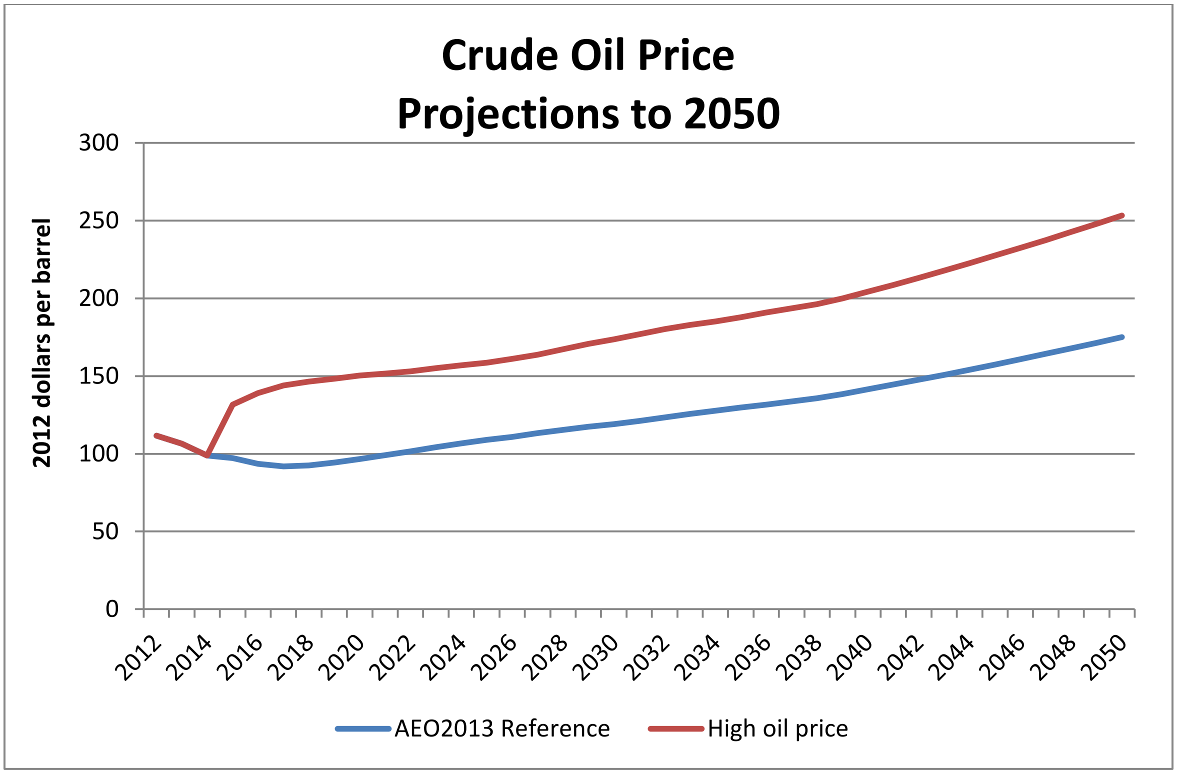


Figure 2-3: Crude oil price projections

Source: **US Energy Information Administration (EIA)**, Annual Energy Outlook, 2014

2.3.2 Refined Petroleum Price Projection

Refined petroleum product price projections are derived from the crude oil price projections sourced from Annual Energy Outlook, 2014. For petroleum and other liquids, the key determinants of long-term supply and prices can be summarized in four broad categories: the economics of non-OPEC supply; OPEC investment and production decisions; the economics of other liquids supply; and world demand for petroleum and other liquids (AEO, 2014).

Figure 2-4 below shows major petroleum product price projections based on the crude oil price projection in Figure 2-3 above.

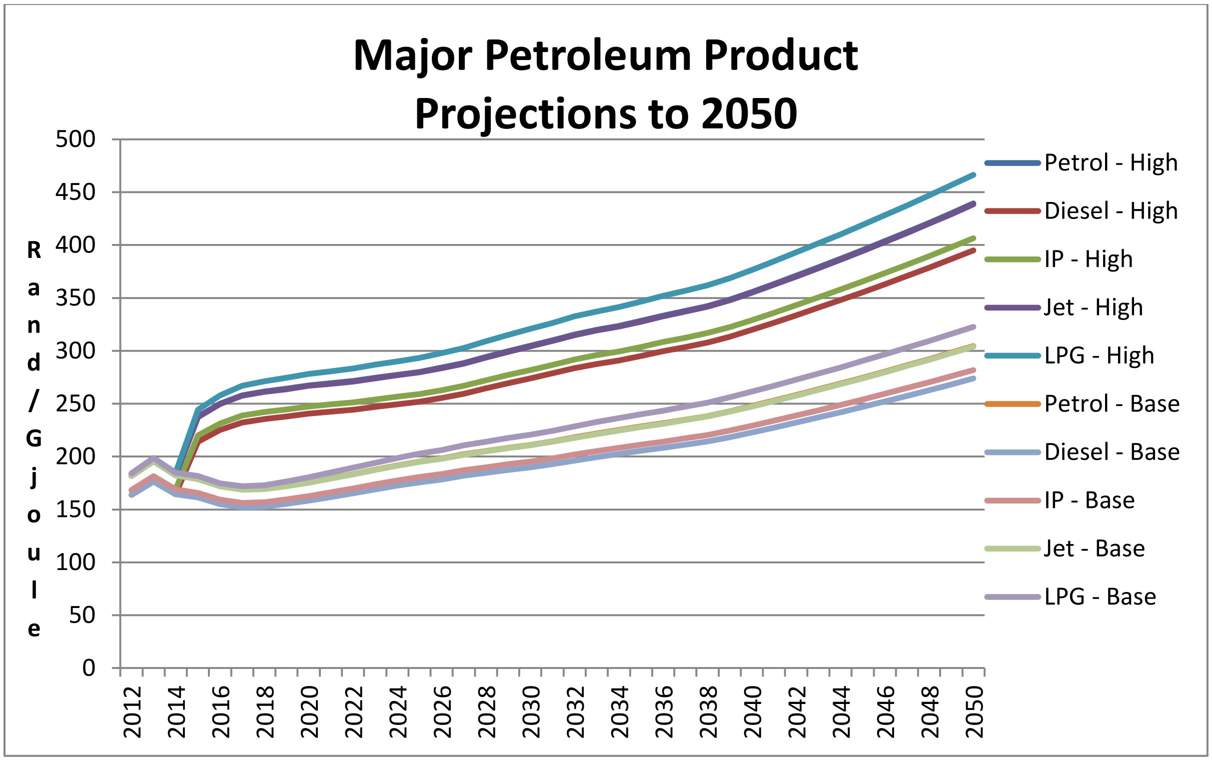


Figure 2-4: Major petroleum product price projections

Source: DoE Analysis; 2015

2.3.3 Natural Gas Price Projection

The International Energy Agency (IEA) develops and publishes the World Energy Outlook on an Annual basis. The natural gas price projections are based on the projections for average gas import prices in Europe in the 2011 World Energy Outlook.

According to the World Energy Outlook, historically natural gas prices in the OECD have been closely correlated to oil prices through indexation clauses in long-term supply contracts and also as a result of competition between gas and oil products in power generation and end-use markets. However different pricing mechanisms in different parts of the world lead to differences in the actual level of prices. When oil prices are high, oil-indexed gas prices also tend to be high (with a certain lag period). However gas prices which are driven by competition and supply/demand dynamics tend to be lower than oil-indexed prices as has been seen in Europe and the US.

The 2011 World Energy Outlook provides gas price projections for three scenarios: the Current Policies Scenario; the New Policies Scenario; and the 450 Scenario within three regions, namely United States, Europe and Japan; however the IEP report uses European natural gas price projections. The IEP report uses the New Policies Scenario to inform the moderate natural gas price projections and the Current Policies Scenario to inform the high natural gas price projections. The price projections in the 2011 World Energy Outlook have been revised down from the 2010 release, primarily because of improved prospects for the commercial production of unconventional gas. The gas price projections sourced from 2011 World Energy Outlook used in the IEP study have been revised to use 2012 as a base year.

