INTEGRATED RESOURCE PLAN FOR ELECTRICITY
(IRP)
2010-2030

UPDATE
REPORT
2013

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ABBREVIATIONS

CCGT	Closed Cycle Gas Turbine
CO_2	Carbon Dioxide
COUE	Cost of Unserved Energy
CSIR	Council for Scientific and Industrial Research
CSP	Concentrating Solar Power
DoE	Department of Energy
DSM	Demand Side Management
EEDSM	Energy Efficiency Demand Side Management
EBLS	Expensive Base Load Station
EPRI	Electric Power Research Institute
FBC	Fluidised Bed Combustion
FGD	Flue Gas Desulphurisation
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GJ	Gigajoules
GLF	Gross Load Factor
GW	Gigawatt (One thousand Megawatts)
GWh	Gigawatt hour
IGCC	Integrated Gasification Combined Cycle
IMC	Inter-Ministerial Committee on energy
IPP	Independent Power Producer
IRP	Integrated Resource Plan
kW	Kilowatt (One thousandth of a Megawatt)
kWp	Kilowatt-Peak (for Photovoltaic options)
LNG	Liquefied Natural Gas
LTMS	Long Term Mitigation Strategy
MCDM	Multi-criteria Decision Making
MTO	Medium Term Outlook
MTPPP	Medium Term Power Purchase Programme
MW	Megawatt
MWh	Megawatt hour
MYPD	Multi-Year Price Determination
NERSA	National Energy Regulator of South Africa; alternatively the Regulator
NOx	Nitrogen Oxide
OCGT	Open Cycle Gas Turbine
O&M	Operating and Maintenance (cost)
PF	Pulverised Fuel
PPD	Peak-Plateau-Decline
PV	Present Value; alternatively Photo-Voltaic
RAB	Regulatory Asset Base
RTS	Return to Service
SOx	Sulphur Oxide
TW	Terawatt (One million Megawatts)
TWh	Terawatt hour
UE	Unserved Energy

GLOSSARY

“Base-load plant” refers to energy plant or power stations that are able to produce energy at a constant, or near constant, rate, i.e. power stations with high capacity factors.

“Capacity factor” refers to the expected output of the plant over a specific time period as a ratio of the output if the plant operated at full rated capacity for the same time period.

“**Comparative Prices”** refer to calculated prices that can be used only to compare outcomes arising from changes to input assumptions, scenarios or test cases. These prices do not indicate what future prices may be (indicative prices).

“Cost of Unserved Energy” refers to the opportunity cost to electricity consumers (and the economy) from electricity supply interruptions.

“Demand Side” refers to the demand for, or consumption of, electricity.

“Demand Side Management” refers to interventions to reduce energy consumption.

“Discount rate” refers to the factor used in present value calculations that indicates the time value of money, thereby equating current and future costs.

“Energy efficiency” refers to the effective use of energy to produce a given output (in a production environment) or service (from a consumer point of view), i.e. a more energy-efficient technology is one that produces the same service or output with less energy input.

“Gross Domestic Product” refers to the total value added from all economic activity in the country, i.e. total value of goods and services produced.

“Integrated Resource Plan” refers to the co-ordinated schedule for generation expansion and demand-side intervention programmes, taking into consideration multiple criteria to meet electricity demand.

“Integrated Energy Plan” refers to the over-arching co-ordinated energy plan combining the constraints and capabilities of alternative energy carriers to meet the country’s energy needs.

“Levelised cost of energy” refers to the discounted total cost of a technology option or project over its economic life, divided by the total discounted output from the technology option or project over that same period, i.e. the levelised cost of energy provides an indication of the discounted average cost relating to a technology option or project.

“Peaking plant” refers to energy plant or power stations that have very low capacity factors, i.e. generally produce energy for limited periods, specifically during peak demand periods, with storage that supports energy on demand.

“Policy” refers to an option that when implemented is assured will achieve a particular objective.

“Present value” refers to the present worth of a stream of expenses appropriately discounted by the discount rate.

“Reserve margin” refers to the excess capacity available to serve load during the annual peak.

“Scenario” refers to a particular set of assumptions and set of future circumstances, providing a mechanism to observe outcomes from these circumstances.

“Sensitivity” refers to the rate of change in the model output relative to a change in inputs, with sensitivity analysis considering the impact of changes in key assumptions on the model outputs.

“Steps” refers to the gradual change in assumptions, specifically in those adopted in IRP 2010 and the effect these changes have on model outputs.

"Strategy" is used synonymously with Policy, referring to decisions that, if implemented, assume specific objectives will be achieved.

"Supply side" refers to the production, generation or supply of electricity.

"Test case" refers to a mechanism to test the impact of certain input assumptions or forced output requirements on the model outcomes.

SUMMARY

Since the promulgation of the Integrated Resource Plan (IRP) 2010-30 there have been a number of developments in the energy sector in South and Southern Africa. In addition the electricity demand outlook has changed markedly from that expected in 2010.

A revised economic and electricity sector outlook has been developed to inform decisions required in the lead-up to a new iteration of the IRP (which will also be influenced by the approved Integrated Energy Plan) expected in 2014. The demand in 2030 is now projected to be in the range of 345- 416 TWh as opposed to 454 TWh expected in the policy-adjusted IRP. From a peak demand perspective this means a reduction from 67800 MW to 61200 MW (on the upper end of the range), with the consequence that at least 6600 MW less capacity is required (in terms of reliable generating capacity).

The Update considers the aspirational economic growth suggested by the National Development Plan in order to reduce unemployment and alleviate poverty in South Africa. This growth rate (an average of 5,4% per year until 2030) is also aligned with a shift in economic development away from energy-intensive industries which is assumed to dramatically reduce the electricity intensity of the economy allowing the growth rate to have a less imposing impact on electricity demand to 2030 and beyond. It should also be noted that this is an aspirational objective and the reality is that demand may not reach the levels required (especially not in the next five years) which raises the risk of overbuilding generation capacity to meet the target.

Apart from the uncertainty regarding the future demand there are additional variables in the energy sector, specifically the potential for shale gas, the extent of other gas developments in the region, the global agenda to combat climate change and the resulting mitigation requirements on South Africa, as well as the uncertainty in the cost of nuclear capacity and future fuel costs (specifically coal and gas), including fuel availability. All these uncertainties suggest that an alternative to a fixed capacity plan (as espoused in the IRP 2010) is a more flexible approach taking into account the different outcomes based on changing assumptions (and scenarios) and looking at the determinants required in making key investment decisions.

The Update considers determinants at the turning-points for the investment decisions and provides recommendations on which investment should be pursued under different conditions when they arise. In the shorter term (of the next two to three years) there are clear guidelines arising from the scenarios, specifically:

- The nuclear decision can possibly be delayed. The revised demand projections suggest that no new nuclear base-load capacity is required until after 2025 (and for lower demand not until at earliest 2035) and that there are alternative options, such as regional hydro, that can fulfil the requirement and allow further exploration of the shale gas potential before prematurely committing to a technology that may be redundant if the electricity demand expectations do not materialise;

- Procurement for a new set of fluidised bed combustion coal generation should be launched for a total of 1000-1500 MW capacity (as a preferable implementation of the “Coal 3” programme). It is recommended that these should be based on discard coal;

- Regional hydro projects in Mozambique and Zambia are realised including the infrastructure developments that may have positive spinoffs in unleashing other potential in the region. Additionally regional coal options are attractive due to the emissions not accruing to South Africa, and in cases where the pricing is competitive with South African options, would be preferred;

- Regional and domestic gas options are pursued and shale exploration stepped up;

- Continue with the current renewable bid programme with additional annual rounds (of 1000 MW PV capacity; 1000 MW wind capacity and 200 MW CSP capacity), with the potential for hydro at competitive rates.

- A standard offer approach is developed by the Department of Energy in which an agency similar to Eskom's Single Buyer Office purchases energy from embedded generators at a set price (with a self-correcting mechanism based on uptake) so as to render municipalities indifferent between their Eskom supply and embedded generators and thus support small-scale distributed generation;

- Additional analysis on the potential of extending the life of Eskom's existing fleet should be undertaken, to firm up on the costs involved, weighing up against the environmental impacts (specifically the Departments of Water Affairs and Environmental Affairs should agree on the appropriate way forward to deal with the impacts of flue gas desulphurisation on water resources in Mpumalanga). Alternatives to extending the life of the plant would be to build new coal-fired generation which is more efficient and with lower emission rates, or non-emitting alternatives under more aggressive climate mitigation objectives.

- Formalise funding for EEDSM programmes and secure the appropriate mandate for the national entity to facilitate these programmes (possibly with targets on electricity intensity of the economy).

Many of the options considered for future generating capacity would involve contracts that may be dollar denominated. The current thinking against dollar-denominated contracting needs to be adjusted as it would jeopardise the feasibility of these options. In particular it forces developers into a shorter-term contacting paradigm in order to hedge their currency exposure and it limits the interest from potential developers. In particular development of gas options would be greatly prejudiced unless the current aversion to dollar denominated contracts is dropped.

The assessment of the transmission impact of the Update indicates that five possible Transmission Power Corridors will be required to enable key generation scenarios. The main difference between these scenarios is the physical amount of transmission infrastructure within these corridors and their timing. The transmission impact assessment has been based on the reasonable spatial location of the future generation taking into account current knowledge and information. Therefore there is still opportunity to consider better generation location strategies in the longer term. One generation strategy that can provide advantages in terms of reducing the network integration costs and minimising system losses is to consider a large distributed generation network with more appropriately sized units. These would be smaller sized plants that can be integrated into the distribution networks utilising their infrastructure and reducing the loading of the Transmission Grid. Initially this can be achieved with PV but later extended, with the associated transport infrastructure, to gas and even coal plants located near large loads or major load centres.

Considering the changes in consumption patterns and technology costs over the past three years it is imperative that the IRP should be updated on a regular basis (possibly even annually), while flexibility in decisions should be the priority to favour decisions of least regret. This would suggest that commitments to long range large-scale investment decisions should be avoided.

1 BACKGROUND

1.1 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 be revised by the Department of Energy (DoE) every two years. This would mean that by March 2013 there should be a new iteration of the plan.

1.2 The current planning activities in the DoE are focused on producing the Integrated Energy Plan (IEP). One of the criticisms of the IRP 2010-30 was that it was developed without an appropriate energy plan to inform the interactions with other energy carriers. The IEP provides a platform for integration between planning processes in each of the energy carrier environments with feedback loops into these plans. The IRP would benefit from the finalisation of the IEP process.

1.3 While the next iteration of the IRP will commence once the IEP is finalised there is an opportunity now to undertake a high-level review or update of the IRP 2010-30 allowing for updated assumptions based on new information as well as the consideration of additional scenarios but not undertaking an entire re-iteration of the plan.

1.4 The finalisation and publication of the National Development Plan (NDP) by the National Planning Commission provided further clarity on national policy objectives and broader economic imperatives. These objectives are considered in this update.

2 UPDATE PROCESS

2.1 The IRP 2010 identified the preferred generation technology (and assumed energy efficiency demand side management) 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.

2.2 There has been some progress over the past three years, since the promulgation of the IRP 2010, in executing the programmes identified in the final plan. Table 1 indicates the policy-adjusted plan and the results of the Ministerial Determinations (in 2011 and 2012) which identified the capacity to be procured from independent power producers (IPPs). In addition 800 MW of co-generation capacity was added to that preferred in the IRP plans. Of these determinations the Renewable Bid Programme has already contracted 2470 MW of renewable capacity and the contracts with the DoE OCGT peakers have been finalised.

2.3 While the IRP 2010 remains the official government plan for new generation capacity until replaced by a full iteration, this IRP update is intended to provide insight into critical changes for consideration on key decisions in the interim. In particular it considers:

2.3.1 The changed landscape over the past three years, in particular in electricity demand and the underlying relationship with economic growth;

2.3.2 New developments in technology and fuel options (locally and globally); and

2.3.3 Scenarios for carbon mitigation strategies and the impact on electricity supply beyond 2030;

2.3.4 The affordability of electricity and its impact on demand and supply beyond 2030.

2.4 The update follows the approach of:

2.4.1 Developing a new Base Case from the IRP 2010 by updating some of the underlying assumptions based on new information; and

2.4.2 Considering different scenarios or test cases (identified schematically in Figure 1) based on alternative government policies or strategies and differences in future economic and resource terrains.

2.5 In order to ensure that the proposed resource choices under some of the key scenarios can meet demand adequately in the future (under most foreseeable circumstances), additional adequacy studies have been concluded, as well as an assessment of the impact on transmission network expansion. These are both included as appendices to the report.

2.6 The intention is to develop a proposed path of least regret, incorporating the benefits of flexibility, and identify decision trees that consider the key determinants in decisions required and the proposed solutions under different outcomes of these determinants.

Figure 1 – IRP2010 Update schematic of test cases and scenarios

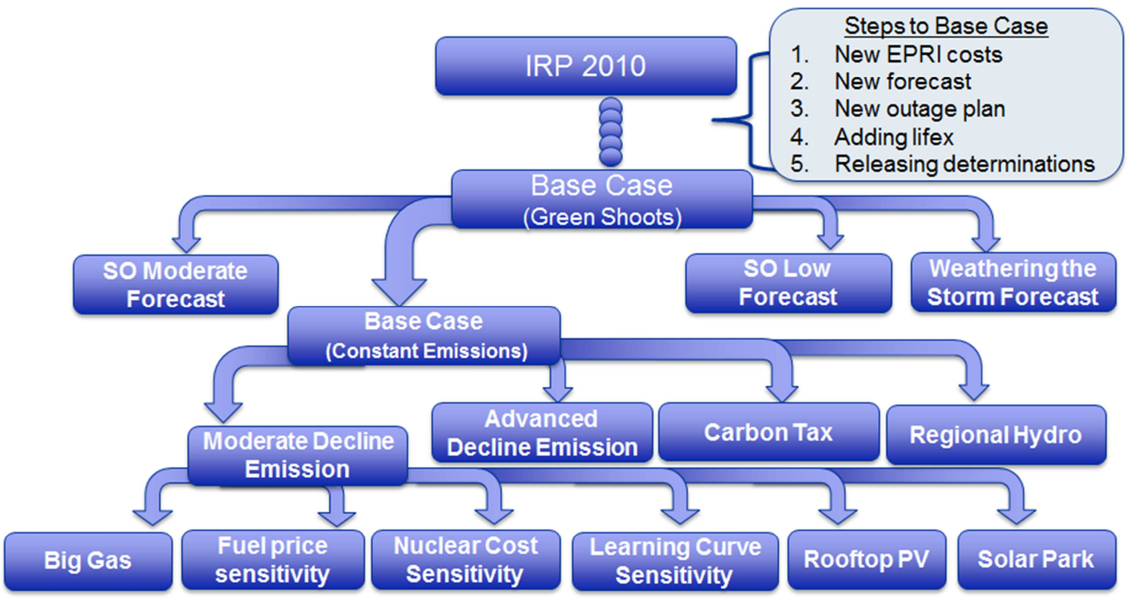


Table 1 – IRP2010 Policy Adjusted Plan with Ministerial Determinations

	New build options								Committed					Non IRP
	Coal (PF, FBC, imports, own build)	Nuclear	Import hydro	Gas – CCGT	Peak – OCGT[1]	Wind	CSP	Solar PV	Coal	Other	DoE Peaker	Wind[2]	Other Renew.	Co-generation
	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
2010	0	0	0	0	0	0	0	0	380	260	0	0	0	0
2011	0	0	0	0	0	0	0	0	679	130	0	0	0	0
2012	0	0	0	0	0	0	0	300	303	0	0	400	100	0
2013	0	0	0	0	0	0	0	300	823	333	1020	400	25	0
2014	500	0	0	0	0	400	0	300	722	999	0	0	100	0
2015	500	0	0	0	0	400	0	300	1444	0	0	0	100	200
2016	0	0	0	0	0	400	100	300	722	0	0	0	0	200
2017	0	0	0	0	0	400	100	300	2168	0	0	0	0	200
2018	0	0	0	0	0	400	100	300	723	0	0	0	0	200
2019	250	0	0	237	0	400	100	300	1446	0	0	0	0	0
2020	250	0	0	237	0	400	100	300	723	0	0	0	0	0
2021	250	0	0	237	0	400	100	300	0	0	0	0	0	0
2022	250	0	1 143	0	805	400	100	300	0	0	0	0	0	0
2023	250	1 600	1 183	0	805	400	100	300	0	0	0	0	0	0
2024	250	1 600	283	0	0	800	100	300	0	0	0	0	0	0
2025	250	1 600	0	0	805	1 600	100	1 000	0	0	0	0	0	0
2026	1 000	1 600	0	0	0	400	0	500	0	0	0	0	0	0
2027	250	0	0	0	0	1 600	0	500	0	0	0	0	0	0
2028	1 000	1 600	0	474	690	0	0	500	0	0	0	0	0	0
2029	250	1 600	0	237	805	0	0	1 000	0	0	0	0	0	0
2030	1 000	0	0	948	0	0	0	1 000	0	0	0	0	0	0
Total	6 250	9 600	2 609	2 370	3 910	8 400	1 000	8 400	10133	1722	1020	800	325	800

2011 Determinations   2012 Determinations   Eskom commitments (pre IRP)

Notes: 1. OCGT is seen as natural gas in the determination
2. Includes Sere (100MW)

3 CHANGED CONDITIONS FROM 2010

Technology options and costs

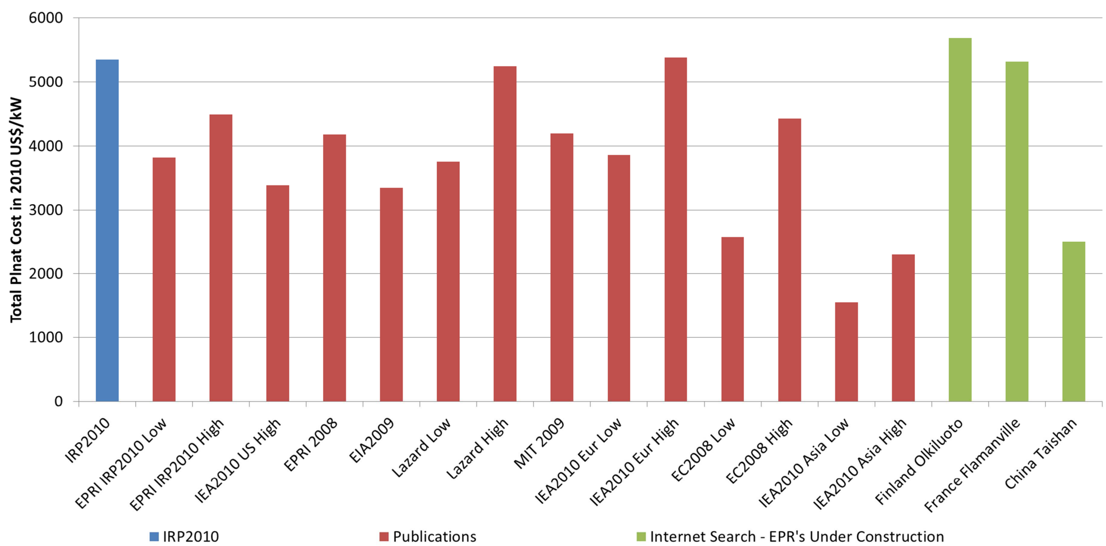
3.1 The costs for generic technologies used in the IRP 2010 were based on the July 2010 EPRI report (“Power Generation Technology Data for Integrated Resource Plan of South Africa”)[1]. The generic technology data was used for all options, except for solar photovoltaic generation which was provided by 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).

[1] Downloadable from the Department of Energy’s IRP website (http://www.doe-irp.co.za/)

3.2 EPRI has developed an updated report on the generic technology costs in April 2012 based on more recent data. This review utilises the updates provided by EPRI for the same technologies; for photovoltaic, sugar bagasse and regional options the 2010 costs have been inflated with South African consumer inflations rates, while Eskom has provided an updated view of the pumped storage costs.

3.3 A persistent and unresolved uncertainty surrounds nuclear capital costs. Based on a number of expert studies and reported project costs for new nuclear investment, generic nuclear capital costs were possible in the $3800/kW to $7000/kW range. These studies (indicated in Figure 2) suggest that, outside of Asia, costs for new nuclear capacity reach the nuclear cost value included in the final scenarios of IRP2010 (after the consultation process), adjusted for inflation from 2010. This equates to $5800/kW overnight cost (in 2012 dollars). This is taken as the generic cost of nuclear capacity for purposes of the Update.

Figure 2 – Nuclear capital costs (in 2010 $/kW) from different sources



Note: The IRP 2010 value is that adopted after the consultation process (40% increase on the initial EPRI cost)

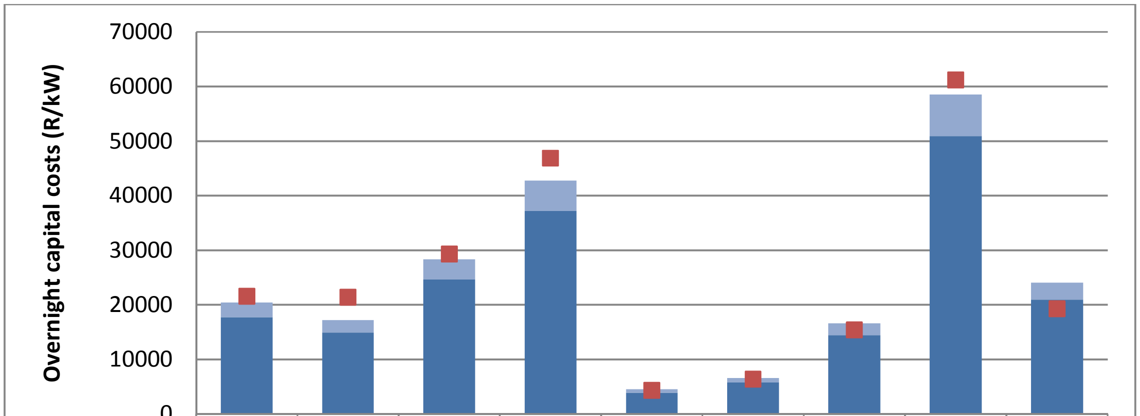
3.4 Another departure from the methodology adopted in IRP 2010 is the categorisation of photovoltaic technologies. In IRP 2010 the main differentiator was between crystalline PV and thin-film, whereas in the Update crystalline PV is used as a proxy for both technologies and the main differentiation is between fixed tilt and tracking systems for PV installations, along with location (as a key input into the load factor associated with the PV installation).

3.5 Figure 3 indicates a comparison on some of the changes in capital costs. Detail on the cost estimates are provided in Appendix B.

3.6 The learning rates adopted in IRP 2010 are maintained in this review. Recent information suggests that the somewhat aggressive learning rates for photovoltaic technologies have been realised in the industry (as evidenced in the rate of change between the first and second bid windows of the Department of Energy's Renewable Bid Programme). Similarly there have been reductions in wind technology costs, whereas concentrated solar technologies have yet to support the learning expected in 2010. However this learning is continued in the base case developed below with some sensitivity analysis on the impact if this does not materialise. Figure 4 indicates the learning applied in the Update.

3.7 Figure 44 in Appendix B provides a screening curve for the main technologies included in the Update as well as indicating the impact of learning for the renewable technologies. The model also has two prices for natural gas (R70/GJ for domestic and regional, and R92/GJ for imported liquefied natural gas). The screening curve indicates the impact of the lower price of natural gas for the regional options and how this is more competitive against coal-fired generation.

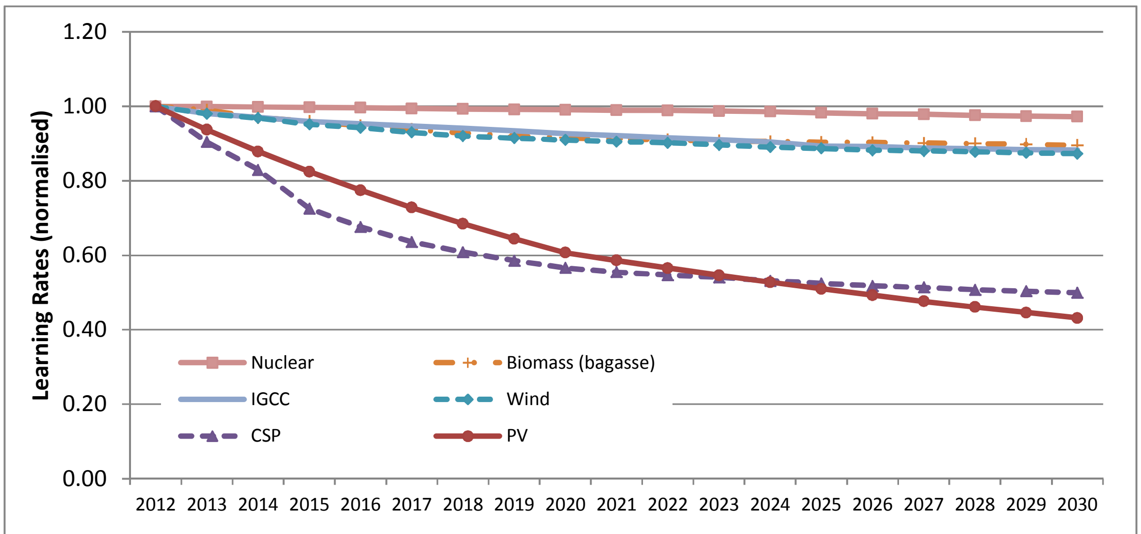
Figure 3 – Comparison of overnight capital costs between IRP 2010 and the Update



	PF Coal (with FGD)	FBC Coal (with FGD)	IGCC	Nuclear	OCGT	CCGT	Wind	CSP (Parabolic, 9 hrs)	PV crystalline (fixed tilt)
Inflation	2 655	2 234	3 682	5 554	590	863	2 156	7 599	3 130
IRP 2010	17785	14965	24670	37205	3955	5780	14445	50910	20971
IRP Update	21572	21440	29282	46841	4357	6406	15394	61176	19250

Note: The IRP 2010 capital costs are those adopted following the consultation process (PV and nuclear were revised)

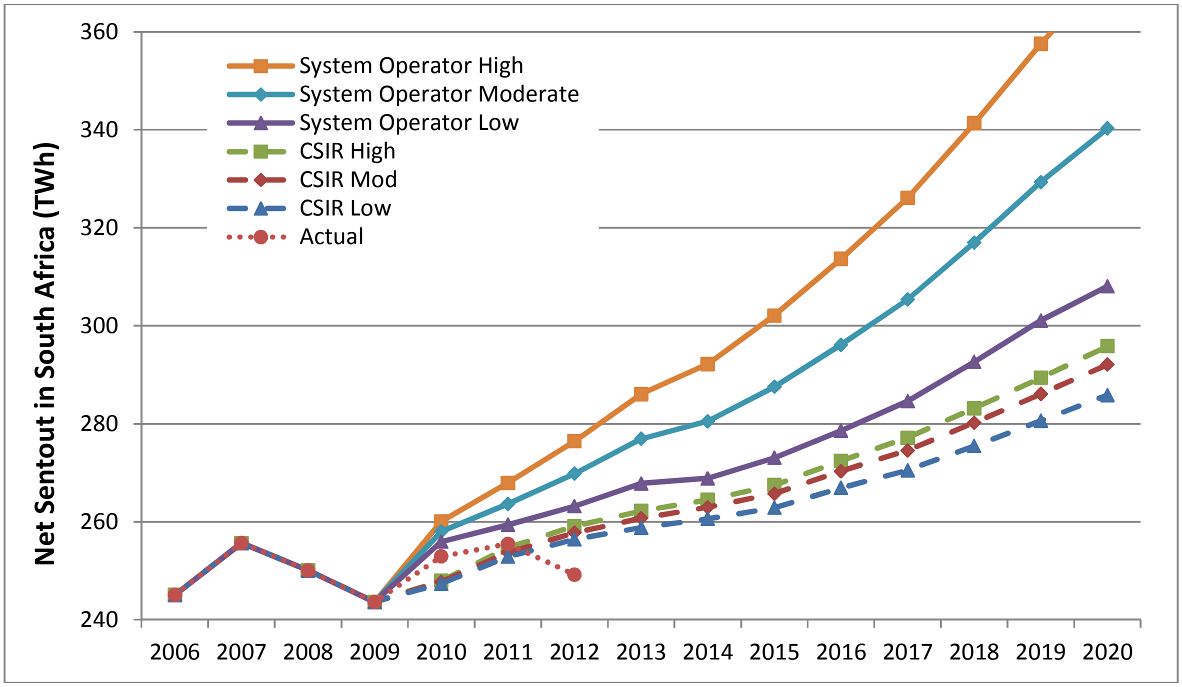
Figure 4 – Technology cost paths applied in Update Base Case



Expected Demand

3.8 Actual national electricity demand has been lower over the past three years than expected in the IRP 2010, especially when compared to the System Operator Moderate forecast which was used as the base forecast for the final policy-adjusted IRP. In 2012 the expected SO moderate demand (net of expected EEDSM) was 270 TWh while the actual was 249 TWh. This last year's data is skewed by the application of power buy-backs by Eskom (in which certain industrial consumers were paid to switch off production capacity), notwithstanding, the underlying trend indicates a lower growth in electricity demand relative to the previous planning assumptions.

Figure 5 – Expected RSA sent-out from IRP 2010 vs actual



Note: The System Operator Moderate was the demand forecast used in the policy-adjusted IRP
Sources: StatsSA (for actual), IRP 2010 (forecasts)

3.9 Whilst electricity demand was lower than forecasted, economic activity has been only marginally different from that forecasted. Total GDP growth for each year was 2,9%, 3,4% and 2,4% for 2010, 2011 and 2012 respectively against an expectation (in the moderate growth scenario) of 2,4%, 3,7% and 4%. The 2012 lower growth departs from the forecast and has a high impact on the resulting electricity demand. This is indicated in the lower manufacturing output against expectation in Figure 7.

3.10 The underlying causes of the reduced demand are many-fold, including:

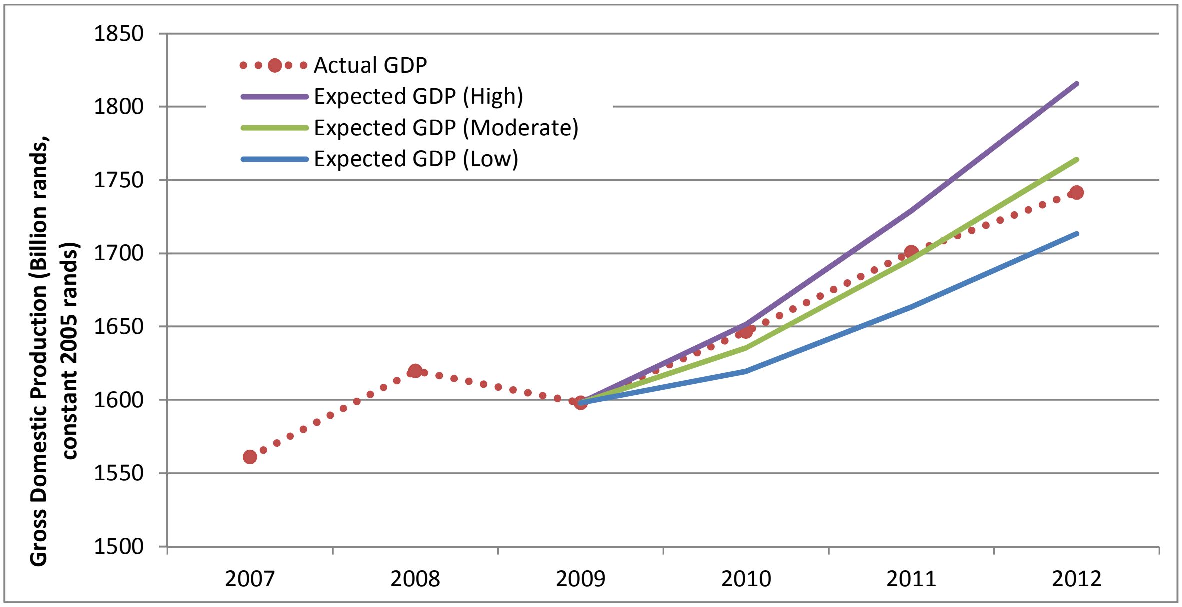
3.10.1 Eskom's buyback programme which incentivised certain industrial consumers to reduce their demand in 2011 and 2012. The extent to which this plays a role in the result depends on the counter-factual of what the consumers were likely to have consumed if not paid to keep plant off the system. It is possible that up to 4 TWh was reduced through this mechanism in each year.

3.10.2 The constraints imposed by the supply situation and the strong likelihood for suppressed demand, by industrial consumers as well as domestic consumers.

3.10.3 The price increases over the past five years which have led to large adjustments in consumer demand. There was criticism in the IRP 2010 that insufficient attention was paid to price elasticity in demand forecasting, and there is a strong case that the price increases are a major contributor to a contraction in demand, especially from energy intensive electricity consumers. There is evidence to suggest that current electricity prices are causing some energy intensive users to relocate smelting operation to countries with more competitive electricity prices. From an industrial consumer perspective then there is a strong indication that electricity prices have reached the threshold for a more price-elastic demand. Quantifying the impact of prices on electricity demand into the future is almost impossible, but the impact is reflected by assuming a progressive decline in electricity intensity of GDP. This is further discussed in Appendix A.

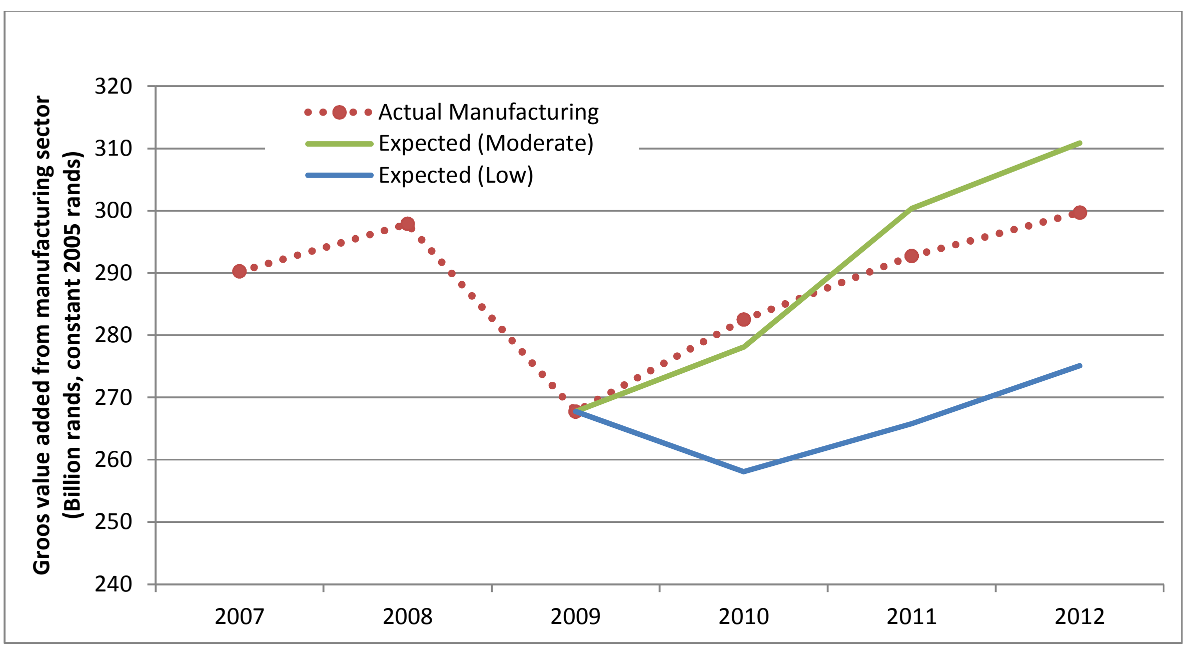
3.10.4 Improved energy efficiency, partly as a response to the price increases which would greatly improve the payback for many efficiency investments, and partly as a response to concerted efforts by municipalities, Eskom and the Department of Energy.

Figure 6 – Expected GDP growth from IRP 2010 vs actual



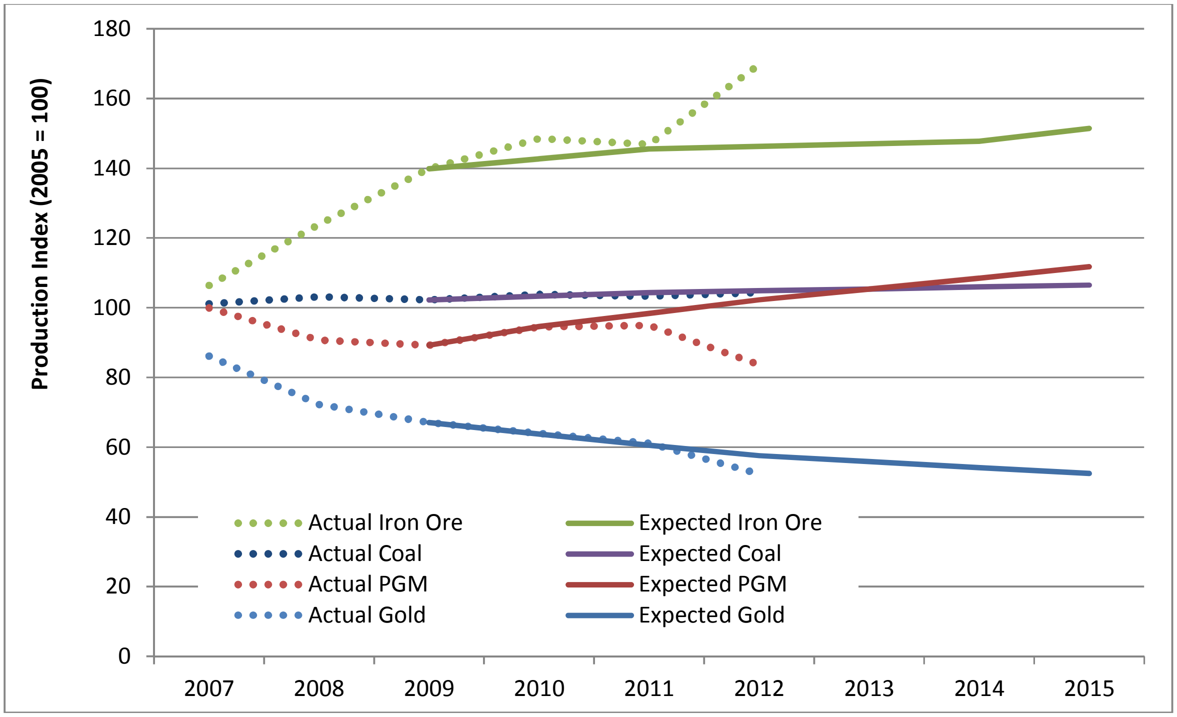
Source: StatsSA, IRP 2010 assumptions

Figure 7 – Actual manufacturing sector gross value added relative to IRP 2010 expectations



Source: StatsSA, IRP 2010 assumptions

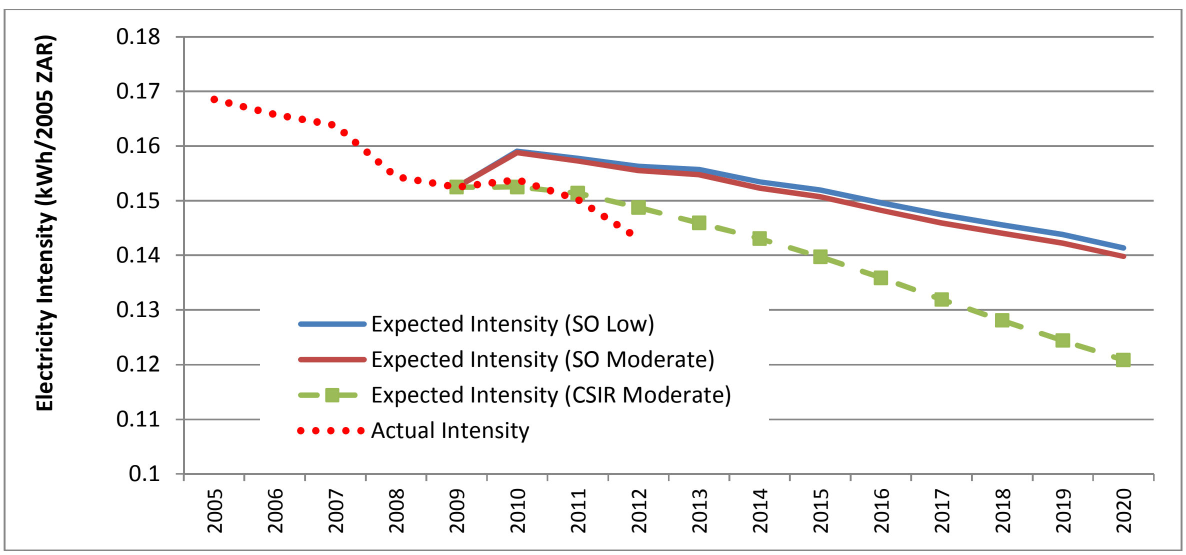
Figure 8 – Actual mining output relative to IRP2010 expectations



Source: StatsSA, IRP 2010 assumptions

3.11 The continued decline in electricity intensity (as measured by the electricity sent-out in kWh required to produce one rand of total gross value added (in constant 2005 rands) in the South African economy) over the past three years has exceeded the expectation in the CSIR Moderate forecast and that of the SO Moderate and Low forecasts.

