DEPARTMENT OF ENERGY

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REPUBLIC OF SOUTH AFRICA

INTEGRATED RESOURCE PLAN UPDATE

ASSUMPTIONS, BASE CASE RESULTS AND OBSERVATIONS

OCTOBER 2016

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1. BACKGROUND

The Integrated Resource Plan (IRP) 2010-30 was promulgated in March 2011. It was indicated at the time that the IRP should be a "living plan" which would continue to be revised by the Department of Energy (DoE).

One of the criticisms of the IRP 2010-30 was that it was developed without an appropriate overarching energy plan which considers the interactions with other energy carriers. The planning activities in the DoE in the last few years have therefore focused on producing the Integrated Energy Plan (IEP). Building on the IEP, the IRP update will focus on the electricity-related elements of the IEP.

This report covers the following:

- It describes the process followed in updating the key assumptions since the IRP2010
- It details the actual key assumptions, including technology costs, technical parameters, macroeconomic assumptions, policy constraints and targets
- It highlights some of the key results and observations from the Base Case
- It provides a draft list of scenarios that will be analysed
- It also outlines the planned way forward towards finalising the IRP

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2. THE IRP UPDATE PROCESS

The IRP 2010-30 identified the preferred generation technology mix required to meet expected demand growth up to 2030. The policy adjusted IRP incorporated a number of government objectives, including affordable electricity, carbon mitigation, reduced water consumption, localisation and regional development, producing a balanced strategy toward diversified electricity generation sources and gradual decarbonisation of the electricity sector in South Africa.

Over the past few years, progress has been made in executing the programmes identified in the promulgated IRP 2010-30. A number of Ministerial Determinations were issued and these include new capacity in renewable energy, nuclear, coal and gas. In addition to Medupi, Kusile and Ingula which are currently under construction, the Department of Energy, through the Independent Power Producer programme, has procured over 6GW of renewable energy.

While the IRP 2010-30 remains the official government plan for new generation capacity until it is replaced by an updated plan, there are a number of assumptions that have changed and these include:

- The changed landscape over the past years, in particular in electricity demand and the underlying relationship with economic growth;
- New developments in technology and fuel options (locally and globally);
- Scenarios for carbon mitigation strategies and the impact on electricity supply up to 2050; and
- The affordability of electricity and its impact on demand and supply.

The IRP update process, as depicted in Figure 1 takes the following approach:

1. Developing a credible Base Case from the IRP 2010 by updating the underlying assumptions based on new information;

2. Considering different scenarios or test cases based on alternative government policies or strategies and differences in future economic and resource terrains. Information from these scenarios will be used to inform the policy adjustment phase of the IRP; and

3. The development of a proposed path of least regret, incorporating the benefits of flexibility by developing decision trees to indicate decisions needed before the next update.