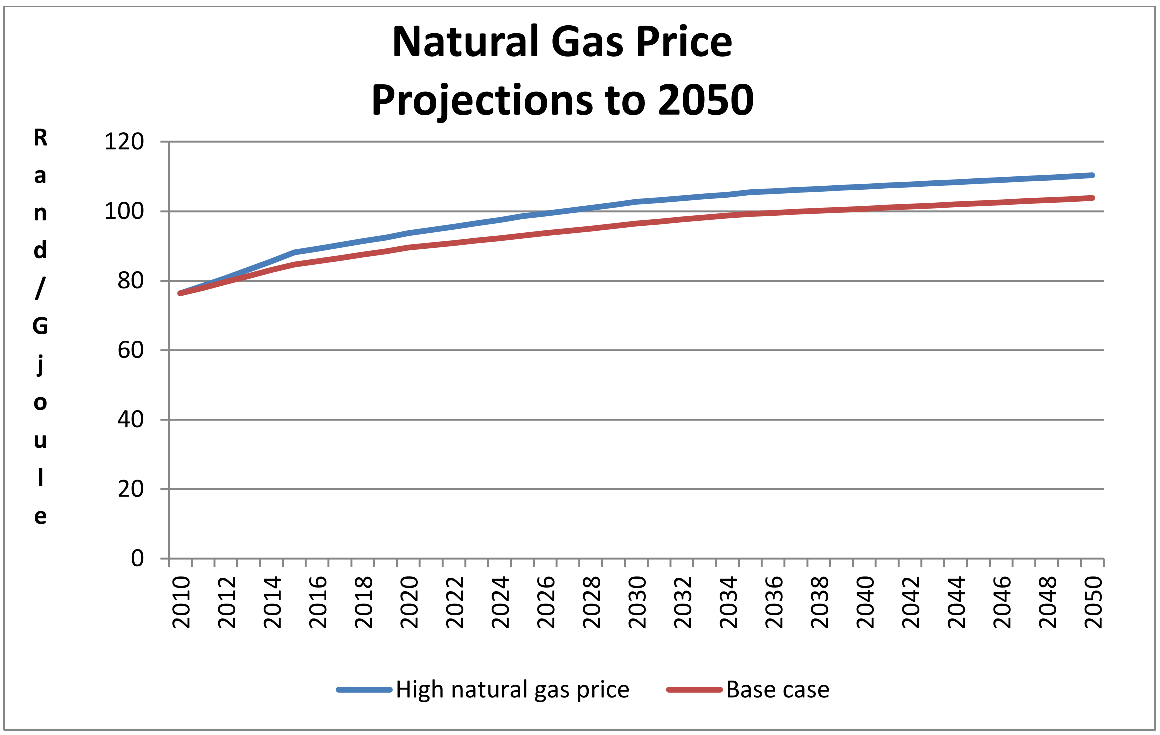


Figure 2-5: Natural gas price projections

Source: World Energy Outlook, 2011

2.3.4 Coal Price

For electricity generation, coal price used in the IEP is sourced from Eskom. There are two coal technology prices considered, the pulverised coal and fluidized bed combustion coal which assumed R7.5 G/J and R15.00 G/J respectively. The cost of the coal for existing

power plants are based on long term contacts and are embedded in the operating costs of the power plants.

Coal used for final demand and coal to liquids is not given a direct price but the cost of mining the coal is calculated within the IEP model. Various capital, fixed and operating costs for a "coal mine" technology, which provides this coal, is used to determine the coal costs. This allows for the cost of providing the coal to vary with the costs of the energy inputs into mining such as electricity and petroleum products.

2.3.5 Shale Gas Costs

Shale gas extraction costs are based on numbers generated by PetroSA feasibility studies on Shale gas operations in SA. PetroSA anticipates that at full scale their operation will run 500 wells with expected output of 43 billion cubic feet per year. Capital costs and fixed costs are estimated at R372/GJ and R6/GJ per annum respectively.

According to a June 2013 report released by EIA, South Africa has 390 trillion cubic feet (Tcf) of technically recoverable shale gas resources, making the country the eighth-largest holder of technically recoverable shale gas resources in the world (US Energy Information Administration, 2015).

3 Socio-Economic Assumptions

3.1 Demographics

The population forecast used in the current IEP studies was developed by Institute for Security Studies[2] (ISS) in collaboration with the Frederick S Pardee Centre for International Futures[3]. Using the International Futures (IFs) model and data from the South African 2011 National Census, three potential population futures for RSA up to 2050 were simulated and compared to the National Development Plan (NDP) 2030 forecasts and results from other institutions such as United Nations Population Division (UNPD), International Institute for Applied System Analysis (IIASA).

The methodology considers a representation of three drivers of population change namely; fertility, mortality and migration. Fertility is most commonly expressed as the Total Fertility Rate (TRF) and implies the average number of times a woman is expected to give birth by the end of her reproductive years. Mortality is generally measured by Life Expectancy (LE) at birth and indicates the average number of years that new born infants can expect to live based on current conditions. Migration is analysed by using the Push-Pull model. Push factors are those that drive people to leave their country and Pull factors are those that attract people to a country of destination.

To forecast the population of RSA, the IFs base case is developed for each of the three drivers of population then a sensitivity analysis is conducted on the migration. The one sensitivity looks at the slowing migration and the other on migration shock. The three scenarios are then analysed in comparison with the scenarios outlined in the NDP 2030, e.g. The IFs Base Case suggests that life expectancy will continue to increase to 58 years by 2030 which is far below the NDP target of 70 years.

[2] ISS is an African organization which aims to enhance human security on the continent
[3] The Pardee Centre is the home of the International Futures modeling system

3.1.1 Total Fertility Rate

South Africa‟s fertility levels have declined considerably over the past decades as indicated by Figure 3-1 below. Factors contributing to this decline include a rise in median income level and improvement in female educational attainment. Even though the IFs Base Case forecasts that the downward trend in TFR is likely to continue, a number of uncertainties need to be taken into consideration. These are, inter alia, RSA future economic success, HIV/AIDS, educational attainment, female employment, economic independence, availability of information around family planning. All these factors will most likely influence future fertility rate of South Africa.

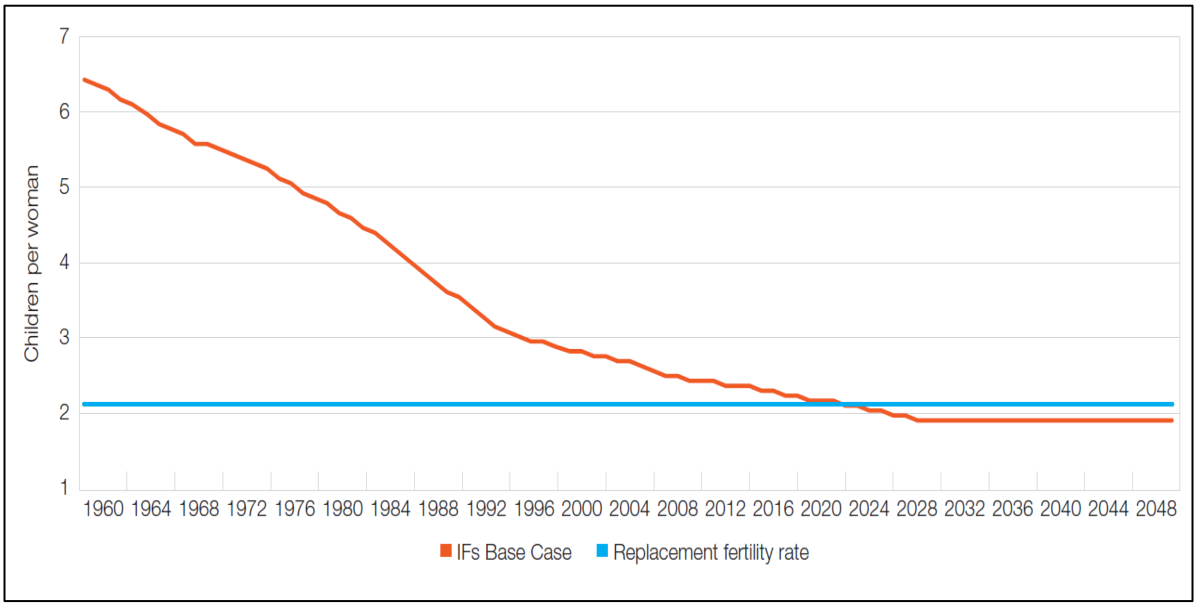


Figure 3-1: Total fertility rate of RSA: History and forecast (IFs Base Case)

Source: Institute for Security Studies, 2013

3.1.2 Life Expectancy

South Africa‟s average life expectancy improved substantially between 1960 and 1990, from approximately 49 to 60 years according to data from the UN. However, HIV/AIDS reversed this trend dramatically, with life expectancy plummeting to approximately 51.7 years by 2005. With the introduction and continued scale up of antiretroviral therapy (ART) life expectancy improved slightly to about 52.4 in 2010. Figure 3-2 shows RSA life expectance figures and forecasts sourced from the UNPD and IFs Base Case respectively. The life expectancy by 2030, according to the IFs model, will continue to increase to 58

years and is lower than the projected NDP target of 70 years. This is based on a conservative initialisation and forecast.