Figure 9 – Actual electricity intensity relative to IRP2010 expectations



Source: Own calculations based on StatsSA actuals, IRP 2010 assumptions

3.12 A new set of demand trajectories have been developed as a result of the changes in economic assumptions and incorporating (on the System Operator side) inputs from customers on their changed expectations on demand. Details for these demand forecasts are available in Appendix A.

Performance of the Eskom fleet

3.13 Since the 2008 electricity supply crisis Eskom was able to meet electricity demand through delaying maintenance on the generation fleet. This has led to the deterioration in performance of the aging fleet, exacerbating the current crisis but also incurring a longer term impact on the effectiveness of the fleet to meet future demand. The IRP 2010 assumed the fleet to have an average availability of 86% but actual performance, however, declined to less than 80%.

3.14 Consequently to avoid continued stress on the fleet Eskom has proposed a new generation maintenance strategy that aims to ensure the required maintenance is carried out on key identified generators, regardless of the demand-supply balance. The final objective is to arrest the decline in performance and return the average availability factor of the current fleet to 80% over the next ten years. The Eskom generation five-year maintenance plan for the current fleet (the "80:10:10" strategy) is used as the basis for the planned maintenance and unplanned outage probabilities in the Base Case.

Potential for extending economic life of existing fleet

3.15 The current maintenance schedule for the Eskom's existing fleet includes additional interventions to comply with the air quality requirements for existing generation facilities. The Base Case also includes the additional outages required to retrofit flue gas desulphurisation at each of the large coal-fired generators (excluding the return to service stations which will be decommissioned between 2020 and 2029).

3.16 Beyond the return to service stations the coal-fired power stations are all expected to be decommissioned at the end of 50 year plant life (details for the default decommissioning is included in Appendix B). There is the potential, however, with refurbishment for the life of these power stations to be extended by another ten years, providing a mechanism to defer new capital expenditure and contain electricity price increases.

3.17 The modelling indicates that life extension of these large coal-fired generators, whilst requiring additional capital expenditure over the next ten years, is a potentially viable economic option which defers the cost of replacement capacity in the period 2025-2040. However, this result is sensitive to the assumptions of the capital expenditure required for the refurbishment and is further constrained by:

3.17.1 Extending the security of existing coal supplies at an acceptable price for at least another 10 years. The latest Coal Road Map for South Africa indicates a decline in coal supply and an increase in prices with the likelihood of augmenting existing Mpumalanga coal supplies with coal from rail from the Waterberg which will further add to the price of coal.

3.17.2 The environmental impacts of continuing production from less efficient power stations with high air quality emission impacts. Eskom would need exemption for the older power stations from the requirements for air quality specified by the Department of Environmental Affairs or the inclusion of a 'grand-fathering clause' for all facilities that existed before the new regulations. The decision to grant exemption would also need to consider the additional water consumption required by FGD and the Departments of Water Affairs and Environmental Affairs would need to jointly consider the impact these FGD facilities would have on scarce water resources in Mpumalanga.

3.18 For the above reasons extending the life of the large coal-fired generators was included as an option in the Base Case as this is a change from the original IRP 2010 plan.

4 BASE CASE

4.1 The Base Case is produced by updating the IRP 2010 assumption in five discrete "update steps". Each step represents a set of new information or changes to IRP 2010 assumptions. The results of each of the steps can be seen in Appendix E. The steps are:

4.1.1 Step 1: The Ministerial Determinations[2] are forced into the result with the IRP2010 SO Moderate forecast extrapolated out to 2050 and the CO_2 emissions limit maintained at 275 MT per annum. The technology costs, including fuel, capital and operating and maintenance costs, are updated. All these costs were in 2012 rands (whereas the IRP2010 had used 2010 rands).

4.1.2 Step 2: The demand forecast is updated with the CSIR Green Shoots forecast (detailed in Appendix A) with all other aspects constant. The CSIR Green Shoots forecast was selected as the median forecast from the four trajectories identified (detailed in Section 5 below).

4.1.3 Step 3: The performance of the Eskom fleet is updated to 80% EAF reflecting the new Eskom 80:10:10 strategy. The assumption in IRP 2010 was 86% EAF.

4.1.4 Step 4: The option of life extension ("lifex") of the existing Eskom coal-fired generators is included as explained above.

4.1.5 Step 5: The new generation capacities called for in the Ministerial Determinations that are not yet committed are allowed to lapse. This means that only Rounds 1 and 2 of the renewable bid programme and the OCGT peaker programme are committed with all other capacity freed up for the model to optimise. It should be noted that even though Round 3 of the bid programme is already in progress these have not yet been committed and the final determination of capacity is not known so was left open for the model to choose. The results of the Base Case indicate that alternative capacity options to IRP 2010 are preferred by the model – these are put forward in the report for government's consideration.

4.2 The Base Case maintains a number of the limitations imposed in the IRP2010 in particular an annual limit of new capacity for wind (1600 MW) and photovoltaic (1000 MW). The wind construction limit was imposed in the IRP based on the average construction rates in Spain over the 2003-2009 period, whereas the photovoltaic limit was not based on any research but required in order to limit the major switch to this technology when the aggressive learning reached a tipping point. These concerns still exist but impose an arbitrary constraint that needs to be tested. For the purposes of the IRP Update these constraints will continue until credible information becomes available on solar and wind conditions and how the models can be further developed to analyse the impacts of the stochastic nature of the supply.

4.3 Table 2 provides the snapshot of the changes in capacity in 2030 between the Base Case relative to the original IRP 2010 policy adjusted plan. By the end of 2030 the life extension would have increased the existing coal fleet to 36230 MW while new coal is substantially less

[2] The Ministerial Determinations were issues in 2011 and 2012 and detailed:

- IPP renewable capacity of 3825 MW (in the first determination) and an additional 3200 MW (in the second);
- IPP base-load capacity of 8461 MW (of which 3200 MW coal, 2652 MW gas CCGT, 2609 MW import hydro);
- IPP medium term risk mitigation capacity of 1274 MW (of which 800 MW industrial cogeneration and 474 MW of gas CCGT)
- IPP diesel-fired open cycle gas turbine capacity of 1005 MW;
- Nuclear capacity of 9600 MW with Eskom as the owner and operator. *(from the Statement on the Cabinet meeting of 7 November 2012, designating Eskom as the owner-operator (but the size of the nuclear procurement was not specified)).*

at 2450 MW. The nuclear capacity is reduced from 11400 to 6660 (of which Koeberg remains 1800MW, implying only 4860 MW new nuclear capacity). The gas capacity increases to 3550 MW, while CSP increases substantially at the expense of wind capacity with PV increasing slightly. The total capacity required is a full 8182 MW less than in the IRP 2010 which would have an impact on electricity prices over the next fifteen years.

Table 2 – Technology options arising from IRP 2010 and the Update Base Case in 2030

Technology option	IRP 2010 (MW)	Base Case (MW)
Existing Coal	34746	36230
New Coal	6250	2450
CCGT	2370	3550
OCGT / Gas Engines	7330	7680
Hydro Imports	4109	3000
Hydro Domestic	700	690
PS (incl Imports)	2912	2900
Nuclear	11400	6660
PV	8400	9770
CSP	1200	3300
Wind[3]	9200	4360
Other	915	640
TOTAL	**89532**	**81350**

Notes:
(1) Demand Response options added to IRP 2010 to ensure comparability (previously not considered in IRP)
(2) "Existing" coal includes Medupi and Kusile

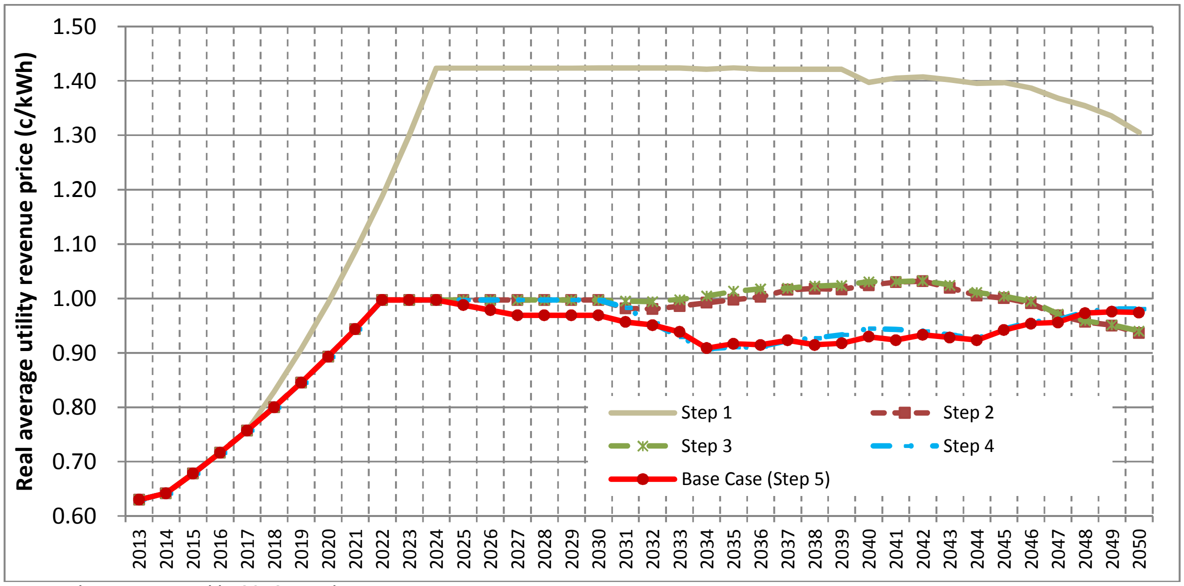
4.4 The price curves[4] in Figure 10 and Figure 11 indicate the changes in the national revenue price path of electricity arising from the successive changes / steps to the Base Case. The difference between the two sets of price curves reflects the impact of the recent multi-year price determination (MYPD3) issued by NERSA. Figure 10 shows the 8% annual nominal price increases through to 2018 and then assumed 12% annual nominal price increases thereafter until the utility debt situation stabilises below an 80:20 debt ratio. Figure 11 shows how the prices would have to increase in the absence of the MYPD3 in order to maintain an appropriate debt: equity ratio throughout the period. Even in the Base Case without the constraint of the MYPD3 price the electricity price would rise to 90c/kWh by 2018 before starting to decline thereafter. With the MYPD3 price curve the price increase is delayed but the consequent utility debt escalation requires prices to eventually rise and stay higher for longer in order to reduce the debt situation. The impact of the MYPD3 decision eventually works out of the system by 2035. For the purposes of this report the second set of price curves (without the MYPD3 determination) are used to compare the impact of the scenarios or test cases and the choices implied.

4.5 Initially the IRP 2010 moderate forecast is extrapolated to 2050 to show how the prices would result with the new costs and original forecast, but this is modified by first, the new forecast, then the changed availability of the existing fleet and the options for life extension which dramatically delays the requirement for new capital expenditure (even at the expense of increased fuel costs). Finally Step 5 indicates the extent to which price increases can be delayed by shifting out the committed new build from IRP 2010 (such as the nuclear fleet and the other Ministerial determinations).

[3] The reduced wind capacity (in the Update relative to the IRP 2010) results from incorporating new wind data into the model. The combination of these new wind sites and the application of annual limits (1600MW per year) resulted in some wind sites being selected in the model (preferred to Nuclear as the next option) and others falling below Nuclear. Revision of these assumptions would greatly alter the wind outcomes.

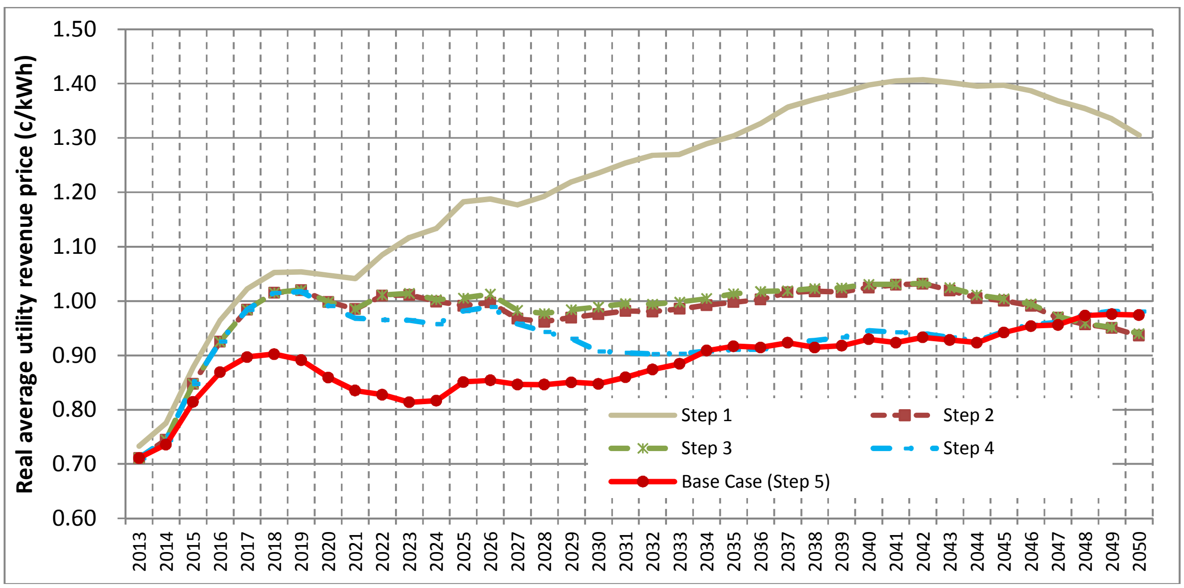
[4] The description of the pricing model and assumptions used to derive the comparative revenue price paths is included in Appendix D.

Figure 10 – Comparative real average revenue price path following each step to the Base Case (using MYPD3 determination)



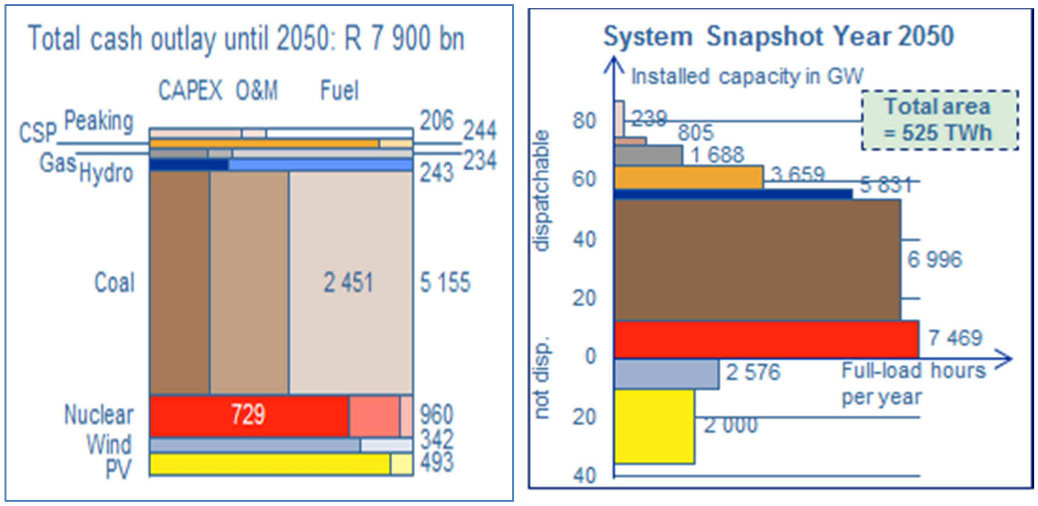
Note: Prices expressed in 2013 Rands

Figure 11 – Comparative real average revenue price path following each step to the Base Case (without MYPD3 determination)



Note: Prices expressed in 2013 Rands

Figure 12 – Costs implications and system snapshot for Base Case



4.6 The greatest contribution to electricity costs in the Base Case remains coal fuel costs (to the value of R2,45tn (undiscounted) of the total R7,9tn over the period). Coal-fired generation also remains the main source of dispatchable generation in 2050 (as reflected in the 2050 snapshot).

5 DEMAND FORECAST TRAJECTORIES

5.1 A number of updated demand forecasts were developed during 2012 based on the latest economic indicators and measured electricity demand.

5.1.1 The Eskom System Operator forecasts (developed by the System and Market Operator Division) consider information from key customers regarding their expectations of future demand and evaluate these against different forecasts for macro-economic conditions. For the purposes of the IRP Update two forecasts are included from the System Operator: an SO Low and SO Moderate. The details for these forecasts are included in Appendix A.

5.1.2 The CSIR prepared five electricity demand forecasts based on five economic projections developed by the Eskom System and Market Operator Division. These details are also included in Appendix A.

5.2 For the purposes of the IRP Update cases only four of the trajectories are used (shown in Figure 13, along with the other trajectories developed and compared to the IRP 2010 forecasts):

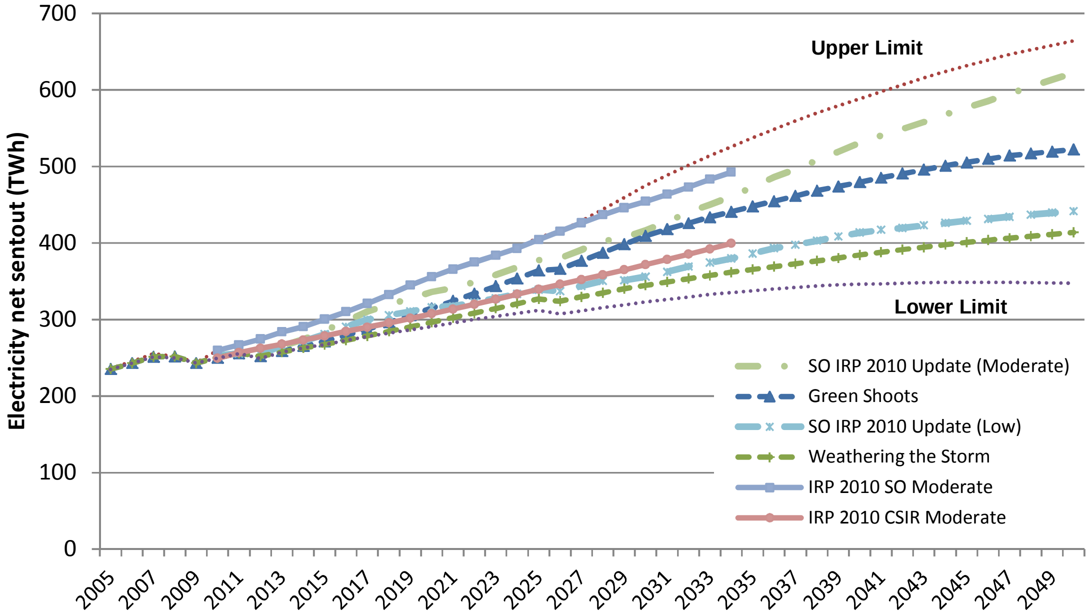
5.2.1 The CSIR Green Shoots forecast, based on the NDP's average 5,4 % GDP growth to 2030, but assuming significant shifts in economic activity away from classical energy-intensive industries, results in an average annual electricity demand growth of 2,7 % to 2030 (and only 1,9% to 2050) and is used for the Base Case and most of the other test cases;

5.2.2 The SO Moderate forecast, also based on an average 5,4 % GDP growth to 2030 but with less of a restructuring of the industry, results in an average annual electricity demand growth of 2,8 % to 2030 (and 2,4 % to 2050);

5.2.3 The SO Low forecast which is based on an average 4,5 % GDP growth to 2030, result in an average annual electricity demand growth of 1,9 % to 2030 (and 1,5% to 2050); and

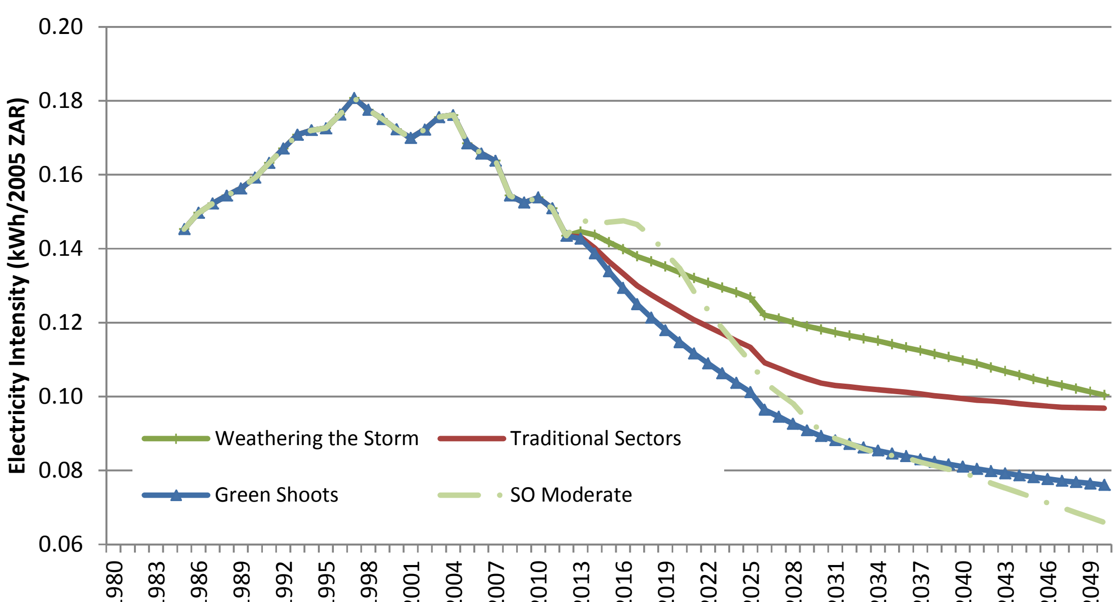
5.2.4 The CSIR Weathering the Storm forecast which has a 2,9 % GDP growth to 2030 and results in a 1,8 % average annual electricity demand growth to 2030 (and 1,3% to 2050).

Figure 13 – Expected electricity demand trajectories to 2050



5.3 Combining the electricity demand and economic growth forecasts results in declining electricity intensity expectations over the next forty years as indicated in Figure 14. The SO Low and SO Moderate follow exactly the same intensity path (indicated as the SO Moderate), climbing initially before dropping extensively to meet and then exceed the decline in the Green Shoots intensity. Importantly the difference between the Green Shoots and Traditional Sectors intensity graphs reflect the impact of the assumed sector shift in the economy as energy intensive industries make way for less intensive industries.

Figure 14 – Electricity Intensity for each of the demand trajectories



5.4 The results from the four optimisation runs (detailed in Appendix E) on the trajectories indicate that regardless of the demand the requirement for new coal generation remains much the same as it is constrained by the emissions cap, thus with the life extension the new coal is between 2450 MW (in the Green Shoots/ Base Case) and 2700 MW in the SO Moderate. The nuclear requirement is entirely dependent on the demand projection as there is no nuclear build in either the SO Low or the Weathering the Storm scenarios. CSP is similarly reduced in the SO Low and Weathering the Storm to no new plant beyond the current bid windows and the current Eskom project. PV and wind capacity follows the load requirement more gradually. CCGT capacity is relatively similar between all cases except the Weathering the Storm scenario.

Table 3 – Technology options arising from the four demand trajectories in 2030

Technology option	SO Moderate (MW)	Green Shoots (MW)	SO Low (MW)	Weathering the Storm (MW)	Scenario-wise decom-position (MW)
Existing Coal	36230	36230	36230	36700	36047
New Coal	2700	2450	2450	2450	2355
CCGT	2840	3550	2840	1420	3760
OCGT / Gas Engines	8280	7680	6960	6720	7731
Hydro Imports	3000	3000	3000	3000	3000
Hydro Domestic	690	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900	2900
Nuclear	8260	6660	1860	1860	6717
PV	10050	9770	8860	7400	9770
CSP	2900	3300	300	300	3166
Wind	4090	4360	3240	2260	4402
Other	640	640	640	640	640
TOTAL	**82580**	**81350**	**69970**	**66340**	**81179**

Notes:

(1) "Existing" coal includes Medupi and Kusile

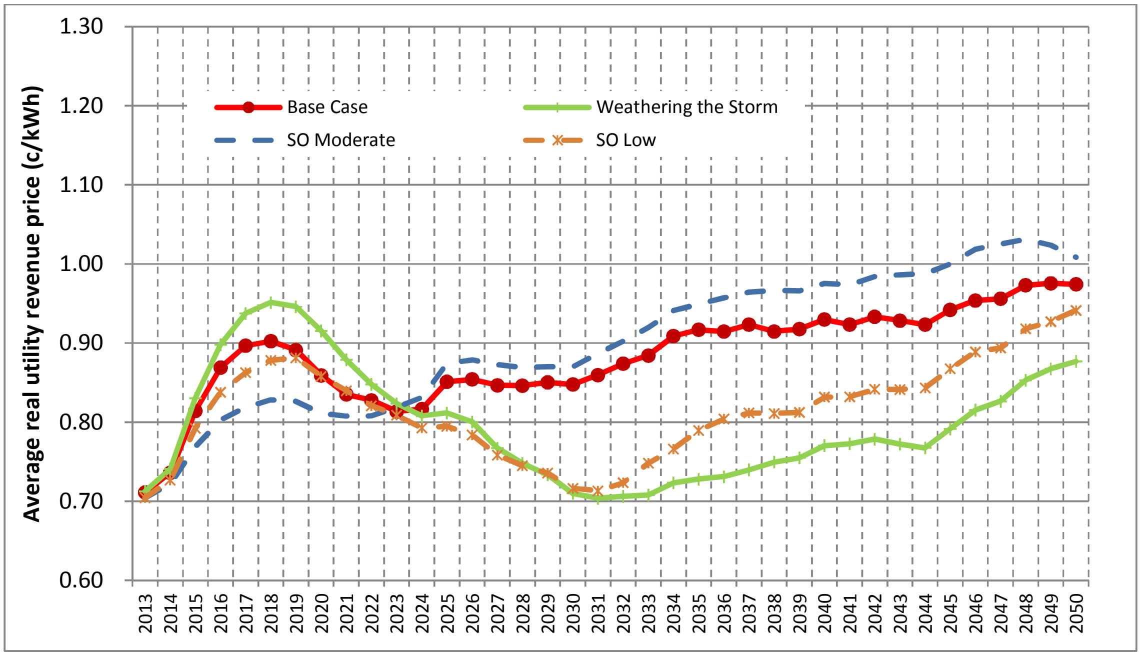
(2) The scenario-wise decomposition scenario is not based on mixed integer optimisation (i.e. optimised output allows for partial construction of units) whereas all other scenarios are mixed integer (i.e. capacity reflects whole units with no partial construction allowed)

5.5 Both the Green Shoots scenario and SO Moderate incorporate the aspirations of the National Development Plan by indicating the trajectory that would be required in order to provide the generation capacity to meet the high growth plan. While this indicates the top end of the expectation the reality is that the economy is unlikely to grow at this level for the full period and may undershoot substantially. However if generation capacity is only built to manage a low growth path the electricity system will forever remain a constraint on the appropriate growth required to reduce unemployment and poverty in the country. Thus in the decisions required over the next ten years it should be clear that the Green Shoots represents an aspiration but that the lower growth of the SO Low may constitute the reality, thus building for the higher demand may result in over-capacity and stranded investment but building for the low could constraint the development path. The dynamics of the decision should be to allow maximum flexibility to build for the low as a minimum, but provide options for faster, more flexible development to meet the aspirations of the country.

5.6 This would suggest that the minimum required over the next twenty years would include limited new coal-fired generation (all FBC), investment in CCGT from domestic and regional gas along with OCGT or gas engines based on the same gas sources; continuation of the PV and Wind roll-out; but no additional nuclear or CSP developments. This would meet the lower end of the demand requirements, but run the risk of remaining a constraint on new growth should other constraints identified in the National Development Plan be adequately tackled.

5.7 The revenue price paths in Figure 15 show how electricity prices would have to increase steeply in the next five to ten years if demand is much lower than the current MYPD3 expectation in order to generate the required revenue to fund the current build before the overcapacity situation under these scenarios allows prices to fall away again before new capacity is required. This is shown in the extreme case of the Weathering the Storm scenario where prices rise to 95 c/kWh before declining eventually to 71 c/kWh in 2031.

Figure 15 – Comparative real average revenue price path for each demand trajectory



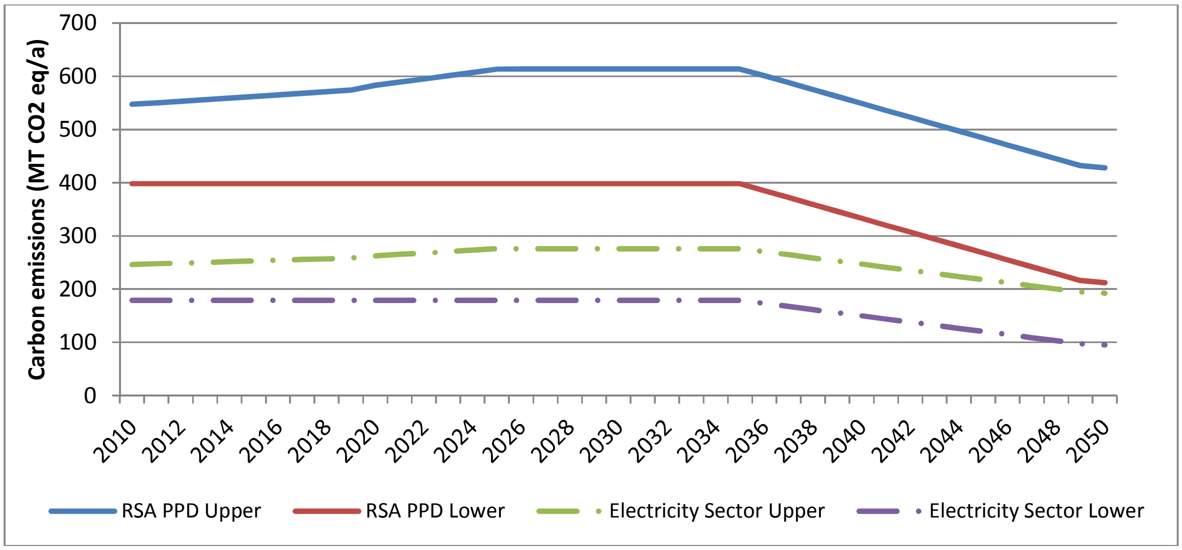
5.8 Instead of looking at which expansion plan best suits a particular demand trajectory, an alternative approach is to allow the optimisation model to incorporate the uncertainty regarding different demand outlooks into the decision directly through scenario-wise decomposition. This approach requires applying a probability distribution to the different demand trajectory and allowing the model to build a least regret expansion plan to attempt to meet the different trajectories and minimise the cost of regret under each condition. For the purposes of this approach it was assumed that each of the four trajectories had the same probability of being realised, thus the outcome tends to weight the two higher trajectories equally to the two lower. The outcome (indicated in Table 3) suggests that flexibility has a premium to large-scale commitments in this approach due to higher OCGT capacity, indicating that the least regret move is to accept higher fuel costs (in the higher demand outcome) offsetting the reduced capital costs, which would have been an increased (and possibly under-utilised) burden in the lower demand outcome.

6 CLIMATE CHANGE MITIGATION

6.1 A key issue for extending the study period for the IRP Update was to consider other strategies to reduce carbon emissions in the period following 2030. By excluding the period after 2030 there is a risk of building coal-fired generation in the period leading up to 2030 on the assumption that the carbon emission caps would continue at the same level, but this would lead to a constraint in reducing the emissions or under-utilisation of generation capacity if the cap needed to be reduced over time as indicated by the government's peak-plateau-decline (PPD) objective.

6.2 The peak-plateau-decline objective suggests that emissions would be allowed to peak in 2025 (originally indicated at 550 million tons per annum for South Africa as a whole), then plateau for some period before declining. In August 2011 the Department of Environmental Affairs published an explanatory note titled 'Defining South Africa's Peak, Plateau and Decline Greenhouse Gas Emission Trajectory" which indicated the range of expected carbon dioxide emissions up to 2050. Under the PPD range, South Africa's upper limit is expected at 428 MT/a in 2050 and the lower limit at 212 MT/a. The Long Term Mitigation Scenarios (LTMS) (October 2007) indicated that the electricity sector greenhouse gas contribution was 45% in 2003. The IRP 2010 assumed a 50% contribution, but this was seen by some observers at the time as an indulgence. Assuming the less indulgent 45% contribution, the upper limit for the electricity would be 193 MT/a in 2050 and the lower limit would be 95 MT/a.

Figure 16 – DEA Peak, Plateau and Decline range with assumed electricity industry contribution



Source: DEA, own calculations

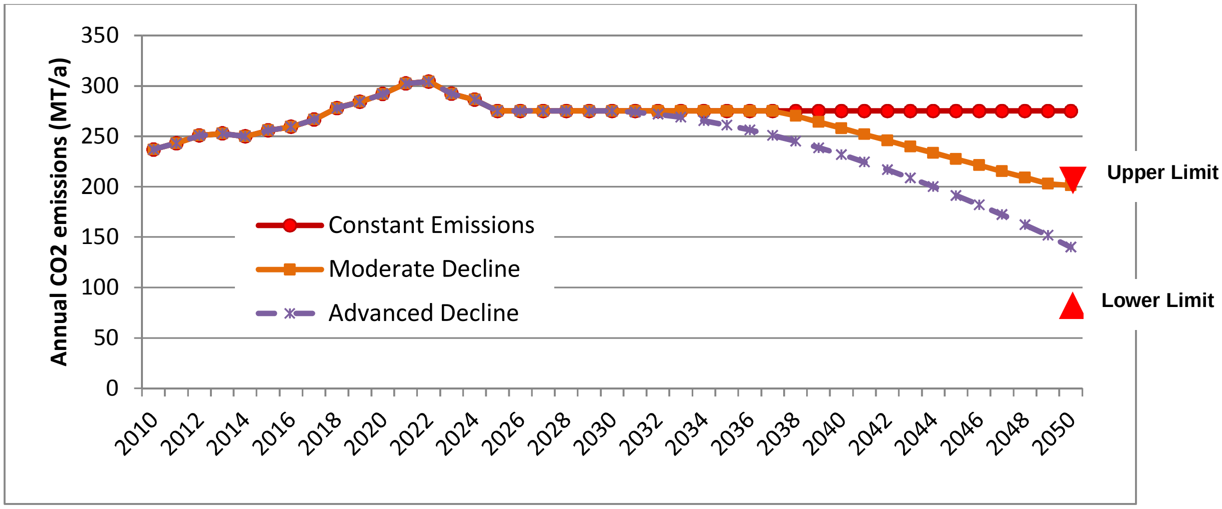
6.3 Three alternatives are proposed for future carbon mitigation (indicated in Figure 17) with increasing impact on costs for the electricity sector. These are:

6.3.1 To continue the emission target established in the IRP 2010 of 275 million tons per annum. Although this target does not meet the DEA expectation of a PPD it establishes a counter-factual for the impact of the target on costs in the electricity sector. This still serves as the assumption in the Base Case (as a continuation of the IRP 2010 trajectory).

6.3.2 One approach to the DEA's requirement for the PPD is a moderate decline in carbon emissions, starting at the 275 million tons established in IRP 2010 and then starting to decline in 2037 at a moderate pace before reaching 210 MT/a in 2050, which is marginally above the DEA upper limit target at a 45% electricity contribution.

6.3.3 The advanced decline scenario allows for an earlier reduction in carbon emissions from the IRP 2010 limit of 275 MT/a in 2030 before declining at an increasing rate to reach 140 MT/a in 2050, which is well within the DEA target at a 45% electricity contribution.

Figure 17 – Emission Trajectory scenarios for the IRP 2010 Update



6.4 As indicated in Table 4 the differences between the three emission options only becomes evident beyond 2030 (even though new domestic coal options built before 2030 would be impacted by the declining emissions). The differences in the 2050 capacity outlook are highlighted in the shift from coal generation to nuclear. In all cases the renewable options, PV, wind and CSP, are relatively constant with CSP increasing in the advanced decline scenario as wind and PV are constrained by the maximum annual limits. The CCGT also increases slightly as the emission requirements reduce.

6.5 The comparative price paths in Figure 18 also show the price increase beyond 2033 as cheaper coal-fired generation is replaced by more expensive nuclear capacity.

6.6 Under both the Moderate and Advanced decline scenarios the increase in nuclear capacity results in the relative increase in fixed capital costs (as reflected in Figure 19) as a proportion of total costs over the period.

6.7 The application of the annual limit constraint results in a higher cost to the system when it is binding (i.e. when the model would not have attained the desired outcome without the constraint). This cost is reflected in the "shadow price" of the constraint which reflects an inherent carbon price associated with the carbon emission limit. Figure 20 indicates the annual shadow price associated with each of the three constraints applied above. These shadow prices represent the marginal cost to the system in meeting the constraint and indicate the extent to which the carbon tax would need to rise in order to achieve the technology switch at the margin that is achieved by the emission constraint.

6.8 The shadow prices associated with the three mitigation paths are similar because the shift in technology is similar between them, from new coal-fired generation to new nuclear generation. This suggests that if the carbon tax were applied at this level the reduction in emissions would at least meet the advanced decline requirement but the impact on competitiveness would be significant" (Genesis Analytics Study: The potential impact of the carbon tax on electricity tariffs and an economic impact assessment, 31 July 2013).