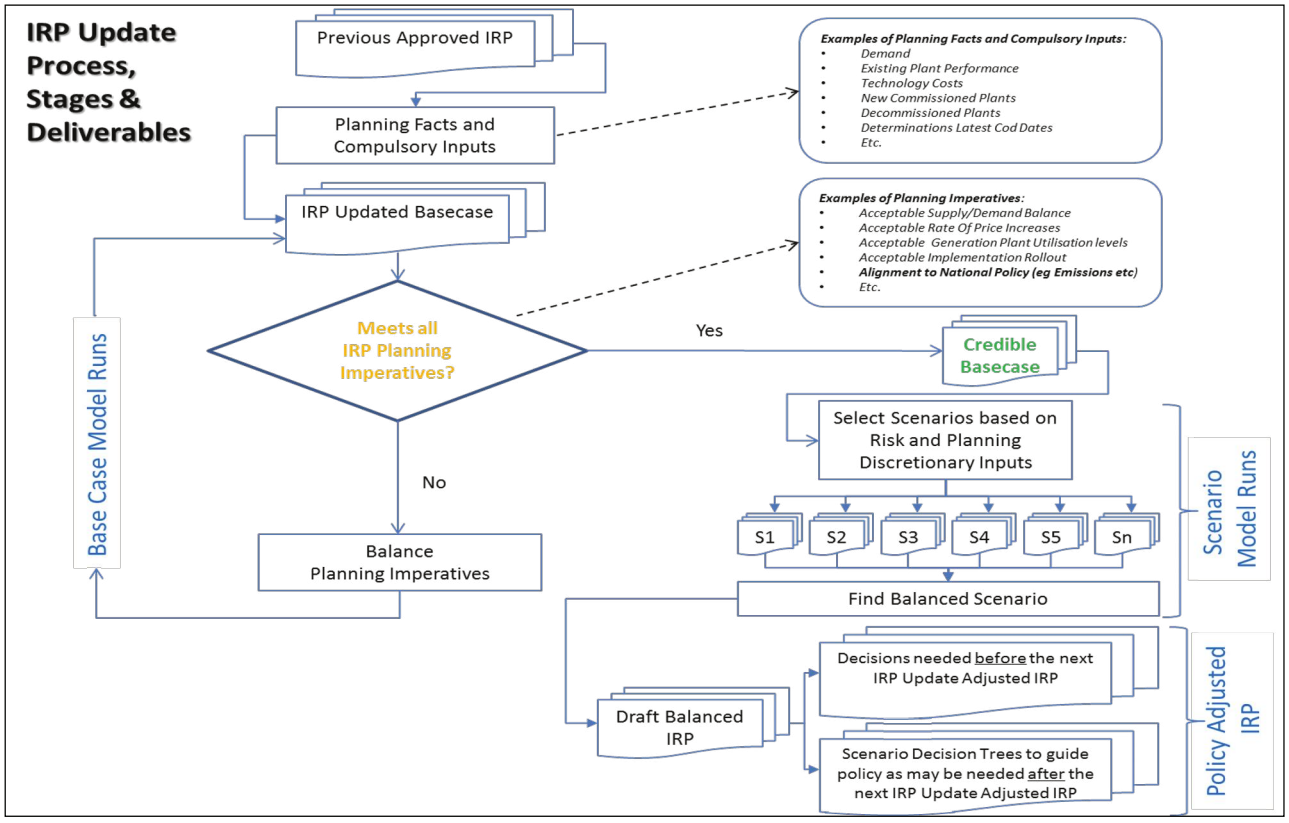

Figure 1: The IRP Update Process

Progress on the current IRP update is as follows:

Table 1: IRP Update Progress

Activity	Status	Comments
Assumptions	Complete	Government Departments were consulted in December 2015 and in August 2016 and inputs received are being considered. External stakeholders consultation workshops will be held early December 2016 and in January 2017.
Base Case	Complete	This is subject to change based on comments received on the assumptions.
Scenarios	In Progress	This is also subject to the changes based on comments received on the assumptions. Additional scenarios may need to be included following external stakeholder consultations
Policy Adjusted IRP	Not yet started	This will follow once the scenarios and public consultation is completed

3. ASSUMPTIONS

Key in the IRP development or update process are the assumptions. Key assumptions that have changed include technology costs, electricity demand projections new installed capacity and existing plant performance.

3.1 Technology Options and Costs

The costs for generic technologies used in the IRP 2010-30 were based on the July 2010 report by the Electric Power Research Institute (EPRI). EPRI is a US based independent and non-profit organisation that conducts research and development relating to the generation, delivery and use of electricity.

In the IRP 2010-30 development, the generic technology data from EPRI was used for all options, except for solar photovoltaic generation which was provided by the Boston Consulting Group in their report ("Outlook on Solar PV"); sugar bagasse generation (provided by the sugar industry as part of the public hearings); pumped storage costs (provided by Eskom) and the regional hydro, gas and coal options (which were based on data compiled in previous Southern African Power Pool plans).

At the request of DoE through Eskom, EPRI has developed an updated report on generic technologies with the latest version of the report released in September 2016. Detailed EPRI report is available on the DoE website. For photovoltaic and wind technologies, the data was obtained from the DoE IPP Office and is based on the Renewable Energy bid window 4. For sugar bagasse and regional options the 2010, costs are used but inflated with South African consumer inflations rates, while Eskom has provided an updated view of the pumped storage costs.

A hybrid cost is used for Nuclear technology based on the study commissioned by the DoE Nuclear Branch. The report considers projects in Asia over and above the United States and Europe which are the only two regions considered in the EPRI report.