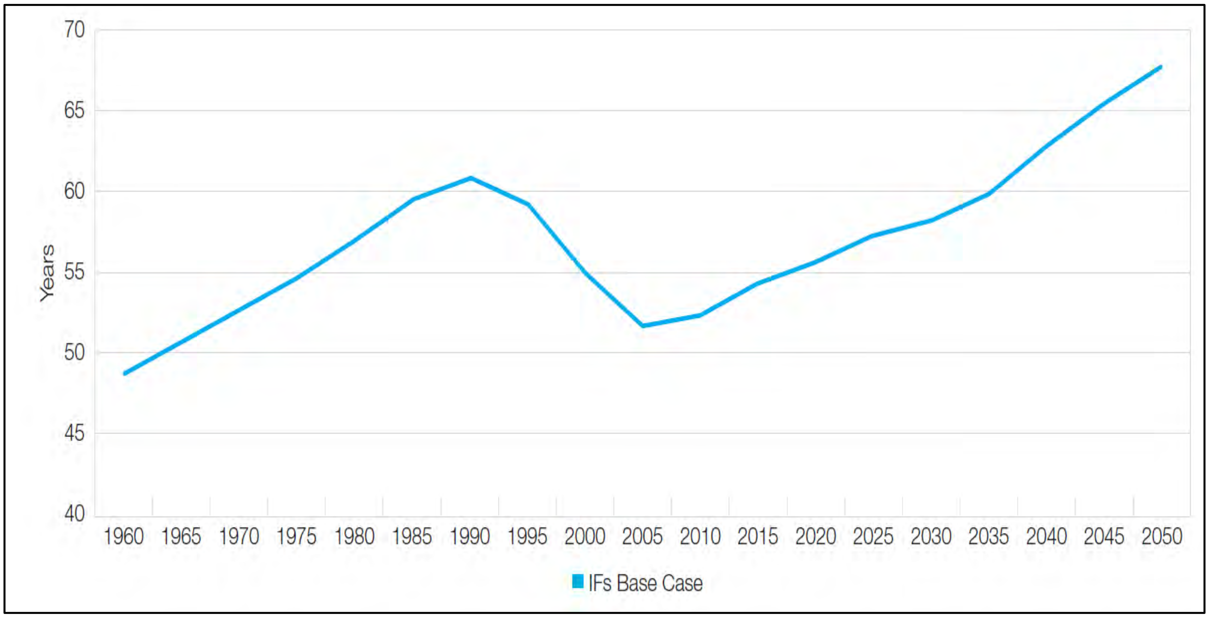


Figure 3-2: RSA life expectancy: History (UNPD) and forecast (IFs Base Case)

Source: Institute for Security Studies, 2013

3.1.3 Migration

Migration flows are constantly driven by changing economic, political and social factors. According to Statistics South Africa (STATS SA) there are between 500 000 to about 1 million undocumented migrants living in RSA. The Human Sciences Research Council (HSRC) estimates about 4 to 8 million undocumented migrants are living in RSA at any one time. This divergence makes it difficult in measuring the flow of undocumented migrants in the country.

Current immigration legislation has instituted a corporative permits regime which makes it compulsory for companies to justify the necessity for migrant workers before granting them legal employment. This makes it more difficult for mining companies to hire foreign workers and as a result the share of migrant workers in the mining sector has declined for 59% in 1997 to 38% in 2006.

Also RSA has become a common destination for refugees and asylum seekers from the rest of the continent. About 160 thousand refugee claims were reported by the South African Government between 1994 and 2004 with nearly 30% being from outside the continent. Future South Africa‟s policy responses to migration will influence the number of future migrants. Also future economic and political conditions in RSA and neighbouring countries will impact future migrations patterns. The IFs Base Case model uses estimates from the World Bank and UNPD to initialise the migration forecast. Figure 3-3 below shows the forecasts from the IFs Base Case and two alternative migration scenarios.

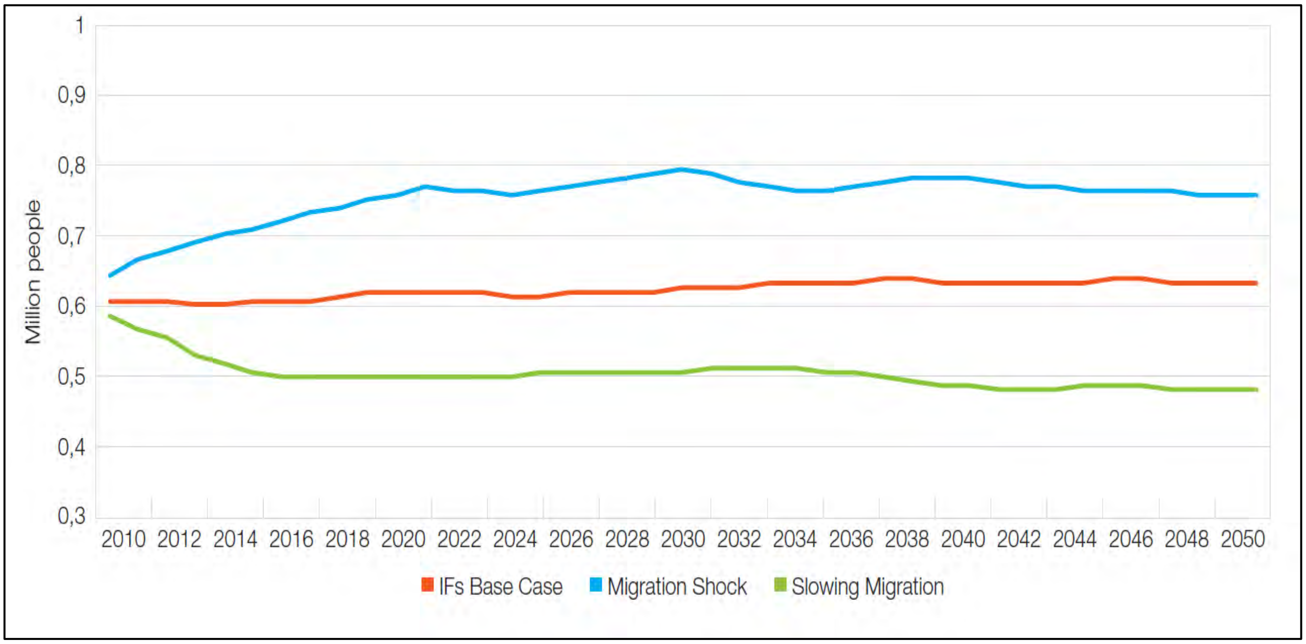


Figure 3-3: RSA Net migration forecast (5 year moving average)

Source: Institute for Security Studies, 2013

3.1.4 Population and Key Drivers Analysis

The three key drivers analysed above have the potential to impact the future size and structure of RSA population. However of the three, migration has the biggest impact compared to the other two drivers and this is emphasised by the analysis shown in Table 3-1 below.