Table 4 – Technology options arising from the three emission options in 2030 and 2050

Technology option	Constant Emissions (MW) 2030	Moderate Decline (MW) 2030	Advanced Decline (MW) 2030	Constant Emissions (MW) 2050	Moderate Decline (MW) 2050	Advanced Decline (MW) 2050
Existing Coal	36230	36230	36230	16120	16120	16120
New Coal	2450	2450	2450	24700	12700	5200
CCGT	3550	3550	3550	6390	9230	8520
OCGT / Gas Engines	7680	7800	7680	12240	11400	11400
Hydro Imports	3000	3000	3000	3000	3000	3000
Hydro Domestic	690	690	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900	2900	2900
Nuclear	6660	6660	6660	12800	20800	28800
PV	9770	9630	9660	25000	25000	25000
CSP	3300	3300	3600	8100	10900	11900
Wind	4360	4250	4530	10520	10680	10770
Other	640	640	640	0	0	0
TOTAL	**81350**	**81100**	**81590**	**122460**	**123420**	**124300**

Notes: (1) "Existing" coal includes Medupi and Kusile

Figure 18 – Comparative real average revenue price path for the carbon mitigation options

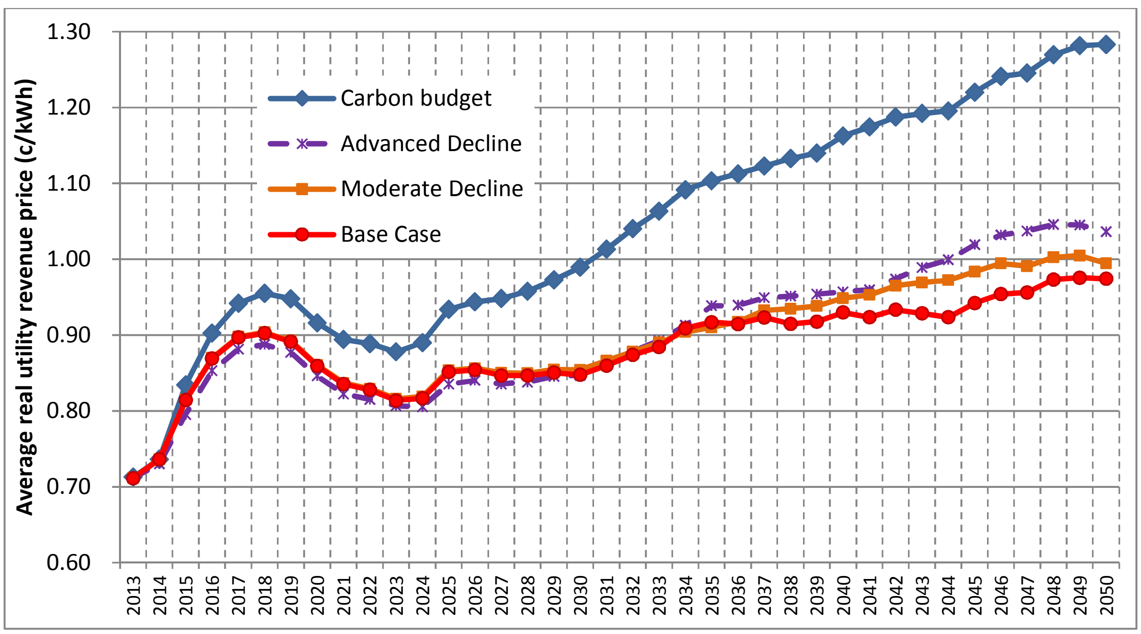
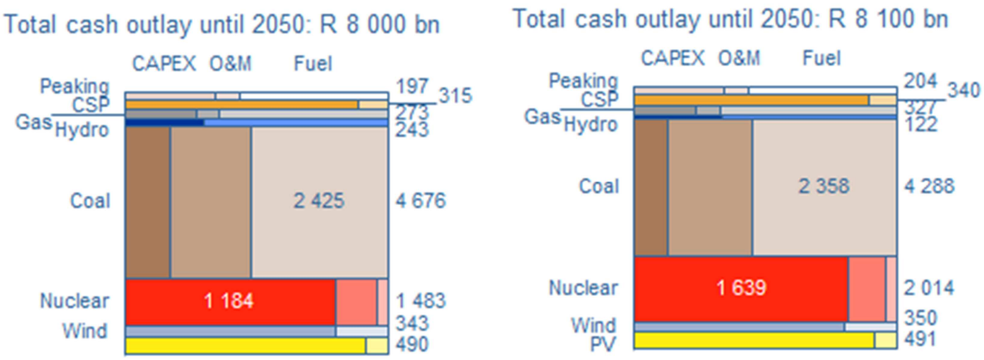


Figure 19 – The cost implications of the Moderate (left) and Advanced (right) decline scenarios

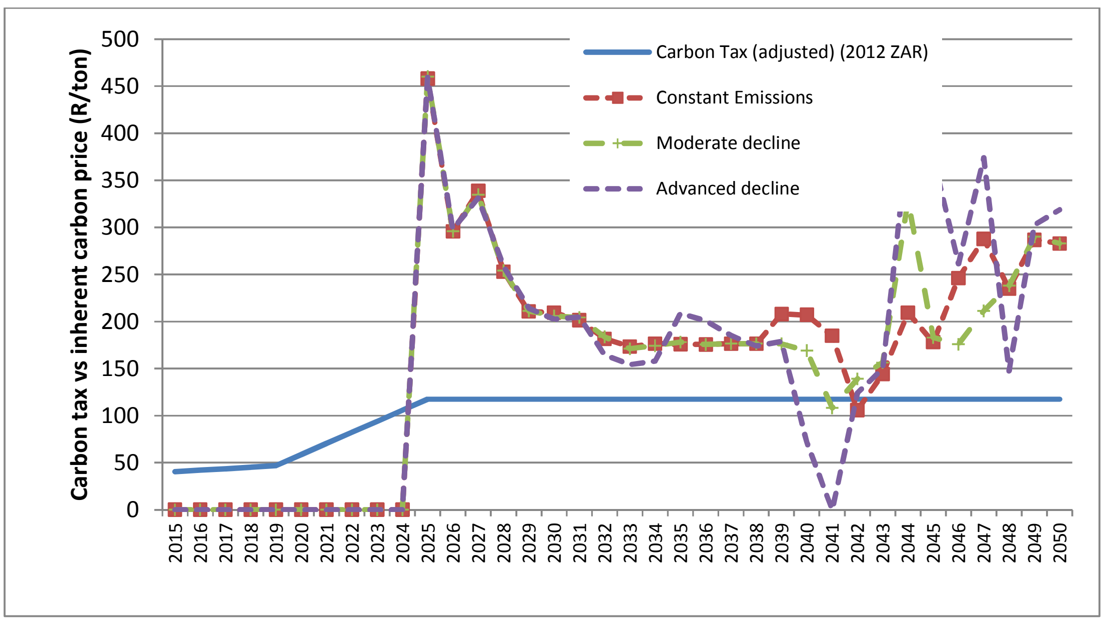


Carbon tax

6.9 National Treasury has issued a series of discussion and position papers on a proposed carbon tax. The latest proposal indicates a R120/ton tax introduced in 2015, escalating by 10% p.a. (in nominal terms) until 2019. In addition the proposal includes a tax free allowance set at 60% with additional allowances awarded for efficiency and participation in other climate change mitigation options. For the purposes of assessing the impact of the carbon tax on the electricity sector the assumption was that the electricity industry as a whole experienced a 60% exemption on the full carbon tax until 2019 after which this tax free allowance is reduced by 10 percentage points every year until its elimination in 2025. In real terms (2012 ZAR) this gives an effective carbon tax of R40/ton in 2015 increasing gradually to R47/ton in 2019 before the more rapid escalation to R117/ton in 2025, as reflected in Figure 20.

6.10 For the purposes of all the Update scenarios the electricity generation levy is maintained at 3,5c/kWh in real terms.

Figure 20 – Effective Carbon Tax (in real terms) on electricity generation against the shadow price of the emission constraints



6.11 The imposition of the carbon tax, even at R117/ton in 2025, is not sufficient to make the optimisation model alter technology choices. As can be seen from the results (Table 5 below), if the emission cap is withdrawn and replaced by a carbon tax as the only instrument, then the preferred option is to continue building cheaper coal-fired generators and pay the tax to the authorities, but not reduce carbon emissions in any meaningful way (indicated in Figure 21).

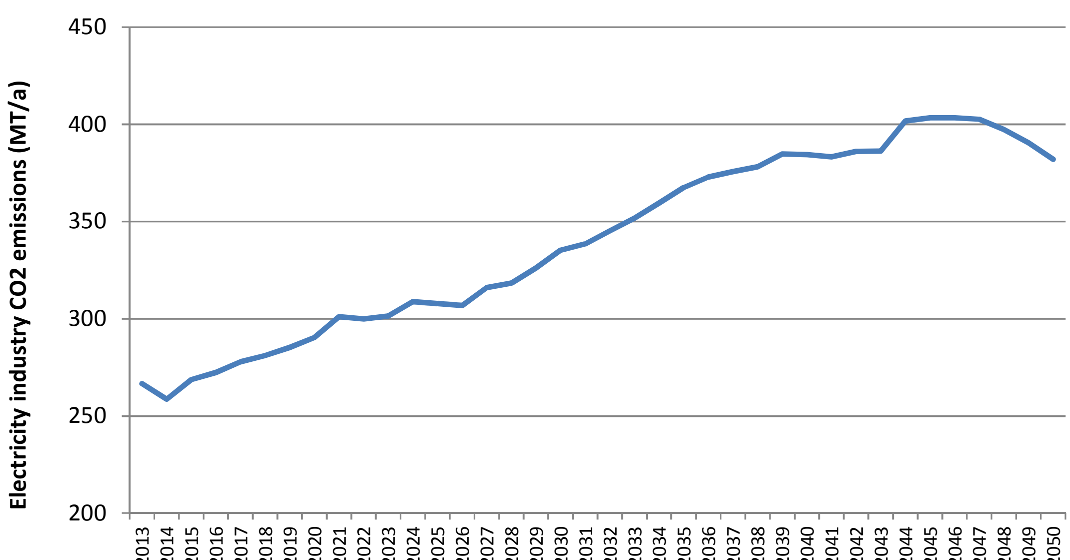
6.12 The application of the emissions limit in the IRP 2010 and the Update provides a more significant carbon price than the carbon tax. This highlights the point that as a result of the emissions limit (including potential declines) the IRP modelling chooses a more aggressive decarbonisation than the proposed carbon tax and consequently consideration should be given to using one of the two but not both.

Table 5 – Technology options arising from the carbon tax relative to emission caps

Technology option	Constant Emissions (MW) 2030	Carbon Tax (MW) 2030	Constant Emissions (MW) 2050	Carbon Tax (MW) 2050
Existing Coal	36230	36230	16120	16120
New Coal	2450	9700	24700	42700
CCGT	3550	2840	6390	6390
OCGT / Gas Engines	7680	7920	12240	14520
Hydro Imports	3000	3560	3000	3560
Hydro Domestic	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900
Nuclear	6660	1860	12800	0
PV	9770	8160	25000	24720
CSP	3300	300	8100	0
Wind	4360	1610	10520	4880
Other	640	640	0	0
TOTAL	**81350**	**76410**	**122460**	**116480**

Notes: (1) "Existing" coal includes Medupi and Kusile

Figure 21 – Electricity industry CO2 emissions under the carbon tax



Carbon budget

6.13 An alternative approach to induce the appropriate climate mitigation path is to set the total emissions allowance for the electricity sector over the study period and impose that as a constraint rather than an annual limit.

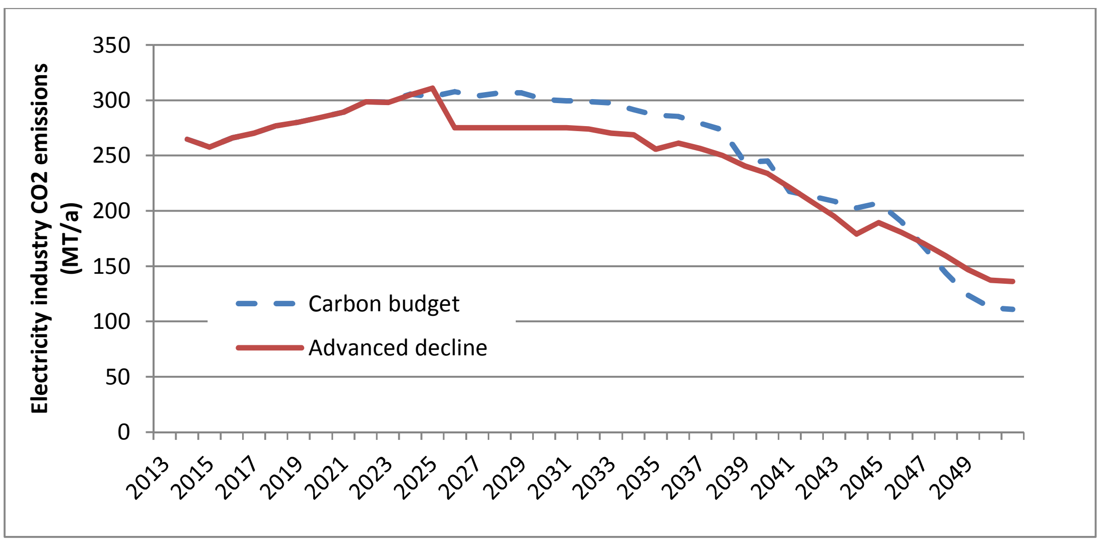
6.14 The World Wildlife Fund in a briefing paper on "Carbon budgeting" suggests a range of 9 to 15 Gt CO_2-equivalent as the maximum South African emissions in the period 2009-2050. The Department of Environmental Affairs paper on the PPD range, referenced above, suggests a range of 13,5 to 21,4 Gt CO_2-equivalent for the country in the period 2013-2050. If the electricity sector is taken at 45% contribution to this, the range for the electricity sector should be 6,1 to 9,6 Gt CO_2-equivalent. The total emissions over the period 2013-50 for the Constant Emissions scenario are 10,4 Gt, for the Moderate Decline 9,9 Gt and for the Advanced Decline 9,4 Gt.

6.15 For the purposes of the carbon budget study the 9,4 Gt of the advanced decline is assumed as the total budget for the electricity sector in the period 2013-50 in order to assess how the optimisation model would prefer to meet the budget constraint rather than a forced annual limit.

6.16 Figure 22 indicates that the optimisation approach would delay the implementation of the constraint but extend the decline to a lower level before 2050[5]. This shifting out of the limit is a clear result of the discounting process in the optimisation model which sees future costs as lower impact the further into the future these are incurred. Thus the premium associated with emission reductions is best delayed under such conditions and if incurred at the end of the period, even if more severe, is preferred to incurring at an earlier date.

6.17 The delay in the application of the emission constraint would also delay the nuclear build (as evidenced in Table 6 but increase the nuclear requirement in the 2040s at the expense of gas CCGT and coal.

Figure 22 – Electricity industry CO_2 emissions under carbon budget vs. advanced decline



[5] A comparison of the total carbon emissions between the carbon budget and Advanced decline cases between 2013 and 2050 show the total under the carbon budget (9613 Mt) is higher than the Advanced decline (9439 Mt). This is due to the optimisation model operating beyond the study end date of 2050 (up to 2055) to avoid end effects in the optimisation routine. In the period 2051-55 the carbon emissions are substantially lower in the carbon budget case and makes up for the 174 Mt difference.

Table 6 – Technology options arising from the carbon budget scenario relative to the Adv decline

Technology option	Advanced Decline (MW) 2030	Carbon budget (MW) 2030	Advanced Decline (MW) 2050	Carbon budget (MW) 2050
Existing Coal	36230	36700	16120	16120
New Coal	2450	4450	5200	4450
CCGT	3550	4260	8520	4970
OCGT / Gas Engines	7680	8160	11400	11040
Hydro Imports	3000	3280	3000	3280
Hydro Domestic	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900
Nuclear	6660	3460	28800	32000
PV	9660	9050	25000	24930
CSP	3600	2800	11900	13100
Wind	4530	3490	10770	11200
Other	640	640	0	0
TOTAL	**81590**	**79880**	**124300**	**124680**

Notes: (1) “Existing” coal includes Medupi and Kusile

7 REGIONAL DEVELOPMENTS

7.1 The policy adjusted IRP only allowed for 2609 MW of regional hydroelectric generation projects, even though it considered an additional 740 MW. Since the promulgation of the IRP 2010 a number of additional hydro options have become available. These include:

7.1.1 The Inga III project in the Democratic Republic of Congo which would allow South Africa access to 2500 MW from the facility. For the purposes of this Update it was assumed this would be available after 2025. Since no costs have been provided as yet for this project the scenario tested the impact of the new option and which technology options it would displace, and the pricing model assumed costs for the Mpanda Nkua from IRP 2010.

7.1.2 The Kobong pumped storage scheme in Lesotho which forms part of the second phase of the Lesotho Highlands Water Project. This facility provides 1200 MW of pumped storage capacity from 2023. Again, without costs to guide the technology choice, the facility was forced in for the Regional Hydro scenario to investigate what, if anything, the facility would displace. The utilisation of the facility in the model remained low for the full study period indicating that it may not be the most cost effective use of capital to invest in yet another pumped storage scheme.

7.1.3 The other hydro projects included in the IRP 2010 were re-introduced in the Regional Hydro scenario to see if they would still be selected at the costs as indicated in IRP 2010 (with escalation at South African CPI). All four projects (Boroma, Ithezi Tezi, Kafue, Kariba North Extension) are selected between 2022 and 2024, indicating the attractiveness of the options if the original cost assumption is indicative of the true cost.

7.2 Additionally in the region there are gas options, specifically Kudu in Namibia, but these are discussed in the Gas outlook below.

7.3 In terms of coal options in the region, the only option considered was for Mmamabula in Botswana. This 1200 MW was included in the Base Case as a fluidised bed combustion option with no emissions (as the emissions take place across the border and therefore accrue outside

South Africa) and is preferred by the model in all cases before other domestic coal-fired generation.

8 EMBEDDED GENERATION

8.1 Given the recent reduction in the cost of photovoltaic generation it has become highly probable that electricity consumers (commercial, residential, and to some extent industrial) will begin installing small-scale (predominantly roof-top) distributed generation to meet some or all of their electricity requirements. This penetration of distributed generation may occur with or without the support and approval of national and local government entities, but it may be prudent to incentivise the appropriate implementation in order to derive social benefits from this development rather than a potentially sub-optimal result because authorities only considered the risks rather than the benefits.

8.2 While there may be many forms of embedded generation, including biogas, biomass and wind, for the purposes of the analysis the Update considers only photovoltaic as it is the most likely form of generation to be embedded.

8.3 The assumed penetration of embedded PV uses residential as a proxy (even though commercial rooftop is more likely to materialise especially as there is a better match of electricity supply from PV and the demand onsite). It was assumed for the purposes of estimating potential PV rollout in homes that only households in living standard measure (LSM) 7 or higher would invest in rooftop PV and that (by 2020) only 50% of these would do so. In these cases the average capacity invested would be 5kWp. Figure 23 indicates the growth in total rooftop PV estimated growing as the number of households in LSM 7 or higher increase. By 2015 it is assumed that 40% of all households (6 million) will be in LSM 7 or higher and that this will rise with the assumed GDP growth to reach 70% in 2050 (14 million out of a total number of households of 20 million).

8.4 The results of the scenario indicate the preferred technology option in the face of this investment, especially as more flexible, mid-merit plant would be required to accommodate the large midday generation that disappears toward the evening peak. This can be seen in the increased requirement for OCGT or gas engines and an increase in CCGT of 1420 MW. The nuclear required is less by 3200 MW, whereas the coal generation is much the same as the Base Case (increase of one unit of 750 MW). The CSP capacity is reduced significantly.

Figure 23 – Possible total small-scale photovoltaic capacity

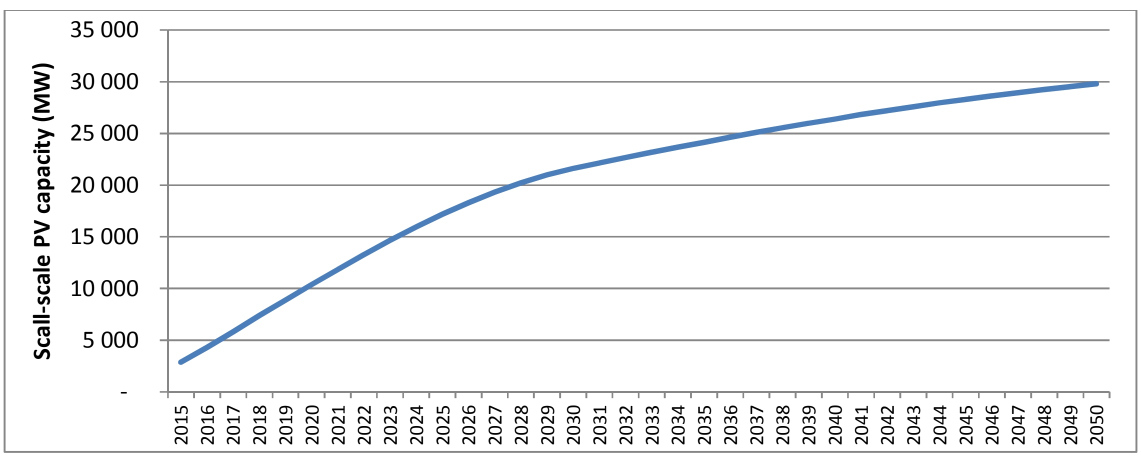


Table 7 – Technology options arising from the Rooftop PV case relative to Moderate Decline

Technology option	Moderate Decline (MW) 2030	Rooftop PV (MW) 2030	Moderate Decline (MW) 2050	Rooftop PV (MW) 2050
Existing Coal	36230	36230	16120	16120
New Coal	2450	2450	12700	13450
CCGT	3550	2840	9230	10650
OCGT / Gas Engines	7800	13440	11400	17160
Hydro Imports	3000	3000	3000	3000
Hydro Domestic	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900
Nuclear	6660	3460	20800	17600
Embedded PV	-	21617	-	29778
PV (additional)	9630	8770	25000	24930
CSP	3300	700	10900	4000
Wind	4250	3790	10680	10870
Other	640	640	0	0
TOTAL	**81100**	**100527**	**123420**	**151148**

Notes: (1) "Existing" coal includes Medupi and Kusile

9 OUTLOOK FOR NATURAL GAS

9.1 In the IRP 2010 the main source of potential gas generation was liquefied natural gas (LNG). This was priced at R80/GJ (in 2010 ZAR) but limited to a maximum 4300 MW of capacity (on the assumption that import capacity would be constrained by LNG terminal size). There was a consideration of the Kudu gas option but this used the parameters from a previous SAPP pool plan. While gas-fired CCGT were evident in many of the scenarios leading up to the final IRP 2010 these were squeezed out by many of the policy options made in the policy-adjusted plan, especially as coal, nuclear, renewables and hydro options were forced, leaving little room for originally preferred technologies.

9.2 In the years since the promulgation of the IRP 2010 there have been a number of new gas finds and developments in the gas market, domestically, regionally and internationally. These have required a change in how the IRP considers gas options:

9.2.1 In the Base Case the domestic gas option (which was not considered at all in IRP 2010) is considered at a fuel price of R70/GJ (in 2012 ZAR) but limited in total energy capacity to 295 PJ. This allows the model to choose how to optimise the consumption of gas over the study period to best suit the electricity demand. Clearly this offers an additional complication as the gas field will require a fairly constant outflow of gas, thus necessitating storage facilities.

9.2.2 In the Base Case regional gas is also considered at a fuel price of R70/GJ and is similarly limited but at 986 PJ. This reflects the Kudu gas field only as it is assumed that the currently operating Mozambique gas fields (Temane and Pande) are already fully committed. As with the domestic gas the modelling system prefers a mid-merit operation for the gas-fired power plants and builds 2840 MW to utilise the gas in this fashion. If operated in a base-load fashion only 800 MW would be built.

9.2.3 LNG is still considered available, uncapped, but at a price of R92/GJ, based on an assumed LNG price of $10/MMBTU. The future price of LNG is assumed to remain at this price in real terms, based on the expectation that the United States will soon start exporting the liquefied product (derived from shale) which is expected to keep the LNG market suppressed for some time. At this price few of the scenarios consider LNG gas as a viable fuel for mid-merit generation, let alone base-load. However it would be feasible for OCGT peaking capacity and thus all new OCGT capacity is assumed to operate on gas rather than the current practice of utilising diesel. The OCGT is assumed to be able to utilise the domestic and regional gas as a first priority and then only LNG if the capacity is reached. This is also an issue for implementation as it requires that the OCGT be able to access gas storage, either from piped gas or LNG, with sufficient capacity to support peaking operation.

9.3 A principle benefit of CCGT gas generation is the low capital cost which lends itself to mid-merit operation. This is supported by the levelised cost comparison between PF coal and CCGT gas in Figure 24 which indicates that, at current fuel cost assumptions, PF coal is preferred for operation at load factors above 46% whereas CCGT is preferred below this. The break-even gas price for base-load generation is indicated in Figure 25. As the coal price increases so the break-even gas price, below which base-load CCGT is preferred to coal, rises. An adjustment is made to indicate the relative benefit of gas in reducing carbon emissions. With the existing assumption on coal costs at R350/ton (or R17.50/GJ) the break-even gas price would be R64.50/GJ. When accounting for the emission benefit this rises to R73.20/GJ.

Figure 24 – Levelised cost comparison between base-load coal and CCGT gas generation

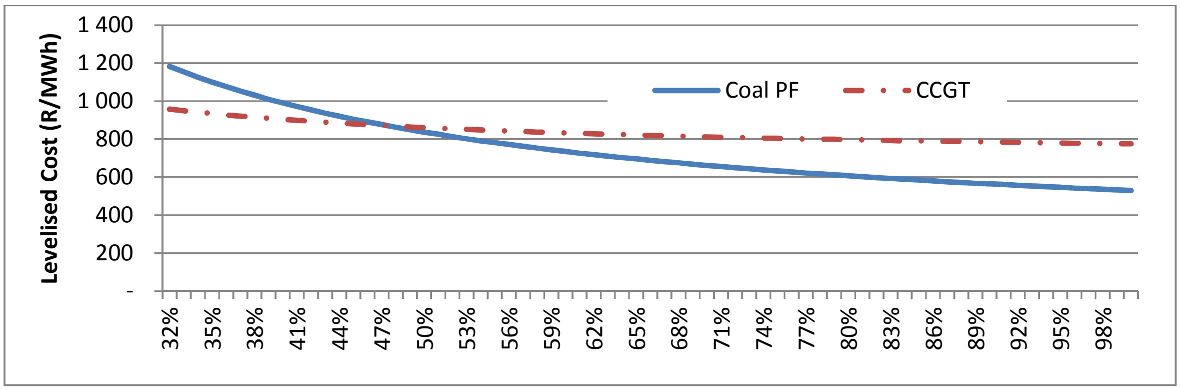
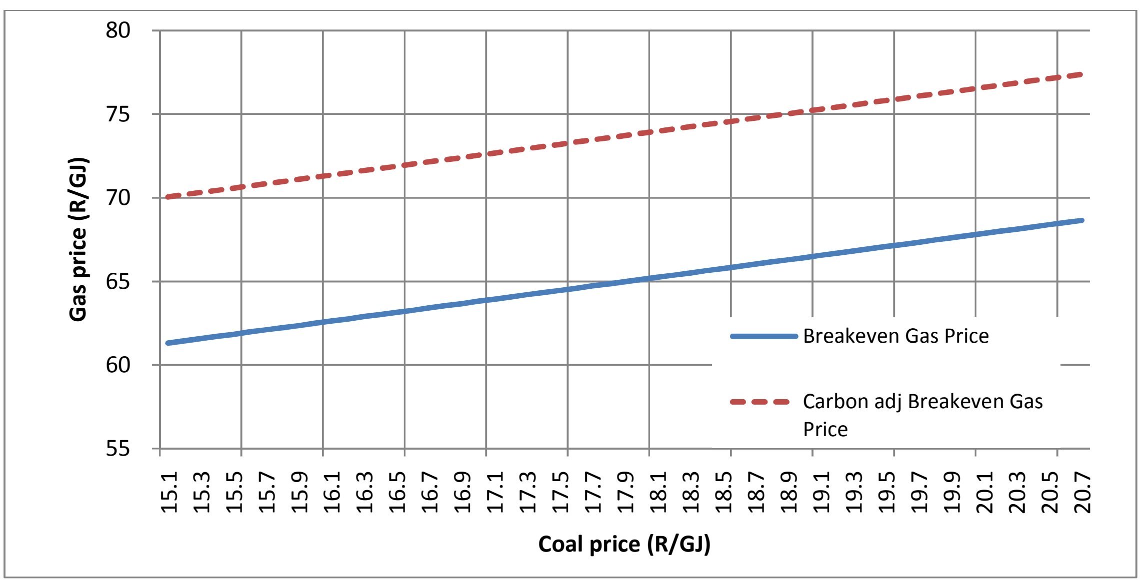


Figure 25 – Breakeven gas price for base-load generation



9.4 An additional scenario (the Big Gas scenario) has been constructed to consider potential regional and local gas developments. These include:

9.4.1 The development of additional conventional off-shore gas fields in Mozambique, specifically in Sofala province, which would increase the volume available at the R70/GJ price from 2020 (by an additional 986 PJ). The large gas fields in the far north of Mozambique (Romvula basin) and Tanzania are not considered in this pool and the distance would lead to higher costs, closer to the LNG price. There may even be an argument that suggests South Africa would be better served to allow this gas to be liquefied and then import it as LNG rather than increase energy dependency on one source of gas.

9.4.2 The potential for shale gas in South Africa, specifically the Karoo, after 2025. The total quantum of potential gas energy is substantial so imposing any cap for own use makes little sense, but the price of the developed shale gas is highly uncertain. If the scale of the operation remains limited then a price similar to the LNG price (R92/GJ) may be realised, but this would decline as the scale of the shale development increases. For the purposes of the scenario the price of shale is assumed at the R92/GJ mark in 2025 but decreases annually to a low of R50/GJ in 2035. This provides an insight to the tipping point where gas would replace coal-fired generation not only for mid-merit operation but also base-load generation.

9.4.3 The possible decrease in the gas price resulting from an expected large-scale exploitation of shale gas results in a switch in electricity generation from coal and nuclear toward a gas dominated regime along with a more limited renewable fleet. This is similar to the experience of the United States in the last five years as shale gas has revolutionised the power generation industry and allowed the US to reduce carbon emissions through the switch from coal to cheaper gas-fired generation.

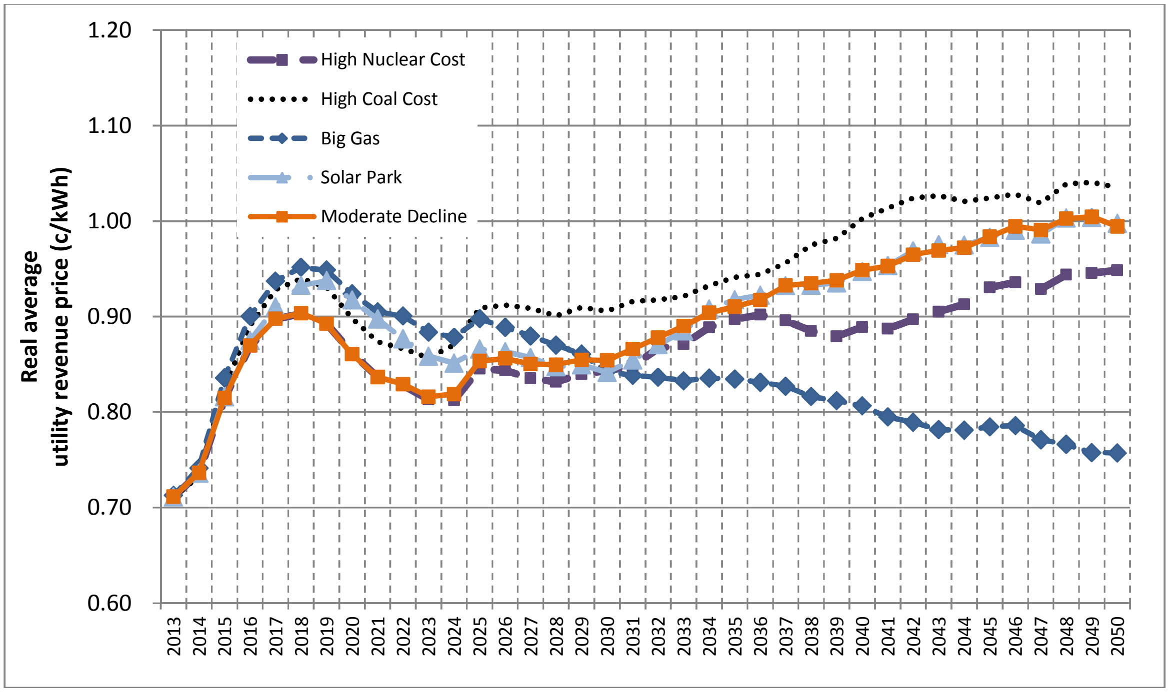
9.4.4 Figure 26 indicates the lower electricity price achievable over the study period if the shale gas costs become a reality.

Table 8 – Technology options arising from the Big Gas Scenario vs Moderate Decline

Technology option	Mod Decline (MW) 2030	Big Gas (MW) 2030	Mod Decline (MW) 2050	Big Gas (MW) 2050
Existing Coal	36230	35090	16120	11690
New Coal	2450	1200	12700	1200
CCGT	3550	16330	9230	62480
OCGT / Gas Engines	7800	4560	11400	6720
Hydro Imports	3000	3000	3000	3000
Hydro Domestic	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900
Nuclear	6660	1860	20800	0
PV	9630	4710	25000	15900
CSP	3300	300	10900	0
Wind	4250	1300	10680	1170
Other	640	640	0	0
TOTAL	**81100**	**72580**	**123420**	**105750**

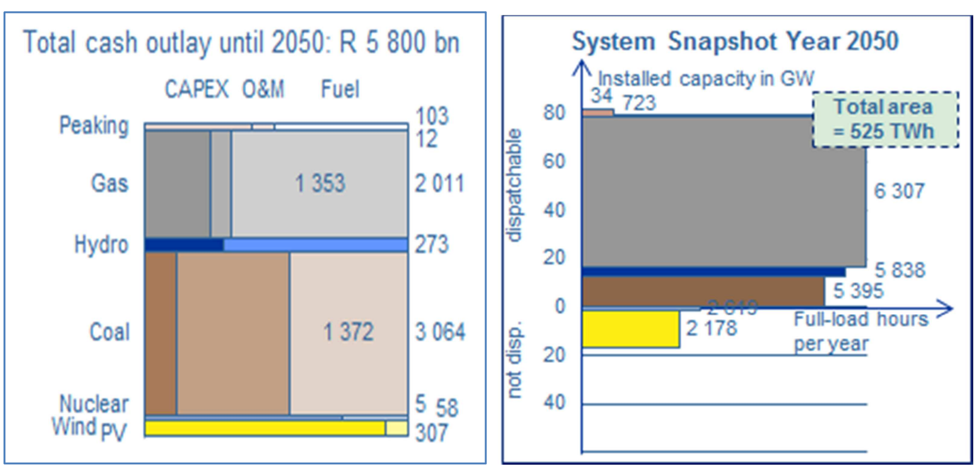
Notes: (1) “Existing” coal includes Medupi and Kusile

Figure 26 – Real average utility revenue price for test cases against the Base Case



9.4.5 The Big Gas scenario increases the exposure of the electricity to future gas prices and strongly reduces the impact of fixed capital costs on future electricity prices (relative to the Base Case and the Moderate Decline scenarios). The snapshot of the system in 2050 (indicated in Figure 27) highlights the large development in gas and the new dominant position in gas relative to other forms of generation.

Figure 27 – Cost implications and system snapshot for the Big Gas scenario



10 ENERGY EFFICIENCY

10.1 The IRP 2010 considered only the Eskom projects for energy efficiency demand side management (EEDSM) as was indicated in the MYPD2 application. These projects were forced into the policy-adjusted plan in the absence of detailed per-unit cost analysis. It was suggested in the IRP 2010 report that additional work would be required to establish a clearer indication of the per unit costs of EEDSM programmes and the potential (beyond Eskom's programmes). This work has not been undertaken thus, once again, the Update relies on Eskom's assumed programmes, this time from the MYPD3 application.

10.2 Beyond this, however, the Update considers a significant decline in the electricity intensity of the South African economy (indicated in Figure 14), driven by:

10.2.1 Changes in the structure of the economy (specifically the move from energy intensive industries to less intensive sectors), which is highlighted by the difference in the Traditional Sectors and Green Shoots intensity curves, since the Traditional Sectors is based on a similar economic structure to the current SA environment, whereas the Green Shoots assumes the shift away from energy intensive industries;

10.2.2 Price elasticity of demand as higher electricity prices impact on energy consumption patterns;

10.2.3 Regular improvements in technology which reduces the energy intensity of production processes and energy requirements on appliances and other elements of electricity consumption.

10.3 In short it is expected that, even without the intervention of a centrally mandated entity, the market will drive some energy efficiency over the next 30 years. However there are limits to market-driven efficiency which still requires an entity to pursue programmes to continue efficiency improvements. These include:

10.3.1 In as much as electricity retail prices do not reflect the long run marginal cost of electricity (due to regulatory intervention, fiscal subsidies, a market driven by over-capacity, or whatever means) the socially optimal level of efficiency investment will not be attained as the true benefit of the efficiency improvement is not realised by the investor;

10.3.2 Access to capital may limit the ability of consumers to undertake the investment required to improve the efficiency relating to their consumption;

10.3.3 Linked to the above is the potentially higher cost of capital for private investors relative to the state (and state-owned enterprises) which could increase the pay-back period of investments and thus lead to a suboptimal investment in efficiency.

10.4 Thus there is a role for a centrally mandated entity to pursue energy efficiency in order to realise the expected electricity intensity (or improve thereon), using programmes to:

10.4.1 Set national targets and efficiency standards (e.g. building codes); as well as work with industry bodies to providing rating mechanisms for appliances, buildings, amongst others.

10.4.2 Provide financing for efficiency programmes (where access to financing limits the rollout of new technologies);

10.4.3 Provide financing for research into new efficiency technologies (where feasible); and

10.4.4 Implement public awareness campaigns and efficiency information.

10.5 The costs and benefits from such programmes require additional research, especially international experience in this field, and should be a high priority for the next full iteration of the IRP.

11 SENSITIVITY ANALYSIS ON BASE CASE ASSUMPTIONS

Nuclear capital costs

11.1 As discussed in 3.3 above the nuclear overnight capital cost assumption for the Base Case is $5800/kW value. Considering the importance of this assumption to the future generation outlook a higher capital cost was considered as a sensitivity test case. The sensitivity test uses $7000/kW for the overnight capital cost.

11.2 The results from the test case indicate the degree to which the results are dependent on this assumption. At the higher cost of nuclear there are no new nuclear units built with this shortfall in capacity taken up by CSP, wind and CCGT gas (using LNG in addition to the domestic and regional gas options). PV is already constrained by the annual maxima applied and this cannot increase any further.

11.3 The lower prices achieved under this scenario (indicated in Figure 26) after 2040 relative to the Moderate Decline test case reflects the switch from a high capital solution toward lower capital but exposure to future fuel costs.

Table 9 – Technology options arising from the High Nuclear Cost Scenario

Technology option	Moderate Decline (MW) 2030	High Nuclear Cost (MW) 2030	Moderate Decline (MW) 2050	High Nuclear Cost (MW) 2050
Existing Coal	36230	36230	16120	16120
New Coal	2450	2950	12700	11950
CCGT	3550	2840	9230	20590
OCGT / Gas Engines	7800	5760	11400	2640
Hydro Imports	3000	3000	3000	3000
Hydro Domestic	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900
Nuclear	6660	1860	20800	0
PV	9630	10270	25000	25000
CSP	3300	13400	10900	38100
Wind	4250	7450	10680	25280
Other	640	640	0	0
TOTAL	**81100**	**87990**	**123420**	**146270**

Notes: (1) “Existing” coal includes Medupi and Kusile

Future coal costs

11.4 The Base Case assumption for future coal cost is R350/ton for new coal-fired generation. There is no allowance for a real price increase over the study period. Even though there have been real price increases over the last ten years it is still not evident that this trend need continue into the future. However the sensitivity of the model to a higher future coal price is assessed by increasing this cost to R500/ton for future PF coal generators. The cost for FBC coal remains the same as this is still assumed to be fired by discard coal which is priced at R150/ton.

11.5 Under this assumption CCGT generation becomes more competitive (with the breakeven price for gas rising to R74/GJ) resulting in more gas capacity (both in terms of peaking and base-load).

11.6 The impact on pricing (also reflected in Figure 26 follows the opposite trajectory to the High Nuclear costs as the more expensive coal (evident throughout the study period) increases the cost of electricity while also forcing the model in the longer term toward the more expensive gas option.