3.2 Expected Demand

Unlike in the IRP 2010-30 which considered the CSIR as well as the Eskom demand forecast, the IRP Update Base Case uses only one forecast which is the forecast developed by the CSIR. The forecast has been agreed upon by both Eskom and the CSIR and accepted by the DoE.

The CSIR develops the annual energy forecast and Eskom uses this forecast to develop the hourly profiles and the annual peak forecast. The energy demand

forecast is shown in Figure 2 below. Report detailing the approach followed in compiling the forecast can be found on the DoE website.

The IRP update uses the High (less energy intense) forecast.

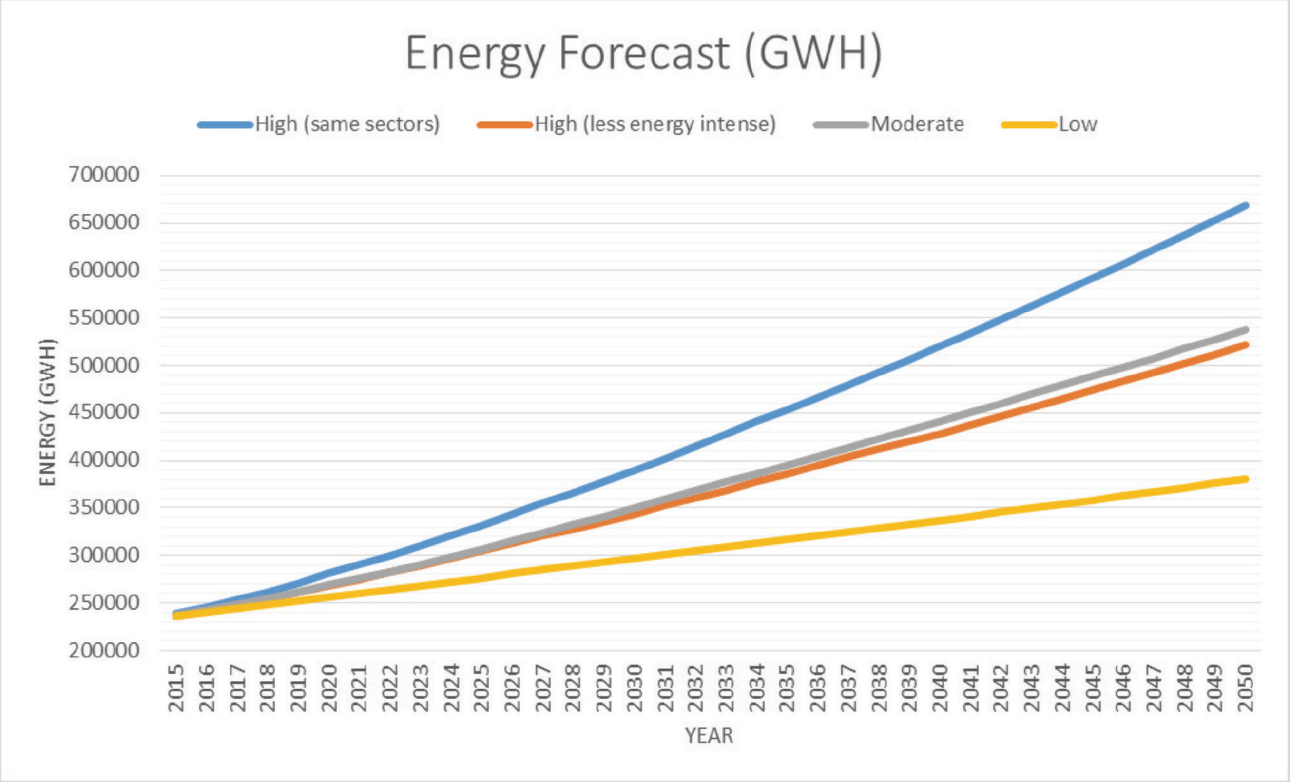

Figure 2: Demand Forecast

3.3 Eskom Plant Performance

The IRP 2010-30 assumed the existing Eskom fleet to have an average availability of 86%, however actual performance has in the recent past declined to less than 70% availability.