Table 3-1: RSA Scenarios Matrix of Population (in millions of people) in 2050

	Low scenario	High scenario	Range of uncertainty
Fertility[52]	81,6	88,3	6,7
HIV/AIDs deaths[53]	82,4	84,8	2,4
Migration	78,7	89,2	10,5

Source: ISS, 2014

3.1.5 RSA Population Projections

The final IFs population forecast depicting the Base Case and two scenarios on migration potential are shown in Figure 3-4 below. The Base Case forecast preserves the annual net migration rate at approximate current levels and the RSA total population would reach 66.4 million people by 2030 and 83.6 million by 2050. Similarly the slow migration and migration shock would reach 64.4 and 68.8 people by 2030 and 78.7 and 89.2 people by 2050 respectively.

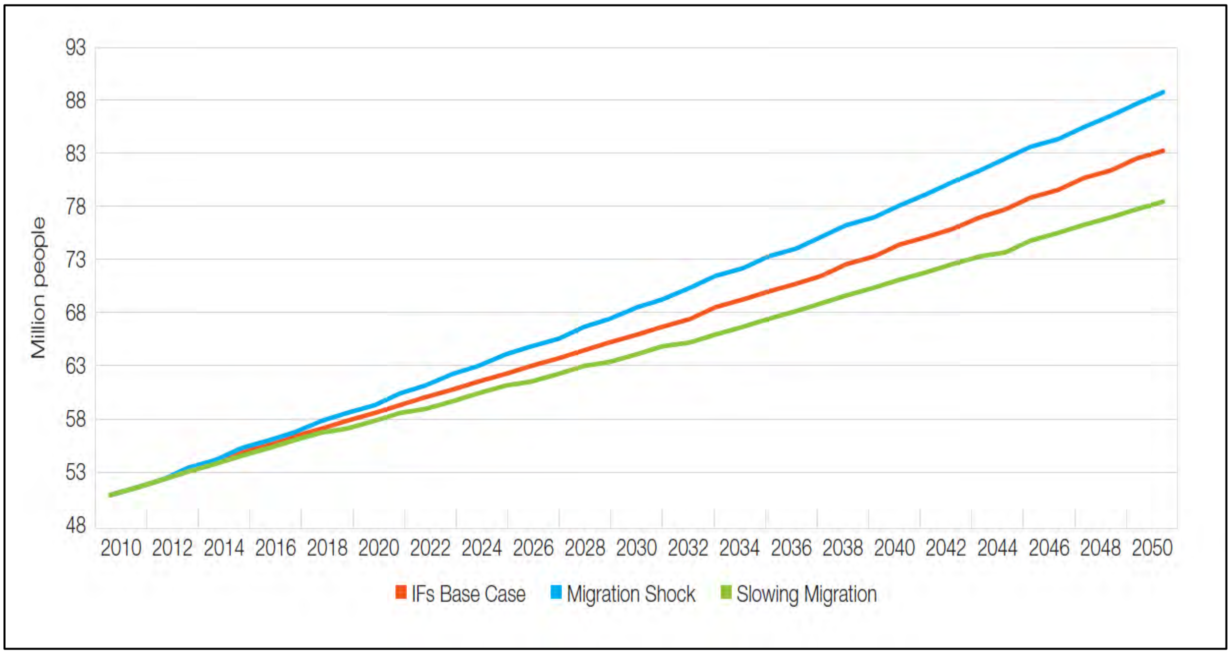


Figure 3-4: RSA Population Forecasts based on IFs model

Source: Institute for Security Studies, 2013

3.2 Potential for Job Creation and Localisation of the electricity generating technologies

This section looks into the potential for job creation and localisation of different electricity generation technologies. The analysis below is based on the potential for localisation and job creation study commissioned by McKinsey and Company.

The McKinsey and Company were commissioned by the DoE to develop a methodology for comparing the localization and job creation potential for multiple electricity generation technologies and their associated primary energy fuels extraction. The methodology calculates job potential, consistently, across four job categories for each of the technologies. The four job categories and their examples are listed in Table 3-2 below.

Table 3-2: Different Job categories and examples

Definition	Examples	
Direct jobs: jobs resulting from construction or operation of the technology	Construction workers Bricklayers Plant operators	Bottom-up methodology
Supplier jobs: jobs resulting from first level suppliers during construction/operation	Turbine manufacturers Cement producers Steel manufacturers	
Indirect jobs: jobs resulting further down the value chain during construction/operation: 'suppliers to suppliers'	Iron ore miners Smelters	Top-down methodology
Induced jobs: jobs resulting from more money in the economy because of the project (e.g., etc.)	Restaurants Transport services Medical facilities	

Source: McKinsey & Company, 2014

Electricity generation technologies assessed for localisation and job creation potential are as follows:

- solar PV
- solar CSP
- onshore wind
- nuclear
- Pulverised coal-fired and coal mining
- CCGT and shale gas as primary input

This study analyses the job creation of additional energy capacity (new build) only and not the job creation effects of changing the technology of existing energy capacity. The analysis is performed assuming 5 000 MW of any technology is required in order to ensure an appropriate like-for-like comparison.

3.2.1 Assessment of spend per technology

Detailed spending per technology is developed for both the construction and operation phase of the project. To better identify and understand which jobs would be direct and supplier jobs, local construction and engineering firms assisted in the identification and break down spend at granular level and to categorise costs into different value pools such as services, utility and goods. It is important to notice that more complex value pools such as integrated plant and equipment are more difficult to localize compared to simpler value pools such as materials and manual labour. Table 3-3 below shows spend breakdown of the generation technologies and associated extraction of coal and shale gas during construction. The shale gas spend breakdown is based on a U.S. Detroit 100 well system.

Table 3-3: Break down of spend during construction of the different technologies into value pools

Percent

	Spend type	Technologies – Renewables – PV	CSP	Wind	Conventional – Nuclear	Coal	CCGT	Extraction – Coal mining	Shale gas[1]
Goods	Basic materials		21	23	17	8	2	36	27
	Low to medium complex equipment and parts	91	38	19	10	3		22	26
	High-complex equipment and parts		9	29	11	13	31	25	20
	Integrated plant equipment solutions		8	6	43	37	31	6	6
Services	Manual and low skill labour services	2	1	2	2	5	3	2	1
	Mid-tier skilled labour	5	8	6	7	14	11	3	7
	Technical support services		10	10	8	13	19	3	7
	Business support services	2		1		2	1	1	2
	Management/EPCM		4	4	2	5	5	3	4
Utilities	Utilities								
Total		100	100	100	100	100	100	100	100

Source: McKinsey & Company, 2014

3.2.2 Assessment of localization potential of spend per technology

The potential to localise each pool of spend in South Africa was qualitatively assessed using two criteria:

- sufficiency of demand for a good or service
- the ability of the country to potentially supply this particular spend component

Localisation requires sufficient long-term demand to justify investing in the resources to deliver the goods. The demand assessment was based on whether or not sufficient demand existed in a 5 GW installation of any given technology. If the demand did not exist, the assessment was first based on whether sufficient demand would be created through adjacent industries (e.g. mining and shale gas). If this demand did not exist, it was then

based on whether there was sufficient demand in the region (Sub-Saharan Africa) to justify building new capacity.

To assess the ability to supply a particular spend component a qualitative analysis of time and effort required to build sufficient skills, infrastructure, capital plant, and regulatory framework to ensure sufficient supply was carried out. The time horizon was assessed on the three dimensions based on supply:

- immediate (less than 3 years)
- short to medium term (between 3 and 7 years)
- long term (more than 7 years)

Each good or service was then plotted on the matrix shown in Table 3-4 mapping the relative ease, cost and complexity of localisation in South Africa, where green indicates the spend item will effectively be automatically localised if 5 GW of capacity is built. Yellow and orange indicate the effort required to localise is relatively straightforward and requires significant collaboration, respectively. Red indicates it is possible to localise, but will require significant investment from government and private industry to deliver. Black indicates that global demand is required to be economically viable.