Table 10 – Technology options arising from the High Coal Cost scenario

Technology option	Moderate Decline (MW) 2030	High Coal Cost (MW) 2030	Moderate Decline (MW) 2050	High Coal Cost (MW) 2050
Existing Coal	36230	36230	16120	16120
New Coal	2450	2950	12700	10450
CCGT	3550	2840	9230	12780
OCGT / Gas Engines	7800	7800	11400	13200
Hydro Imports	3000	3000	3000	3000
Hydro Domestic	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900
Nuclear	6660	6660	20800	19200
PV	9630	9890	25000	25000
CSP	3300	3300	10900	8300
Wind	4250	4450	10680	10390
Other	640	640	0	0
TOTAL	**81100**	**81350**	**123420**	**122030**

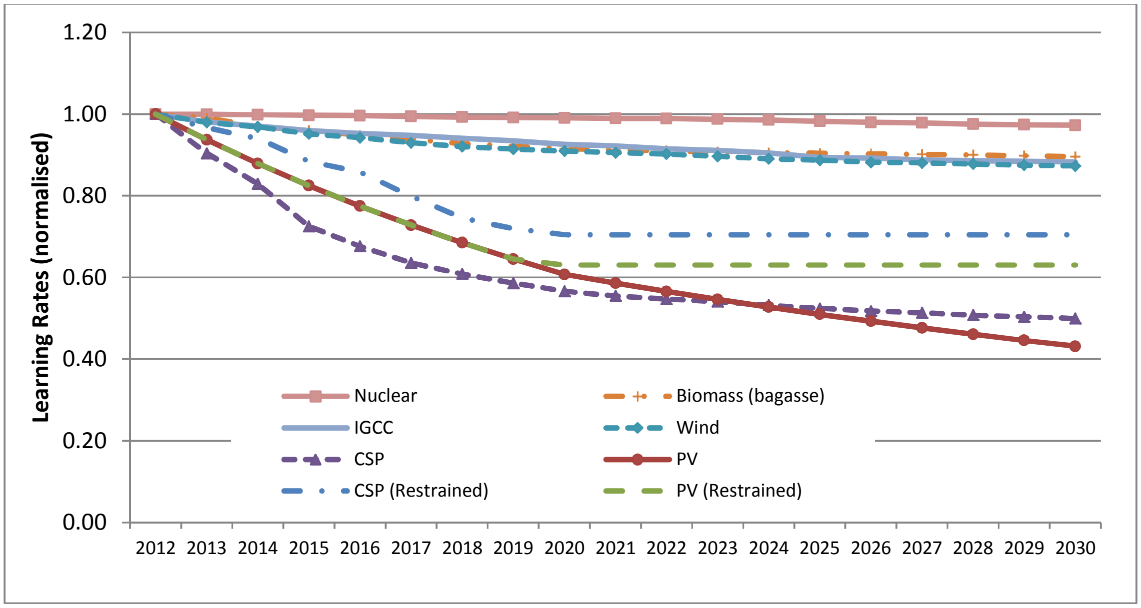
Notes: (1) “Existing” coal includes Medupi and Kusile

Learning rates

11.7 The technology learning rates included in the Base Case have been described as somewhat aggressive (especially for CSP and PV) even though they were based on external credible sources (such as Boston Consulting Group – for PV – and the IEA – for CSP and other technologies). Increased learning for nuclear under a fleet procurement strategy compared to a single site strategy was not considered. This could be considered in future iterations.

11.8 A more restrained set of technology rates has been included as a scenario to identify the sensitivity of the results to these rates. The approach was to test each learning rate individually and then apply a global Restrained Learning scenario. Under this scenario there was no learning applied for nuclear, biomass, IGCC and wind, with a more restrained learning for CSP. The PV learning was the same as the Base Case but only until 2020 and then no learning thereafter. Similarly the restrained learning for CSP stops in 2020 with no learning thereafter. The differences in the technology cost paths arising from these rates are indicated in Figure 28.

Figure 28 – Technology cost paths in the Base Case and Restrained Learning Scenario



11.9 The results (indicated in Table 11) highlight the obvious impact that the higher renewable costs have on the outcomes. Specifically if the CSP learning cannot be realised then CSP is never competitive with the other options and no new CSP is developed after the existing Rounds 1 and 2 options and the committed Eskom plant. Wind is also similarly limited without additional learning as is PV but the PV rates in 2020 allow it to be somewhat competitive (especially with tracking which reduces the levelised costs of PV) and PV would continue development but at a lower penetration. Nuclear and gas CCGT are the technologies chosen to replace the limited renewables under this scenario.

Table 11 – Technology options arising from the Restrained Learning Rate scenario

Technology option	Moderate Decline (MW) 2030	Restrained Learning (MW) 2030	Moderate Decline (MW) 2050	Restrained Learning (MW) 2050
Existing Coal	36230	36230	16120	16120
New Coal	2450	2950	12700	12700
CCGT	3550	2840	9230	12780
OCGT / Gas Engines	7800	6960	11400	9240
Hydro Imports	3000	3560	3000	3560
Hydro Domestic	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900
Nuclear	6660	9860	20800	30400
PV	9630	6860	25000	13450
CSP	3300	300	10900	0
Wind	4250	1300	10680	550
Other	640	640	0	0
TOTAL	**81100**	**75090**	**123420**	**102390**

Notes: (1) "Existing" coal includes Medupi and Kusile

Solar park

11.10 The concept of the solar park or solar corridor has been high on the government agenda for a number of years. While the Moderate Decline delays the construction of CSP until 2030 (when learning rates render these competitive) the Solar Park test case forces construction earlier, allowing for 1000 MW of CSP construction each year from 2018 to 2022. The result is to delay the nuclear construction in the Moderate Decline from 2025 to 2030 (but resulting in the same nuclear construction by 2050), whereas most of the other technologies remain much the same as the Moderate Decline case.

11.11 The Solar Park test case results in higher electricity prices initially (indicated in Figure 26) as the CSP technology is constructed, but over the life of the study the price returns to the same as the Moderate Decline.

Table 12 – Technology options arising from the Solar Park test case

Technology option	Moderate Decline (MW) 2030	Solar Park (MW) 2030	Moderate Decline (MW) 2050	Solar Park (MW) 2050
Existing Coal	36230	36230	16120	16120
New Coal	2450	2450	12700	12700
CCGT	3550	2840	9230	9230
OCGT / Gas Engines	7800	7440	11400	12480
Hydro Imports	3000	3000	3000	3000
Hydro Domestic	690	690	690	690
PS (incl Imports)	2900	2900	2900	2900
Nuclear	6660	5060	20800	20800
PV	9630	8840	25000	24930
CSP	3300	7000	10900	9400
Wind	4250	3550	10680	10560
Other	640	640	0	0
TOTAL	**81100**	**80640**	**123420**	**122810**

Notes: (1) "Existing" coal includes Medupi and Kusile

12 DECISION TREES

12.1 The IRP 2010 indicated preferred options for the period 2010-30 but did recommend the need to be flexible considering inherent high uncertainty and changing circumstances. While the IRP 2010 remains the official strategy, the principle purpose of this report is to provide additional information to guide key decisions before a full reiteration of the IRP can be completed.

12.2 The Update considers a number of scenarios based on changes in underlying assumptions as well as policy direction. A mechanism to consolidate these options is that of decision trees which draw together the key lessons from each of the scenarios. In this section four key decision trees are outlined for the technologies with the greatest divergence in outcomes amongst the scenarios and which involve longer lead times. These are nuclear, new coal, gas CCGT and CSP.

12.3 In all the discussions from the decision trees below the timeline specifies a procurement process (on the assumption of an independent power producer being the responsible entity for the new capacity). However if the determination is for Eskom to build the new capacity, then the same timeline applies but the Minister of Energy needs to consult with the Department of Public Enterprises and Eskom to ensure the funding is in place to develop the generation capacity.

Nuclear

12.4 The choice of nuclear generation is particularly volatile given shifts in underlying assumptions. Total nuclear capacity in 2050 ranges from 0 MW (in the Big Gas and Weathering the Storm scenarios) to 30400 MW (in the restrained learning scenario).

12.5 This would suggest that the decision to develop new nuclear technology would need to consider the determinants that would result in different outcomes for nuclear. Since the earliest that nuclear is considered is 2025, this would suggest that within the next twelve months the following determinants needs to be assessed:

12.5.1 If regional development (Inga III option) occurs, or Embedded Generation (Rooftop PV) or the Solar Park are likely to succeed then the nuclear decision can be delayed by three years (to 2018) in order to get firm answers on the determinants, otherwise,

12.5.2 If, and only if, electricity net-sentout is greater than 265 TWh in 2014 (or 270 TWh in 2015) AND there is no expectation of large-scale gas development then the nuclear procurement should proceed. However, if it is clear that there is no commitment to a nuclear capital cost below $6500/kW then the procurement should be abandoned as the additional cost would suggest an alternative technology instead.

12.6 The decision tree in Figure 30 identifies the different paths for nuclear construction with the SO Moderate scenario building 8 units between 2025 and 2035 (for a total of 12800 MW) and similar, though marginally smaller, builds in the Base Case, Moderate Decline, High coal cost, and Advanced Decline scenarios. This is opposed by the zero nuclear construction under the Big Gas, High Nuclear Cost and Weathering the Storm scenarios. If the renewable learning is not realised then additional nuclear is required (similar to the SO Moderate scenario).

Figure 29 – Total Nuclear capacity under the different scenarios

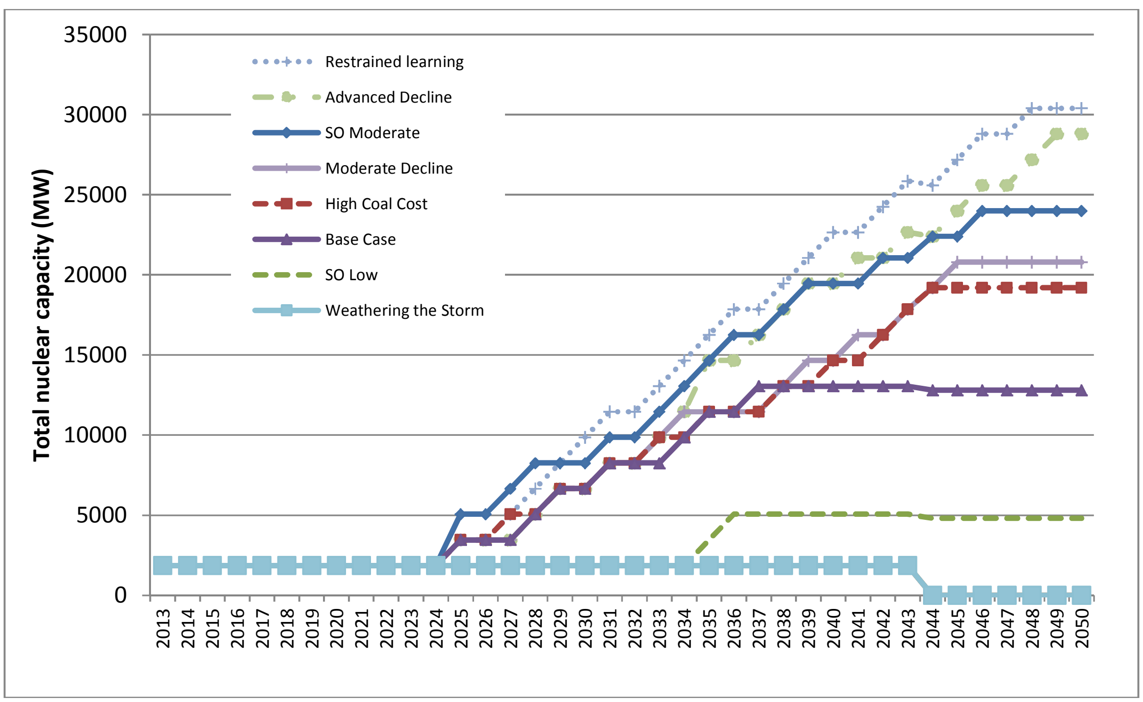
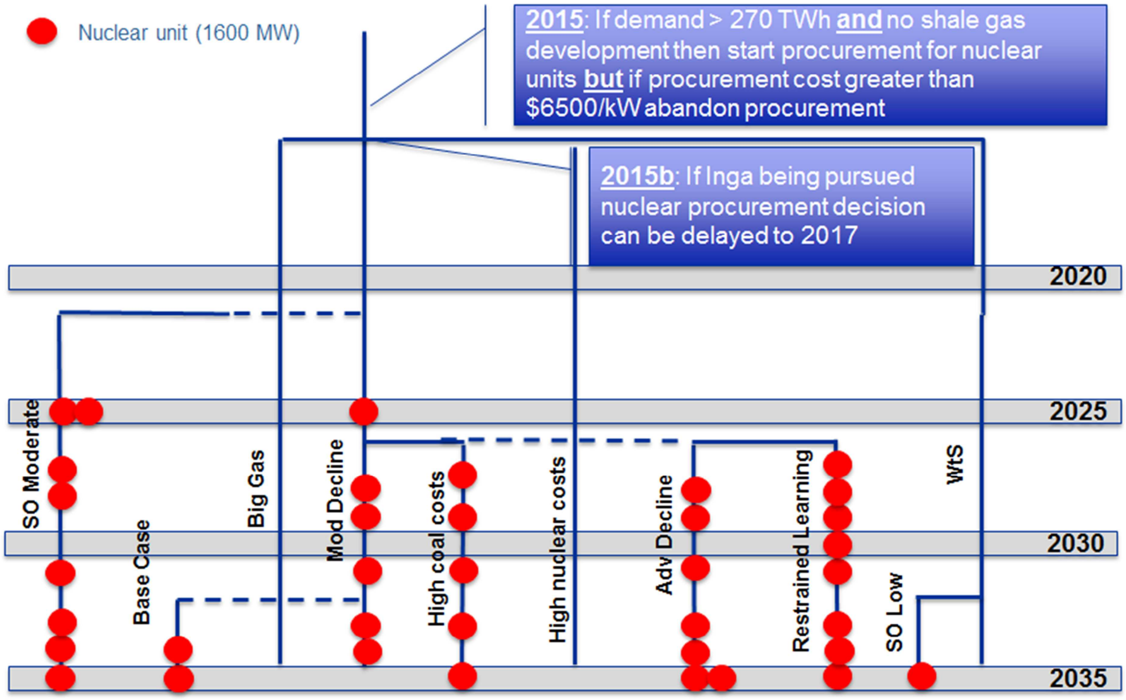


Figure 30 – Decision Tree for nuclear capacity



New coal

12.7 In all scenarios there is a requirement for first new coal-fired generation between 2020 and 2025. The common element is the option for a regional coal project (of the order of 1200 MW) which is preferred to all other coal options because it is expected that the emissions from the generation will not count to the South African total in a future global emission targeting regime. If this is not the case, then there is no preference between a local and regional coal option. The procurement for the regional coal option should be initiated by the end of 2015 to ensure the capacity is available in 2024 or 2025 as required.

12.8 The first major decision point for other coal-fired capacity is during 2014. If total net sent-out exceeds 265 TWh in 2013 (which is exceedingly unlikely at this point) then a procurement process is required to construct 1000 MW of FBC capacity between 2020 and 2025. This is an early indication of a high growth trajectory which would require new capacity by 2021.

12.9 It is recommended that procurement for additional FBC capacity is launched during 2017 if total net sent-out exceeds 280 TWh (except if regional hydro is being pursued). Under these conditions the programme should consider 500 – 1500 MW of new FBC capacity, depending on the underlying conditions as indicated in the decision tree.

12.10 The significance of the lifex decision is highlighted in the decision tree (using the Moderate decline case without the lifex option allowed). If the life extension decision is removed then an additional 9750 MW of pulverised-fuel coal-generation is required between 2029 and 2035.

12.11 Figure 33 indicates the electricity price impact of not pursuing the lifex option in terms of higher prices from 2029-46 in order to pay for the capital costs of the new coal-fired generation.

12.12 Amongst the options still considering lifex a number of cases propose new PF coal generation capacity but only after 2031. It is only in the case of high coal costs, large shale gas exploitation and the Advanced Decline carbon mitigation that there is no requirement for new large-scale domestic coal-fired generation before 2035. Given that the earliest date for new PF coal-fired generation is 2029 (without lifex) and 2031 (with lifex) the "Coal 3" possibility should be limited to small-scale fluidised bed combustion.

Figure 31 – Total new coal-fired generation under each scenario (excluding existing coal fleet)

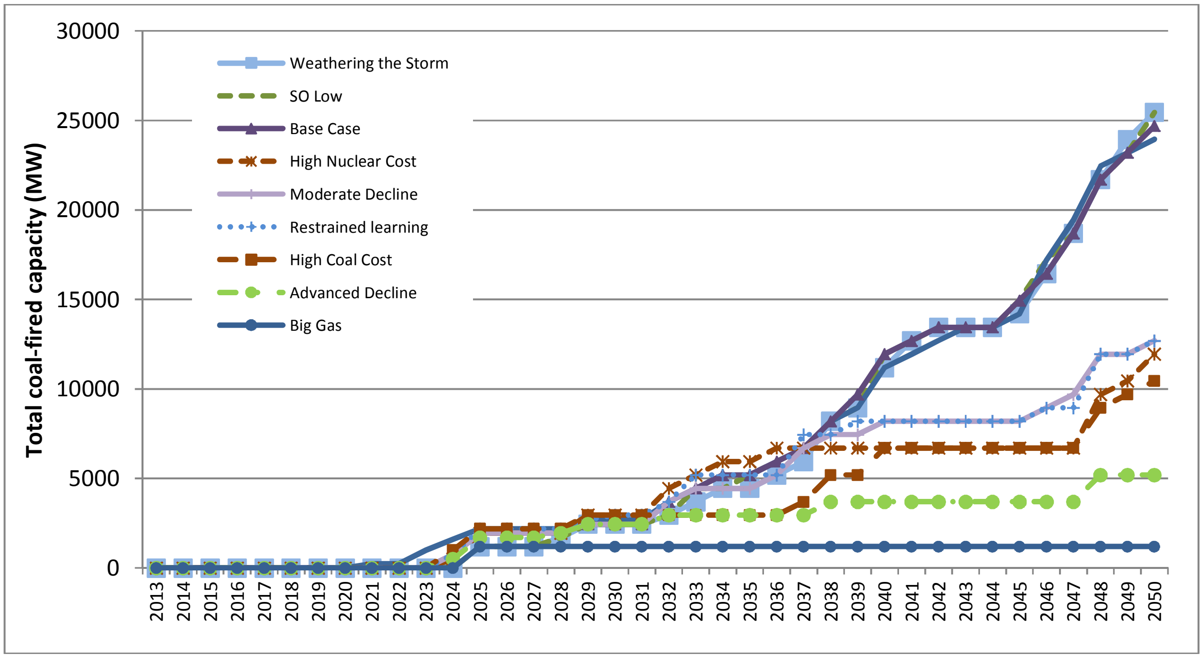


Figure 32 – Decision Tree for new coal-fired capacity

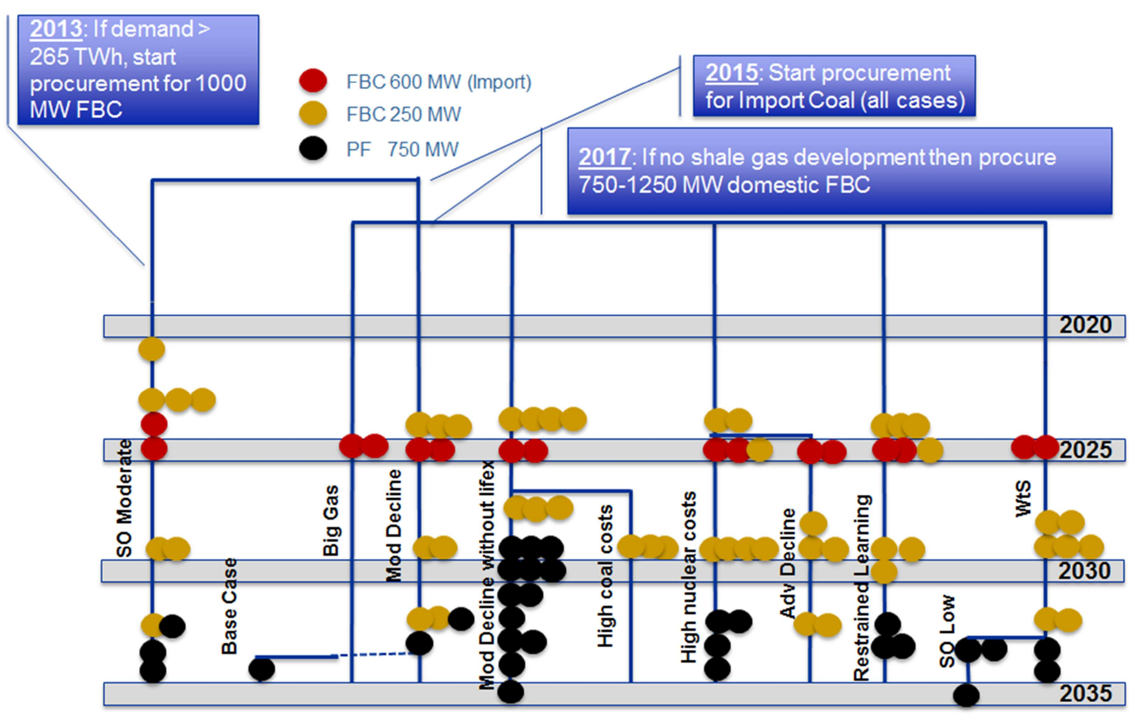
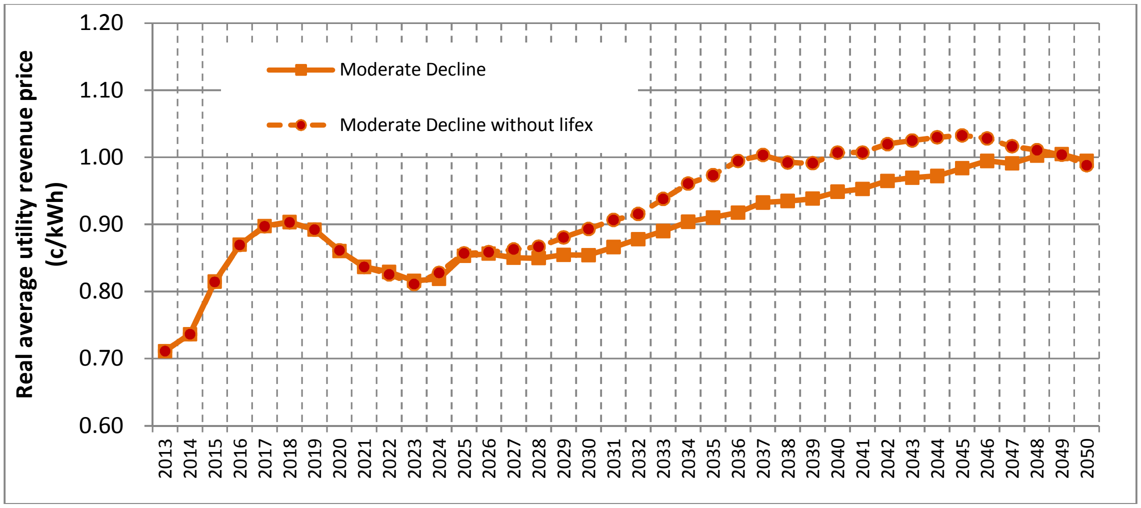


Figure 33 – Real average utility revenue price path on Moderate Decline with and without lifex



Gas CCGT

12.13 The majority of scenarios provide for a limited exposure to new CCGT capacity (between 3550 and 9330 MW in 2050). There are a few outliers, specifically the Big Gas scenario which unsurprisingly calls for 62480 MW of CCGT capacity by 2050, based on large-scale shale exploitation, but also the High Nuclear and High Coal cost scenarios which require investment in alternative sources of fuel including gas and CSP.

12.14 Considering the shorter lead time for CCGT construction there is time to assess the economic and environmental impacts of large-scale shale development before embarking on the procurement process, although the commitment to the technology may be required earlier to be clearer on the nuclear path. It is expected that by 2018 a decision would be made regarding the shale process, otherwise the procurement of CCGT gas would be limited to domestic and regional gas options.

12.15 As discussed above LNG has limited benefit as a fuel source relative to alternatives available in South Africa, unless the costs for LNG reduce below the expectation of R92/GJ. It is only in the case of higher nuclear capital costs and coal fuel costs that the LNG option becomes viable and is pursued but since that capacity is only required after 2030 there is also time to assess developments before committing to the new capacity.

CSP

12.16 There is a wide range of outcomes for CSP development under the different scenarios with many of the options clustering around 8000 MW capacity in 2050. The outliers are:

12.16.1 the Big Gas and Restrained Learning scenarios which would prefer no CSP capacity at all in 2050 (assuming that those constructed under the current bid programme would be decommissioned at end of life after 30 years); and

12.16.2 The High Nuclear Cost scenario which replaces the nuclear fleet with a mixture of alternatives, not least of all 38 000 MW of CSP.

Figure 34 – Total CCGT gas capacity under different scenarios

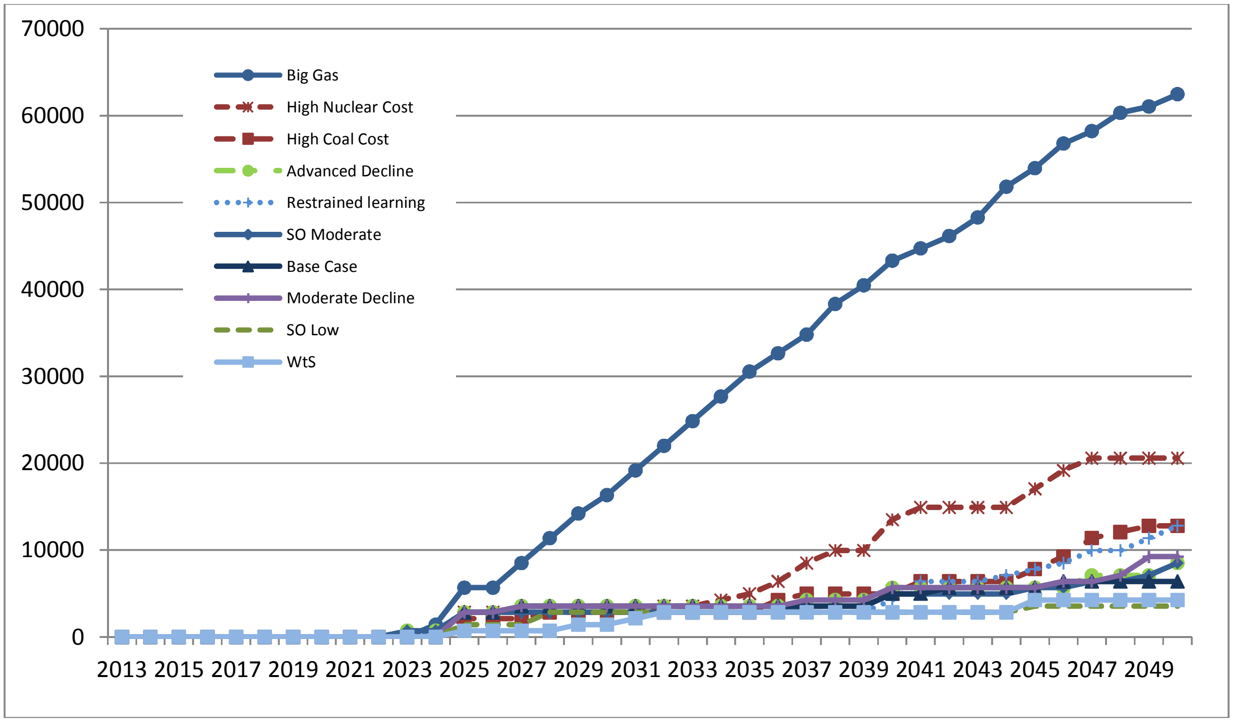
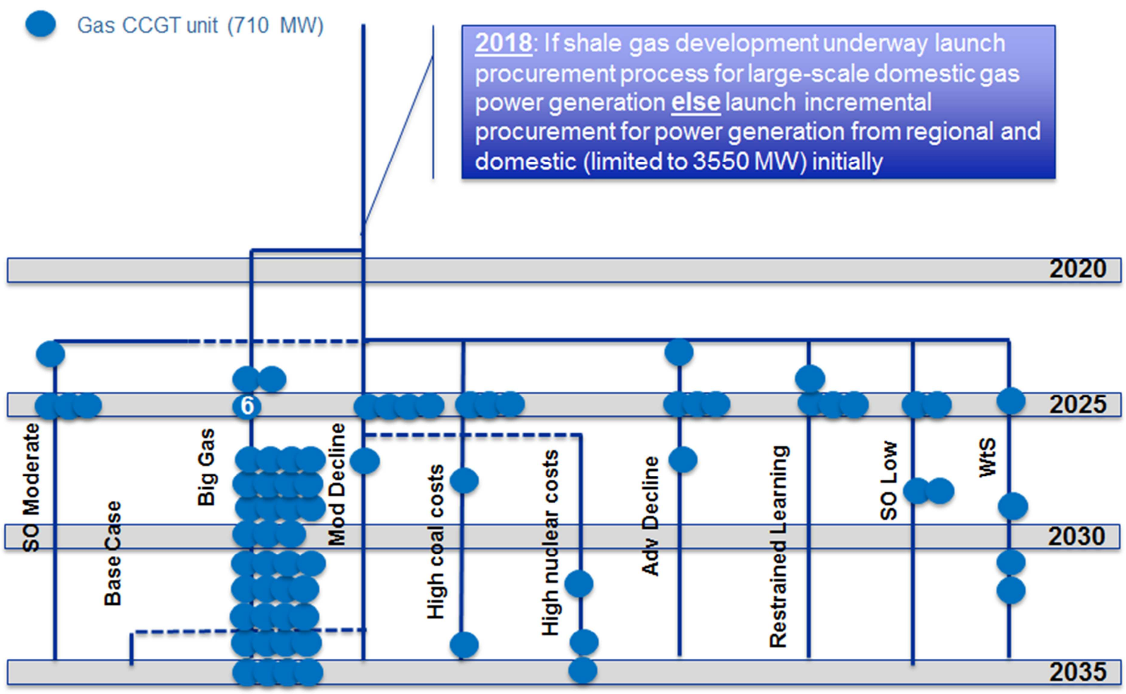


Figure 35 – Decision Tree for CCGT gas capacity



12.17 It is particularly noticeable that all the new CSP capacity (except in the high nuclear cost scenario) is only constructed in 2030 when the technology learning rates reduce the new capital costs to a competitive level. If these learning rates are realisable then there is an argument to be made that early development of these technologies in South Africa, even if more expensive than alternatives, could form part of the global capacity required to ensure that learning materialises. It would also be in keeping with the intention of the IRP 2010 that renewable capacity be accelerated and developed over a longer time rather than delay until it is required by the least-cost optimisation.

12.18 In this light it is recommended that the future rounds of the renewable bid programme allow for annual development of 200 MW CSP capacity until 2018 when four alternatives would occur, either:

12.18.1 Increase the annual CSP procurement capacity to 500 MW, in the case where the nuclear costs are too high and the nuclear option will not be pursued and the total net sent-out in 2018 is greater than 300 TWh; or

12.18.2 Reduce the annual CSP allocations to 100 MW if it is clear demand follows the SO Low trajectory; or

12.18.3 Cease CSP allocations entirely if the total net sent-out is less than 280 TWh OR development of shale gas fields are underway with the expectation of a large-scale exploitation of domestic shale gas OR it is clear there is limited cost reduction being experienced in CSP as proposed under this Update; or

12.18.4 Continue the procurement of 200 MW CSP annually until the next decision point in 2025.

Figure 36 – Total CSP capacity under different scenarios

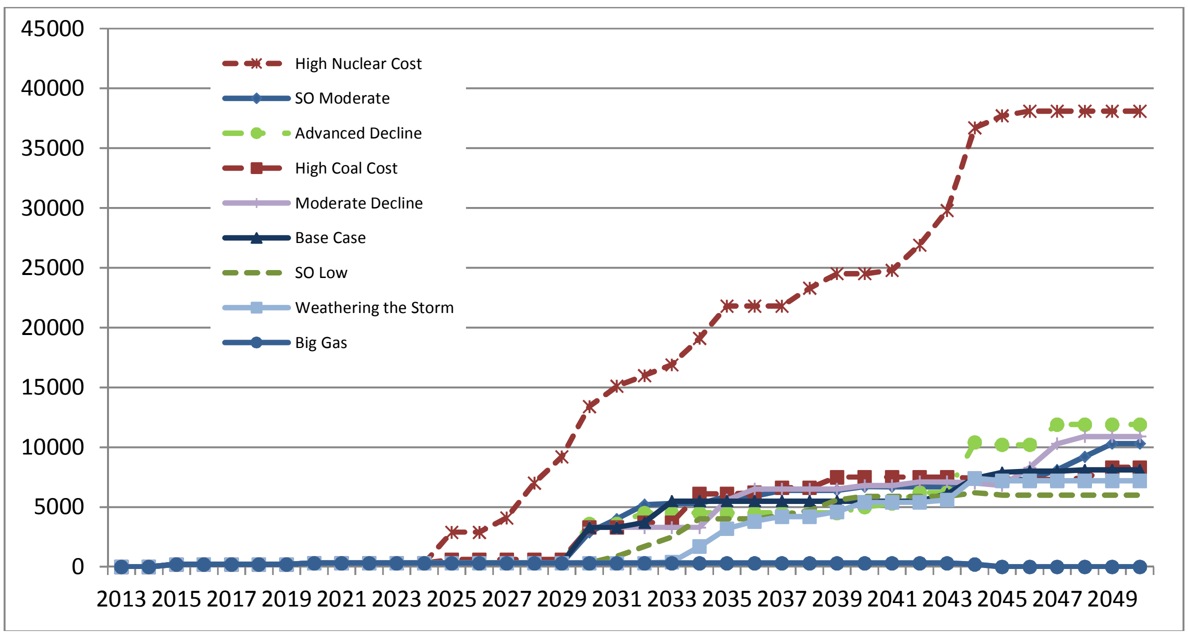
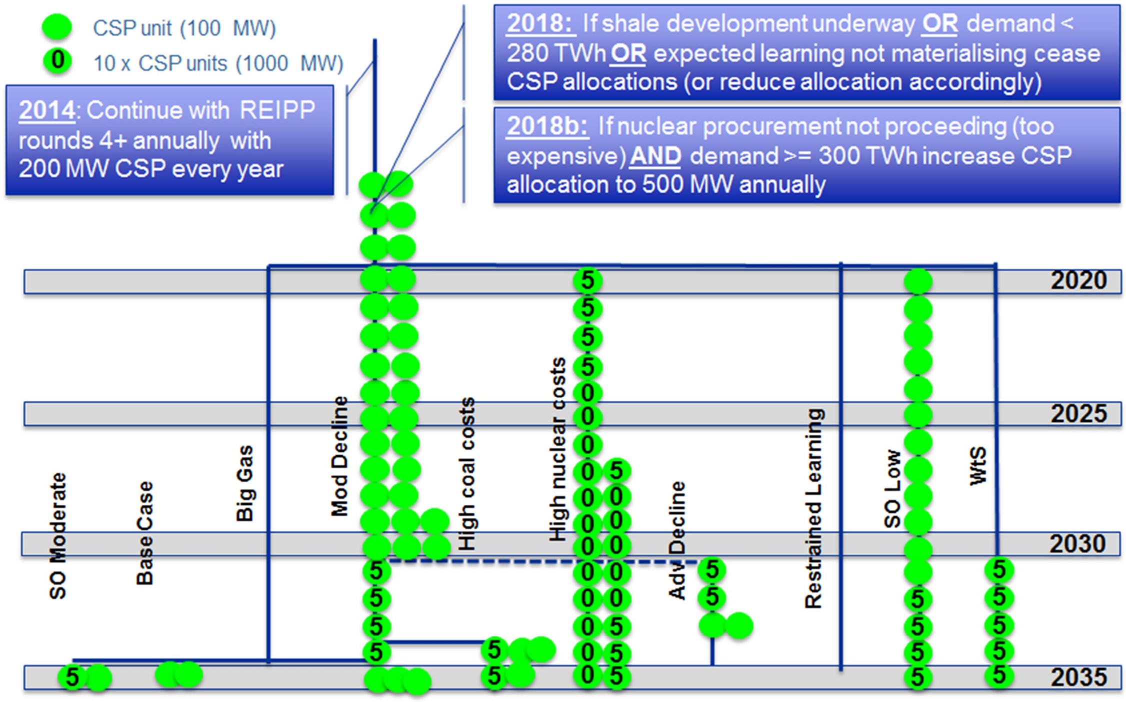


Figure 37 – Decision Tree for CSP capacity



Other technologies

12.19 The decisions for regional hydro are relatively simple. All the proposed hydro options are feasible if the assumed costs can be realised. In essence if the price of the hydro proposal, inclusive of transmission requirements to evacuate the power, can be maintained within the 60c/kWh benchmark for new coal then these options should be pursued as and when they arise. The impact on alternative capacity would have to be considered in follow-up IRPs. Any additional domestic hydro options (especially small-scale) that can meet the same 60c/kWh benchmark should be pursued, especially where embedded close to load centres due to the network benefits from such options.

12.20 Photovoltaic and wind technologies are commonly pursued in almost all scenarios, especially as the artificial annual limits of 1000 MW for PV and 1600 MW for wind limit the upside of further development of these resources. Wind is also impacted by new modelling assumptions that have limited the choices relative to other technologies (see Footnote 3 on page 20). This could change with new data and is susceptible to changes in assumptions in the next iteration. As a result the recommended approach is to continue with annual procurement processes for 1000 MW of PV and 1000 MW of wind until the capacity is reached. It is only in the case of large-scale gas exploitation (specifically the Big Gas scenario) and the Restrained Learning scenario that wind and PV capacity is limited. If this eventuality is realised then wind procurement would need to be curtailed.

12.21 Open-cycle gas turbines or engines are also required in all scenarios, generally in the 10000-14000 MW range, but is dependent on gaining access to gas (regional, domestic or LNG) which is storable in quantities to support very low load factors (less than 5%). If this does not occur then the preference is to engage customers in demand response (particularly peaking demand response) programmes to the maximum extent possible before building additional OCGT and using diesel to fuel generation. If large-scale CCGT generation is feasible (for example in the Big Gas scenario) then OCGT is replaced by CCGT operation and in the high nuclear cost case, OCGT is replaced by CSP and CCGT to meet peak demand requirements.

12.22 The generic costs for land-fill gas are extremely attractive, but this was not included in the modelling due to the uncertainty regarding available options and the impact of local conditions on costs. However if land-fill gas options are available and compete with the 60c/kWh benchmark then these should be pursued for similar reasons to small-scale hydro.