Eskom has adopted a new operation and maintenance strategy which has seen the plant performance improve significantly. Eskom has provided the envisaged plant performance and is reflected in Figure 3 below. Plant performance projections depicts Eskom's aspirational position that quickly restores the plant performance. High plant performance is based on the Eskom Design to Cost methodology aspirations, Medium plant performance is based on what Eskom has compacted on with the Department of Public Enterprises and Low plant performance is based on statistical extrapolation of the actual plant performance data.

The moderate plant performance is used in the IRP update Base Case.

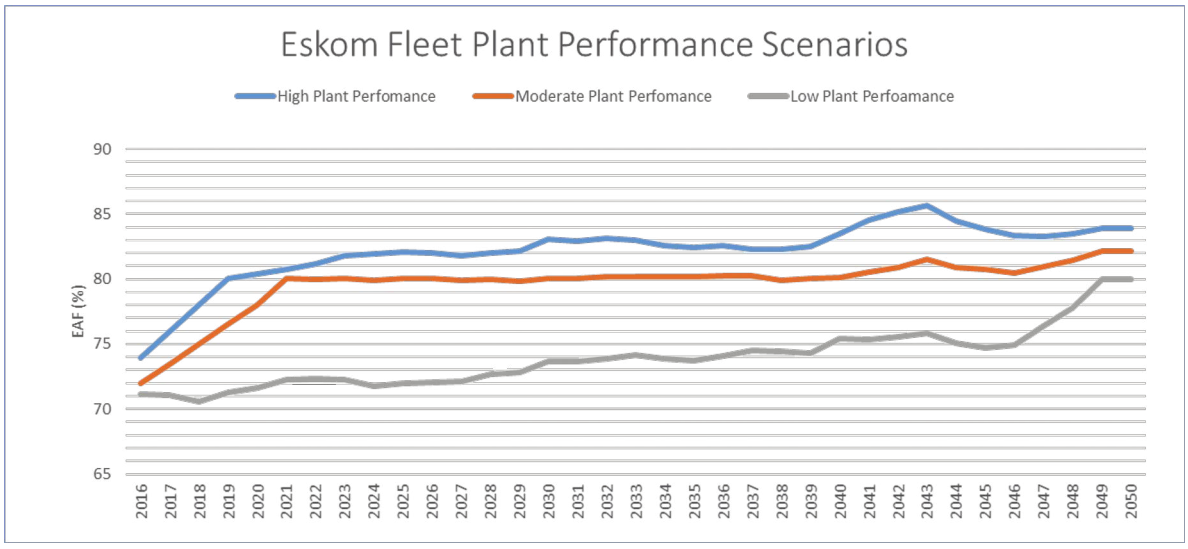

Figure 3: Eskom existing fleet plant performance

3.4 Eskom Plant Life

The current plant life of the existing Eskom generation fleet includes requirements to comply with the national Air Quality act requirements. Eskom, in agreement with the Department of Environmental Affairs, has in place a plan to get all plants to comply within a set period of time. This is indicated in Figure 4 below.

Figure 4 also indicates the 50 – year life decommissioning of units for the various Eskom plants.

The complete schedule of decommissioning dates for all other Eskom plants as well as non-Eskom plants is included in the document titled “Additional Assumptions” which can be found on the DoE website (IRP Annexure C).