Table 3-4: Matrix to assess localisation potential of individual goods or services

Matrix to assess localisation potential of individual goods and services

		Sufficient demand			
		Direct domestic demand provides suitable size + lifetime for local industries (assuming 5GW installed capacity)	Indirect domestic demand can be developed from/to other sectors	SSA demand can be used to export skills technology + expertise	
Time Horizon[1]	Immediate (0 to 3 years)	Localised at 5GW	Potential to localise – Easy (Aggregate demand)	Potential to localise – Collaborative effort required	Global demand required - Requires South Africa to be globally competitive in an industry that can only sustain itself by supplying world-wide demand for industries requiring similar a technology
	Short-medium term (3+ to 7 years)	Potential to localise – Easy (Build local capacity)	Potential to localise – Collaborative effort required	Potential to localise – Significant investment required	
	Long term (7+ years)	Potential to localise – Collaborative effort required	Potential to localise – Significant investment required	Potential to localise – Significant investment required	

1 Capacity includes skills, available investment, infrastructure and regulatory environment

Source: McKinsey & Company, 2014

By applying similar principles as what has been demonstrated above, the outcomes of the localization potential during the capital construction and operational phases are reflected in tables below. Figure 3-5 reflects the outcome of the capital construction spend for the different generation technologies and the three extraction processes. From this it is evident that wind, shale gas, coal mining and CSP have the highest proportion (at least 60%) of spend that could be localized with minimal effort for 5 000 MW capacity installation. Nuclear plants due to high complexity and not enough volumes being built from either a country or regional perspective cannot be economically localized. Similarly CCGT plants are constructed centrally in global locations and are exported to other markets as turnkey projects, it is also not easy to economically localize them.

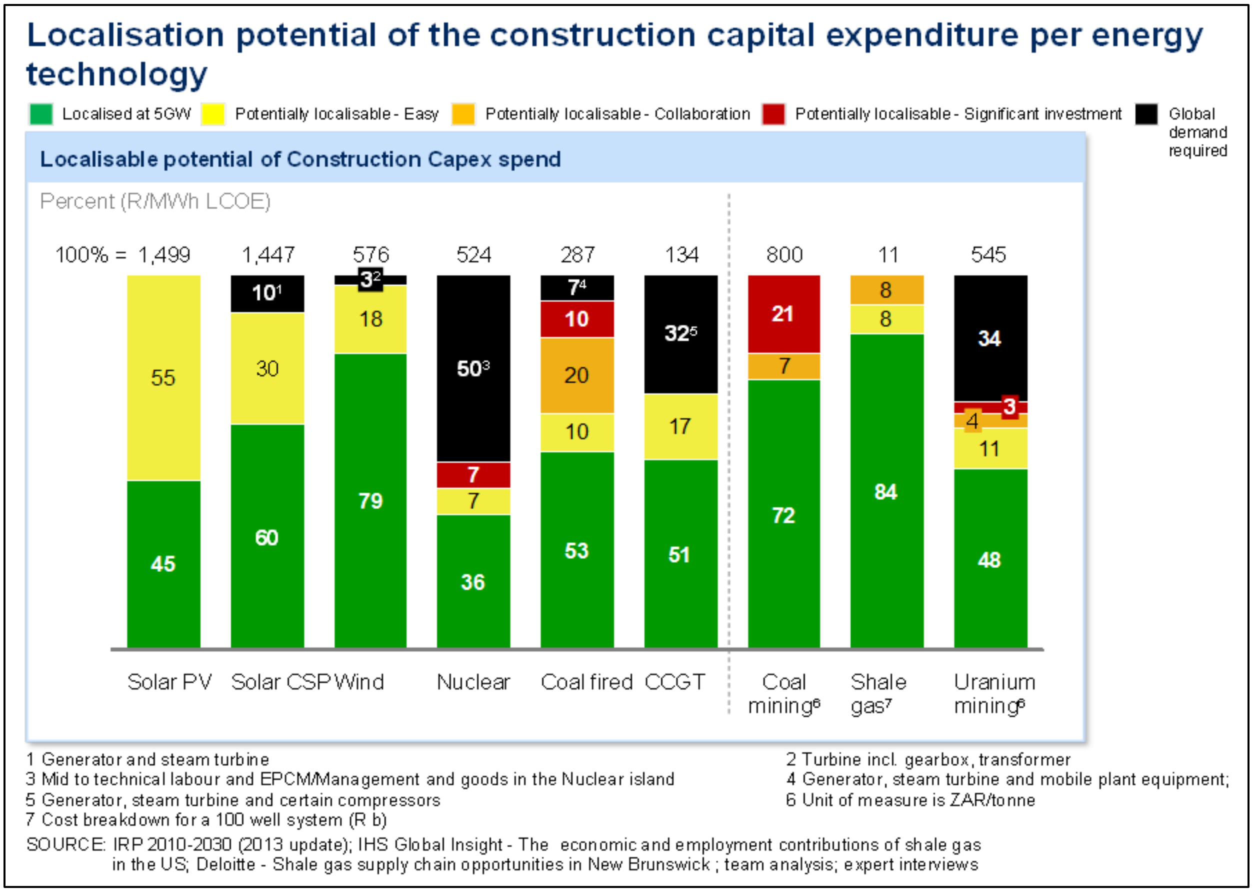


Figure 3-5: Localisation potential of the construction capital expenditure per energy technology

Source: McKinsey & Company, 2014

3.2.3 Translation of localization potential into job creation potential

Using overall spend breakdown, a bottom up methodology was used to determine the direct and supplier based jobs creation potential. Using job category definition in Table 3-2 above the direct and supplier jobs are broken down as follows:

- Direct jobs-: these are the direct employees responsible for building or running the power plants (or primary energy extraction). The spend in the different value pools is deemed to be direct jobs. Using a standard salary range for each of the different jobs in the different value pools the full number of job years that the total spend per plant would create is calculated.
- Supplier jobs-: these are jobs associated with materials and supplies required to support the construction of the project in question. Examples of these jobs are

workers employed in factories of turbine manufacturers, cement producers, boiler makers, etc. The total number of jobs were determined by identifying specific reference factories (in RSA and around the world) producing good required to construct the project and then calculating the total-full time employees required to produce volumes for 5 GW of the electricity generation technology.

Once both direct and supplier jobs have been calculated, it was necessary to normalise across technologies for construction build times, as the different technologies have differing lead time, the construction jobs have been represented as job years per GW of the technology installed.

For the operation of different electricity generation technologies, the direct and supplier job potential are calculated using estimates from Opex spend and are normalised for capacity factor differences. Therefore to compare like for like and account for the different utilisation factors of the different electricity generation technologies, Opex jobs are reflected as annual jobs per TWh produced.

Figure 3-6 below shows the total direct jobs potential for each energy technology and primary energy extraction localised for both Capex and Opex spends. It is evident from this table that CSP, nuclear and coal have the highest job creation potential during the construction phase due to long lead times of these projects. However for the operation phase CSP, wind, PV and shale gas (including CCGT operation and shale gas extraction activities) have the highest job creation potential. It is also interesting to note the normalisation of job potential by energy produced (TWh) makes renewable energy job numbers appear significantly higher than expected. The high number of jobs for shale gas extraction is due to new wells that are continuously drilled over the life of the gas plant to sustain required gas volumes.