Figure 38 – Total wind capacity per scenario

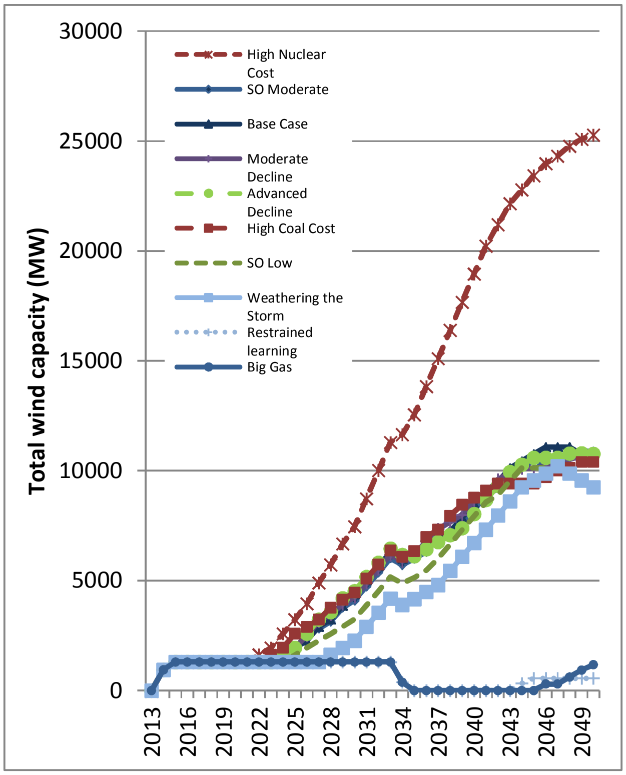
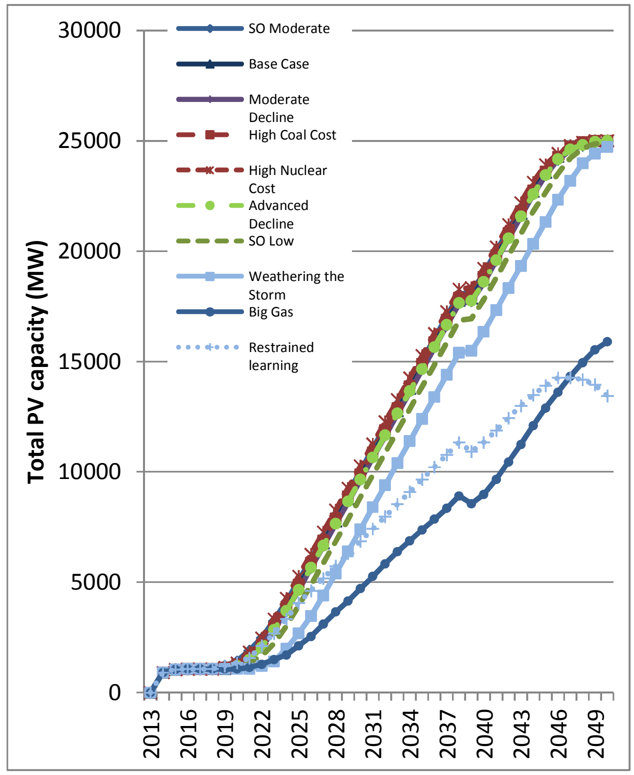


Figure 39 – Total PV capacity per scenario



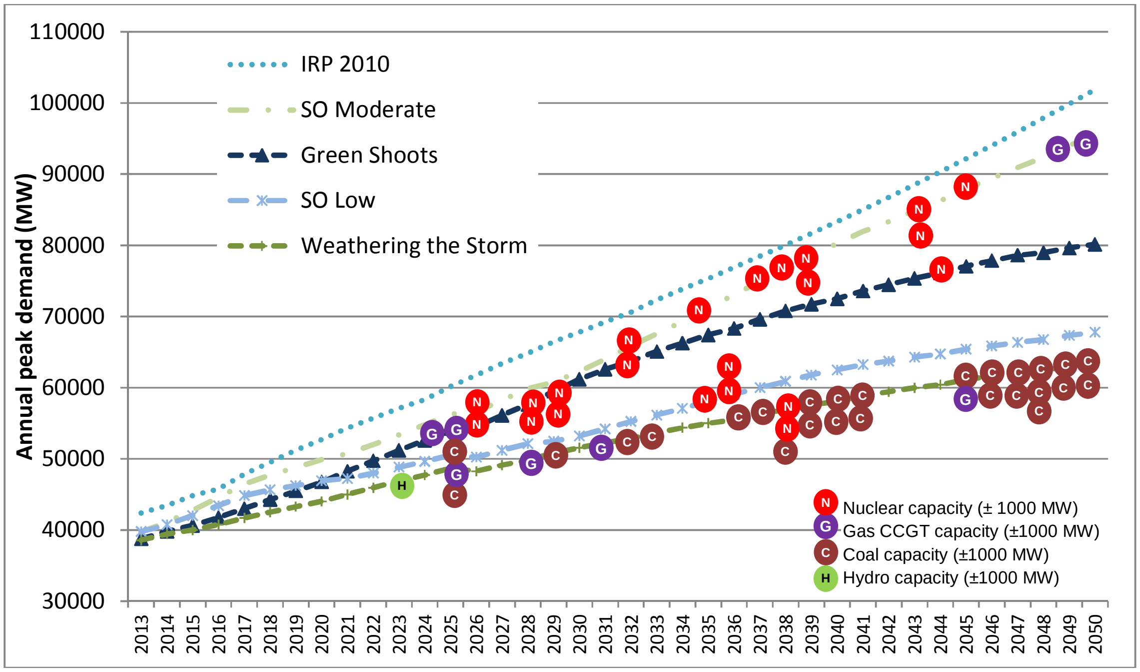
Demand-driven capacity options

12.23 As discussed under Section 5 above, the potential for different demand outcomes has an obvious impact on the capacity requirement. However it needs to be repeated that the Green Shoots demand trajectory, used as a basis for the Base Case and derivative scenarios, is an aspiration for the country. It indicates a minimum requirement in order to meet developmental objectives. However there are severe constraints on the realisation of this aspiration. There is a strong likelihood that the aspiration will not be achieved and so, even as it indicates where the country should be headed, any capacity required to meet this objective may also be stranded, or at least under-utilised, with a result of higher electricity prices as under-utilised capacity needs to be financed.

12.24 The large-scale capacity investment required for each demand trajectory is indicated in Figure 40. This identifies which major investment (excluding renewables and OCGT) is required in each year in addition to that which is required in the lower trajectories. Thus all of the large coal generation is required to meet the lowest demand trajectory (Weathering the Storm) but only incremental gas and nuclear options are required for higher demand trajectories. In all cases the timing of new capacity is brought forward as the demand increases but this is not indicated.

12.25 The critical issue is to indicate that the large-scale investments (with longer lead times) indicated in the Base Case may not be required for lower demand scenarios and that the objective should be to identify flexible options that could meet the capacity requirements for the growth aspiration but minimise the negative impacts of over-investment should the aspiration not be met.

Figure 40 – Peak demand paths indicating incremental large investment requirements



13 CONCLUSION

13.1 The Update and additional analysis provide valuable insights to support decisions over the next two to three years. In particular the following is strongly recommended:

13.1.1 The nuclear decision can possibly be delayed. The revised demand projections suggest that no new nuclear base-load capacity is required until after 2025 and that there are alternative options, such as regional hydro, that can fulfil the requirement and allow further exploration of the shale gas potential before prematurely committing to a technology that may be redundant if the electricity demand expectations do not materialise (especially in the face of widespread embedded photovoltaic generation);

13.1.2 Procurement for a new set of fluidised bed combustion coal generators should be launched for a total of 1000-1500 MW capacity (as a preferable implementation of the "Coal 3" programme). It is recommended that these should be based on discard coal;

13.1.3 Regional hydro projects in Mozambique and Zambia are realised including the infrastructure developments that may have positive spinoffs in unleashing other potential in the region. Additionally regional coal options are attractive due to the emissions not accruing to South Africa, and in cases where the pricing is competitive with South African options, would be preferred;

13.1.4 Regional and domestic gas options are pursued and shale exploration stepped up;

13.1.5 Additional analysis on the potential of extending the life of Eskom's existing fleet should be undertaken, to firm up on the costs involved, weighing up against the environmental impacts (specifically the Departments of Water Affairs and Environmental Affairs should agree on the appropriate way forward to deal with the impacts of flue gas desulphurisation on water resources in Mpumalanga). Alternatives to extending the life of the plant would be to build new coal-fired generation which is more efficient and with lower emission rates, or non-emitting alternatives under more aggressive climate mitigation objectives.

13.1.6 Continue with the current renewable bid programme with additional annual rounds (of 1000 MW PV capacity; 1000 MW wind capacity and 200 MW CSP capacity), with the potential for small hydro and land-fill gas at competitive rates;

13.1.7 A standard offer approach is developed by the Department of Energy in which an agency similar to Eskom's Single Buyer Office purchases energy from embedded generators at a set price (with a self-correcting mechanism based on uptake) so as to render municipalities indifferent between their Eskom supply and embedded generators and thus support small-scale distributed generation;

13.1.8 Formalise funding for EEDSM programmes and secure the appropriate mandate for the national entity to facilitate these programmes (possibly with targets on electricity intensity of the economy).

13.2 Many of the options considered for future generating capacity would involve contracts that may be dollar denominated. The current thinking against dollar-denominated contracting needs to be adjusted as it would jeopardise the feasibility of these options. In particular it forces developers into a shorter-term contacting paradigm in order to hedge their currency exposure and it limits the interest from potential developers. In particular development of gas options would be greatly prejudiced unless the current aversion to dollar denominated contracts is dropped.

13.3 The assessment of the transmission impact of the Update indicates that five possible Transmission Power Corridors will be required to enable key generation scenarios. The main difference between these scenarios is the physical amount of transmission infrastructure within these corridors and their timing. The transmission impact assessment has been based on the reasonable spatial location of the future generation taking into account current knowledge and information. Therefore there is still opportunity to consider better generation location strategies in the longer term. One generation strategy that can provide advantages in terms of reducing the network integration costs and minimising system losses is to consider a large distributed generation network with more appropriately sized units. These would be smaller sized plants that can be integrated into the distribution networks utilising their infrastructure and reducing the loading of the Transmission Grid. Initially this can be achieved with PV but later extended, with the associated transport infrastructure, to gas and even coal plants located near large loads or major load centres.

13.4 Considering the changes in consumption patterns and technology costs over the past three years it is imperative that the IRP should be updated on a regular basis (possibly even annually), while flexibility in decisions should be the priority to favour decisions of least regret. This would suggest that commitments to long range large-scale investment decisions should be avoided.

13.5 There are short term constraints in the electricity supply industry until 2016. There are however few options available to alleviate the situation in this time period, except increased energy efficiency and demand side responses, and improved utilisation of existing generation resources (improving Eskom's fleet performance and incentivising production from existing non-Eskom generation). These options should be strengthened.

14 REFERENCES

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14.4 Electric Power Research Institute, Power Generation Technology Data for Integrated Resource Plan of South Africa, Technical Update, April 2012, Palo Alto, 2012.

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14.6 National Planning Commission, National Development Plan, Pretoria, 2011.

14.7 World Wildlife Fund for Nature, Understanding Carbon Budgets, Briefing Booklet, Cape Town, 2012.

14.8 International Energy Agency, World Energy Outlook 2012, Paris, 2012.

APPENDIX A – EXPECTED DEMAND

Economic outlook

A.1. There has historically been a strong correlation between economic growth in South Africa and the demand for electricity, especially from manufacturing and mining operations. However this relationship has altered over time with decreasing electricity intensity in the South African economy.

A.2. Considering its role as a determinant of electricity demand it was prudent to develop an outlook of economic growth for the next fifty years. This is by no means a prediction of economic growth but serves as a framework to consider the impact of different scenarios on the demand in the electricity industry. The scenarios developed consider the impact of global economic growth in one dimension and the domestic policy environment on the other. The four resulting scenarios indicate:

A.2.1. Traditional Sectors: Where global growth is strong and the domestic policy environment has failed to reform industry structures and dynamics;

A.2.2. Green Shoots: Where global growth is strong and the domestic development agenda, as espoused in the National Development Plan, succeeds in reforming the structure of the South African economy;

A.2.3. Adrift in Troubled Waters: Where global growth is weak and the domestic policy environment fails to provide any internal impetus to growth; and

A.2.4. Weathering the Storm: Where successful domestic policy interventions alleviate the downward pressure from anaemic global economic growth.

Figure 41 – Overview of Economic Growth Scenarios

Traditional Sectors:

Sector	Growth Rate
Primary	+4,1%
Secondary	+5,5%
Tertiary	+5,5%
TOTAL	+5,4%

Green Shoots:

Sector	Growth Rate
Primary	+1,8%
Secondary	+3,8%
Tertiary	+6,1%
TOTAL	+5,4%

Adrift in Troubled Waters:

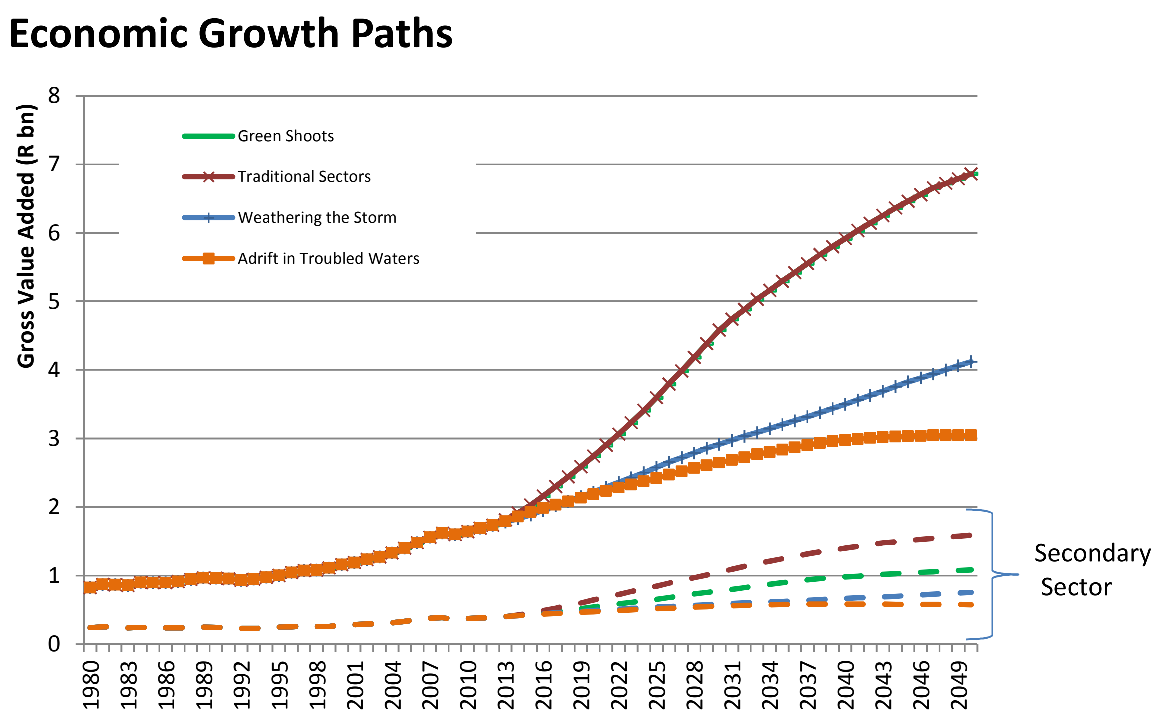
Sector	Growth Rate
Primary	+1,7%
Secondary	+2,0%
Tertiary	+2,6%
TOTAL	+2,4%

Weathering the Storm:

Sector	Growth Rate
Primary	+2,9%
Secondary	+2,3%
Tertiary	+3,1%
TOTAL	+2,9%

A.3. The growth rates associated with each of these scenarios (and particularly the sector growth) is indicated in Figure 41 with Figure 42 representing the total gross value added in each scenario (and the growth in the secondary sector associated with each scenario).

Figure 42 – Economic Growth Paths of the economic growth scenarios



Note: Green Shoots and Traditional Sectors have the same GDP growth rates and thus the Green Shoots GDP growth cannot be identified separately – the difference lies in the growth rates of the component economic sectors.

Figure 43 – Annual GDP growths

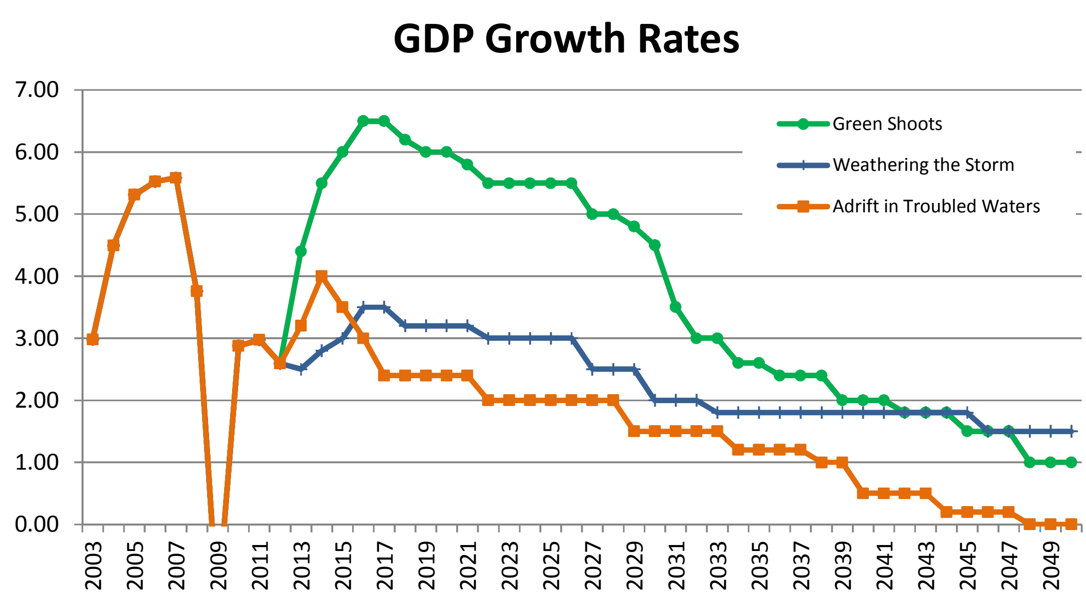


Table 13 – Gross Value Added in each sector based on the economic growth scenarios

	Primary Sector				Secondary Sector				Tertiary Sector			
	Green Shoots	Traditional Sectors	Weathering the Storm	Adrift in Troubled Waters	Green Shoots	Traditional Sectors	Weathering the Storm	Adrift in Troubled Waters	Green Shoots	Traditional Sectors	Weathering the Storm	Adrift in Troubled Waters
2006	140723	140723	140723	140723	352503	352503	352503	352503	985265	985265	985265	985265
2007	141637	141637	141637	141637	374511	374511	374511	374511	1044928	1044928	1044928	1044928
2008	141539	141539	141539	141539	385230	385230	385230	385230	1092969	1092969	1092969	1092969
2009	135553	135553	135553	135553	358714	358714	358714	358714	1103593	1103593	1103593	1103593
2010	140924	140924	140924	140924	374284	374284	374284	374284	1128625	1128625	1128625	1128625
2011	140968	140968	140968	140968	382005	382005	382005	382005	1169751	1169751	1169751	1169751
2012	141957	141957	141957	141957	386209	386209	386209	386209	1208433	1208433	1208433	1208433
2013	144931	147436	146271	145225	401992	401992	399948	400785	1266086	1263581	1233795	1246161
2014	147725	154071	150884	148761	419460	425535	414307	416205	1345539	1333118	1264664	1298891
2015	150518	161447	155808	152708	438241	456564	429586	427298	1438729	1409477	1299356	1349087
2016	153300	168740	161303	156939	456462	490059	442345	437849	1549514	1500476	1347068	1392178
2017	156521	176477	167007	161078	476277	526016	455486	448093	1666831	1597135	1396498	1425481
2018	159850	185065	172652	164248	496953	562483	468899	456882	1785402	1694657	1442049	1462354
2019	163292	194548	178744	167471	518575	601387	479118	465845	1906871	1792802	1492413	1500171
2020	166723	204075	184523	170510	541283	642517	489566	474987	2036056	1897470	1544994	1539195
2021	170266	213584	190461	173838	564008	681461	499890	483156	2168943	2008172	1599743	1580129
2022	173926	223155	196268	177212	585622	722600	510346	491291	2303346	2117139	1652182	1613363
2023	176860	233267	202371	179315	608204	765661	521025	499563	2446289	2232425	1706164	1648625
2024	179868	243166	208892	181498	631807	805454	529950	507975	2597403	2360457	1763605	1684580
2025	182636	253393	214861	183613	655120	847325	539038	515610	2758821	2495858	1823622	1722311
2026	185437	263266	220504	185807	679388	891385	548293	523360	2929563	2639738	1886050	1760798
2027	188301	272762	226397	188172	704362	929198	557048	531230	3091444	2782148	1937772	1799962
2028	190861	282658	231540	190615	730362	968632	565949	539219	3262091	2932023	1991759	1839917
2029	193589	292772	236920	192922	753107	1009595	574996	547074	3437416	3081745	2047063	1868303
2030	196368	303380	241405	195234	776450	1052054	583907	555043	3608579	3225964	2090847	1897145
2031	199123	313472	246011	196720	799954	1093695	592786	560858	3742669	3334580	2135685	1929555
2032	201929	323962	250742	198246	823942	1134704	600611	565661	3858128	3425333	2182618	1963534
2033	204462	333629	255602	199736	848770	1177326	608169	570515	3977287	3519564	2224811	1998101
2034	207036	343617	260594	200309	874200	1212363	615838	575262	4080076	3605332	2267745	2026002
2035	209652	353939	264474	200848	895348	1246485	623620	577701	4190507	3695082	2312679	2056643
2036	212235	362106	268431	201109	916961	1281429	631516	580160	4293403	3779064	2358440	2087945
2037	214861	370477	272466	201457	939194	1317412	639527	582638	4398686	3864852	2405044	2119549
2038	217531	379058	276582	201812	956880	1344458	647657	582803	4511596	3962490	2452505	2148066
2039	220245	386680	280781	201481	968405	1371724	655905	582721	4611077	4041322	2500840	2177805
2040	222647	393706	285115	201152	980098	1397251	664275	582394	4712976	4124764	2550011	2193272
2041	225086	400879	289534	200824	991962	1423289	672768	582081	4816988	4209868	2600089	2208796
2042	227563	408204	292616	200537	1003862	1449656	681385	581520	4911223	4284788	2652512	2224603
2043	230079	415684	295745	200251	1015939	1476555	690128	580970	5007199	4360977	2705917	2240473
2044	232633	422463	298920	199966	1028195	1492728	699000	580289	5104945	4450583	2760322	2247482
2045	235228	429081	302143	199683	1037450	1508831	708002	579623	5188583	4523349	2815746	2254486
2046	237863	435816	305414	199401	1046803	1525154	716962	578973	5273514	4597209	2860903	2261486
2047	240540	442670	308734	199158	1056254	1541701	726058	578338	5359759	4672181	2906737	2268443
2048	243258	449645	312103	198916	1065467	1558007	735290	577630	5414392	4715465	2953258	2269394
2049	246020	456745	315523	198675	1074786	1574550	744662	576763	5469543	4759054	3000476	2270501
2050	248825	463970	318995	198435	1084212	1588465	754175	575914	5525215	4805818	3048402	2271591

Table 14 – Total Gross Value Added and economic growth under each scenario

	Total Gross Value Added (GDP)				Growth Rate			
	Green Shoots	Traditional Sectors	Weathering the Storm	Adrift in Troubled Waters	Green Shoots	Traditional Sectors	Weathering the Storm	Adrift in Troubled Waters
2006	1478491	1478491	1478491	1478491	5.53	5.53	5.53	5.53
2007	1561076	1561076	1561076	1561076	5.59	5.59	5.59	5.59
2008	1619738	1619738	1619738	1619738	3.76	3.76	3.76	3.76
2009	1597860	1597860	1597860	1597860	-1.35	-1.35	-1.35	-1.35
2010	1643833	1643833	1643833	1643833	2.88	2.88	2.88	2.88
2011	1692724	1692724	1692724	1692724	2.97	2.97	2.97	2.97
2012	1736599	1736599	1736599	1736599	2.59	2.59	2.59	2.59
2013	1813009	1813009	1780014	1792170	4.40	4.40	2.50	3.20
2014	1912725	1912725	1829854	1863857	5.50	5.50	2.80	4.00
2015	2027488	2027488	1884750	1929092	6.00	6.00	3.00	3.50
2016	2159275	2159275	1950716	1986965	6.50	6.50	3.50	3.00
2017	2299628	2299628	2018991	2034652	6.50	6.50	3.50	2.40
2018	2442205	2442205	2083599	2083484	6.20	6.20	3.20	2.40
2019	2588737	2588737	2150274	2133487	6.00	6.00	3.20	2.40
2020	2744061	2744061	2219083	2184691	6.00	6.00	3.20	2.40
2021	2903217	2903217	2290094	2237123	5.80	5.80	3.20	2.40
2022	3062894	3062894	2358796	2281866	5.50	5.50	3.00	2.00
2023	3231353	3231353	2429560	2327503	5.50	5.50	3.00	2.00
2024	3409078	3409078	2502447	2374053	5.50	5.50	3.00	2.00
2025	3596577	3596577	2577521	2421534	5.50	5.50	3.00	2.00
2026	3794389	3794389	2654846	2469965	5.50	5.50	3.00	2.00
2027	3984108	3984108	2721217	2519364	5.00	5.00	2.50	2.00
2028	4183313	4183313	2789248	2569752	5.00	5.00	2.50	2.00
2029	4384112	4384112	2858979	2608298	4.80	4.80	2.50	1.50
2030	4581397	4581397	2916159	2647422	4.50	4.50	2.00	1.50
2031	4741746	4741746	2974482	2687134	3.50	3.50	2.00	1.50
2032	4883999	4883999	3033971	2727441	3.00	3.00	2.00	1.50
2033	5030519	5030519	3088583	2768352	3.00	3.00	1.80	1.50
2034	5161312	5161312	3144177	2801572	2.60	2.60	1.80	1.20
2035	5295506	5295506	3200772	2835191	2.60	2.60	1.80	1.20
2036	5422598	5422598	3258386	2869214	2.40	2.40	1.80	1.20
2037	5552741	5552741	3317037	2903644	2.40	2.40	1.80	1.20
2038	5686007	5686007	3376744	2932681	2.40	2.40	1.80	1.00
2039	5799727	5799727	3437525	2962007	2.00	2.00	1.80	1.00
2040	5915721	5915721	3499401	2976818	2.00	2.00	1.80	0.50
2041	6034036	6034036	3562390	2991702	2.00	2.00	1.80	0.50
2042	6142648	6142648	3626513	3006660	1.80	1.80	1.80	0.50
2043	6253216	6253216	3691790	3021693	1.80	1.80	1.80	0.50
2044	6365774	6365774	3758243	3027737	1.80	1.80	1.80	0.20
2045	6461260	6461260	3825891	3033792	1.50	1.50	1.80	0.20
2046	6558179	6558179	3883279	3039860	1.50	1.50	1.50	0.20
2047	6656552	6656552	3941528	3045940	1.50	1.50	1.50	0.20
2048	6723118	6723118	4000651	3045940	1.00	1.00	1.50	0.00
2049	6790349	6790349	4060661	3045940	1.00	1.00	1.50	0.00
2050	6858252	6858252	4121571	3045940	1.00	1.00	1.50	0.00

Table 15 – Annual Expected Electricity Consumption (GWh)

Year	IRP 2010 SO Low	IRP 2010 SO Moderate	IRP 2010 CSIR Moderate	Green Shoots	Traditional Sectors	Weathering the Storm	Adrift in Troubled Waters	Moderate Growth	SO IRP 2010 Update (Modera	SO IRP 2010 Update (Low)
2010	257601	259685	249422	250273	250273	250273	250276	250273	252943	252943
2011	262394	266681	256744	255808	255888	255808	255378	255375	255493	255493
2012	267784	274403	262376	251980	252063	251980	251531	251533	255353	254562
2013	274788	283914	267694	258769	259646	257450	257629	258782	265457	265586
2014	278880	290540	272964	265465	268184	263094	263986	266141	274044	271761
2015	285920	300425	278589	271424	276788	267139	268226	272912	285526	280652
2016	292728	310243	284450	279384	287717	272914	273478	281843	298332	290655
2017	299991	320751	289983	287479	298913	278506	277800	290546	310410	299726
2018	308036	332381	295628	296379	311315	284615	282162	300126	319523	305760
2019	316501	344726	301486	305418	324226	290616	286572	309964	327438	310512
2020	323498	355694	307503	314790	337515	296483	290937	319770	336178	315930
2021	329556	365826	313601	324303	350686	302448	295693	329116	340946	317499
2022	334587	375033	319869	333929	364273	308428	300258	338887	349164	322214
2023	339160	383914	326326	343561	378400	314556	304240	348477	358299	327658
2024	343634	392880	332998	353651	392644	320808	308284	357760	368136	333612
2025	350065	404358	339436	364056	407635	326798	312243	367218	377496	338997
2026	355785	415281	345864	366034	414262	323930	307333	367458	379871	337064
2027	361300	426196	352012	376611	428849	329588	311454	376473	391000	343747
2028	366319	436761	358365	387506	444017	334880	315637	385369	402296	350421
2029	370007	445888	364884	398408	459472	340317	319301	393688	407175	351357
2030	372947	454357	371616	409140	474990	344747	322925	401268	416410	356001
2031	376272	463503	378322	418001	488580	349065	326194	408829	427572	362172
2032	379737	473046	385185	425856	501366	353445	329487	416533	440175	369418
2033	383410	483075	392205	433743	514192	357608	332799	424382	450030	374193
2034	386404	492540	399384	440862	525803	361794	335315	432004	460968	379747
2035				447926	537651	365469	337654	438964	473203	386231
2036				454617	548464	369170	339857	445466	486094	393097
2037				461389	559482	372897	342080	452047	496368	397687
2038				468272	570033	376648	343896	458295	507587	402913
2039				473960	579152	380425	345349	464107	519276	408379
2040				479589	588417	384245	346075	467963	530777	413561
2041				485295	597834	388089	346834	471655	540390	417140
2042				490494	606814	391311	347568	475331	548838	419717
2043				495717	615894	394537	348260	478991	558173	422887
2044				500996	624127	397766	348471	482228	567797	426181
2045				505388	631505	400996	348583	485673	576921	428999
2046				509754	638907	403666	348644	489105	585727	431492
2047				514138	646378	406269	348662	492524	594834	434122
2048				516880	652279	408847	348324	495928	604407	437005
2049				519511	658121	411397	347892	499315	613432	439399
2050				522104	663978	413919	347395	502684	622118	441469

APPENDIX B – SUPPLY SIDE DATA

Existing fleet

B.1. The IRP update considers the Eskom fleet as well as known non-Eskom generation resources as the existing base to which new generation is added.

Table 16 – Existing South African capacity assumed for IRP Update

	Capacity (MW)		Capacity (MW)
Eskom generation	**42330**	**Non-Eskom generation**	**3330**
Camden	1520	Cahorra Bassa	1500
Grootvlei	1080	Aggreko	90
Komati	900	Pretoria West	90
Arnot	2220	Rooiwal	180
Hendrina	1900	Sasol_Infrachem	150
Kriel	2880	Sasol_SSF	500
Duvha	3480	Steenbras	180
Matla	3480	Co-generation	360
Kendal	3840	MTPPP	280
Lethabo	3540		
Matimba	3720		
Tutuka	3540		
Majuba	3840		
Koeberg	1860		
Gariep	360	**Demand Response**	**2560**
VanderKloof	240	DR_Peaking	500
Colleywobbles	70	Interruptible Load	2060
Drakensberg	1000		
Palmiet	400		
Acacia	180		
Port Rex	180		
Ankerlig	1350		
Gourikwa	750		
		TOTAL	**48220**

Table 17 – Assumed decommissioning schedule for existing fleet

	Arnot	Camden	Duvha	Grootvlei	Hendrina	Kendal	Komati	Kriel	Lethabo	Majuba	Matimba	Matla	Tutuka	Pretoria West	Rooiwal	Sasol_InfraChem	Sasol_SSF	Koeberg	Acacia	Aggreko	Ankerlig	DoE_IPP	Gourikwa	PortRex	CoGenEtc	MTPPP
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	190	0	0	380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	570	0	0	380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	0	380	0	0	190	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2024	0	0	0	0	190	0	200	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0
2025	740	0	0	180	190	0	100	0	0	0	0	0	0	0	180	0	500	0	0	0	0	0	0	0	0	0
2026	370	0	0	360	190	0	100	480	0	0	0	0	0	0	0	0	0	0	180	0	0	0	0	180	0	0
2027	370	0	0	180	380	60	300	480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2028	370	0	0	360	0	0	200	960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2029	370	0	0	0	0	0	0	960	0	0	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	1160	0	0	0	0	0	0	0	0	1160	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2031	0	0	580	0	0	0	0	0	0	0	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2032	0	0	580	0	0	0	0	0	0	0	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2033	0	0	580	0	0	0	0	0	0	0	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2034	0	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2035	0	0	0	0	0	0	0	0	590	0	0	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0
2036	0	0	0	0	0	0	0	0	590	0	0	0	1160	0	0	0	0	0	0	0	0	0	0	0	360	0
2037	0	0	0	0	0	0	0	0	0	0	1220	0	580	0	0	0	0	0	0	0	1350	0	750	0	0	0
2038	0	0	0	0	0	630	0	0	1180	0	610	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0
2039	0	0	0	0	0	0	0	0	590	0	610	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	590	0	610	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0
2041	0	0	0	0	0	1890	0	0	0	0	610	0	0	0	0	0	0	0	0	0	0	0	0	0	0	280
2042	0	0	0	0	0	630	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2043	0	0	0	0	0	630	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	0	0
2044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1860	0	0	0	0	0	0	0	0
2045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2046	0	0	0	0	0	0	0	0	0	610	0	0	0	0	0	0	0	0	0	0	0	1020	0	0	0	0
2047	0	0	0	0	0	0	0	0	0	610	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2048	0	0	0	0	0	0	0	0	0	610	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	670	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2050	0	0	0	0	0	0	0	0	0	670	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fuel assumptions

Scenario	Fuel	Assumption
Base Case	Coal	Discard coal for FBC (capacity available up to 1750 MW) at R8.75/GJ Import coal-fired generation up to 1200 MW at R17.5/GJ (but no domestic emissions) PF Coal (uncapped) at R17.5/GJ (for new coal-fired generation)
	Natural Gas (for OCGT and CCGT)	Domestic gas at R70/GJ, capped at 295 PJ Import gas-fired generation up to 986 PJ at R70/GJ Liquefied natural gas uncapped at R92/GJ
Big Gas	Natural Gas	Increase the import gas-fired generation by an additional 986PJ at R70/GJ Shale gas becomes available after 2025, starting at LNG equivalent prices (R92/GJ) and declining with scale exploitation to R50/GJ in 2035
Fuel price sensitivity		PF Coal (uncapped) at R25/GJ (for new coal-fired generation)

Table 18 – Technology costs input (as at 2012, without learning rates) – Part 1

	Pulverised coal, with FGD	Pulverised coal, with CCS	Fluidised bed combustion (coal) with FGD	Fluidised bed combustion (coal) with CCS	IGCC	IGCC, with CCS	Nuclear (single unit)	Nuclear fleet
Rated capacity, net (MW)	4500 (6 x 750)	4500 (6 x 750)	250	250	1288 (644 x 2)	1288 (644 x 2)	1600	9600 (6 X 1600)
Life of programme	30	30	30	30	30	30	60	60
Typical load factor (%)	85%	85%	85%	85%	85%	85%	92%	92%
Overnight capital costs (R/kW)	21572	40845	21440	40165	29282	39079	46841	44010
Lead time	9	9	4	4	5	5	6	16
Phasing in capital spent (% per year) (* indicates commissioning year of 1st unit)	2%, 6%, 13%, 17%*, 17%, 16%, 15%, 11%, 3%	2%, 6%, 13%, 17%*, 17%, 16%, 15%, 11%, 3%	10%, 25%, 45%, 20%	10%, 25%, 45%, 20%	5%, 18%, 35%, 32%*, 10%	5%, 18%, 35%, 32%*, 10%	15%, 15%, 25%, 25%, 10%, 10%	3%, 3%, 7%, 7%, 8%, 8%*, 8%, 8%, 8%, 8%, 8%, 8%, 6%, 6%, 2%, 2%
Adjusted overnight capital costs, accounting for capex phasing (R/kW) and discount rate	25772	48789	23661	44325	32340	43160	58036	59226
Fixed O&M (R/kW/a)	552	923	543	902	794	951	532	532
Variable O&M (R/MWh)	51.2	81.4	110.8	149.1	42.5	65.4	29.5	29.5
Variable Fuel costs (R/GJ)	17.5	17.5	8.75	8.75	17.5	17.5	6.8	6.8
Fuel Energy Content, HHV, kJ/kg	17850	17850	17850	17850	17850	17850	3.9×10^9	3.9×10^9
Heat Rate, kJ/kWh, avg	9812	14106	10081	15425	9758	12541	10762	10762
Equivalent Avail	91.7	91.7	90.4	90.4	85.7	85.7	94.1	94.1
Maintenance	4.8	4.8	5.7	5.7	4.7	4.7	3	3
Unplanned outages	3.7	3.7	4.1	4.1	10.1	10.1	3	3
Water usage, l/MWh	231	320	33	43	256.7	1027	-	-
Sorbent usage, kg/MWh	15.8	22.8	38	59	0	0		
CO2 emissions (kg/MWh)	947.3	136.2	978	150	930	120		
SOx emissions (kg/MWh)	0.46	0.66	0.47	0.72	0.18	0.23		
NOx emissions (kg/MWh)	1.94	0.42	1.39	2.13	0.01	0.01		
Hg (kg/MWh)								
Particulates (kg/MWh)	0.13	0.18	0.13	0.2	0.04	0.05		
Fly ash (kg/MWh)	168	241.5	172.6	264.1				
Bottom ash (kg/MWh)	3.3	4.8	3.4	5.2				
FGD solids (kg/MWh)	25.2	36.2	61.1	93.4				
Levelised Cost								
Adjusted Capital (R/MWh)	287.10	543.51	263.58	493.78	360.27	480.80	524.14	534.89
O&M (R/MWh)	125.33	205.36	183.73	270.24	149.13	193.12	95.51	95.51
Fuel (R/MWh)	171.71	246.86	88.21	134.97	170.77	219.47	73.18	73.18
Total (R/MWh)	584.14	995.72	535.52	898.99	680.17	893.39	692.83	703.58

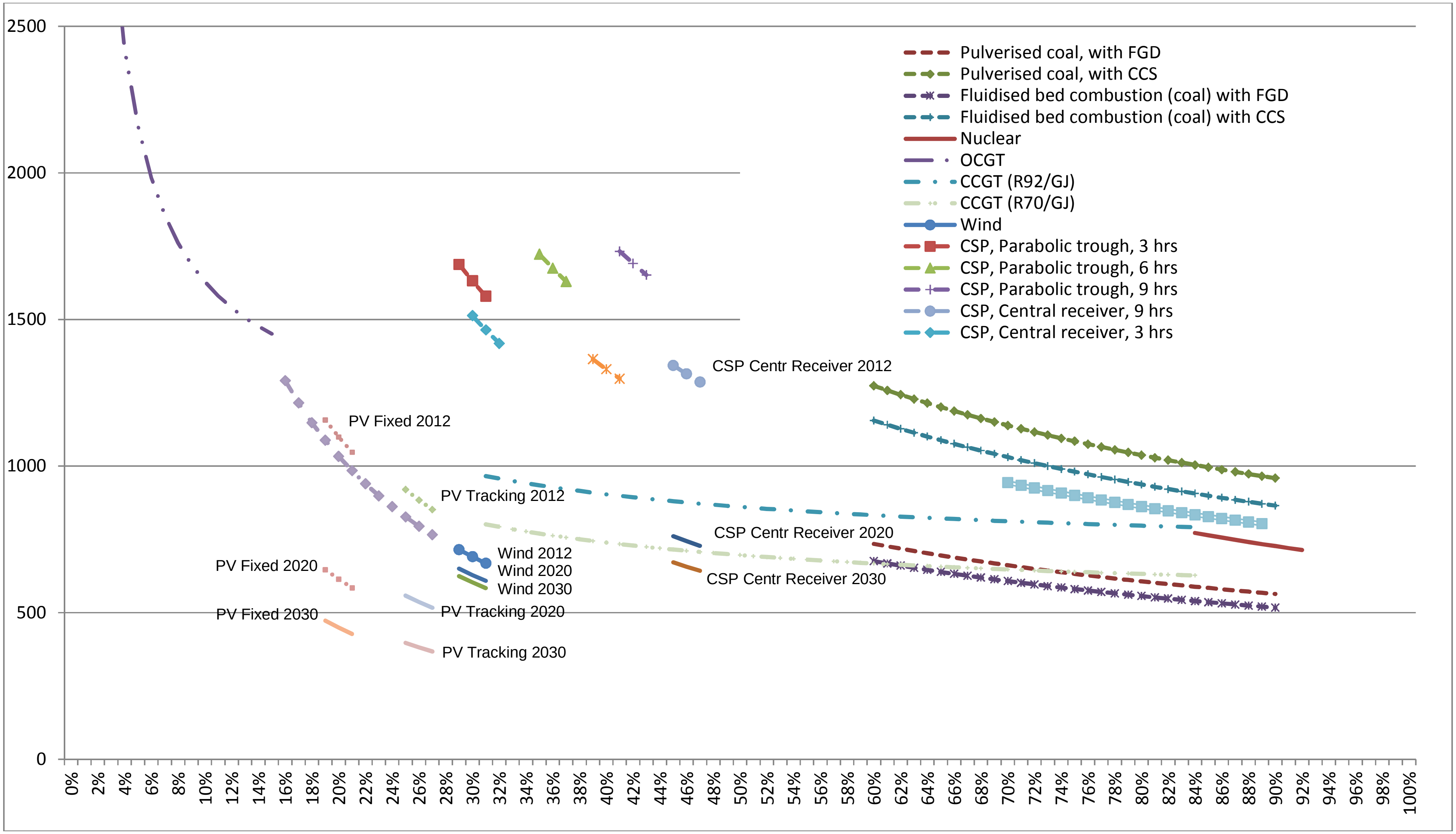
Table 19 – Technology costs input (as at 2012, without learning rates) – Part 2