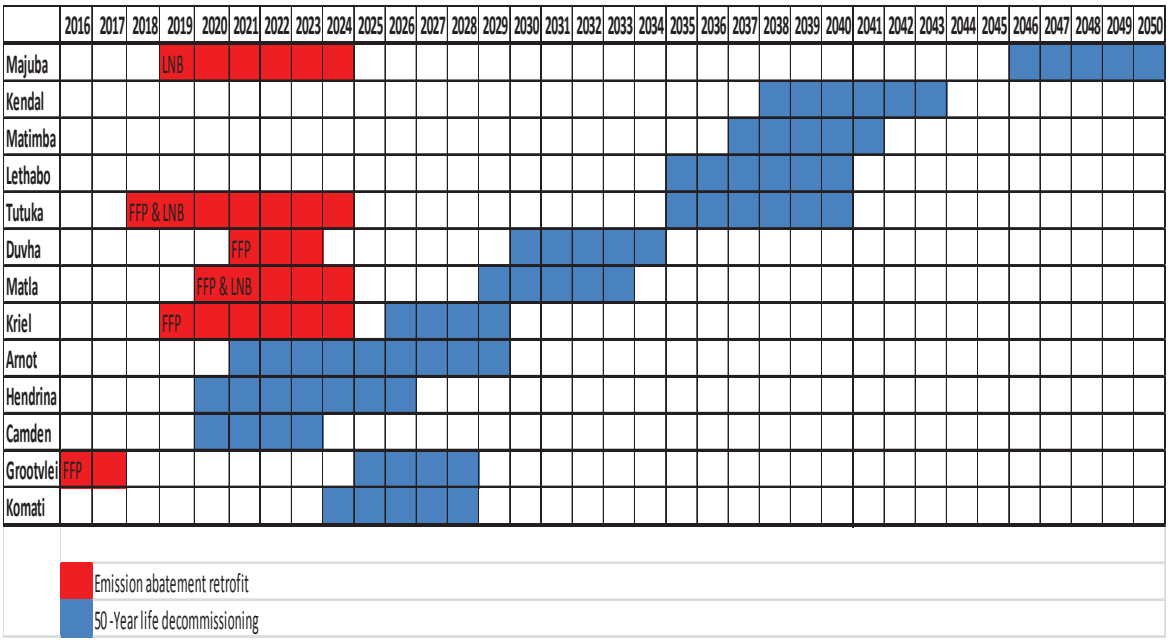

Figure 4: Eskom fleet air quality retrofit plan and 50-Year life decommissioning

3.5 Learning Rates

The learning rates adopted in IRP 2010-30 are maintained in this review with PV and Wind learning rates adjusted to reflect the quick fall in prices experienced in South Africa and are reflected in Table 2. This is currently being reviewed following comments already received from an internal government consultation process.

Table 2: technology Learning Rates

Technology	2015 (R/kW)	2050 (R/KW)
PV (fixed tilt)	16860.6	13425.03408
PV (tracking)	17860.6	14221.26959
Wind	19208.1	17287.405
Nuclear	55260	53768.80047

3.6 Greenhouse Gas Emissions Trajectory

In line with government policy to reduce greenhouse gas emissions, the IRP update uses the moderate decline constraint for greenhouse gas emissions. This is subject to change following recent correspondence received from Department of Environmental Affairs indicating that carbon budget methodology must be used instead of emissions decline constraints.

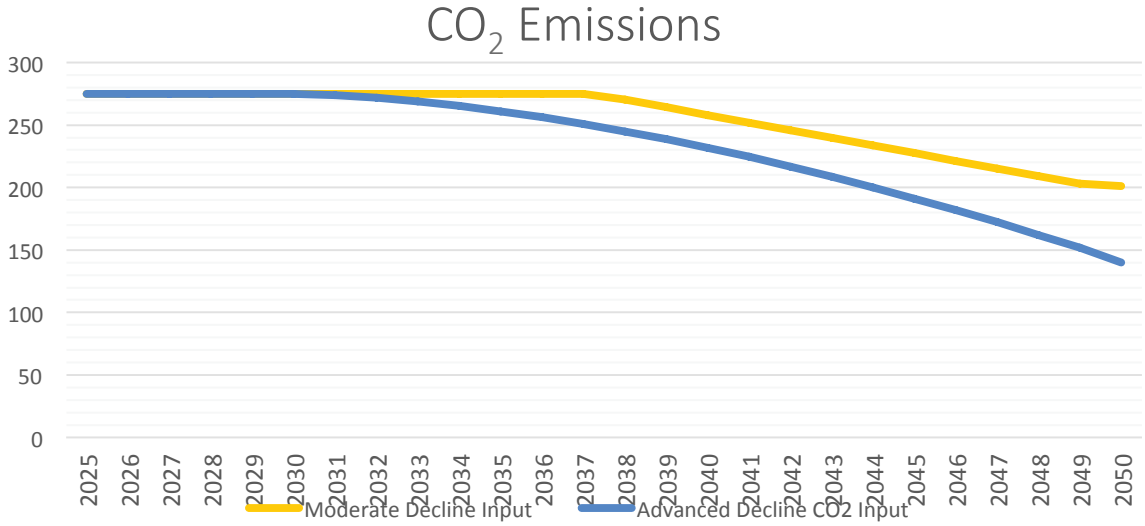

Figure 5: GHG Emission Decline annual constraints

3.7 Discount Rate

The 2010 IRP used a social discount rate of 8.4% but this has since been revised by National Treasury to 8.2%. Detailed presentation in this regard is available on the DoE website.