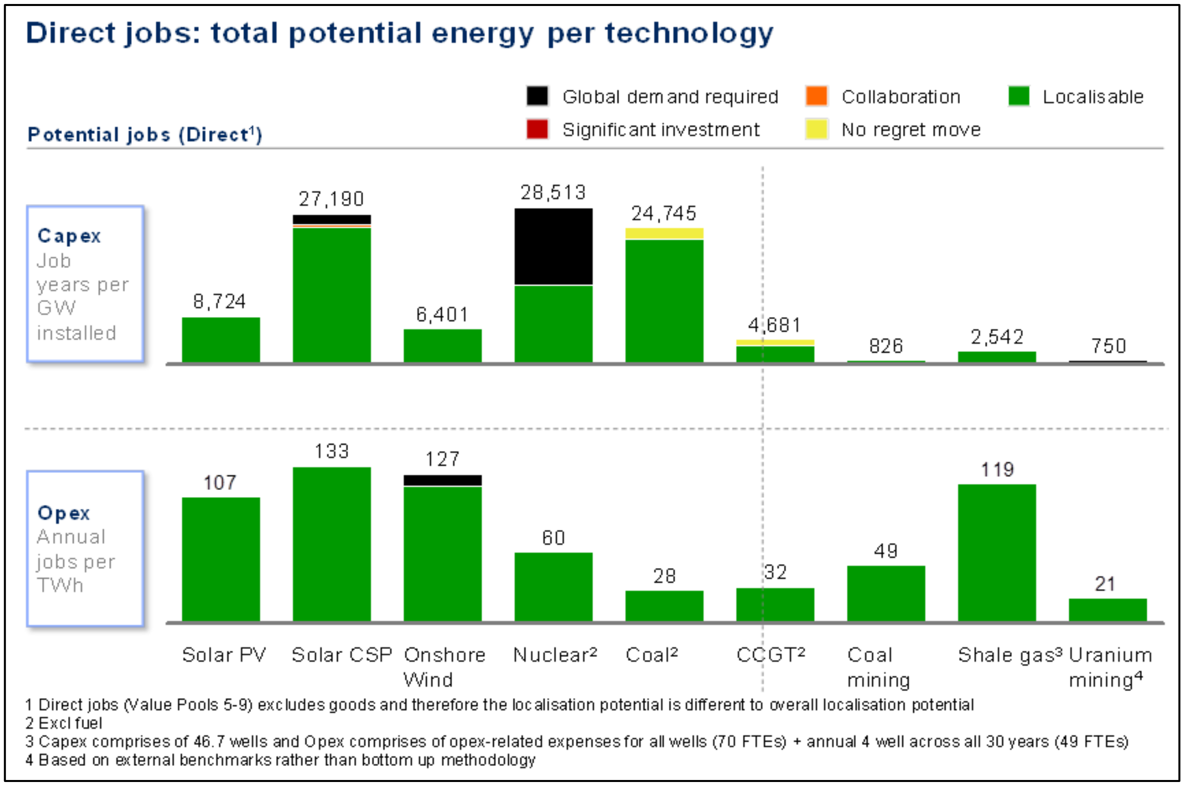


Figure 3-6: Direct Jobs: total potential energy per technology

Source: McKinsey & Company, 2014

Figure 3-7 below shows the total number of supplier job potential for each electricity generation technology and primary energy extraction. Comparison between the direct jobs and supplier jobs is that it is much easier to localise the former than the latter. This is due to direct jobs being created on site and supplier jobs existing where materials and equipment are being manufactured which is almost always not on the construction site.

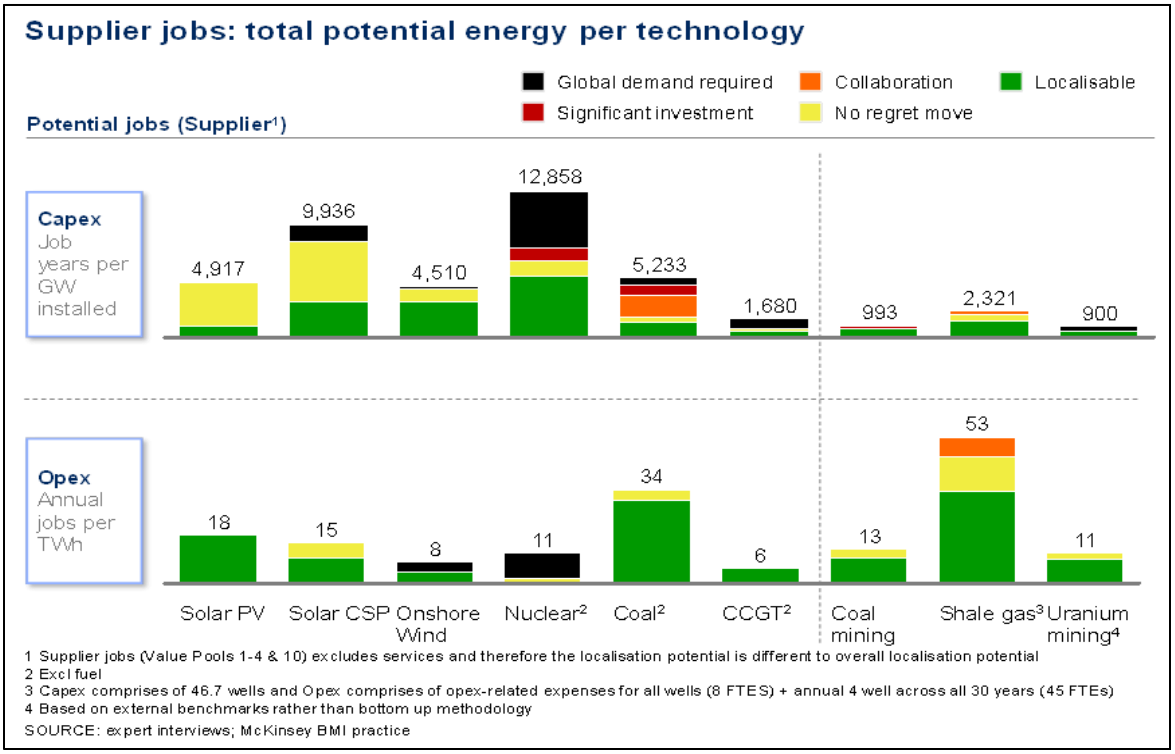


Figure 3-7: Supplier Jobs: Total potential energy per technology

Source: McKinsey & Company, 2014

3.2.4 Job and localisation potential of Indirect and Induced jobs

Indirect jobs are jobs associated with second and third level suppliers during construction and operation of the electricity generation technology; smelters, iron ore miners are some of the examples of such jobs. Induced jobs are as a result of economic activity responding to cash injection associated with the construction or operation of the project and are more supporting jobs in nature; transport services, medical facilities, etc are some of the examples of such jobs.

The methodology for calculating indirect and induced jobs is the top-down methodology that is built on the bottom-up calculations for the direct and supplier jobs. This methodology considers two criteria:

- Detail spend breakdown at a granular level
- Job to job multiplier calculation for each portion of spend

Due to the detailed industry breakdown and the calculation of the value pools, a unique multiplier was created for each technology according to the breakdown of spends across the industry whereas traditionally, for this type of projects construction multiplier derived from industry average will be used as there is an assumption that new builds projects only creates construction workers. These multipliers are then used to calculate the indirect and induced full time employees for each of the electricity generating technologies and extraction of the primary energy.

Figure 3-8 below show the calculated multipliers for the different technologies in which extractive industries of coal mining and shale gas are higher than those for the energy technologies themselves. A multiplier measures how much of an endogenous variable change in response to a change in exogenous variable.