	OCGT	CCGT	CCGT with CCS	Wind	CSP, Parabolic trough, 3 hrs	CSP, Parabolic trough, 6 hrs	CSP, Parabolic trough, 9 hrs	CSP, Central receiver, 3 hrs	CSP, Central receiver, 6 hrs	CSP, Central receiver, 9 hrs	PV, crystalline silicon, Fixed Tilt
Rated capacity, net (MW)	115	711	591	100 (50 x 2)	125	125	125	125	125	125	10
Life of programme	30	30	30	20	30	30	30	30	30	30	25
Typical load factor (%)	10%	50%	50%	30%	30.90%	36.90%	42.80%	31.80%	40.00%	46.80%	19.40%
Overnight capital costs (R/kW)	4357	6406	13223	15394	40438	51090	61176	37577	44866	51604	28910
Lead time	2	3	3	4	4	4	4	4	4	4	2
Phasing in capital spent (% per year) (* indicates commissioning year of 1st unit)	90%, 10%	40%, 50%, 10%	40%, 50%, 10%	5%, 5%, 10%, 80%	10%, 25%, 45%, 20%	10%, 25%, 45%, 20%	10%, 25%, 45%, 20%	10%, 25%, 45%, 20%	10%, 25%, 45%, 20%	10%, 25%, 45%, 20%	10%, 90%
Adjusted overnight capital costs, accounting for capex phasing (R/kW) and discount rate	4671	7089	14632	15945	44626	56381	67512	41469	49513	56949	29141
Fixed O&M (R/kW/a)	78	163	292	310	582	599	616	537	555	573	208
Variable O&M (R/MWh)	0.2	0.7	0.7	0	1.9	2	2	0	0	0	0
Variable Fuel costs (R/GJ)	92	92	92	0							
Fuel Energy Content, HHV, kJ/kg	39.3†	39.3†	39.3†	0							
Heat Rate, kJ/kWh, avg	11926	7487	9010	0							
Equivalent Avail	88.8	88.8	88.8	94-97	95	95	95	92	92	92	95
Maintenance	6.9	6.9	6.9	6							5
Unplanned outages	4.6	4.6	4.6								
Water usage, l/MWh	19.8	12.7	19.2		299	304	308	310	302	300	
Sorbent usage, kg/MWh											
CO2 emissions (kg/MWh)	618	388	47								
SOx emissions (kg/MWh)	0	0	0								
NOx emissions (kg/MWh)	0.27	0.29	0.35								
Hg (kg/MWh)											
Particulates (kg/MWh)											
Fly ash (kg/MWh)											
Bottom ash (kg/MWh)											
FGD solids (kg/MWh)											
Levelised Cost											
Adjusted Capital (R/MWh)	442.29	134.25	277.10	575.93	1367.51	1446.80	1493.62	1234.81	1172.09	1152.24	1498.70
O&M (R/MWh)	89.24	37.91	67.37	117.96	216.91	187.31	166.30	192.77	158.39	139.77	122.39
Fuel (R/MWh)	1097.19	688.80	828.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total (R/MWh)	1628.73	860.97	1173.39	693.89	1584.42	1634.11	1659.92	1427.58	1330.48	1292.01	1621.09

Table 20 – Import hydro option costs

	Import hydro (Mozambique A)	Import hydro (Mozambique B)	Import hydro (Mozambique C)	Import hydro (Zambia A)	Import hydro (Zambia B)	Import hydro (Zambia C)
	Hydro	Hydro	Hydro	Hydro	Hydro	Hydro
Rated capacity, net (MW)	1500 MW	850 MW	160 MW	120 MW	250 MW	120 MW
Life of programme	60	60	60	60	60	60
Typical load factor (%)	66,7%	38%	42%	64%	46%	38%
Overnight capital costs (R/kW)	17834.37	8339.10	14492	10174	6159	4440
Lead time	9	9	4	3	8	4
Phasing in capital spent (% per year)	5%, 5%, 5%, 5%, 10%, 25%, 20%, 20%, 5%	5%, 5%, 5%, 5%, 10%, 25%, 20%, 20%, 5%	10%, 25%, 45%, 20%	15%, 55%, 30%	5%, 5%, 5%, 5%, 10%, 25%, 25%, 20%	10%, 25%, 45%, 20%
Adjusted overnight capital costs, accounting for capex phasing (R/kW) and discount rate	21116.81	9873.95	17413.74	10876.69	7355.33	4900.49
Fixed O&M (R/kW/a)	344	80,2	80,2	80,2	80,2	80,2
Variable O&M (R/MWh)	0	13,9	13,9	13,9	13,9	13,9
Variable Fuel costs (R/GJ)	N/A	N/A	N/A	N/A	N/A	N/A
Equivalent Avail	90	90	90	90	90	90
Maintenance	7	7	5	5	5	5
Unplanned outages	3	3	5	5	5	5
Levelised Cost						
Adjusted Capital (R/MWh)	273.36	224.36	357.99	146.74	138.06	111.35
O&M (R/MWh)	58.87	38.00	35.71	28.22	33.81	38.00
Fuel (R/MWh)	0	0	0	0.00	0.00	0.00
Total (R/MWh)	332.23	262.38	393.70	174.96	171.88	149.35

Figure 44 – Screening curve with levelised costs of technology options at different load factors (including learning)



Learning rates

B.2. The learning rates used in the IRP 2010 are retained in the Base Case, while allowing for a testing of the sensitivity of the results to this learning. A Restrained Learning scenario is included with less aggressive learning for PV and CSP and no learning at all for nuclear, biomass and wind.

Table 21 – Assumed international installed capacity

International installed capacity (GW)				
Technology	**2010**	**2020**	**2030**	**Learning rate**
CSP	1	148	337	10%
Wind (onshore)	120	562	830	7%
Biomass (electricity production)	60	275	370	5%
IGCC	4	40	120	3%
Nuclear	370	475	725	3%

Source: IEA Energy Technology Perspectives 2008 for learning rates; IEA road maps for CSP, Wind, Nuclear for global capacity expectations; remaining technologies assumed**.**

Table 22 – Expected overnight capital costs

Overnight capital costs (R/kWp)							
Technology	**Storage (hrs)**	**Base Case**			**Restrained learning**		
		2012	**2020**	**2030**	**2012**	**2020**	**2030**
PV Fixed Tilt	-	19660	10984	8029	19660	10984	10984
PV Thin Film	-	20660	12545	8916	20660	13026	13026
CSP Parabolic Trough	3	44626	25258	22289	44626	31448	31448
	6	56381	31912	28160	56381	39731	39731
	9	67512	38212	33719	67512	47575	47575
CSP Central Receiver	3	41469	23471	20712	41469	29223	29223
	6	49513	28024	24729	49513	34891	34891
	9	56949	32233	28443	56949	40131	40131
Wind	-	15945	14502	13922	15945	15945	15945
Biomass (bagasse)	-	22184	20302	19861	22184	22184	22184
Biomass (MSW)	-	74497	68177	66696	74497	74497	74497
Biomass (forest waste)	-	35900	32855	32141	35900	35900	35900
IGCC	-	32340	29956	28544	32340	32340	32340
Nuclear III	-	60659	60095	58988	60659	60659	60659

Source: All Base Case calculations are based on the learning rates used in IRP 2010.

APPENDIX C – PRICING MODEL ASSUMPTIONS AND OTHER PARAMETERS

C.1. Even though the Plexos cost optimization ranks scenarios from low cost to higher cost, there is some value to be obtained by comparing the price trajectories that arise from the different scenarios and also how prices change in the short to medium term, and what longer term price trend could be expected. It should be noted that all prices in the report are *comparative* and cannot be used to show what the actual or indicative prices in the future may be.

C.2. In order to simplify the calculation of highly uncertain future prices, the approach starts with the calculation of a “business as usual” future using the latest published Eskom results for the full business (generation, transmission and distribution) and escalating the cost buckets as shown in the financial statements with inflation and growth, appropriately weighed based on previous experience. This view produces a price path in real terms with the basic assumption that unit cost for generation, transmission and distribution would remain close to the historic values, and this would be the pricing base-scenario for a specific load forecast.

C.3. All new generation options are modelled using the utility pricing rules to ensure consistency in results in an environment where future options could be utility built or IPP financed. Since these decisions are not clearly identified at present, the comparison between scenarios is done by consistently using the same pricing rules, and at present the utility approach is perhaps the best understood.

C.4. To obtain a unique price curve for each scenario, new generation is simulated as an extending aging fleet of coal based plant, and its cost is simulated and the annual cost of this new generation option is subtracted from the full-cost base-scenario. Using the EPRI cost data, the new generation cost of each scenario is calculated and added to the remaining cost in the model. It silently assumes that the transmission and distribution cost of each scenario is the same, which might not be the case, and this could be an area of improvement in future, simulating the marginal transmission cost of scenarios in some detail.

C.5. In order to produce maximum value in the pricing curves, MYPD determinations (current and future) are ignored and the pricing rules are followed implicitly instead, to show the full short term implication of scenario differences. This does not mean the IRP team does not accept any MYPD decisions of the regulator. The value in the differences in price curves in the early years would be lost if all cases were following a managed price transition from current prices to the required price levels of each scenario, and additional assumptions would be needed after the MYPD3 period to manage such price movements for an extended period, with no regulatory indication of how that would be done at the time. Such discretionary assumptions of future regulatory decisions are problematic. Thus it was deemed a better choice to follow the pricing rules for all years, avoiding a thorny issue and adding value to the price curves, right from year one. An approximation of an MYPD3 influenced price is shown for clarity.

C.6. It is important to note that interest, tax and dividends paid do not affect the price of electricity directly, since the real rate of return produces the revenue to fund those payments. The real rate of return is determined by NERSA and no effort is made in the pricing calculations to replicate the calculations of this value. Dividend policy was adjusted (compared to assumptions used in IRP2010 calculations) to ensure a stable debt: equity ratio for the base case.

Table 23 – Assumptions used in Pricing calculations

Base year for Price Output	2013
Assumed SA Inflation rate	6.00%
Average Cost of Eskom capacity for Gx, Tx and Dx in Business-as-Usual (USD/kW)	5 450
Assumed US inflation rate	2.0%
Target Reserve Margin	15%
R/USD in year 2012	8.01
(Exchange rate moves with inflation differential)	
Rate of Return (real)	5.00%
Depreciation of new assets over	30
Depreciation of old assets over	40
Debt rate above inflation	4.0%
Return on cash investments	1.80%
Dividend policy of Government:	
Start in 2018 at 5% of regulated profits	
Increase dividend payments at 5 percentage points per year	
Maximum dividend percentage of 35% of regulated profits is reached in 2024	

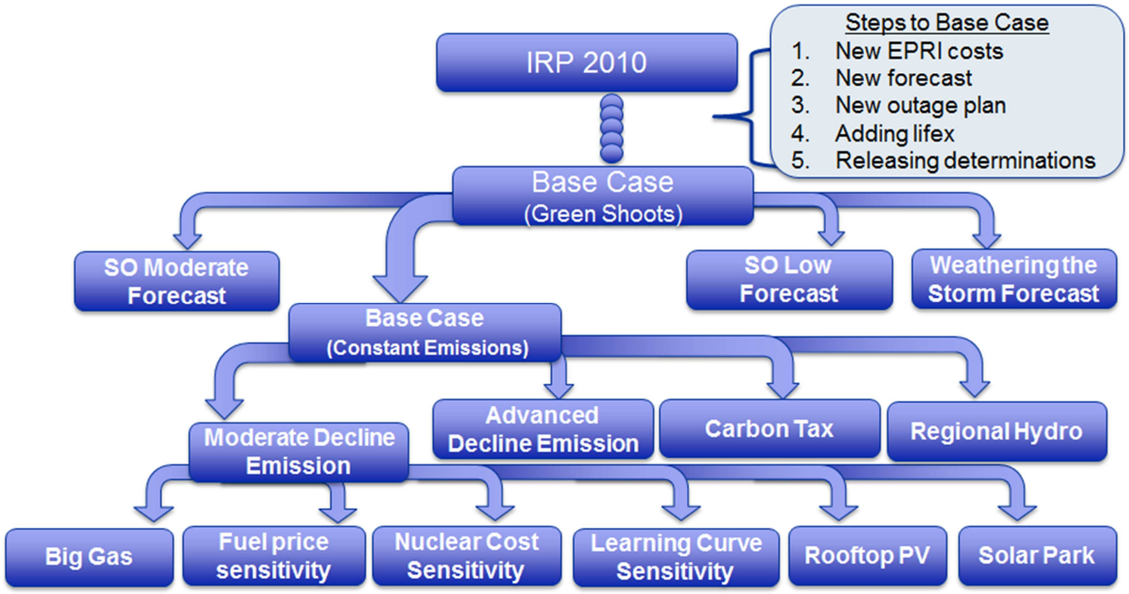
C.7. All assumptions are in line with the assumptions made for the IRP optimization calculations to ensure alignment. Some additional assumptions were made where the pricing calculations required it.

C.8. The pricing rules in theoretical format were used to calculate future electricity prices. Together with the use of a “real” rate of return (which excludes inflation), asset values are indexed with the expected inflation rates of future years, to ensure the utility is compensated for the effects of inflation when making long term capital investments.

Other Parameters

Parameter	Assumption	Value/Reference
Exchange Rate	R8.01/US$	As at 1 Jan 2012
Cost reference year (for modelling purposes, not electricity price paths)	1 January 2012	
Economic Parameters	a. Net, real, post tax Discount Rate (%) b. Cost of Unserved Energy (R/MWh)	a. 8 b. 75000

APPENDIX D – SCENARIOS AND RESULTS



Scenario	Assumption
Base Case	• New EPRI costs • CSIR Green Shoots Forecast • New 80:10:10 outage plans for existing fleet • Life extension and FGD retrofitting of existing fleet included as options • Only Renewables IPP Programme Round 1 & 2, DOE Peaker are forced; all other determinations including Nuclear are relaxed
SO Moderate	As with Base Case, but using the SO Moderate forecast
SO Low	As with Base Case, but using the SO Low forecast
Weathering the Storm	As with Base Case, but using the CSIR Weathering the Storm forecast
Constant emissions	Same as Base Case (275 MT/a carbon emissions limit throughout the period)
Moderate decline	As with Base Case, but allowing moderate decline in annual emission limits to 201 MT/a in 2050
Advanced decline	As with Base Case, but allowing advanced decline in annual emission limits to 140 MT/a in 2050
Carbon Tax	Removing all carbon emissions limits, apply carbon tax (starting at R40/ton in 2015 (at 2012 Rands), escalating to R117/ton in 2025 (at 2012 Rands))
Regional Hydro	As with Base Case, forcing in 2500 MW from Inga in 2022 and 1200 MW from Kobong (pumped storage) in 2023
Rooftop PV	As with Base Case, but force in an assumed amount of PV installation from households acting without incentives up to 28 000 MW in 2050
Solar Park	As with Base Case, but force in 5000 MW of CSP (1000 MW per year from 2018 to 2022)

Big Gas	As with Moderate Decline, but allowing for shale gas (unlimited) and at a declining price (from R92/GJ in 2025 to R50/GJ in 2035 as scale exploitation occurs), and an additional development of regional gas in the Sofala field (an additional 800 MW at R70/GJ).
Fuel price sensitivity	As with Moderate Decline, but coal for new coal-fired generation at R25/GJ.
Learning rates sensitivity	As with Moderate Decline, but with the learning on technologies occurs more conservatively (with a conservative wind and PV learning case, and another for nuclear and CSP).
Nuclear Cost sensitivity	As with Moderate Decline, but with the a higher nuclear capital cost at $7000/kW (or R56000/kW)

Table 24 – Details of Base Case development: Step 1

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	42416	14.6	9.0	256.1
2014	37580	2460	1500	700	1580	1860	1330	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48590	2560	43436	18.9	8.6	257.4
2015	39010	2460	1500	750	2900	1860	1930	200	1600	3500	0	0	0	0	0	0	0	0	0	0	200	53100	2810	44865	26.3	12.7	264.7
2016	41070	3480	1500	750	2900	1860	2290	300	2000	3750	0	0	0	0	0	0	0	0	0	0	400	57240	3060	45786	34.0	18.3	266.6
2017	43210	3480	1500	750	2900	1860	2650	400	2400	3750	500	0	0	0	0	0	0	0	0	0	600	60940	3060	47870	36.0	19.5	273.0
2018	44640	3480	1500	750	2900	1860	2890	500	2800	2750	1000	0	0	0	0	0	0	0	0	0	800	63810	2060	49516	34.5	19.4	277.3
2019	45350	3480	1500	750	2900	1860	3150	600	3200	2750	1250	240	0	0	0	0	0	0	0	0	800	65770	2060	51233	33.8	18.1	283.7
2020	44970	3480	1500	750	2900	1860	3150	700	3200	2750	1500	480	0	0	0	0	0	140	0	0	800	66120	2060	52719	30.5	15.1	291.3
2021	44400	3480	1500	750	2900	1860	3150	700	3200	2750	1750	720	0	0	0	0	0	350	0	0	800	66250	2060	54326	26.8	11.5	303.0
2022	43390	3480	1500	750	2900	1860	3150	700	3200	2750	2000	720	840	1143	0	0	0	840	0	0	800	67963	2060	55734	26.6	10.8	306.1
2023	42760	3480	1500	750	2900	1860	3150	700	3200	2750	2250	720	1680	2326	0	0	0	1410	0	0	800	70176	2060	57097	27.5	11.1	309.3
2024	42310	3480	1500	750	2900	1860	3150	700	3200	2750	2500	720	1680	2609	0	0	0	2200	0	0	800	71049	2060	58340	26.2	8.8	315.8
2025	40420	3480	1500	750	2900	1860	3150	700	3200	2750	3700	2850	2520	2609	0	0	3200	3130	0	320	800	77779	2060	60150	33.9	14.9	275.0
2026	38920	3120	1500	750	2900	1860	3150	700	3200	690	3700	2850	2520	2609	0	0	4800	4130	0	640	800	78839	0	61770	27.6	10.5	275.0
2027	37150	3120	1500	750	2900	1860	3150	700	3200	690	3700	2850	5040	2609	0	0	4800	5130	0	960	800	80909	0	63404	27.6	8.9	275.0
2028	35260	3120	1500	750	2900	1860	3150	700	3200	690	5200	2850	5280	2609	0	0	6400	6130	0	1280	800	83679	0	64867	29.0	8.9	275.0
2029	33350	3120	1500	750	2900	1860	3150	700	3200	690	7450	2850	5280	2609	0	0	8000	7130	0	1600	800	86939	0	66460	30.8	9.3	275.0
2030	31030	3120	1500	750	2900	1860	3150	700	3200	690	9950	2850	6120	2609	0	0	8000	8130	0	1920	800	89279	0	67809	31.7	8.8	275.0
2031	29870	3120	1500	750	2900	1860	3150	700	3200	690	11450	2850	6120	2609	0	0	9600	9130	0	2240	800	92539	0	69258	33.6	9.5	275.0
2032	28710	3120	1500	750	2900	1860	3150	700	3200	690	12450	2850	6360	2609	0	0	11200	10130	0	2560	800	95539	0	70615	35.3	9.9	274.7
2033	27550	3120	1500	750	2900	1860	3150	700	3200	690	12950	2850	7320	2609	0	0	11200	11130	1000	3200	800	98479	0	72344	36.1	8.7	275.0
2034	26970	3120	1500	750	2900	1860	3150	700	2270	690	13700	2850	7920	2609	0	0	12800	12130	1000	3840	800	101559	0	73856	37.5	9.5	275.0
2035	25800	3120	1500	750	2900	1860	3150	700	1600	690	14450	3330	8880	2609	0	0	12800	13130	2100	4480	800	104649	0	75358	38.9	9.5	275.0
2036	24050	3120	1500	750	2900	1860	3150	700	1200	330	16700	3330	9120	2609	0	0	14400	14130	2100	4820	800	107569	0	76890	39.9	9.9	275.0
2037	22250	1020	1500	750	2900	1860	3150	700	800	330	18950	3330	11520	2609	0	0	16000	15130	2100	5140	800	110839	0	78453	41.3	10.7	274.9
2038	19250	1020	1500	750	2900	1860	3150	700	400	330	21200	4530	11760	2609	0	0	16000	16130	3200	5780	800	113869	0	80048	42.3	10.2	275.0
2039	18050	1020	1500	750	2900	1860	1900	700	0	330	22700	4530	11760	2609	0	0	17600	17130	3200	6290	800	115629	0	81676	41.6	10.3	275.0
2040	16270	1020	1500	750	2900	1860	1220	700	0	280	24950	4530	11760	2609	0	0	19200	18130	3200	6610	800	118289	0	83336	41.9	10.7	275.0
2041	13770	1020	1500	750	2900	1860	880	700	0	0	27950	4770	12600	2609	0	0	20800	19130	3200	6930	800	122169	0	85031	43.7	12.0	275.0
2042	13140	1020	1500	750	2900	1860	550	700	0	0	27950	4770	12600	2609	0	0	22400	20130	3200	7250	800	124129	0	86759	43.1	11.0	270.9
2043	12360	1020	1500	750	2900	1860	300	700	0	0	29450	4770	12600	2609	0	0	22400	21130	4100	7890	1600	127139	800	88523	44.9	10.7	275.0
2044	12360	1020	1500	750	2900	0	0	600	0	0	29450	4770	12600	2609	0	0	25600	22130	4100	8510	800	129699	0	90323	43.6	9.8	275.0
2045	12360	1020	1500	750	2900	0	0	300	0	0	29450	4770	12600	2609	0	0	25600	22990	6800	8830	600	133079	0	92160	44.4	8.9	275.0
2046	11750	0	1500	750	2900	0	0	200	0	0	29450	5010	14520	2609	0	0	27200	23780	6800	8830	400	135699	0	94033	44.3	8.7	275.0
2047	11140	0	1500	750	2900	0	0	100	0	0	29450	6450	14520	2609	0	0	27200	24290	8300	9150	200	138559	0	95945	44.4	8.1	275.0
2048	10530	0	1500	750	2900	0	0	0	0	0	30950	6930	14520	2609	0	0	28800	24720	8500	9470	0	142179	0	97896	45.2	9.0	275.0
2049	9860	0	1500	750	2900	0	0	0	0	0	30950	7170	14520	2609	0	0	28800	24930	11000	9790	0	144779	0	99886	44.9	7.8	275.0
2050	9190	0	1500	750	2900	0	0	0	0	0	30950	9330	15120	2609	0	0	28800	25000	11500	10110	0	147759	0	101917	45.0	8.1	275.0

Table 25 – Details of Base Case development: Step 2

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	235.3
2014	37580	2460	1500	700	1580	1860	1330	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48590	2560	38924	33.6	21.4	236.6
2015	39010	2460	1500	750	2900	1860	1930	150	1600	3500	0	0	0	0	0	0	0	0	0	0	200	53050	2810	39703	43.8	27.6	240.9
2016	41070	3480	1500	750	2900	1860	2290	300	2000	3750	0	0	0	0	0	0	0	0	0	0	400	57240	3060	40608	52.4	33.7	240.9
2017	43210	3480	1500	750	2900	1860	2650	400	2400	3750	500	0	0	0	0	0	0	0	0	0	600	60940	3060	41679	57.8	37.6	245.0
2018	44640	3480	1500	750	2900	1860	2890	500	2800	2750	1000	0	0	0	0	0	0	0	0	0	800	63810	2060	42485	57.8	39.5	247.2
2019	45350	3480	1500	750	2900	1860	3150	600	3200	2750	1250	240	0	0	0	0	0	0	0	0	800	65770	2060	43713	57.9	38.7	251.1
2020	44970	3480	1500	750	2900	1860	3150	700	3200	2750	1500	480	0	0	0	0	0	0	0	0	800	65980	2060	44977	53.7	35.1	258.0
2021	44400	3480	1500	750	2900	1860	3150	700	3200	2750	1750	720	0	0	0	0	0	0	0	0	800	65900	2060	46481	48.4	30.5	267.3
2022	43390	3480	1500	750	2900	1860	3150	700	3200	2750	2000	720	840	1143	0	0	0	0	0	0	800	67123	2060	47952	46.3	29.1	269.3
2023	42760	3480	1500	750	2900	1860	3150	700	3200	2750	2250	720	1680	2326	0	0	0	140	0	0	800	68906	2060	49442	45.4	28.5	273.4
2024	42310	3480	1500	750	2900	1860	3150	700	3200	2750	2500	720	1680	2609	0	0	0	350	0	0	800	69199	2060	50895	41.7	24.9	280.6
2025	40420	3480	1500	750	2900	1860	3150	700	3200	2750	2500	720	2520	2609	0	0	1600	910	0	0	800	70309	2060	52593	39.1	21.9	275.0
2026	38920	3120	1500	750	2900	1860	3150	700	3200	690	2500	720	2520	2609	0	0	3200	1470	0	0	800	70609	0	52995	33.2	19.1	264.5
2027	37150	3120	1500	750	2900	1860	3150	700	3200	690	2500	720	2520	2609	0	0	3200	2260	0	0	800	69629	0	54745	27.2	12.0	271.6
2028	35260	3120	1500	750	2900	1860	3150	700	3200	690	2750	960	3600	2609	0	0	4800	3190	0	0	800	71839	0	56482	27.2	10.9	266.2
2029	33350	3120	1500	750	2900	1860	3150	700	3200	690	4250	960	4080	2609	0	0	6400	4190	0	0	800	74509	0	58547	27.3	9.8	260.0
2030	31030	3120	1500	750	2900	1860	3150	700	3200	690	7250	1200	4440	2609	0	0	6400	5190	0	0	800	76789	0	60509	26.9	8.4	265.6
2031	29870	3120	1500	750	2900	1860	3150	700	3200	690	8000	1200	5280	2609	0	0	8000	6190	0	0	800	79819	0	62159	28.4	8.7	263.0
2032	28710	3120	1500	750	2900	1860	3150	700	3200	690	8000	1200	6000	2609	0	0	9600	7190	0	150	800	82129	0	63463	29.4	8.4	256.4
2033	27550	3120	1500	750	2900	1860	3150	700	3200	690	10250	1200	6480	2609	0	0	9600	8190	0	470	800	85019	0	64969	30.9	8.5	262.6
2034	26970	3120	1500	750	2900	1860	3150	700	2270	690	11750	1200	7320	2609	0	0	9600	9190	0	790	800	87169	0	66210	31.7	8.8	270.0
2035	25800	3120	1500	750	2900	1860	3150	700	1600	690	13850	1200	7320	2609	0	0	9600	10190	0	1380	800	89019	0	67414	32.0	8.2	272.6
2036	24050	3120	1500	750	2900	1860	3150	700	1200	330	16100	1200	8760	2609	0	0	9600	11190	0	1700	800	91519	0	68341	33.9	9.0	275.0
2037	22250	1020	1500	750	2900	1860	3150	700	800	330	18950	1910	10800	2609	0	0	9600	12190	0	2020	800	94139	0	69621	35.2	9.4	275.0
2038	19250	1020	1500	750	2900	1860	3150	700	400	330	21950	3330	10800	2609	0	0	9600	13190	0	2340	800	96479	0	70777	36.3	9.6	275.0
2039	18050	1020	1500	750	2900	1860	1900	700	0	330	22700	3330	10920	2609	0	0	9600	14190	600	2980	800	96739	0	71736	34.9	8.2	274.8
2040	16270	1020	1500	750	2900	1860	1220	700	0	280	24950	3330	10920	2609	0	0	9600	15190	2100	3620	800	99619	0	72495	37.4	9.1	275.0
2041	13770	1020	1500	750	2900	1860	880	700	0	0	27950	3330	10920	2609	0	0	9600	16190	3900	4260	800	102939	0	73599	39.9	9.4	275.0
2042	13140	1020	1500	750	2900	1860	550	700	0	0	28700	3330	11280	2609	0	0	9600	17190	4400	4900	800	105229	0	74482	41.3	9.3	275.0
2043	12360	1020	1500	750	2900	1860	300	700	0	0	28700	3330	11880	2609	0	0	9600	18190	5500	5540	800	107539	0	75368	42.7	8.9	275.0
2044	12360	1020	1500	750	2900	0	0	600	0	0	28700	3330	11880	2609	0	0	11200	19190	5500	6180	800	108519	0	76112	42.6	7.6	275.0
2045	12360	1020	1500	750	2900	0	0	300	0	0	28700	3330	12120	2609	0	0	11200	20190	6500	6820	600	110899	0	77059	43.9	7.1	275.0
2046	11750	0	1500	750	2900	0	0	200	0	0	29450	3330	13560	2609	0	0	11200	21190	6500	7400	400	112739	0	77841	44.8	6.7	275.0
2047	11140	0	1500	750	2900	0	0	100	0	0	29450	5010	13680	2609	0	0	11200	22190	6500	7720	200	114949	0	78603	46.2	6.9	275.0
2048	10530	0	1500	750	2900	0	0	0	0	0	29450	6210	13680	2609	0	0	11200	23050	6500	8040	0	116419	0	78969	47.4	7.0	275.0
2049	9860	0	1500	750	2900	0	0	0	0	0	30200	7410	13680	2609	0	0	11200	23840	6500	8040	0	118489	0	79640	48.8	7.7	275.0
2050	9190	0	1500	750	2900	0	0	0	0	0	30950	7170	13920	2609	0	0	11200	24280	6500	8040	0	119009	0	80163	48.5	7.1	275.0

Table 26 – Details of Base Case development: Step 3

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	253.8
2014	37580	2460	1500	700	1580	1860	1330	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48590	2560	38924	33.6	21.4	245.8
2015	39010	2460	1500	750	2900	1860	1930	200	1600	3500	0	0	0	0	0	0	0	0	0	0	200	53100	2810	39703	43.9	27.7	251.0
2016	41070	3480	1500	750	2900	1860	2290	300	2000	3750	0	0	0	0	0	0	0	0	0	0	400	57240	3060	40608	52.4	33.7	252.3
2017	43210	3480	1500	750	2900	1860	2650	400	2400	3750	500	0	0	0	0	0	0	0	0	0	600	60940	3060	41679	57.8	37.6	256.3
2018	44640	3480	1500	750	2900	1860	2890	500	2800	2750	1000	0	0	0	0	0	0	0	0	0	800	63810	2060	42485	57.8	39.5	256.5
2019	45350	3480	1500	750	2900	1860	3150	600	3200	2750	1250	240	0	0	0	0	0	0	0	0	800	65770	2060	43713	57.9	38.7	259.7
2020	44970	3480	1500	750	2900	1860	3150	700	3200	2750	1500	480	0	0	0	0	0	0	0	0	800	65980	2060	44977	53.7	35.1	265.0
2021	44400	3480	1500	750	2900	1860	3150	700	3200	2750	1750	720	0	0	0	0	0	0	0	0	800	65900	2060	46481	48.4	30.5	273.5
2022	43390	3480	1500	750	2900	1860	3150	700	3200	2750	2000	720	840	1143	0	0	0	70	0	0	800	67193	2060	47952	46.4	29.1	275.5
2023	42760	3480	1500	750	2900	1860	3150	700	3200	2750	2250	720	1680	2326	0	0	0	210	0	0	800	68976	2060	49442	45.6	28.5	280.7
2024	42310	3480	1500	750	2900	1860	3150	700	3200	2750	2500	720	1680	2609	0	0	0	480	0	0	800	69329	2060	50895	42.0	24.9	288.1
2025	40420	3480	1500	750	2900	1860	3150	700	3200	2750	3100	720	2520	2609	0	0	1600	1040	0	0	800	71039	2060	52593	40.6	23.1	275.0
2026	38920	3120	1500	750	2900	1860	3150	700	3200	690	3100	720	2520	2609	0	0	3200	1600	0	0	800	71339	0	52995	34.6	20.2	264.3
2027	37150	3120	1500	750	2900	1860	3150	700	3200	690	3100	720	2520	2609	0	0	3200	2390	0	0	800	70359	0	54745	28.5	13.1	272.8
2028	35260	3120	1500	750	2900	1860	3150	700	3200	690	3350	720	3840	2609	0	0	4800	3320	0	0	800	72569	0	56482	28.5	11.9	268.1
2029	33350	3120	1500	750	2900	1860	3150	700	3200	690	4850	720	4320	2609	0	0	6400	4320	0	0	800	75239	0	58547	28.5	10.8	261.5
2030	31030	3120	1500	750	2900	1860	3150	700	3200	690	7850	720	4920	2609	0	0	6400	5320	0	0	800	77519	0	60509	28.1	9.3	265.9
2031	29870	3120	1500	750	2900	1860	3150	700	3200	690	8600	720	5640	2609	0	0	8000	6320	0	0	800	80429	0	62159	29.4	9.5	262.6
2032	28710	3120	1500	750	2900	1860	3150	700	3200	690	8600	720	6240	2609	0	0	9600	7320	0	220	800	82689	0	63463	30.3	9.0	255.0
2033	27550	3120	1500	750	2900	1860	3150	700	3200	690	10850	720	6480	2609	0	0	9600	8320	0	540	800	85339	0	64969	31.4	8.7	261.4
2034	26970	3120	1500	750	2900	1860	3150	700	2270	690	12350	720	7560	2609	0	0	9600	9320	0	860	800	87729	0	66210	32.5	9.4	271.8
2035	25800	3120	1500	750	2900	1860	3150	700	1600	690	14450	1430	7560	2609	0	0	9600	10320	0	1500	800	90339	0	67414	34.0	9.8	275.0
2036	24050	3120	1500	750	2900	1860	3150	700	1200	330	16700	2140	7560	2609	0	0	9600	11320	0	1820	800	92109	0	68341	34.8	9.6	275.0
2037	22250	1020	1500	750	2900	1860	3150	700	800	330	18200	2850	10680	2609	0	0	9600	12320	0	2140	800	94459	0	69621	35.7	9.6	275.0
2038	19250	1020	1500	750	2900	1860	3150	700	400	330	21950	2850	11040	2609	0	0	9600	13320	300	2780	800	97109	0	70777	37.2	9.7	275.0
2039	18050	1020	1500	750	2900	1860	1900	700	0	330	22700	2850	11040	2609	0	0	9600	14320	1700	3420	800	98049	0	71736	36.7	8.8	275.0
2040	16270	1020	1500	750	2900	1860	1220	700	0	280	24950	2850	11040	2609	0	0	9600	15320	2500	4060	800	100229	0	72495	38.3	9.1	275.0
2041	13770	1020	1500	750	2900	1860	880	700	0	0	27200	2850	11040	2609	0	0	9600	16320	4800	4700	800	103299	0	73599	40.4	8.7	274.9
2042	13140	1020	1500	750	2900	1860	550	700	0	0	27950	2850	11400	2609	0	0	9600	17320	5100	5340	800	105389	0	74482	41.5	8.5	275.0
2043	12360	1020	1500	750	2900	1860	300	700	0	0	28700	2850	11400	2609	0	0	9600	18320	6100	5980	800	107749	0	75368	43.0	8.2	275.0
2044	12360	1020	1500	750	2900	0	0	600	0	0	28700	2850	11400	2609	0	0	11200	19320	6700	6620	800	109329	0	76112	43.6	7.4	275.0
2045	12360	1020	1500	750	2900	0	0	300	0	0	28700	2850	12120	2609	0	0	11200	20320	6900	7110	600	111239	0	77059	44.4	6.9	275.0
2046	11750	0	1500	750	2900	0	0	200	0	0	28700	4290	13200	2609	0	0	11200	21320	6900	7430	400	113149	0	77841	45.4	6.8	275.0
2047	11140	0	1500	750	2900	0	0	100	0	0	29450	4530	13560	2609	0	0	11200	22250	6900	7750	200	114839	0	78603	46.1	6.5	275.0
2048	10530	0	1500	750	2900	0	0	0	0	0	29450	5730	13560	2609	0	0	11200	23110	6900	8070	0	116309	0	78969	47.3	6.5	275.0
2049	9860	0	1500	750	2900	0	0	0	0	0	30200	6690	13680	2609	0	0	11200	23840	6900	8070	0	118199	0	79640	48.4	7.1	275.0
2050	9190	0	1500	750	2900	0	0	0	0	0	30950	7170	13680	2609	0	0	11200	24280	6900	8070	0	119199	0	80163	48.7	7.1	274.9