3.8 Other Assumptions

Details on other additional assumptions used in the modelling and analysis of the base such as the exchange rate, primary fuel costs etc. can be found on the DoE website.

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4. RESULTS AND OBSERVATIONS FROM THE BASE CASE

The Base Case is produced by updating the IRP model with the latest assumptions.

The new generation capacities called for in the Ministerial Determinations that are not yet committed (no procurement has started) are allowed to lapse. This means that only procurement up to bid window 4.5 for renewables (expedited including smalls) and coal 900MW are considered committed.

The Base Case maintains a number of policy positions imposed in the IRP 2010-30 in particular an annual build limit of new capacity for wind (1600 MW) and photovoltaic (1000 MW).

4.1 High Level Results from the Base Case

Figure 6 shows percentage share of installed capacity (MW) per technology for the periods 2016, 2020, 2030, 2040 and 2050.

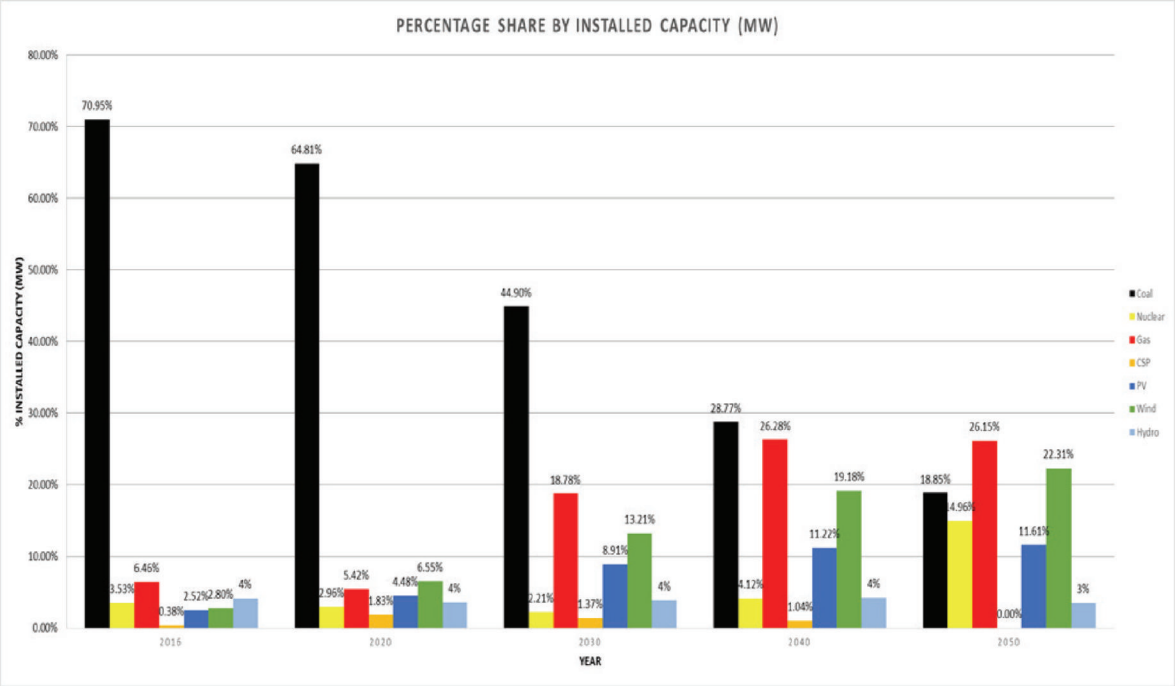


Figure 6: Percentage Share by Installed Capacity (MW)

It is important to note that due to different technologies load factors (operating pattern), the projected technologies contribution to the energy mix is as indicated in Figure 7 . Higher installed capacity does not necessarily imply higher contribution towards the electricity generation energy mix.