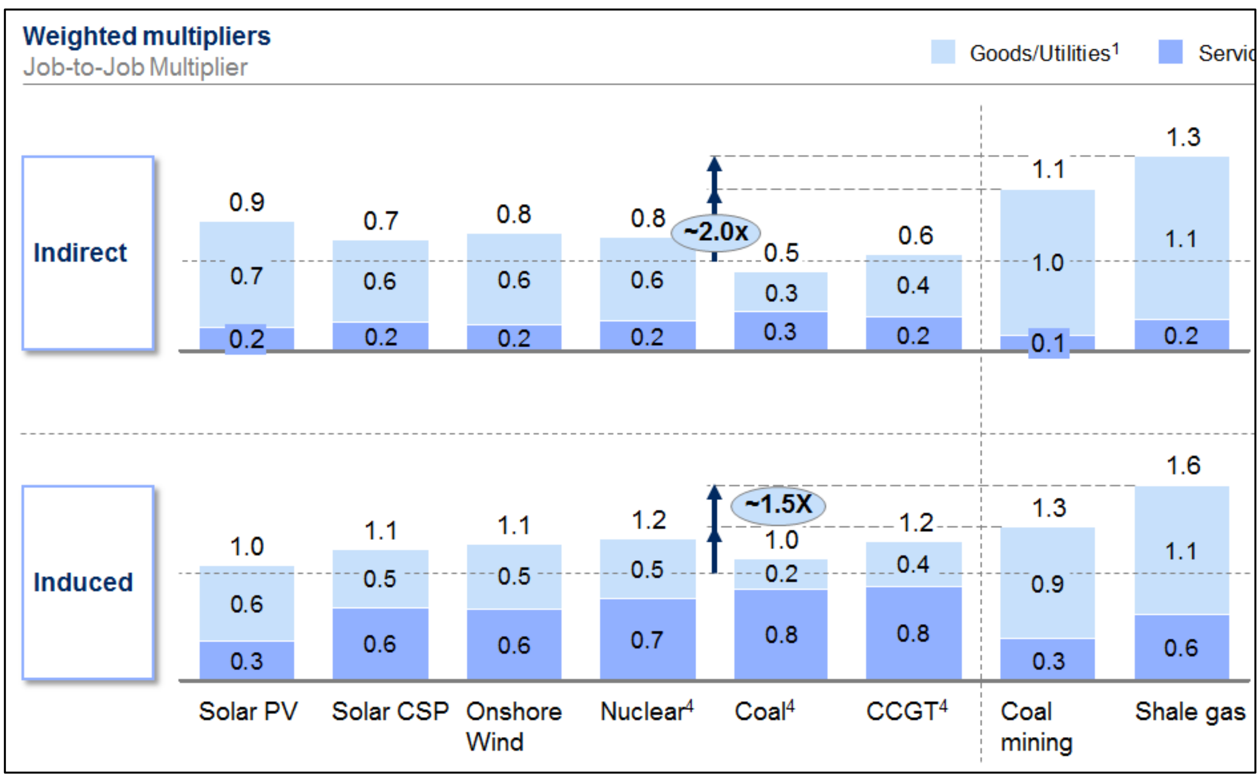


Figure 3-8: Supplier Jobs: Total potential energy per technology

Source: McKinsey & Company, 2014

The indirect and induced job potential is quantified in comparison to the direct and indirect job potential identified. The study used the multipliers adjusted for each different industry

based on breakdown of spends in that industry as well as job multipliers calculated as job-to-job multiplier. To put the job multiplier into perspective, for every one direct job created, an average of 0.84 indirect jobs are created; and for every one indirect job created, an average of 1.18 induced jobs are created. This could mean that there is more job potential through the indirect jobs that direct jobs. Technologies with high job multiplier means there is more indirect and induced job potential in those technologies than others.

To further quantify the localisation potential of the number of indirect and induced jobs created, an assumption was made that if the direct or supplier jobs created are localisable then the derived indirect and induced jobs will also be localisable.

3.3 Potential for Job Creation in the Liquid Fuels Sector

PetroSA commissioned studies to assess the macro-economic impact of possible investment in the petroleum sector particularly the impact of the development of the F-O gas field in Bredasdorp Basin, 40 km south-east of the F-A platform which is currently in use; the development of the Coal to Liquid project at Lephalale in Limpopo Province; and the development of a new crude oil refinery at Coega in Western Cape. The studies were conducted separately to analyse the impact at a macro-economic level for the identified projects, however only the socio-economic issues were extracted from the studies for the purpose of IEP process.

3.3.1 Coal to Liquid (CTL) Plant

The development of the coal to liquid refinery project involves two distinct project, open pit coal mine and gas to liquid plant which will use the coal from the mine to synthetically produce refined petroleum products. The key characteristics of the project are as follows:

- Ability to generate liquid fuels and related products from coal;
- Refinery capacity of approximately 80 000 barrels per day (bpd);
- Prioritize the production of liquid fuels; and
- The syngas to be sold to CTL plant, CCGT and chemical plants.

The study considered two scenarios; Case 1, The Reference Option: the “do-nothing” scenario and Case 2, Recommended Option: to construct a new CTL refinery in Limpopo.

The two options are subjected to the socio-economic valuation with the objective of quantifying the economic costs and benefits of the project.

To determine the impact on job creation potential for the Coal to Liquid plant two models were used: the macro-economic model and Input-Output model.

- Macro-Economic Model

The framework of the econometric model used to generate long term projections for the South African economy portrays, the most important linkages between policy instruments, intermediate targets and performance indicators. Policy instruments include the range of fiscal and monetary policy variables, as well as labour market and foreign trade policy instruments that impact either directly or indirectly on the performance indicators.

- Input-Output Model

The input-output model measures the impact of the CTL plant, to the model utilises the forecast and assumptions made in the macro-econometric model as inputs for the input-output model. This model gives the direct, indirect, induces and economy-wide impacts of the CTL project on the South African economy.

3.3.1.1 Jobs creation potential of the construction and operational phase of the open pit coal mine

The job creation potential of the CTL was analysed through two distinctive projects, the open pit coal mine and the GTL facility. The report did not include the jobs associated with conversion of coal to syngas process but only the extraction of the feedstock and the GTL facility jobs. During the construction phase of the open pit mine, an average of 2 202 highly skilled labourers will be required, followed by 7 439 skilled labourers and 10 526 semi-skilled labourers per year, however many of these jobs will not be permanent. Unskilled labourers will also be required although they are not quantified. Potential employment during the operational phase will require 2 291 highly skilled labourers, 8 080 skilled labourers and 10 963 semi- and unskilled labourers. A total employment requirement could be around 27 032. Figure 3-9 below depicts the total job creation potential of the CTL.

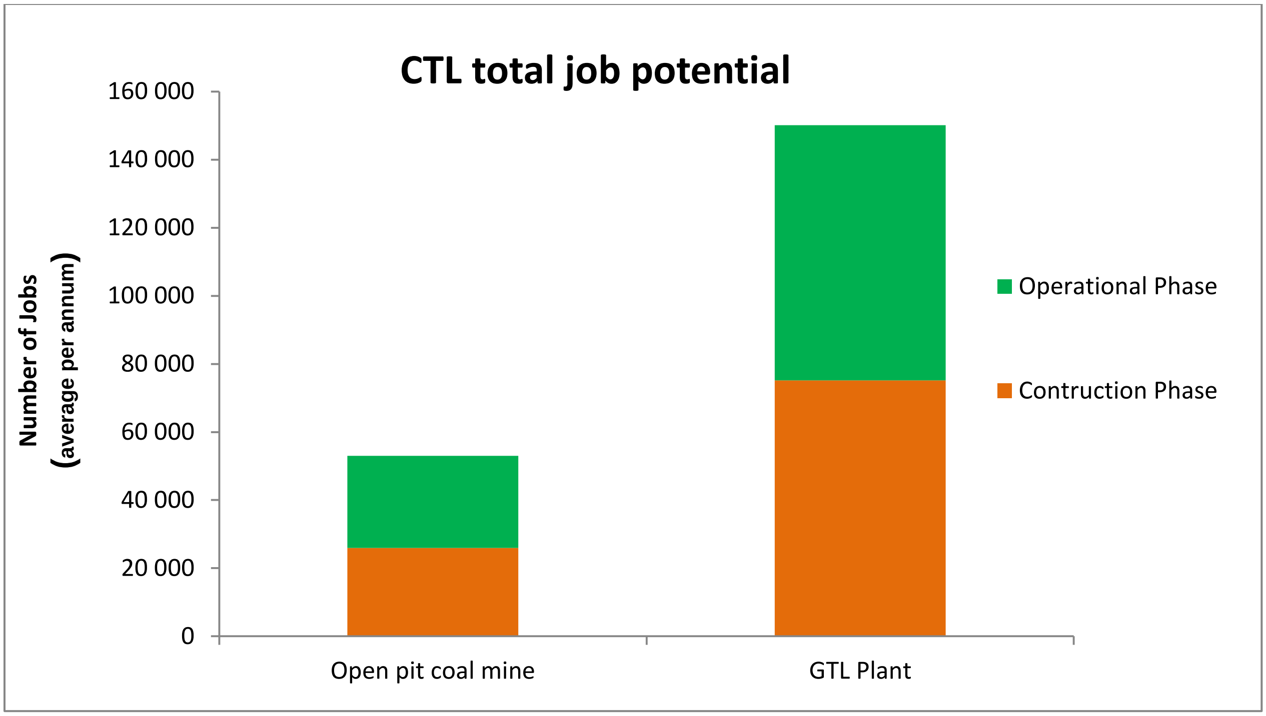


Figure 3-9: Total Job creation potential of a CTL plant

Source: PetroSA, 2010

3.3.1.2 Job creation potential of the construction and operational phase of a coal to liquid plant (CTL) petroleum plant construction and operational phase

During the construction phase of the coal to liquid plant, the following are the average job potential identified: 6 365 highly skilled labourers, 21 504 skilled labourers and 30 428 semi- and unskilled labourers. The employment requirement during the operational phase will be 6 920 highly skilled people per year. A further 23 405 skilled workers will be required with 29 627 semi- and unskilled workers. In total, there is job potential of 203 028 labourers (open pit mine and the CTL) if the CTL plant was to be developed, although some will not be permanent jobs.