Table 27 – Details of Base Case development: Step 4

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	264.8
2014	37580	2460	1500	700	1580	1860	1330	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48590	2560	38924	33.6	21.4	257.1
2015	39010	2460	1500	750	2900	1860	1930	200	1600	3500	0	0	0	0	0	0	0	0	0	0	200	53100	2810	39703	43.9	27.7	262.9
2016	41070	3480	1500	750	2900	1860	2290	300	2000	3750	0	0	0	0	0	0	0	0	0	0	400	57240	3060	40608	52.4	33.7	264.7
2017	43210	3480	1500	750	2900	1860	2650	400	2400	3750	500	0	0	0	0	0	0	0	0	0	600	60940	3060	41679	57.8	37.6	268.6
2018	44640	3480	1500	750	2900	1860	2890	500	2800	2750	1000	0	0	0	0	0	0	0	0	0	800	63810	2060	42485	57.8	39.5	269.0
2019	45350	3480	1500	750	2900	1860	3150	600	3200	2750	1250	240	0	0	0	0	0	0	0	0	800	65770	2060	43713	57.9	38.7	272.4
2020	44970	3480	1500	750	2900	1860	3150	700	3200	2750	1500	480	0	0	0	0	0	0	0	0	800	65980	2060	44977	53.7	35.1	277.8
2021	44400	3480	1500	750	2900	1860	3150	700	3200	2750	1750	720	0	0	0	0	0	0	0	0	800	65900	2060	46481	48.4	30.5	287.0
2022	43390	3480	1500	750	2900	1860	3150	700	3200	2750	2000	720	840	1143	0	0	0	70	0	0	800	67193	2060	47952	46.4	29.1	289.4
2023	42760	3480	1500	750	2900	1860	3150	700	3200	2750	2250	720	1680	2326	0	0	0	210	0	0	800	68976	2060	49442	45.6	28.5	294.1
2024	42310	3480	1500	750	2900	1860	3150	700	3200	2750	2500	720	1680	2609	0	0	0	520	0	0	800	69369	2060	50895	42.0	24.9	301.5
2025	40420	3480	1500	750	2900	1860	3150	700	3200	2750	3700	2140	2520	2609	0	0	1600	1080	0	0	800	73099	2060	52593	44.7	27.0	275.0
2026	38920	3120	1500	750	2900	1860	3150	700	3200	690	3700	2140	2520	2609	0	0	3200	1710	0	0	800	73469	0	52995	38.6	24.0	272.9
2027	37620	3120	1500	750	2900	1860	3150	700	3200	690	3700	2140	2520	2609	0	0	3200	2570	0	0	800	73029	0	54745	33.4	17.7	275.0
2028	36670	3120	1500	750	2900	1860	3150	700	3200	690	3700	2140	2520	2609	0	0	4800	3500	0	0	800	74609	0	56482	32.1	15.2	275.0
2029	36270	3120	1500	750	2900	1860	3150	700	3200	690	3700	2140	2520	2609	0	0	6400	4500	0	0	800	76809	0	58547	31.2	13.2	273.5
2030	36230	3120	1500	750	2900	1860	3150	700	3200	690	3700	2140	3120	2609	0	0	6400	5500	0	320	800	78689	0	60509	30.0	10.6	275.0
2031	35640	3120	1500	750	2900	1860	3150	700	3200	690	3700	2140	3960	2609	0	0	8000	6500	0	640	800	81859	0	62159	31.7	10.8	275.0
2032	34480	3120	1500	750	2900	1860	3150	700	3200	690	3700	2140	4440	2609	0	0	9600	7500	0	960	800	84099	0	63463	32.5	10.1	269.3
2033	33320	3120	1500	750	2900	1860	3150	700	3200	690	5200	2140	5520	2609	0	0	9600	8500	0	1540	800	87099	0	64969	34.1	10.0	275.0
2034	32740	3120	1500	750	2900	1860	3150	700	2270	690	5450	2850	7560	2609	0	0	9600	9500	0	2180	800	90229	0	66210	36.3	11.5	275.0
2035	32740	3120	1500	750	2900	1860	3150	700	1600	690	5700	2850	7560	2609	0	0	9600	10500	1800	2820	800	93249	0	67414	38.3	11.3	275.0
2036	32740	3120	1500	750	2900	1860	3150	700	1200	330	5950	2850	7560	2609	0	0	9600	11500	3200	3330	800	95649	0	68341	40.0	10.8	275.0
2037	32270	1020	1500	750	2900	1860	3150	700	800	330	6200	2850	10440	2609	0	0	11200	12500	3200	3650	800	98729	0	69621	41.8	11.9	275.0
2038	31330	1020	1500	750	2900	1860	3150	700	400	330	8450	2850	10440	2609	0	0	11200	13500	3200	4080	800	101069	0	70777	42.8	11.9	275.0
2039	29820	1020	1500	750	2900	1860	1900	700	0	330	9200	2850	10440	2609	0	0	12800	14500	3200	4610	800	101789	0	71736	41.9	11.6	275.0
2040	27540	1020	1500	750	2900	1860	1220	700	0	280	11450	2850	10440	2609	0	0	12800	15500	3700	5250	800	103169	0	72495	42.3	11.0	275.0
2041	26970	1020	1500	750	2900	1860	880	700	0	0	12950	2850	10440	2609	0	0	12800	16500	4200	5890	800	105619	0	73599	43.5	10.8	275.0
2042	26970	1020	1500	750	2900	1860	550	700	0	0	12950	2850	11280	2609	0	0	12800	17500	4400	6530	800	107969	0	74482	45.0	11.1	275.0
2043	26820	1020	1500	750	2900	1860	300	700	0	0	12950	3090	11760	2609	0	0	12800	18500	5000	7170	800	110529	0	75368	46.7	11.2	275.0
2044	26820	1020	1500	750	2900	0	0	600	0	0	12950	3090	11760	2609	0	0	14400	19500	5900	7810	800	112409	0	76112	47.7	10.6	275.0
2045	25650	1020	1500	750	2900	0	0	300	0	0	14450	3330	12360	2609	0	0	14400	20500	5900	8130	600	114399	0	77059	48.5	10.4	275.0
2046	23900	0	1500	750	2900	0	0	200	0	0	15950	5010	12600	2609	0	0	14400	21500	5900	8450	400	116069	0	77841	49.1	9.9	275.0
2047	22100	0	1500	750	2900	0	0	100	0	0	18200	5250	12600	2609	0	0	14400	22430	5900	8770	200	117709	0	78603	49.8	9.6	275.0
2048	19100	0	1500	750	2900	0	0	0	0	0	21200	5250	12600	2609	0	0	14400	23290	5900	8830	0	118329	0	78969	49.8	8.7	275.0
2049	17900	0	1500	750	2900	0	0	0	0	0	23450	5010	13200	2609	0	0	14400	23980	5900	8830	0	120429	0	79640	51.2	9.6	275.0
2050	16120	0	1500	750	2900	0	0	0	0	0	24950	4770	13200	2609	0	0	14400	24420	5900	8510	0	120029	0	80163	49.7	8.1	275.0

Table 28 – Details of Base Case scenario (following Step 5)

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO_2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	264.8
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.7
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	265.9
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	270.1
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	277.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	280.2
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	43713	41.6	31.5	284.5
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	58850	2060	44977	37.1	27.0	289.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	420	0	0	0	58560	2060	46481	31.8	21.6	298.5
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	980	0	0	0	59235	2060	47952	29.1	18.0	298.1
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	1770	0	0	0	59770	2060	49442	26.1	13.9	304.9
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	750	0	0	1500	0	0	0	2700	0	320	0	61320	2060	50895	25.6	11.4	310.9
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1950	2840	0	1500	0	0	1600	3700	0	640	0	66390	2060	52593	31.4	15.2	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1950	2840	840	1500	0	0	1600	4700	0	960	0	67160	0	52995	26.7	12.1	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1950	3550	3240	1500	0	0	1600	5700	0	1600	0	70610	0	54745	29.0	12.2	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	1950	3550	4560	1500	0	0	3200	6700	0	1920	0	73430	0	56482	30.0	11.5	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4680	1500	0	0	4800	7700	0	2560	0	76890	0	58547	31.3	11.0	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4680	1500	0	0	4800	8700	3000	3060	0	81350	0	60509	34.4	10.4	275.0
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4800	1500	0	0	6400	9700	3000	3700	0	84690	0	62159	36.2	10.5	275.0
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	3700	3550	5160	1500	0	0	6400	10700	3400	4340	0	87180	0	63463	37.4	9.6	275.0
2033	33890	3120	1500	690	2900	1860	1070	300	1300	640	4450	3550	5160	1500	0	0	6400	11700	5200	4980	0	90210	0	64969	38.9	8.2	275.0
2034	33310	3120	1500	690	2900	1860	1070	300	370	640	5200	3550	6240	1500	0	0	8000	12700	5200	5620	0	93770	0	66210	41.6	10.3	275.0
2035	33310	3120	1500	690	2900	1860	1070	300	0	640	5200	3550	6240	1500	0	0	9600	13700	5200	6260	0	96640	0	67414	43.4	10.9	275.0
2036	32840	3120	1500	690	2900	1860	1070	300	0	280	5950	3550	6840	1500	0	0	9600	14700	5200	6580	0	98480	0	68341	44.1	10.3	275.0
2037	32370	1020	1500	690	2900	1860	1070	300	0	280	6700	3550	9720	1500	0	0	11200	15700	5200	6900	0	102460	0	69621	47.2	12.2	271.8
2038	31900	1020	1500	690	2900	1860	1070	300	0	280	8200	3550	9720	1500	0	0	11200	16700	5200	7220	0	104810	0	70777	48.1	12.0	275.0
2039	30390	1020	1500	690	2900	1860	160	300	0	280	9700	3550	9720	1500	0	0	11200	17700	5200	7860	0	105530	0	71736	47.1	10.7	275.0
2040	28110	1020	1500	690	2900	1860	20	300	0	280	11950	4970	9840	1500	0	0	11200	18700	5200	8500	0	108540	0	72495	49.7	11.9	275.0
2041	26970	1020	1500	690	2900	1860	0	300	0	0	12700	4970	9840	1500	0	0	11200	19700	5200	9020	0	109370	0	73599	48.6	9.5	275.0
2042	26970	1020	1500	690	2900	1860	0	300	0	0	13450	5680	10800	1500	0	0	11200	20700	5200	9480	0	113250	0	74482	52.0	11.7	275.0
2043	26820	1020	1500	690	2900	1860	0	300	0	0	13450	5680	10800	1500	0	0	11200	21700	5800	10120	0	115340	0	75368	53.0	10.8	275.0
2044	26820	1020	1500	690	2900	0	0	200	0	0	13450	5680	10800	1500	0	0	12800	22700	7200	10440	0	117700	0	76112	54.6	10.5	275.0
2045	25650	1020	1500	690	2900	0	0	0	0	0	14950	5680	10800	1500	0	0	12800	23560	7900	10760	0	119710	0	77059	55.3	10.0	275.0
2046	23900	0	1500	690	2900	0	0	0	0	0	16450	6390	12000	1500	0	0	12800	24280	8000	11080	0	121490	0	77841	56.1	9.9	275.0
2047	22100	0	1500	690	2900	0	0	0	0	0	18700	6390	12000	1500	0	0	12800	24720	8000	11080	0	122380	0	78603	55.7	9.5	275.0
2048	19100	0	1500	690	2900	0	0	0	0	0	21700	6390	12000	1500	0	0	12800	24930	8100	11080	0	122690	0	78969	55.4	9.0	275.0
2049	17900	0	1500	690	2900	0	0	0	0	0	23200	6390	12240	1500	0	0	12800	25000	8100	10760	0	122980	0	79640	54.4	8.7	275.0
2050	16120	0	1500	690	2900	0	0	0	0	0	24700	6390	12240	1500	0	0	12800	25000	8100	10520	0	122460	0	80163	52.8	7.5	275.0

Table 29 – Details of SO Moderate scenario

	Existing/Committed										New																
Year	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	39282	24.3	17.9	270.7
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	40210	27.9	17.4	265.7
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	41816	32.3	20.3	278.1
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	43440	35.5	23.2	287.2
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	45111	35.2	23.3	296.7
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	45942	32.8	23.4	299.5
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	140	0	0	0	59130	2060	46994	31.6	22.2	303.8
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	120	0	0	0	0	350	0	0	0	59180	2060	48154	28.4	18.7	309.8
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	250	0	480	0	0	0	0	840	0	0	0	59710	2060	48958	27.3	16.8	313.8
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	250	0	480	1125	0	0	0	1400	0	0	0	60385	2060	50221	25.4	14.1	311.5
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	1000	710	480	1500	0	0	0	2190	0	0	0	62380	2060	51639	25.8	13.3	317.3
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	1600	710	480	1500	0	0	0	3050	0	320	0	63710	2060	53051	24.9	10.7	319.1
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	2200	2840	480	1500	0	0	3200	3980	0	640	0	69000	2060	54596	31.3	15.2	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	2200	2840	1320	1500	0	0	3200	4980	0	1190	0	70000	0	55057	27.1	12.2	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	2200	2840	3000	1500	0	0	4800	5980	0	1510	0	73300	0	56890	28.8	12.3	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	2200	2840	4680	1500	0	0	6400	6980	0	1830	0	76480	0	58683	30.3	12.2	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2700	2840	5160	1500	0	0	6400	7980	0	2470	0	78700	0	59857	31.5	11.3	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2700	2840	5160	1500	0	0	6400	8980	2600	2790	0	82580	0	61596	34.1	10.5	275.0
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2700	2840	5280	1500	0	0	8000	9980	3700	3430	0	87020	0	63592	36.8	11.0	275.0
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	3700	2840	6360	1500	0	0	8000	10980	4900	4070	0	90780	0	65605	38.4	10.3	275.0
2033	33890	3120	1500	690	2900	1860	1070	300	1300	640	4450	2840	6360	1500	0	0	9600	11980	5000	4710	0	93710	0	67414	39.0	9.5	275.0
2034	33310	3120	1500	690	2900	1860	1070	300	370	640	5200	2840	7320	1500	0	0	11200	12980	5000	5350	0	97150	0	69232	40.3	10.4	275.0
2035	33310	3120	1500	690	2900	1860	1070	300	0	640	5200	2840	7320	1500	0	0	12800	13980	5600	5990	0	100620	0	71218	41.3	10.2	275.0
2036	32840	3120	1500	690	2900	1860	1070	300	0	280	5950	2840	8040	1500	0	0	14400	14980	5600	6310	0	104180	0	73073	42.6	10.6	274.8
2037	32370	1020	1500	690	2900	1860	1070	300	0	280	6700	3550	11040	1500	0	0	14400	15980	6100	6950	0	108210	0	74899	44.5	11.0	275.0
2038	31900	1020	1500	690	2900	1860	1070	300	0	280	8200	3550	11040	1500	0	0	16000	16980	6100	7270	0	112160	0	76719	46.2	11.9	275.0
2039	30390	1020	1500	690	2900	1860	160	300	0	280	8950	3550	11040	1500	0	0	17600	17980	6100	7590	0	113410	0	78594	44.3	10.4	273.5
2040	28110	1020	1500	690	2900	1860	20	300	0	280	11200	4970	11160	1500	0	0	17600	18980	6400	8230	0	116720	0	80232	45.5	10.5	275.0
2041	26970	1020	1500	690	2900	1860	0	300	0	0	11950	4970	12120	1500	0	0	17600	19980	6400	8870	0	118630	0	81955	44.8	8.8	275.0
2042	26970	1020	1500	690	2900	1860	0	300	0	0	12700	4970	12600	1500	0	0	19200	20980	6400	9190	0	122780	0	83342	47.3	10.5	271.8
2043	26820	1020	1500	690	2900	1860	0	300	0	0	13450	4970	12600	1500	0	0	19200	21980	6400	9830	0	125020	0	84864	47.3	9.4	275.0
2044	26820	1020	1500	690	2900	0	0	200	0	0	13450	4970	12600	1500	0	0	22400	22840	7200	10150	0	128240	0	86260	48.7	9.8	273.6
2045	25650	1020	1500	690	2900	0	0	0	0	0	14200	5680	13800	1500	0	0	22400	23630	7300	10470	0	130740	0	87966	48.6	9.4	275.0
2046	23900	0	1500	690	2900	0	0	0	0	0	17200	5680	13800	1500	0	0	24000	24140	7300	10240	0	132850	0	89443	48.5	9.6	274.9
2047	22100	0	1500	690	2900	0	0	0	0	0	19450	6390	13800	1500	0	0	24000	24580	8100	10560	0	135570	0	90940	49.1	9.6	275.0
2048	19100	0	1500	690	2900	0	0	0	0	0	22450	6390	13800	1500	0	0	24000	24790	9200	10880	0	137200	0	92341	48.6	8.7	275.0
2049	17900	0	1500	690	2900	0	0	0	0	0	23200	7100	14400	1500	0	0	24000	24930	10300	10880	0	139300	0	94038	48.1	8.3	275.0
2050	16120	0	1500	690	2900	0	0	0	0	0	23950	8520	14280	1500	0	0	24000	25000	10300	10880	0	139640	0	95519	46.2	6.9	275.0

Table 30 – Details of SO Low scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	39301	24.3	17.8	270.8
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	39868	29.1	18.5	263.5
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	41086	34.8	22.5	273.6
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	42293	39.5	26.6	280.1
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	43512	40.5	28.0	287.1
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	43886	39.3	29.3	287.6
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	44472	39.1	29.2	288.8
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	58850	2060	45147	36.6	26.5	290.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	280	0	0	0	58420	2060	45469	34.6	24.3	292.6
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	375	0	0	0	580	0	0	0	58085	2060	46207	31.6	20.9	292.0
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	1140	0	0	0	59140	2060	47072	31.4	19.7	290.5
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	1930	0	0	0	59480	2060	47913	29.7	16.6	293.8
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1200	1420	0	1500	0	0	0	2860	0	320	0	61460	2060	48858	31.3	16.1	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1200	1420	0	1500	0	0	0	3790	0	640	0	61320	0	48678	26.0	12.4	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1200	1420	2760	1500	0	0	0	4790	0	960	0	64100	0	49847	28.6	12.9	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	1700	2840	3240	1500	0	0	0	5790	0	1280	0	66400	0	50964	30.3	12.5	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2450	2840	3240	1500	0	0	0	6790	0	1600	0	68070	0	51521	32.1	12.1	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2450	2840	3840	1500	0	0	0	7790	0	1940	0	69970	0	52562	33.1	11.2	275.0
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2450	2840	4560	1500	0	0	0	8790	600	2580	0	72910	0	53799	35.5	10.9	275.0
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	5520	1500	0	0	0	9790	1400	3220	0	75650	0	55019	37.5	10.1	275.0
2033	33890	3120	1500	690	2900	1860	1070	300	1300	640	4450	2840	5520	1500	0	0	0	10790	2200	3860	0	78430	0	56031	40.0	9.9	275.0
2034	33310	3120	1500	690	2900	1860	1070	300	370	640	4450	2840	6240	1500	0	0	0	11790	3700	4500	0	80780	0	57024	41.7	9.5	275.0
2035	33310	3120	1500	690	2900	1860	1070	300	0	640	5200	2840	6240	1500	0	0	1600	12790	3700	5140	0	84400	0	58129	45.2	11.6	275.0
2036	32840	3120	1500	690	2900	1860	1070	300	0	280	5950	2840	6240	1500	0	0	3200	13790	3700	5460	0	87240	0	59093	47.6	12.5	275.0
2037	32370	1020	1500	690	2900	1860	1070	300	0	280	6700	2840	8760	1500	0	0	3200	14790	4000	6010	0	89790	0	60008	49.6	12.5	275.0
2038	31900	1020	1500	690	2900	1860	1070	300	0	280	8200	2840	8760	1500	0	0	3200	15790	4400	6650	0	92860	0	60898	52.5	13.2	275.0
2039	30390	1020	1500	690	2900	1860	160	300	0	280	8950	2840	8760	1500	0	0	3200	16790	5300	7290	0	93730	0	61810	51.6	11.5	275.0
2040	28110	1020	1500	690	2900	1860	20	300	0	280	11950	2840	9240	1500	0	0	3200	17790	5600	7930	0	96730	0	62514	54.7	12.7	275.0
2041	26970	1020	1500	690	2900	1860	0	300	0	0	12700	2840	9240	1500	0	0	3200	18790	5600	8570	0	97680	0	63263	54.4	10.6	275.0
2042	26970	1020	1500	690	2900	1860	0	300	0	0	13450	2840	10200	1500	0	0	3200	19790	5600	8890	0	100710	0	63735	58.0	12.6	275.0
2043	26820	1020	1500	690	2900	1860	0	300	0	0	13450	2840	10200	1500	0	0	3200	20790	5600	9530	0	102200	0	64295	59.0	11.7	275.0
2044	26820	1020	1500	690	2900	0	0	200	0	0	13450	2840	10200	1500	0	0	4800	21790	6000	10130	0	103840	0	64746	60.4	11.0	275.0
2045	25650	1020	1500	690	2900	0	0	0	0	0	14950	3550	10560	1500	0	0	4800	22650	6000	10130	0	105900	0	65412	61.9	11.9	275.0
2046	23900	0	1500	690	2900	0	0	0	0	0	17200	3550	11760	1500	0	0	4800	23510	6000	10130	0	107440	0	65890	63.1	12.1	275.0
2047	22100	0	1500	690	2900	0	0	0	0	0	18700	3550	12000	1500	0	0	4800	24210	6000	10130	0	108080	0	66370	62.8	11.2	275.0
2048	19100	0	1500	690	2900	0	0	0	0	0	21700	3550	12000	1500	0	0	4800	24650	6000	9810	0	108200	0	66765	62.1	10.4	275.0
2049	17900	0	1500	690	2900	0	0	0	0	0	23200	3550	12600	1500	0	0	4800	24860	6000	9490	0	108990	0	67359	61.8	10.6	275.0
2050	16120	0	1500	690	2900	0	0	0	0	0	25450	3550	12600	1500	0	0	4800	24930	6000	9150	0	109190	0	67783	61.1	10.5	275.0

Table 31 – Details of Weathering the Storm scenario

	Existing/Committed										New																
Year	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38082	28.5	21.7	263.6
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38568	33.7	22.5	255.7
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39061	42.4	29.0	262.4
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	39641	49.6	35.2	264.8
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	40335	52.5	38.3	269.5
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	40728	50.7	39.5	269.6
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	41508	49.5	38.5	271.7
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58710	2060	42258	46.1	35.3	274.0
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58140	2060	43229	41.2	30.8	280.6
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	57270	2060	44154	36.1	25.7	283.0
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	375	0	0	0	350	0	0	0	57225	2060	45119	32.9	22.4	286.6
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	750	0	0	0	910	0	0	0	57710	2060	46008	31.3	19.9	288.4
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1200	710	0	1500	0	0	0	1610	0	0	0	59180	2060	47040	31.6	18.9	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1200	710	0	1500	0	0	0	2400	0	0	0	58580	0	46721	25.4	15.1	271.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1200	710	1560	1500	0	0	0	3330	0	0	0	59770	0	47737	25.2	13.2	274.9
2028	37140	3120	1500	690	2900	1860	1070	300	1300	640	1700	710	3120	1500	0	0	0	4330	0	320	0	62200	0	48652	27.8	13.6	275.0
2029	36740	3120	1500	690	2900	1860	1070	300	1300	640	2450	1420	3120	1500	0	0	0	5330	0	640	0	64580	0	49872	29.5	13.1	275.0
2030	36700	3120	1500	690	2900	1860	1070	300	1300	640	2450	1420	3600	1500	0	0	0	6330	0	960	0	66340	0	50879	30.4	11.9	275.0
2031	36680	3120	1500	690	2900	1860	1070	300	1300	640	2450	2130	3720	1500	0	0	0	7330	0	1600	0	68790	0	51836	32.7	11.8	275.0
2032	35520	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	4320	1500	0	0	0	8330	0	2240	0	71080	0	52629	35.1	11.7	275.0
2033	34360	3120	1500	690	2900	1860	1070	300	1300	640	3700	2840	5160	1500	0	0	0	9330	100	2880	0	73250	0	53541	36.8	11.1	275.0
2034	33780	3120	1500	690	2900	1860	1070	300	370	640	4450	2840	5760	1500	0	0	0	10330	1400	3520	0	76030	0	54326	40.0	12.0	275.0
2035	33780	3120	1500	690	2900	1860	1070	300	0	640	4450	2840	5760	1500	0	0	0	11330	2900	4160	0	78800	0	55004	43.3	12.3	275.0
2036	33310	3120	1500	690	2900	1860	1070	300	0	280	5200	2840	5760	1500	0	0	0	12330	3500	4480	0	80640	0	55496	45.3	11.9	275.0
2037	32840	1020	1500	690	2900	1860	1070	300	0	280	5950	2840	8520	1500	0	0	0	13330	3900	4800	0	83300	0	56268	48.0	12.6	275.0
2038	31900	1020	1500	690	2900	1860	1070	300	0	280	8200	2840	8520	1500	0	0	0	14330	3900	5440	0	86250	0	56928	51.5	14.0	275.0
2039	30390	1020	1500	690	2900	1860	160	300	0	280	8950	2840	8520	1500	0	0	0	15330	4300	6080	0	86620	0	57579	50.4	12.1	275.0
2040	28110	1020	1500	690	2900	1860	20	300	0	280	11200	2840	8760	1500	0	0	0	16330	5100	6720	0	89130	0	58083	53.5	12.6	275.0
2041	26970	1020	1500	690	2900	1860	0	300	0	0	12700	2840	8760	1500	0	0	0	17330	5100	7320	0	90790	0	58857	54.3	11.5	275.0
2042	26970	1020	1500	690	2900	1860	0	300	0	0	13450	2840	8760	1500	0	0	0	18330	5100	7960	0	93180	0	59421	56.8	12.0	275.0
2043	26820	1020	1500	690	2900	1860	0	300	0	0	13450	2840	9240	1500	0	0	0	19330	5300	8600	0	95350	0	59985	59.0	12.0	275.0
2044	26820	1020	1500	690	2900	0	0	200	0	0	13450	2840	9240	1500	0	0	0	20330	7200	9240	0	96930	0	60429	60.4	10.1	275.0
2045	25650	1020	1500	690	2900	0	0	0	0	0	14200	4260	9960	1500	0	0	0	21330	7200	9560	0	99770	0	61142	63.2	11.6	275.0
2046	23900	0	1500	690	2900	0	0	0	0	0	16450	4260	10200	1500	0	0	0	22330	7200	9880	0	100810	0	61641	63.5	10.4	275.0
2047	22100	0	1500	690	2900	0	0	0	0	0	18700	4260	10200	1500	0	0	0	23190	7200	10200	0	102440	0	62111	64.9	10.4	275.0
2048	19100	0	1500	690	2900	0	0	0	0	0	21700	4260	10200	1500	0	0	0	23980	7200	9880	0	102910	0	62463	64.8	9.7	275.0
2049	17900	0	1500	690	2900	0	0	0	0	0	23950	4260	10200	1500	0	0	0	24420	7200	9560	0	104080	0	63066	65.0	10.1	275.0
2050	16120	0	1500	690	2900	0	0	0	0	0	25450	4260	10200	1500	0	0	0	24720	7200	9240	0	103780	0	63553	63.3	8.7	275.0

Table 32 – Details of Scenario-Wise Decomposition scenario

	Existing/Committed										New																
Year	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	256.1
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.4
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	264.7
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	266.6
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	273.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	277.3
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	43713	41.6	31.5	283.7
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	58850	2060	44977	37.1	27.0	291.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	420	0	0	0	58560	2060	46481	31.8	21.6	302.8
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1126	0	0	0	980	0	0	0	59236	2060	47952	29.1	18.0	305.8
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	1770	0	48	0	59818	2060	49442	26.2	13.9	308.8
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	794	116	0	1500	0	0	0	2700	0	368	0	61528	2060	50895	26.0	11.8	314.1
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1994	2804	0	1500	0	0	1355	3700	0	688	0	66201	2060	52593	31.0	14.7	275.0
2026	39047	3120	1500	690	2900	1860	1070	300	1300	640	1994	2804	1365	1500	0	0	1355	4700	0	1008	0	67154	0	52995	26.7	12.0	275.0
2027	37747	3120	1500	690	2900	1860	1070	300	1300	640	1994	3760	3259	1500	0	0	1660	5700	0	1648	0	70649	0	54745	29.0	12.2	275.0
2028	36527	3120	1500	690	2900	1860	1070	300	1300	640	1994	3760	4324	1500	0	0	3326	6700	0	1968	0	73479	0	56482	30.1	11.6	275.0
2029	36127	3120	1500	690	2900	1860	1070	300	1300	640	2355	3760	4611	1500	0	0	4857	7700	0	2608	0	76899	0	58547	31.3	11.0	275.0
2030	36047	3120	1500	690	2900	1860	1070	300	1300	640	2355	3760	4611	1500	0	0	4857	8700	2866	3102	0	81179	0	60509	34.2	10.1	275.0
2031	36027	3120	1500	690	2900	1860	1070	300	1300	640	2441	3760	4837	1500	0	0	6271	9700	2866	3742	0	84524	0	62159	36.0	10.2	275.0
2032	34867	3120	1500	690	2900	1860	1070	300	1300	640	3582	3760	5106	1500	0	0	6716	10700	3134	4382	0	87127	0	63463	37.3	9.6	270.1
2033	34162	3120	1500	690	2900	1860	1070	300	1300	640	4085	3760	5106	1500	0	0	6716	11700	5045	5022	0	90477	0	64969	39.3	8.7	272.8
2034	33582	3120	1500	690	2900	1860	1070	300	370	640	4678	3760	6227	1500	0	0	8158	12700	5045	5662	0	93762	0	66210	41.6	10.4	270.4
2035	33582	3120	1500	690	2900	1860	1070	300	0	640	4698	3760	6227	1500	0	0	9627	13700	5045	6302	0	96521	0	67414	43.2	10.8	267.8
2036	33455	3120	1500	690	2900	1860	1070	300	0	280	5474	3760	6838	1500	0	0	10095	14700	5045	6622	0	99208	0	68341	45.2	11.4	272.9
2037	32985	1020	1500	690	2900	1860	1070	300	0	280	6294	3760	9818	1500	0	0	10615	15700	5045	6942	0	102278	0	69621	46.9	12.0	270.8
2038	32315	1020	1500	690	2900	1860	1070	300	0	280	8018	3760	9818	1500	0	0	11180	16700	5045	7262	0	105218	0	70777	48.7	12.6	274.2
2039	30805	1020	1500	690	2900	1860	160	300	0	280	8962	3760	9818	1500	0	0	11447	17700	5081	7902	0	105685	0	71736	47.3	11.0	274.4
2040	28565	1020	1500	690	2900	1860	20	300	0	280	11305	4350	9930	1500	0	0	11447	18700	5081	8542	0	107990	0	72495	49.0	11.2	271.5
2041	27425	1020	1500	690	2900	1860	0	300	0	0	12795	4350	9930	1500	0	0	11447	19700	5081	8975	0	109474	0	73599	48.7	9.8	271.4
2042	27425	1020	1500	690	2900	1860	0	300	0	0	13162	5044	10816	1500	0	0	11447	20700	5081	9467	0	112911	0	74482	51.6	11.3	275.0
2043	26820	1020	1500	690	2900	1860	0	300	0	0	13718	5044	10816	1500	0	0	11447	21700	5499	10059	0	114872	0	75368	52.4	10.5	273.2
2044	26820	1020	1500	690	2900	0	0	200	0	0	13718	5044	10816	1500	0	0	13152	22700	6844	10379	0	117282	0	76112	54.1	10.2	270.0
2045	25650	1020	1500	690	2900	0	0	0	0	0	15396	5044	10816	1500	0	0	13152	23560	7500	10699	0	119426	0	77059	55.0	10.0	269.1
2046	23900	0	1500	690	2900	0	0	0	0	0	16992	5801	12045	1500	0	0	13152	24280	7611	11019	0	121390	0	77841	55.9	10.1	268.5
2047	22100	0	1500	690	2900	0	0	0	0	0	18745	6048	12045	1500	0	0	13152	24720	7611	11019	0	122030	0	78603	55.2	9.3	271.4
2048	19100	0	1500	690	2900	0	0	0	0	0	21500	6048	12045	1500	0	0	13152	24930	7611	11019	0	121995	0	78969	54.5	8.5	270.7
2049	17900	0	1500	690	2900	0	0	0	0	0	23197	6162	12314	1500	0	0	13152	25000	7611	10699	0	122625	0	79640	54.0	8.5	272.1
2050	16120	0	1500	690	2900	0	0	0	0	0	24678	6162	12314	1500	0	0	13152	25000	7611	10459	0	122086	0	80163	52.3	7.4	272.0

Table 33 – Details of Moderate Decline scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	264.8
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.7
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	265.9
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	270.1
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	277.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	280.2
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	43713	41.6	31.5	284.5
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	58850	2060	44977	37.1	27.0	289.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	420	0	0	0	58560	2060	46481	31.8	21.6	298.5
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	980	0	0	0	59235	2060	47952	29.1	18.0	298.1
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	120	1500	0	0	0	1770	0	0	0	59890	2060	49442	26.4	14.2	304.9
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	750	0	120	1500	0	0	0	2630	0	320	0	61370	2060	50895	25.7	11.6	311.0
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1950	2840	120	1500	0	0	1600	3560	0	640	0	66370	2060	52593	31.3	15.4	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1950	2840	720	1500	0	0	1600	4560	0	1200	0	67140	0	52995	26.7	12.0	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1950	3550	3360	1500	0	0	1600	5560	0	1840	0	70830	0	54745	29.4	12.5	275.0
2028	37140	3120	1500	690	2900	1860	1070	300	1300	640	1950	3550	3960	1500	0	0	3200	6560	0	2160	0	73400	0	56482	30.0	11.4	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4680	1500	0	0	4800	7560	0	2630	0	76820	0	58547	31.2	11.1	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4680	1500	0	0	4800	8560	3000	2950	0	81100	0	60509	34.0	10.3	275.0
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4680	1500	0	0	6400	9560	3000	3590	0	84320	0	62159	35.7	10.2	275.0
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	3700	3550	5400	1500	0	0	6400	10560	3000	4230	0	86770	0	63463	36.7	9.5	275.0
2033	34460	3120	1500	690	2900	1860	1070	300	1300	640	4450	3550	5400	1500	0	0	8000	11560	3000	4870	0	90170	0	64969	38.8	10.0	275.0
2034	33880	3120	1500	690	2900	1860	1070	300	370	640	4450	3550	6480	1500	0	0	9600	12560	3000	5510	0	92980	0	66210	40.4	11.0	275.0
2035	33880	3120	1500	690	2900	1860	1070	300	0	640	4450	3550	6480	1500	0	0	9600	13560	5300	6150	0	96550	0	67414	43.2	11.0	275.0
2036	33410	3120	1500	690	2900	1860	1070	300	0	280	5200	3550	6960	1500	0	0	9600	14560	6200	6790	0	99490	0	68341	45.6	11.1	275.0
2037	32940	1020	1500	690	2900	1860	1070	300	0	280	6700	4260	9000	1500	0	0	9600	15560	6200	7350	0	102730	0	69621	47.6	11.7	275.0
2038	32000	1020	1500	690	2900	1860	1070	300	0	280	7450	4260	9000	1500	0	0	11200	16560	6200	7670	0	105460	0	70777	49.0	12.0	270.3
2039	30960	1020	1500	690	2900	1860	160	300	0	280	7450	4260	9000	1500	0	0	12800	17560	6200	7990	0	106430	0	71736	48.4	11.4	264.1
2040	28680	1020	1500	690	2900	1860	20	300	0	280	8200	5680	9480	1500	0	0	12800	18560	6500	8630	0	108600	0	72495	49.8	11.2	258.0
2041	27540	1020	1500	690	2900	1860	0	300	0	0	8200	5680	9480	1500	0	0	14400	19560	6500	8950	0	110080	0	73599	49.6	10.0	250.1
2042	27540	1020	1500	690	2900	1860	0	300	0	0	8200	5680	10080	1500	0	0	14400	20560	6800	9590	800	112620	800	74482	52.8	10.3	245.8
2043	26820	1020	1500	690	2900	1860	0	300	0	0	8200	5680	10080	1500	0	0	16000	21560	6800	9910	0	114820	0	75368	52.3	9.9	239.7
2044	26820	1020	1500	690	2900	0	0	200	0	0	8200	5680	10080	1500	0	0	19200	22560	6800	10110	0	117260	0	76112	54.1	10.6	233.6
2045	25650	1020	1500	690	2900	0	0	0	0	0	8200	5680	10680	1500	0	0	20800	23420	6800	10110	0	118950	0	77059	54.4	10.5	226.6
2046	23900	0	1500	690	2900	0	0	0	0	0	8950	6390	11400	1500	0	0	20800	24140	8300	10190	0	120660	0	77841	55.0	9.7	221.4
2047	22100	0	1500	690	2900	0	0	0	0	0	9700	6390	11400	1500	0	0	20800	24580	10300	10190	0	122050	0	78603	55.3	8.7	215.3
2048	19100	0	1500	690	2900	0	0	0	0	0	11950	7100	11400	1500	0	0	20800	24790	10900	10510	0	123140	0	78969	55.9	8.7	209.2
2049	17900	0	1500	690	2900	0	0	0	0	0	11950	9230	11400	1500	0	0	20800	24930	10900	10680	0	124380	0	79640	56.2	9.0	203.0
2050	16120	0	1500	690	2900	0	0	0	0	0	12700	9230	11400	1500	0	0	20800	25000	10900	10680	0	123420	0	80163	54.0	7.0	201.2

Table 34 – Details of Advanced Decline scenario

	Existing/Committed										New																
Year	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	264.8
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.7
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	265.9
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	270.1
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	277.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	280.2
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	43713	41.6	31.5	284.5
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	58850	2060	44977	37.1	27.0	289.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	420	0	0	0	58560	2060	46481	31.8	21.6	298.5
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	980	0	0	0	59235	2060	47952	29.1	18.0	298.1
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	710	0	1500	0	0	0	1770	0	0	0	60480	2060	49442	27.6	15.4	304.8
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	500	710	0	1500	0	0	0	2630	0	320	0	61710	2060	50895	26.4	12.3	311.3
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1700	2840	0	1500	0	0	1600	3590	0	640	0	66030	2060	52593	30.7	14.7	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1700	2840	960	1500	0	0	1600	4590	0	1280	0	67240	0	52995	26.9	12.0	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1700	3550	3480	1500	0	0	1600	5590	0	1920	0	70810	0	54745	29.3	12.3	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	1950	3550	4320	1500	0	0	3200	6590	0	2260	0	73420	0	56482	30.0	11.3	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4560	1500	0	0	4800	7590	0	2890	0	76990	0	58547	31.5	11.0	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4560	1500	0	0	4800	8590	3300	3230	0	81590	0	60509	34.8	10.5	275.0
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4560	1500	0	0	6400	9590	3300	3870	0	84810	0	62159	36.4	10.4	274.0
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	2950	3550	5640	1500	0	0	6400	10590	4200	4510	0	87770	0	63463	38.3	9.9	271.9
2033	34460	3120	1500	690	2900	1860	1070	300	1300	640	2950	3550	5640	1500	0	0	8000	11590	4200	5150	0	90420	0	64969	39.2	9.2	269.0
2034	33880	3120	1500	690	2900	1860	1070	300	370	640	2950	3550	6000	1500	0	0	9600	12590	4200	5790	800	92510	800	66210	41.4	9.5	265.4
2035	33880	3120	1500	690	2900	1860	1070	300	0	640	2950	3550	6000	1500	0	0	12800	13590	4200	6110	0	96660	0	67414	43.4	11.9	259.3
2036	33410	3120	1500	690	2900	1860	1070	300	0	280	2950	3550	7320	1500	0	0	12800	14590	4200	6430	0	98470	0	68341	44.1	11.2	256.3
2037	32940	1020	1500	690	2900	1860	1070	300	0	280	2950	4260	9600	1500	0	0	14400	15590	4200	6750	0	101810	0	69621	46.2	12.2	250.9
2038	32470	1020	1500	690	2900	1860	1070	300	0	280	3700	4260	9600	1500	0	0	16000	16590	4200	7070	0	105010	0	70777	48.4	13.2	245.0
2039	30960	1020	1500	690	2900	1860	160	300	0	280	3700	4260	9600	1500	0	0	17600	17590	4200	7390	0	105510	0	71736	47.1	11.9	238.2
2040	28680	1020	1500	690	2900	1860	20	300	0	280	3700	5680	9600	1500	0	0	17600	18590	4700	8030	800	106650	800	72495	48.8	10.6	231.4
2041	27540	1020	1500	690	2900	1860	0	300	0	0	3700	5680	9720	1500	0	0	19200	19590	5000	8670	0	108870	0	73599	47.9	9.5	220.6
2042	27540	1020	1500	690	2900	1860	0	300	0	0	3700	5680	9720	1500	0	0	19200	20590	5900	9310	1600	111410	1600	74482	52.9	9.8	216.9
2043	26820	1020	1500	690	2900	1860	0	300	0	0	3700	5680	9720	1500	0	0	20800	21590	5900	9950	800	113930	800	75368	52.8	9.6	208.7
2044	26820	1020	1500	690	2900	0	0	200	0	0	3700	5680	9720	1500	0	0	22400	22590	10200	10270	0	119190	0	76112	56.6	11.0	200.2
2045	25650	1020	1500	690	2900	0	0	0	0	0	3700	5680	9720	1500	0	0	24000	23450	10200	10590	0	120600	0	77059	56.5	10.1	191.3
2046	23900	0	1500	690	2900	0	0	0	0	0	3700	5680	10920	1500	0	0	25600	24170	10200	10590	0	121350	0	77841	55.9	9.1	181.9
2047	22100	0	1500	690	2900	0	0	0	0	0	3700	7100	10920	1500	0	0	25600	24610	11900	10590	0	123110	0	78603	56.6	8.7	172.2
2048	19100	0	1500	690	2900	0	0	0	0	0	5200	7100	11040	1500	0	0	27200	24820	11900	10780	0	123730	0	78969	56.7	8.6	162.2
2049	17900	0	1500	690	2900	0	0	0	0	0	5200	7100	11400	1500	0	0	28800	24960	11900	10790	0	124640	0	79640	56.5	8.6	151.8
2050	16120	0	1500	690	2900	0	0	0	0	0	5200	8520	11400	1500	0	0	28800	25000	11900	10770	0	124300	0	80163	55.1	7.5	140.0