As an example, it can be seen that higher share of installed capacity from Gas and Renewables (Figure 6) in year 2050 does not necessarily translate to higher share of contribution to the energy mix (Figure 7) in 2050. Even though the share of Coal capacity has significantly decreased (Figure 6), Coal and Nuclear contribute the most to the energy supply and hence the Base Case is the least cost case. The coal and nuclear technologies are considered base load options with load factors in the regions above 85% while Gas technology is considered mid-merit (CCGT) or peaking (OCGT) with load factors between 30% and 5% respectively.

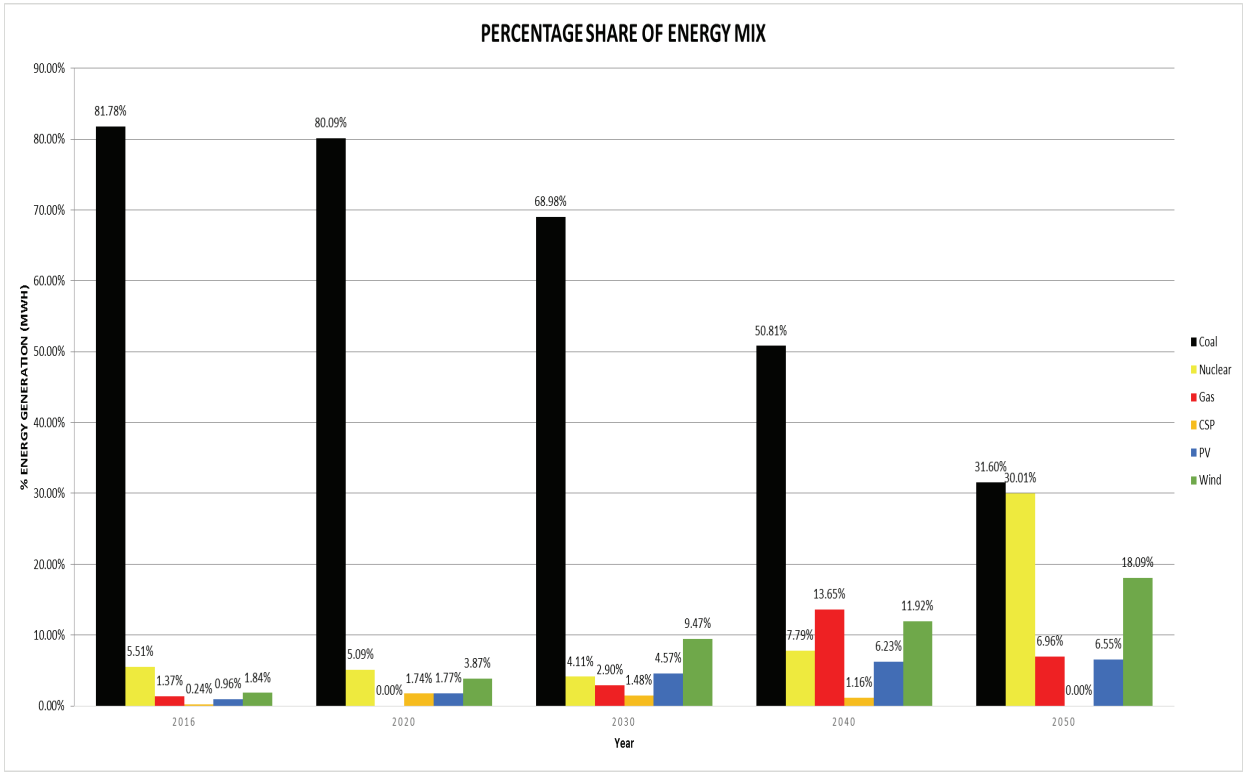
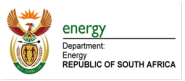


Figure 7: Percentage share towards Electricity Energy Mix (MWh)

4.2 Pace and Scale of New Capacity Rollout

Table 3 below shows a snapshot of the updated Base Case results with the timing of when capacity comes online. The following observations can be made on the Base Case:

- Based on least cost and moderate emissions reduction trajectory, the model results indicates, 18GW of PV, 37GW of Wind, 20GW of Nuclear, 34GW of Gas, 2500 of Hydro, 15GW of Coal by end of the study horison (year 2050);



- Looking at same study period used in the promulgated IRP 2010-30, the model results indicate 4.7GW of PV ,6.4GW of Wind, 12.7GW of Gas and 5.3GW of Coal by year 2030;
- The first unit of Nuclear appears around year 2037, but this is sensitive to other technology primary fuel costs and their associated emission assumptions. These will be tested as a scenario as indicated in the next section.
- The 2030 figures in the Base Case are different from those in the IRP 2010-30 because they exclude the capacity already procured/under procurement (6.2GW of renewable energy as well as 900MW of coal). The figures are also different because adjustment based on scenario analysis and policy has not been done.
- Following the point above, it is evident that the pace and scale of Ministerial Determinations issued to date will be impacted and will have to be looked at in more detail.