3.3.2 Gas to Liquid (GTL) Plant

PetroSA conducted a study on brown field GTL refinery located in Mosselbay. For the Brownfield GTL refinery, the job creation potential numbers do not give a true reflection for a construction of a new GTL. Therefore this numbers are not considered in the IEP process. For the CTL plant the study provides assumptions for the GTL facility and nothing for the conversion of coal to syngas process. It was recommended by PetroSA that the job

potential numbers of the GTL facility in the CTL be used for a Greenfield GTL plant by removing the impact of the coal supply portion of the project. Figure 3-10 below shows the total job creation potential of the GTL plant, both the development and operational phase of the project.

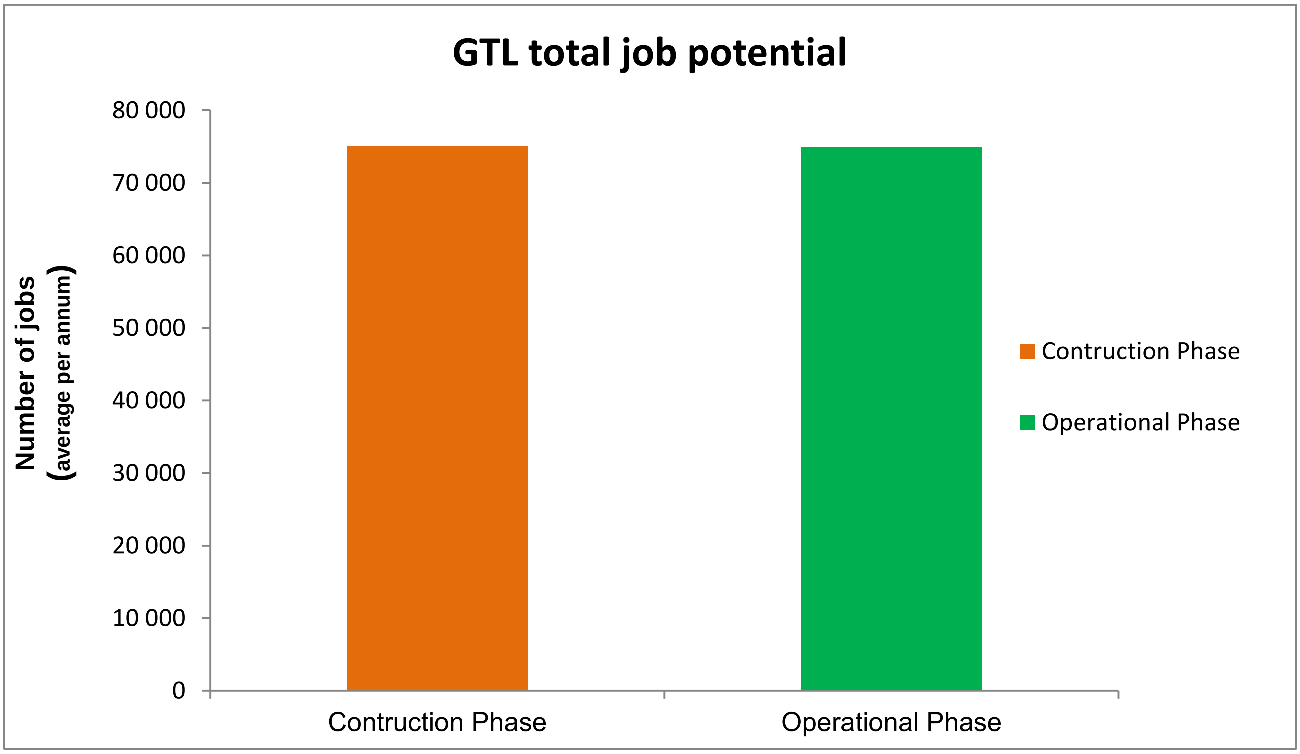


Figure 3-10: Total job creation potential of a GTL

Source: PetroSA, 2010

3.3.3 Crude Oil Refinery

The development of a new crude oil refinery in Coega, Eastern Cape, South Africa. The key characteristics of the proposed project are as follows:

- Ability to process both sweet and heavy sour crude oil;
- Refinery capacity of approximately 385 000 barrels per day (bpd);
- Prioritise the production of diesel;
- Initial excess to West and East Cape demand will be shipped to the inland market via Durban or exported; and
- Project to exclude petrochemical complex.

Two scenarios were considered for the crude oil refinery study, Case 1, the Reference Option: the “do-nothing” scenario, and Case 2: the Recommended Option: To construct a new crude oil refinery at Coega, in the Eastern Cape. The two cases are subjected to the socio-economic valuation with the objective of quantifying the economic costs and benefits of the project.

To analyse the macro-economic impact assessment of a new crude oil refinery in South Africa, the same methodology used for the impact analysis of the coal to liquid and the gas to liquid projects is also used for the crude oil refinery project.

3.3.3.1 Job creation potential of the construction and operational phase of a crude oil refinery

Construction phase: The job creation potential identified annually per skill during the development phase of the new crude oil refinery is as follows: 7 554 highly skilled labourers, 25 521 skilled labourers and 36 112 semi- and unskilled labourers which also implies that the highly skilled labourers contributes 11% of the total job pool, 52% is the semi- and unskilled labourers. During the operational phase, the project will require around 8 591 highly skilled labourers, of which the company would most likely employ 500 of those; 29 424 skilled labourers; and 36 572 semi- and unskilled labourers per. Figure 3-11 shows the total job creation potential of the crude oil refinery.

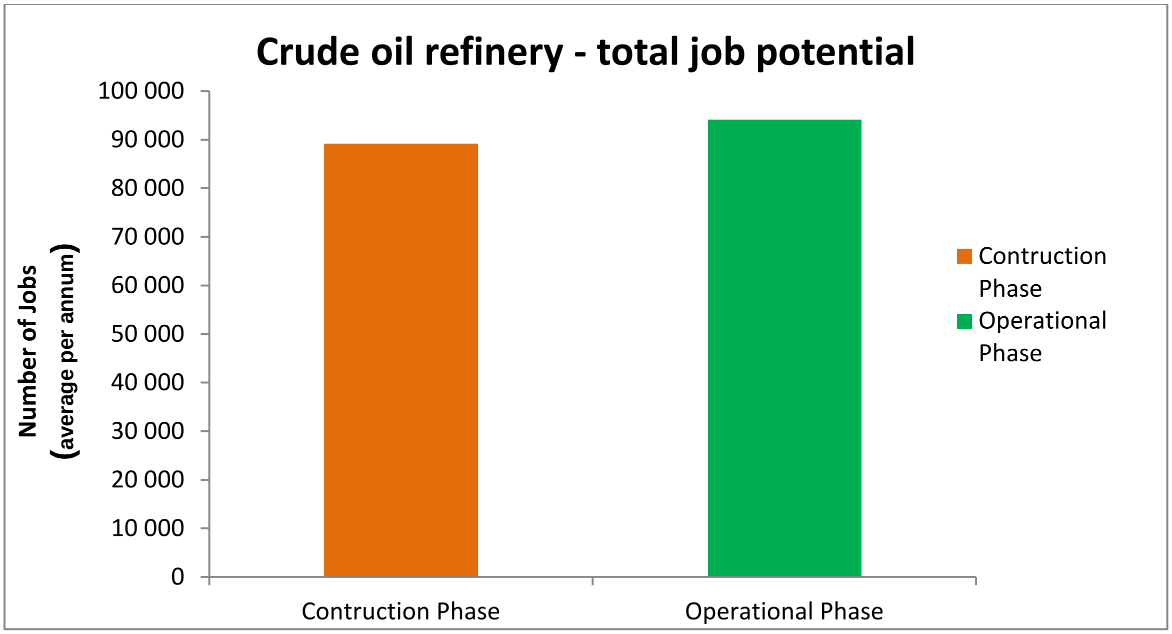


Figure 3-11: Job creation potential of a new crude oil refinery

Source: PetroSA, 2010