Table 3: Output from the IRP Update Base Case

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		Base Case8.2% Dicount rate										
	New Build Options											
	PV	Wind	LandfillGas	DR	Nuclear	OCGT	CCGT	Coal PF w FGD	Inga	CO2 Emissions	Peak Demand (MW)	Firm Reserve Margins (%)
2016												
2017												
2018												
2019												
2020										253	44916	24
2021	160									264	46130	28
2022	160									268	47336	23
2023	370	200								272	48547	20
2024	440	500		1000		396				279	49656	18
2025	650	1000	15	1000		2376	732			278	51015	19
2026	580	1000	5	1000		264	1464			278	52307	19
2027	580	1000	230	1000		264	2196			276	53561	19
2028	580	1000		500		396	1464	1500		277	54567	20
2029	580	1100		1000			1464	1500		273	56009	18
2030	580	1200		1000		1716		2250	1000	274	57274	20
2031	580	1200		1000		1584		750		274	58630	20
2032	580	1000		500			732	1500	1000	278	59878	22
2033	580	1200					1464	750	500	276	61388	23
2034	580	1600		1000		1452				278	62799	22
2035	580	1600		500			1464	1500		278	64169	23
2036	580	1600		1000				1500		278	65419	21
2037	580	1400		500	1359		732	2250		277	66993	22
2038	580	1600				1848	1464	750		273	68375	22
2039	650	1500			1359		2928			267	69584	22
2040	650	1600		1000		1056	732			261	70777	20
2041	650	1600		1000	4077	792		750		236	72343	21
2042	650	1600		500			2196			233	73800	21
2043	650	1600		500						232	75245	21
2044	650	1800		500	1359					228	76565	21
2045	770	1600			2718		2196			230	78263	23
2046	790	1600		500	1359	924				225	79716	20
2047	720	1800		1000	1359		732			219	81177	19
2048	720	1600		500	2718	264				211	82509	20
2049	660	1500		500	1359					206	84213	20
2050	720	1400		500	2718					196	85804	20
Total (MW	17600	37400	250	500	20385	13332	21960	15000	2500			

5. SCENARIOS TO BE CONSIDERED

The DoE is currently modelling and simulating a number of scenarios which will be used to inform the policy adjustment phase of the IRP. These scenarios include but are not limited to:

- Greenhouse Gas Emissions Constraints (Advanced decline, Carbon budget)

- Primary Fuel tipping point (Coal, Gas and Nuclear)
- Demand trajectories (Low)
- Embedded Generation / Rooftop PV penetration study
- Renewable Energy Annual Cap Removal
- Additional Energy Efficiency
- Eskom Plant performance (Low)
- Regional options
- Eskom Plant Life extension

Sensitivity studies will also be conducted on :

- Primary energy prices;
- Learning rates (No learning, Battery storage with learning)

6. WAY FORWARD

The following are the proposed next steps:

	ACTIVITY	WHEN
i.	Continue inter-departmental consultation platform	Ongoing
ii.	Public consultation at various platforms including NEDLAC , Provincial road shows etc. in respect of: a. Assumptions (demand, technology costs) b. Demand c. Scenarios	By end January 2017
iii.	Collation and consolidation of public inputs	February 2017
iv.	Incorporation of stakeholder comments into the IRP	February 2017
v.	Policy adjustment	March 2017
vi.	Promulgation of final IRP	

7. IRP ANNEXURES (to be found at www.energy.gov.za)

7.1 EPRI Report (Technology Costs)

7.2 Demand Forecast

7.3 Technology Learning Rates

7.4 Discount Rate Presentation

7.5 Additional Assumptions Report