Table 35 – Details of Carbon Budget scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	264.8
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.7
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	265.9
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	270.1
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	277.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	280.2
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	43713	41.6	31.5	284.5
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	58850	2060	44977	37.1	27.0	289.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	350	0	0	0	58490	2060	46481	31.7	21.6	298.7
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	840	0	0	0	59095	2060	47952	28.8	18.0	298.4
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1780	0	0	0	1400	0	0	0	59680	2060	49442	26.0	14.5	305.4
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	1200	0	0	1780	0	0	0	2190	0	0	0	61220	2060	50895	25.4	12.7	303.2
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	4450	0	0	1780	0	0	0	3050	0	0	0	63440	2060	52593	25.5	11.6	308.3
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	4450	0	2640	1780	0	0	0	3980	0	320	0	65940	0	52995	24.4	12.0	304.3
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	4450	2130	3960	1780	0	0	0	4980	0	640	0	69410	0	54745	26.8	12.5	306.2
2028	37140	3120	1500	690	2900	1860	1070	300	1300	640	4450	4260	4560	1780	0	0	0	5980	0	960	0	72510	0	56482	28.4	12.4	302.5
2029	36740	3120	1500	690	2900	1860	1070	300	1300	640	4450	4260	4920	1780	0	0	1600	6980	0	1550	0	75660	0	58547	29.2	11.4	296.8
2030	36700	3120	1500	690	2900	1860	1070	300	1300	640	4450	4260	5040	1780	0	0	1600	7980	2500	2190	0	79880	0	60509	32.0	10.5	295.2
2031	36680	3120	1500	690	2900	1860	1070	300	1300	640	4450	4260	5160	1780	0	0	3200	8980	2500	2830	0	83220	0	62159	33.9	10.6	294.7
2032	36090	3120	1500	690	2900	1860	1070	300	1300	640	4450	4260	6120	1780	0	0	3200	9980	3500	3470	0	86230	0	63463	35.9	10.1	292.9
2033	34930	3120	1500	690	2900	1860	1070	300	1300	640	4450	4260	6120	1780	0	0	4800	10980	4200	4110	0	89010	0	64969	37.0	9.1	284.6
2034	34350	3120	1500	690	2900	1860	1070	300	370	640	4450	4260	6120	1780	0	0	8000	11980	4200	4750	0	92340	0	66210	39.5	10.9	280.7
2035	34350	3120	1500	690	2900	1860	1070	300	0	640	4450	4260	6120	1780	0	0	9600	12980	4200	5390	0	95210	0	67414	41.2	11.4	279.4
2036	33880	3120	1500	690	2900	1860	1070	300	0	280	4450	4260	6120	1780	0	0	11200	13980	4200	5710	0	97300	0	68341	42.4	11.1	272.4
2037	33410	1020	1500	690	2900	1860	1070	300	0	280	4450	4260	9120	1780	0	0	12800	14980	4200	6030	0	100650	0	69621	44.6	12.2	266.1
2038	32470	1020	1500	690	2900	1860	1070	300	0	280	4450	4260	9120	1780	0	0	16000	15980	4200	6350	0	104230	0	70777	47.3	13.7	246.2
2039	30960	1020	1500	690	2900	1860	160	300	0	280	4450	4260	9120	1780	0	0	16000	16980	5500	6990	0	104750	0	71736	46.0	11.3	245.2
2040	28100	1020	1500	690	2900	1860	20	300	0	280	4450	4260	9120	1780	0	0	19200	17980	6500	7630	0	107590	0	72495	48.4	11.6	218.7
2041	26960	1020	1500	690	2900	1860	0	300	0	0	4450	4260	9240	1780	0	0	19200	18980	8200	8270	0	109610	0	73599	48.9	9.7	213.7
2042	26390	1020	1500	690	2900	1860	0	300	0	0	4450	4260	9480	1780	0	0	20800	19980	8200	8910	0	112520	0	74482	51.1	10.4	201.4
2043	26240	1020	1500	690	2900	1860	0	300	0	0	4450	4260	9480	1780	0	0	20800	20980	9000	9550	0	114810	0	75368	52.3	9.7	200.9
2044	26240	1020	1500	690	2900	0	0	200	0	0	4450	4260	9480	1780	0	0	22400	21980	9700	10190	0	116790	0	76112	53.4	9.0	202.7
2045	25070	1020	1500	690	2900	0	0	0	0	0	4450	4260	9480	1780	0	0	24000	22840	11200	10830	0	120020	0	77059	55.8	9.4	187.9
2046	23320	0	1500	690	2900	0	0	0	0	0	4450	4260	9480	1780	0	0	27200	23630	12000	11150	0	122360	0	77841	57.2	9.5	164.0
2047	21520	0	1500	690	2900	0	0	0	0	0	4450	4260	9600	1780	0	0	28800	24140	12100	11470	0	123210	0	78603	56.8	8.6	152.6
2048	18520	0	1500	690	2900	0	0	0	0	0	4450	4260	11040	1780	0	0	30400	24580	13100	11790	0	125010	0	78969	58.3	8.9	133.7
2049	17320	0	1500	690	2900	0	0	0	0	0	4450	4260	11040	1780	0	0	32000	24790	13100	11520	0	125350	0	79640	57.4	8.4	124.2
2050	16120	0	1500	690	2900	0	0	0	0	0	4450	4970	11040	1780	0	0	32000	24930	13100	11200	0	124680	0	80163	55.5	7.0	120.2

Table 36 – Details of Carbon Tax scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	264.8
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.7
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	265.9
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	270.1
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	277.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	280.2
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	43713	41.6	31.5	284.5
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	58850	2060	44977	37.1	27.0	289.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	280	0	0	0	58420	2060	46481	31.5	21.6	298.8
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	550	0	0	0	58805	2060	47952	28.1	18.0	298.9
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	600	0	0	1500	0	0	0	1110	0	0	0	59710	2060	49442	26.0	15.1	301.2
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	1450	0	0	1500	0	0	0	1670	0	0	0	60670	2060	50895	24.2	12.6	304.1
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	5950	0	0	1500	0	0	0	2370	0	0	0	63980	2060	52593	26.6	13.9	308.6
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	5950	0	1560	1500	0	0	0	3160	0	0	0	64940	0	52995	22.5	12.1	305.6
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	5950	1420	3000	2060	0	0	0	4090	0	0	0	67990	0	54745	24.2	12.4	310.7
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	6700	2840	3960	2060	0	0	0	5090	0	20	0	70720	0	56482	25.2	11.9	311.1
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	8200	2840	4800	2060	0	0	0	6090	0	310	0	73950	0	58547	26.3	11.5	317.3
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	9700	2840	4800	2060	0	0	0	7090	0	310	0	76410	0	60509	26.3	10.3	325.6
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	11200	2840	5400	2060	0	0	0	8090	0	630	0	79810	0	62159	28.4	10.8	334.9
2032	35620	3120	1500	690	2900	1860	1070	300	1300	640	11950	2840	6480	2060	0	0	0	9090	0	950	0	82370	0	63463	29.8	10.7	338.6
2033	34460	3120	1500	690	2900	1860	1070	300	1300	640	14200	2840	6840	2060	0	0	0	10090	0	1270	0	85140	0	64969	31.0	10.5	345.2
2034	33880	3120	1500	690	2900	1860	1070	300	370	640	16450	2840	7200	2060	0	0	0	11090	0	1590	0	87560	0	66210	32.2	11.2	357.3
2035	33880	3120	1500	690	2900	1860	1070	300	0	640	17950	2840	7320	2060	0	0	0	12090	0	1910	0	90130	0	67414	33.7	11.6	367.8
2036	33410	3120	1500	690	2900	1860	1070	300	0	280	19450	2840	7680	2060	0	0	0	13090	0	1910	0	92160	0	68341	34.9	11.6	371.7
2037	32940	1020	1500	690	2900	1860	1070	300	0	280	20950	2840	10680	2060	0	0	0	14090	0	2230	0	95410	0	69621	37.0	12.4	375.4
2038	32470	1020	1500	690	2900	1860	1070	300	0	280	22450	2840	11400	2060	0	0	0	15090	0	2230	0	98160	0	70777	38.7	13.1	379.9
2039	30960	1020	1500	690	2900	1860	160	300	0	280	24700	2840	11400	2060	0	0	0	16090	0	2550	0	99310	0	71736	38.4	12.7	383.1
2040	28680	1020	1500	690	2900	1860	20	300	0	280	26950	2840	11520	2060	0	0	0	17090	0	2870	0	100580	0	72495	38.7	11.8	383.9
2041	27540	1020	1500	690	2900	1860	0	300	0	0	28450	2840	12840	2060	0	0	0	18090	0	3190	0	103280	0	73599	40.3	12.2	384.7
2042	26970	1020	1500	690	2900	1860	0	300	0	0	29200	2840	13200	2060	0	0	0	19090	0	3330	0	104960	0	74482	40.9	11.6	384.6
2043	26820	1020	1500	690	2900	1860	0	300	0	0	29950	2840	13440	2060	0	0	0	20090	0	3650	0	107120	0	75368	42.1	11.5	387.4
2044	26820	1020	1500	690	2900	0	0	200	0	0	32200	2840	13440	2060	0	0	0	21090	0	3960	0	108720	0	76112	42.8	11.0	403.4
2045	25650	1020	1500	690	2900	0	0	0	0	0	34450	2840	13440	2060	0	0	0	21950	0	4280	0	110780	0	77059	43.8	11.0	405.5
2046	23900	0	1500	690	2900	0	0	0	0	0	36700	3550	14040	2060	0	0	0	22810	0	4280	0	112430	0	77841	44.4	10.9	407.2
2047	22100	0	1500	690	2900	0	0	0	0	0	38200	4260	14520	2060	0	0	0	23540	0	4550	0	114320	0	78603	45.4	11.1	406.3
2048	19100	0	1500	690	2900	0	0	0	0	0	41200	4260	14520	2060	0	0	0	23980	0	4530	0	114740	0	78969	45.3	10.6	404.8
2049	17900	0	1500	690	2900	0	0	0	0	0	42700	4970	14520	2060	0	0	0	24420	0	4560	0	116220	0	79640	45.9	10.9	403.8
2050	16120	0	1500	690	2900	0	0	0	0	0	42700	6390	14520	2060	0	0	0	24720	0	4880	0	116480	0	80163	45.3	9.9	399.3

Table 37 – Details of Regional Hydro scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	264.8
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.7
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	265.9
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	270.1
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	277.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	280.2
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	43713	41.6	31.5	284.5
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	58850	2060	44977	37.1	27.0	289.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	350	0	0	0	58490	2060	46481	31.7	21.6	298.7
2022	43390	3480	4000	690	2900	1860	1070	300	1300	2700	0	0	0	490	0	0	0	740	0	0	0	60860	2060	47952	32.6	22.0	290.1
2023	42760	3480	4000	690	4100	1860	1070	300	1300	2700	0	0	0	1615	0	0	0	1300	0	0	0	63115	2060	49442	33.2	21.7	292.6
2024	42310	3480	4000	690	4100	1860	1070	300	1300	2700	0	0	0	1990	0	0	0	2090	0	0	0	63830	2060	50895	30.7	18.1	298.2
2025	40420	3480	4000	690	4100	1860	1070	300	1300	2700	1200	2840	0	2150	0	0	0	3020	0	320	0	67390	2060	52593	33.4	18.8	275.0
2026	38920	3120	4000	690	4100	1860	1070	300	1300	640	1200	2840	0	2150	0	0	0	4020	0	640	0	66850	0	52995	26.1	13.2	275.0
2027	37620	3120	4000	690	4100	1860	1070	300	1300	640	1200	3550	2040	2150	0	0	0	5020	0	970	0	69630	0	54745	27.2	12.4	275.0
2028	36670	3120	4000	690	4100	1860	1070	300	1300	640	1450	3550	2880	2150	0	0	1600	6020	0	1290	0	72690	0	56482	28.7	12.2	275.0
2029	36270	3120	4000	690	4100	1860	1070	300	1300	640	2200	3550	2880	2150	0	0	3200	7020	0	1830	0	76180	0	58547	30.1	11.9	275.0
2030	36230	3120	4000	690	4100	1860	1070	300	1300	640	2450	3550	3240	2150	0	0	3200	8020	1300	2460	0	79680	0	60509	31.7	10.7	275.0
2031	36210	3120	4000	690	4100	1860	1070	300	1300	640	2450	3550	3240	2150	0	0	4800	9020	1300	3100	0	82900	0	62159	33.4	10.6	275.0
2032	35050	3120	4000	690	4100	1860	1070	300	1300	640	3450	3550	3240	2150	0	0	6400	10020	1300	3520	0	85760	0	63463	35.1	10.8	275.0
2033	33890	3120	4000	690	4100	1860	1070	300	1300	640	4450	3550	3360	2150	0	0	6400	11020	2300	4160	0	88360	0	64969	36.0	9.3	275.0
2034	33310	3120	4000	690	4100	1860	1070	300	370	640	5200	3550	4200	2150	0	0	8000	12020	2300	4800	0	91680	0	66210	38.5	11.1	275.0
2035	33310	3120	4000	690	4100	1860	1070	300	0	640	5200	3550	4200	2150	0	0	9600	13020	2300	5440	0	94550	0	67414	40.3	11.6	275.0
2036	33310	3120	4000	690	4100	1860	1070	300	0	280	5200	3550	5160	2150	0	0	9600	14020	3000	6080	0	97490	0	68341	42.7	11.8	275.0
2037	32840	1020	4000	690	4100	1860	1070	300	0	280	5950	3550	8280	2150	0	0	9600	15020	3800	6690	0	101200	0	69621	45.4	12.5	275.0
2038	31900	1020	4000	690	4100	1860	1070	300	0	280	8200	3550	8280	2150	0	0	9600	16020	4500	7330	0	104850	0	70777	48.1	13.3	275.0
2039	30390	1020	4000	690	4100	1860	160	300	0	280	8950	3550	8280	2150	0	0	9600	17020	5300	7970	0	105620	0	71736	47.2	11.6	275.0
2040	28110	1020	4000	690	4100	1860	20	300	0	280	11950	3550	8280	2150	0	0	9600	18020	5500	8610	0	108040	0	72495	49.0	11.9	275.0
2041	26970	1020	4000	690	4100	1860	0	300	0	0	13450	3550	8280	2150	0	0	9600	19020	5500	8980	0	109470	0	73599	48.7	10.4	275.0
2042	26970	1020	4000	690	4100	1860	0	300	0	0	13450	4260	9120	2150	0	0	9600	20020	5500	9370	0	112410	0	74482	50.9	11.4	275.0
2043	26820	1020	4000	690	4100	1860	0	300	0	0	13450	4970	9120	2150	0	0	9600	21020	5900	10010	0	115010	0	75368	52.6	11.4	275.0
2044	26820	1020	4000	690	4100	0	0	200	0	0	13450	4970	9120	2150	0	0	11200	22020	7200	10650	0	117590	0	76112	54.5	11.0	275.0
2045	25650	1020	4000	690	4100	0	0	0	0	0	14950	4970	9120	2150	0	0	11200	22880	7800	10970	0	119500	0	77059	55.1	10.5	275.0
2046	23900	0	4000	690	4100	0	0	0	0	0	16450	5680	10320	2150	0	0	11200	23670	7900	11080	0	121140	0	77841	55.6	10.3	275.0
2047	22100	0	4000	690	4100	0	0	0	0	0	18700	5680	10320	2150	0	0	11200	24280	7900	11070	0	122190	0	78603	55.5	9.8	275.0
2048	19100	0	4000	690	4100	0	0	0	0	0	21700	5680	10320	2150	0	0	11200	24720	7900	11070	0	122630	0	78969	55.3	9.3	275.0
2049	17900	0	4000	690	4100	0	0	0	0	0	23200	5680	10440	2150	0	0	11200	24930	7900	10850	0	123040	0	79640	54.5	8.9	275.0
2050	16120	0	4000	690	4100	0	0	0	0	0	24700	5680	10440	2150	0	0	11200	25000	7900	10540	0	122520	0	80163	52.8	7.7	275.0

Table 38 – Details of Rooftop PV scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	264.8
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.7
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	2870	0	0	0	54480	2810	39703	47.7	26.8	262.5
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	4316	0	0	0	59026	3060	40608	57.2	31.9	265.1
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	5823	0	0	0	62673	3060	41679	62.3	33.7	270.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	7378	0	0	0	65658	2060	42485	62.4	33.6	270.4
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	8887	0	0	0	67877	2060	43713	63.0	31.5	273.3
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	10453	0	0	0	69163	2060	44977	61.2	27.0	276.6
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	12060	0	0	0	70200	2060	46481	58.0	21.6	284.4
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	375	0	0	0	13769	0	0	0	71274	2060	47952	55.3	16.4	286.0
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	15705	0	0	0	73705	2060	49442	55.6	13.9	286.3
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	960	1500	0	0	0	17804	0	320	0	76634	2060	50895	56.9	11.8	290.7
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1700	1420	1440	1500	0	0	0	19955	0	660	0	80835	2060	52593	60.0	11.7	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1700	1420	4200	1500	0	0	0	22011	0	980	0	84581	0	52995	59.6	12.3	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1700	2130	6720	1500	0	0	0	24030	0	1300	0	88850	0	54745	62.3	12.4	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	1700	2840	8880	1500	0	0	0	25929	0	1850	0	92749	0	56482	64.2	11.8	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2200	2840	9240	1500	0	0	1600	27695	0	2170	0	96895	0	58547	65.5	11.5	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2450	2840	10320	1500	0	0	1600	29317	400	2490	0	100527	0	60509	66.1	10.6	275.0
2031	35640	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	10320	1500	0	0	3200	30847	400	3130	0	104207	0	62159	67.6	10.4	275.0
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	10320	1500	0	0	4800	32366	400	3770	0	107376	0	63463	69.2	10.0	274.4
2033	33890	3120	1500	690	2900	1860	1070	300	1300	640	4450	2840	11280	1500	0	0	4800	33875	500	4410	0	110925	0	64969	70.7	9.8	275.0
2034	33310	3120	1500	690	2900	1860	1070	300	370	640	5200	2840	11880	1500	0	0	6400	35372	500	5050	0	114502	0	66210	72.9	11.2	275.0
2035	33310	3120	1500	690	2900	1860	1070	300	0	640	5200	2840	11880	1500	0	0	8000	36858	500	5690	0	117858	0	67414	74.8	11.7	275.0
2036	32840	3120	1500	690	2900	1860	1070	300	0	280	5950	2840	12840	1500	0	0	8000	38332	500	6300	0	120822	0	68341	76.8	11.8	275.0
2037	32370	1020	1500	690	2900	1860	1070	300	0	280	7450	2840	15960	1500	0	0	8000	39794	500	6620	0	124654	0	69621	79.0	12.8	275.0
2038	31900	1020	1500	690	2900	1860	1070	300	0	280	8200	2840	15960	1500	0	0	9600	41243	500	6940	0	128303	0	70777	81.3	13.7	270.3
2039	30390	1020	1500	690	2900	1860	160	300	0	280	8200	2840	15960	1500	0	0	11200	42679	500	7260	0	129239	0	71736	80.2	12.5	263.3
2040	28110	1020	1500	690	2900	1860	20	300	0	280	8200	4970	16440	1500	0	0	11200	44101	500	7900	0	131491	0	72495	81.4	12.0	258.0
2041	27540	1020	1500	690	2900	1860	0	300	0	0	8200	4970	16440	1500	0	0	12800	45509	500	8250	0	133979	0	73599	82.0	11.5	250.7
2042	26970	1020	1500	690	2900	1860	0	300	0	0	8200	4970	17040	1500	0	0	12800	46903	500	8890	800	136043	800	74482	84.6	10.8	245.8
2043	26820	1020	1500	690	2900	1860	0	300	0	0	8200	4970	17040	1500	0	0	12800	48282	2800	9530	0	140212	0	75368	86.0	10.9	239.7
2044	26820	1020	1500	690	2900	0	0	200	0	0	8200	4970	17040	1500	0	0	16000	49645	2800	9850	0	143135	0	76112	88.1	11.6	233.6
2045	25650	1020	1500	690	2900	0	0	0	0	0	8200	4970	17160	1500	0	0	17600	50923	2800	9830	0	144743	0	77059	87.8	10.8	227.5
2046	23900	0	1500	690	2900	0	0	0	0	0	8950	7100	17160	1500	0	0	17600	52114	3200	10150	0	146764	0	77841	88.5	10.3	221.4
2047	22100	0	1500	690	2900	0	0	0	0	0	8950	9230	17160	1500	0	0	17600	53149	4000	10470	0	149249	0	78603	89.9	10.3	215.3
2048	19100	0	1500	690	2900	0	0	0	0	0	11200	9230	17160	1500	0	0	17600	53886	4000	10560	0	149326	0	78969	89.1	8.9	209.2
2049	17900	0	1500	690	2900	0	0	0	0	0	11950	10650	17160	1500	0	0	17600	54376	4000	10870	0	151096	0	79640	89.7	9.3	203.0
2050	16120	0	1500	690	2900	0	0	0	0	0	13450	10650	17160	1500	0	0	17600	54708	4000	10870	0	151148	0	80163	88.6	8.2	201.2

Table 39 – Details of Solar Park scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	256.1
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.4
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	264.7
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	266.6
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	273.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	1000	0	0	59280	2060	42485	46.6	34.9	277.3
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	2000	0	0	60990	2060	43713	46.4	34.0	283.7
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	3000	0	0	61850	2060	44977	44.1	30.7	291.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	280	4000	0	0	62420	2060	46481	40.5	26.4	302.8
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	560	5000	0	0	62690	2060	47952	36.6	21.5	305.8
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	750	0	0	0	1120	5000	0	0	63370	2060	49442	33.7	18.0	308.8
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	1910	5000	320	0	64780	2060	50895	32.7	15.4	314.1
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1450	2130	0	1500	0	0	0	2840	5000	640	0	67720	2060	52593	34.0	15.0	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1450	2130	1320	1500	0	0	0	3770	5000	960	0	68900	0	52995	30.0	12.9	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1450	2130	2520	1500	0	0	1600	4770	5000	1280	0	71720	0	54745	31.0	12.2	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	1700	2840	4080	1500	0	0	1600	5770	5000	1600	0	74140	0	56482	31.3	10.9	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2450	2840	4320	1500	0	0	3200	6770	5000	1920	0	77650	0	58547	32.6	10.9	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2450	2840	4320	1500	0	0	3200	7770	6700	2250	0	80640	0	60509	33.3	8.9	275.0
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2450	2840	4320	1500	0	0	4800	8770	6700	2890	0	83860	0	62159	34.9	8.9	275.0
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	3700	2840	4920	1500	0	0	4800	9770	6700	3530	800	86190	800	63463	37.5	8.4	270.1
2033	33890	3120	1500	690	2900	1860	1070	300	1300	640	4450	2840	4920	1500	0	0	6400	10770	6700	4170	0	89020	0	64969	37.0	7.6	272.8
2034	33310	3120	1500	690	2900	1860	1070	300	370	640	5200	2840	5760	1500	0	0	8000	11770	6700	4810	0	92340	0	66210	39.5	9.4	270.4
2035	33310	3120	1500	690	2900	1860	1070	300	0	640	5200	2840	5880	1500	0	0	9600	12770	6700	5450	0	95330	0	67414	41.4	10.1	267.8
2036	32840	3120	1500	690	2900	1860	1070	300	0	280	5950	2840	7080	1500	0	0	9600	13770	6700	6090	0	98090	0	68341	43.5	10.6	272.9
2037	32370	1020	1500	690	2900	1860	1070	300	0	280	7450	2840	9480	1500	0	0	9600	14770	6800	6730	0	101160	0	69621	45.3	10.8	270.8
2038	31900	1020	1500	690	2900	1860	1070	300	0	280	8200	2840	9480	1500	0	0	11200	15770	6800	7050	0	104360	0	70777	47.4	11.8	274.2
2039	30390	1020	1500	690	2900	1860	160	300	0	280	8200	2840	9480	1500	0	0	12800	16770	6800	7370	0	104860	0	71736	46.2	10.6	274.4
2040	28110	1020	1500	690	2900	1860	20	300	0	280	8950	4260	9960	1500	0	0	12800	17770	7600	8010	0	107530	0	72495	48.3	10.8	271.5
2041	26970	1020	1500	690	2900	1860	0	300	0	0	8950	4970	10200	1500	0	0	12800	18770	7600	8650	0	108680	0	73599	47.7	8.7	271.4
2042	26970	1020	1500	690	2900	1860	0	300	0	0	8950	4970	10200	1500	0	0	14400	19770	7600	8970	0	111600	0	74482	49.8	9.7	275.0
2043	26820	1020	1500	690	2900	1860	0	300	0	0	8950	4970	10200	1500	0	0	16000	20770	7600	9290	0	114370	0	75368	51.7	10.5	273.2
2044	26820	1020	1500	690	2900	0	0	200	0	0	8950	4970	10200	1500	0	0	19200	21770	7600	9290	0	116610	0	76112	53.2	11.1	270.0
2045	25650	1020	1500	690	2900	0	0	0	0	0	8950	4970	10200	1500	0	0	20800	22630	7600	9290	0	117700	0	77059	52.7	10.1	269.1
2046	23900	0	1500	690	2900	0	0	0	0	0	8950	5680	12240	1500	0	0	20800	23490	8700	9610	0	119960	0	77841	54.1	9.9	268.5
2047	22100	0	1500	690	2900	0	0	0	0	0	9700	5680	12240	1500	0	0	20800	24210	10200	9930	0	121450	0	78603	54.5	8.7	271.4
2048	19100	0	1500	690	2900	0	0	0	0	0	11950	6390	12360	1500	0	0	20800	24650	11400	10250	0	123490	0	78969	56.4	9.2	270.7
2049	17900	0	1500	690	2900	0	0	0	0	0	11950	8520	12480	1500	0	0	20800	24860	10400	10570	0	124070	0	79640	55.8	9.1	272.1
2050	16120	0	1500	690	2900	0	0	0	0	0	12700	9230	12480	1500	0	0	20800	24930	9400	10560	0	122810	0	80163	53.2	7.3	272.0

Table 40 – Details of Big Gas scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	256.1
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.4
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	264.7
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	266.6
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	273.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	277.3
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58990	2060	43713	41.6	31.5	283.7
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58710	2060	44977	36.8	27.0	291.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	70	0	0	0	58210	2060	46481	31.0	21.6	302.8
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	210	0	0	0	58465	2060	47952	27.4	18.0	305.8
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	420	0	0	0	58420	2060	49442	23.3	13.9	308.8
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	0	1420	0	1500	0	0	0	630	0	0	0	59600	2060	50895	22.0	12.5	314.1
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1200	5680	0	1500	0	0	0	1050	0	0	0	63590	2060	52593	25.8	15.7	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1200	5680	720	1500	0	0	0	1470	0	0	0	63340	0	52995	19.5	12.2	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1200	8520	1200	1500	0	0	0	2030	0	0	0	65920	0	54745	20.4	12.3	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	1200	11360	1440	1500	0	0	0	2590	0	0	0	68140	0	56482	20.6	11.8	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	1200	14200	1440	1500	0	0	0	3080	0	0	0	71070	0	58547	21.4	12.1	275.0
2030	35090	3120	1500	690	2900	1860	1070	300	1300	640	1200	16330	1440	1500	0	0	0	3640	0	0	0	72580	0	60509	19.9	10.0	275.0
2031	33930	3120	1500	690	2900	1860	1070	300	1300	640	1200	19170	1440	1500	0	0	0	4200	0	0	0	74820	0	62159	20.4	9.8	275.0
2032	32770	3120	1500	690	2900	1860	1070	300	1300	640	1200	22010	1440	1500	0	0	0	4760	0	0	0	77060	0	63463	21.4	10.2	270.1
2033	31610	3120	1500	690	2900	1860	1070	300	1300	640	1200	24850	1440	1500	0	0	0	5320	0	0	0	79300	0	64969	22.1	10.2	272.8
2034	31030	3120	1500	690	2900	1860	1070	300	370	640	1200	27690	1440	1500	0	0	0	5810	0	0	0	81120	0	66210	22.5	11.1	270.4
2035	30450	3120	1500	690	2900	1860	1070	300	0	640	1200	30530	1440	1500	0	0	0	6300	0	0	0	83500	0	67414	23.9	12.3	267.8
2036	29980	3120	1500	690	2900	1860	1070	300	0	280	1200	32660	1440	1500	0	0	0	6790	0	0	0	85290	0	68341	24.8	12.7	272.9
2037	29510	1020	1500	690	2900	1860	1070	300	0	280	1200	34790	2760	1500	0	0	0	7280	0	0	0	86660	0	69621	24.5	11.9	270.8
2038	27280	1020	1500	690	2900	1860	1070	300	0	280	1200	38340	2880	1500	0	0	0	7840	0	0	0	88660	0	70777	25.3	12.1	274.2
2039	25180	1020	1500	690	2900	1860	160	300	0	280	1200	40470	3600	1500	0	0	0	8400	0	0	0	89060	0	71736	24.2	11.7	274.4
2040	22870	1020	1500	690	2900	1860	20	300	0	280	1200	43310	3600	1500	0	0	0	8960	0	0	0	90010	0	72495	24.2	11.2	271.5
2041	22870	1020	1500	690	2900	1860	0	300	0	0	1200	44730	3600	1500	0	0	0	9660	0	0	0	91830	0	73599	24.8	11.1	271.4
2042	22240	1020	1500	690	2900	1860	0	300	0	0	1200	46150	3600	1500	0	0	0	10450	0	0	0	93410	0	74482	25.4	10.8	275.0
2043	21460	1020	1500	690	2900	1860	0	300	0	0	1200	48280	3600	1500	0	0	0	11240	0	0	0	95550	0	75368	26.8	11.3	273.2
2044	21460	1020	1500	690	2900	0	0	200	0	0	1200	51830	3600	1500	0	0	0	12100	0	0	0	98000	0	76112	28.8	12.4	270.0
2045	20870	1020	1500	690	2900	0	0	0	0	0	1200	53960	3600	1500	0	0	0	12890	0	0	0	100130	0	77059	29.9	12.9	269.1
2046	18510	0	1500	690	2900	0	0	0	0	0	1200	56800	4680	1500	0	0	0	13610	0	290	0	101680	0	77841	30.6	12.5	268.5
2047	16100	0	1500	690	2900	0	0	0	0	0	1200	58220	5520	1500	0	0	0	14330	0	290	0	102250	0	78603	30.1	11.3	271.4
2048	14250	0	1500	690	2900	0	0	0	0	0	1200	60350	5520	1500	0	0	0	14950	0	610	0	103470	0	78969	31.0	11.2	270.7
2049	12970	0	1500	690	2900	0	0	0	0	0	1200	61060	5880	1500	0	0	0	15530	0	930	0	104160	0	79640	30.8	10.1	272.1
2050	11690	0	1500	690	2900	0	0	0	0	0	1200	62480	6720	1500	0	0	0	15900	0	1170	0	105750	0	80163	31.9	10.7	272.0

Table 41 – Details of High Coal Cost scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	256.1
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.4
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	264.7
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	266.6
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	273.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	277.3
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	70	0	0	0	59060	2060	43713	41.8	31.5	283.7
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	210	0	0	0	58920	2060	44977	37.3	27.0	291.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	540	0	0	0	58680	2060	46481	32.1	21.6	302.8
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	1100	0	0	0	59355	2060	47952	29.3	18.0	305.8
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	1890	0	320	0	60210	2060	49442	27.1	14.1	308.8
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	1000	0	0	1500	0	0	0	2820	0	640	0	62010	2060	50895	27.0	12.1	314.1
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	2200	2130	0	1500	0	0	1600	3820	300	1280	0	66990	2060	52593	32.6	15.0	275.0
2026	38920	3120	1500	690	2900	1860	1070	300	1300	640	2200	2130	1320	1500	0	0	1600	4820	300	1600	0	67770	0	52995	27.9	11.9	275.0
2027	37620	3120	1500	690	2900	1860	1070	300	1300	640	2200	2130	2880	1500	0	0	3200	5820	300	1920	0	70950	0	54745	29.6	11.9	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	2200	2840	4560	1500	0	0	3200	6820	300	2460	0	73930	0	56482	30.9	11.3	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	4680	1500	0	0	4800	7820	300	2830	0	77370	0	58547	32.1	11.1	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	4680	1500	0	0	4800	8820	3000	3150	0	81350	0	60509	34.4	10.1	275.0
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	4920	1500	0	0	6400	9820	3000	3790	0	84810	0	62159	36.4	10.4	275.0
2032	35620	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	6360	1500	0	0	6400	10820	3400	4430	0	87700	0	63463	38.2	10.1	270.1
2033	35030	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	6360	1500	0	0	8000	11820	3400	5070	0	90350	0	64969	39.1	9.4	272.8
2034	35020	3120	1500	690	2900	1860	1070	300	370	640	2950	2840	7200	1500	0	0	8000	12820	5800	5710	0	94290	0	66210	42.4	10.5	270.4
2035	35020	3120	1500	690	2900	1860	1070	300	0	640	2950	2840	7200	1500	0	0	9600	13820	5800	6350	0	97160	0	67414	44.1	11.0	267.8
2036	35020	3120	1500	690	2900	1860	1070	300	0	280	2950	4260	7440	1500	0	0	9600	14820	5900	6990	0	100200	0	68341	46.6	11.7	272.9
2037	34550	1020	1500	690	2900	1860	1070	300	0	280	3700	4970	10080	1500	0	0	9600	15820	6300	7310	0	103450	0	69621	48.6	12.3	270.8
2038	33610	1020	1500	690	2900	1860	1070	300	0	280	5200	4970	10080	1500	0	0	11200	16820	6300	7950	0	107250	0	70777	51.5	13.8	274.2
2039	32100	1020	1500	690	2900	1860	160	300	0	280	5200	4970	10080	1500	0	0	11200	17820	7200	8450	0	107230	0	71736	49.5	11.1	274.4
2040	29820	1020	1500	690	2900	1860	20	300	0	280	6700	4970	10440	1500	0	0	12800	18820	7200	8770	0	109590	0	72495	51.2	11.7	271.5
2041	28680	1020	1500	690	2900	1860	0	300	0	0	6700	6390	10440	1500	0	0	12800	19820	7200	9090	0	110890	0	73599	50.7	10.1	271.4
2042	28110	1020	1500	690	2900	1860	0	300	0	0	6700	6390	11040	1500	0	0	14400	20820	7200	9410	0	113840	0	74482	52.8	11.2	275.0
2043	27390	1020	1500	690	2900	1860	0	300	0	0	6700	6390	11040	1500	0	0	16000	21820	7200	9410	0	115720	0	75368	53.5	11.0	273.2
2044	26820	1020	1500	690	2900	0	0	200	0	0	6700	6390	11040	1500	0	0	19200	22750	7200	9410	0	117320	0	76112	54.1	10.9	270.0
2045	25650	1020	1500	690	2900	0	0	0	0	0	6700	7810	11280	1500	0	0	19200	23610	7300	9410	0	118570	0	77059	53.9	10.1	269.1
2046	23900	0	1500	690	2900	0	0	0	0	0	6700	9230	13200	1500	0	0	19200	24280	7300	9700	0	120100	0	77841	54.3	9.8	268.5
2047	22100	0	1500	690	2900	0	0	0	0	0	6700	11360	13200	1500	0	0	19200	24720	7300	10020	0	121190	0	78603	54.2	9.3	271.4
2048	19100	0	1500	690	2900	0	0	0	0	0	8950	12070	13200	1500	0	0	19200	24930	7400	10120	0	121560	0	78969	53.9	8.8	270.7
2049	17900	0	1500	690	2900	0	0	0	0	0	9700	12780	13200	1500	0	0	19200	25000	8300	10390	0	123060	0	79640	54.5	9.0	272.1
2050	16120	0	1500	690	2900	0	0	0	0	0	10450	12780	13200	1500	0	0	19200	25000	8300	10390	0	122030	0	80163	52.2	7.0	272.0

Table 42 – Details of High Nuclear Cost scenario

	Existing/Committed										New																
Year	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO2 emissions
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	256.1
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.4
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	264.7
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	266.6
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	273.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	277.3
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	70	0	0	0	59060	2060	43713	41.8	31.5	283.7
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	280	0	0	0	58990	2060	44977	37.5	27.0	291.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	770	0	0	0	58910	2060	46481	32.6	21.6	302.8
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	1410	0	320	0	59985	2060	47952	30.7	18.2	305.8
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	2270	0	640	0	60910	2060	49442	28.6	14.3	308.8
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	500	0	120	1500	0	0	0	3200	0	1280	0	62650	2060	50895	28.3	11.7	314.1
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1950	2840	120	1500	0	0	0	4200	2600	1920	0	69290	2060	52593	37.1	15.8	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1950	2840	240	1500	0	0	0	5200	2600	2650	0	69750	0	52995	31.6	11.6	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1950	2840	2640	1500	0	0	0	6200	3800	3590	0	73990	0	54745	35.2	11.8	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	1950	2840	2640	1500	0	0	0	7200	6700	4420	0	77300	0	56482	36.9	9.1	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	2640	1500	0	0	0	8200	8900	5380	800	82060	800	58547	42.1	9.3	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	2640	1500	0	0	0	9200	13100	6150	0	87990	0	60509	45.4	9.4	275.0
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	2640	1500	0	0	0	10200	14800	7430	0	91950	0	62159	47.9	8.6	275.0
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	4450	3550	2640	1500	0	0	0	11200	15700	8710	0	96180	0	63463	51.6	9.4	270.1
2033	33890	3120	1500	690	2900	1860	1070	300	1300	640	5200	3550	2640	1500	0	0	0	12200	16600	9990	0	98950	0	64969	52.3	7.6	272.8
2034	33310	3120	1500	690	2900	1860	1070	300	370	640	5950	4260	2640	1500	0	0	0	13200	18800	11270	0	103380	0	66210	56.1	8.9	270.4
2035	33310	3120	1500	690	2900	1860	1070	300	0	640	5950	4970	2640	1500	0	0	0	14200	21500	12550	0	108700	0	67414	61.2	10.6	267.8
2036	32840	3120	1500	690	2900	1860	1070	300	0	280	6700	6390	2640	1500	0	0	0	15200	21500	13830	0	112320	0	68341	64.4	11.6	272.9
2037	32370	1020	1500	690	2900	1860	1070	300	0	280	6700	8520	2640	1500	0	0	0	16200	21500	15110	800	114160	800	69621	65.9	9.9	270.8
2038	31900	1020	1500	690	2900	1860	1070	300	0	280	6700	9940	2640	1500	0	0	0	17200	23000	16390	800	118890	800	70777	69.9	11.1	274.2
2039	30390	1020	1500	690	2900	1860	160	300	0	280	6700	9940	2640	1500	0	0	0	18200	24200	17670	0	119950	0	71736	67.2	8.6	274.4
2040	28110	1020	1500	690	2900	1860	20	300	0	280	6700	13490	2640	1500	0	0	0	19200	24200	18950	800	123360	800	72495	72.1	10.1	271.5
2041	26970	1020	1500	690	2900	1860	0	300	0	0	6700	14910	2640	1500	0	0	0	20200	24500	20230	0	125920	0	73599	71.1	8.9	271.4
2042	26970	1020	1500	690	2900	1860	0	300	0	0	6700	14910	2640	1500	0	0	0	21200	26600	21190	0	129980	0	74482	74.5	9.5	275.0
2043	26820	1020	1500	690	2900	1860	0	300	0	0	6700	14910	2640	1500	0	0	0	22200	29500	22150	0	134690	0	75368	78.7	10.5	273.2
2044	26820	1020	1500	690	2900	0	0	200	0	0	6700	14910	2640	1500	0	0	0	23130	36500	22790	0	141300	0	76112	85.6	12.2	270.0
2045	25650	1020	1500	690	2900	0	0	0	0	0	6700	17040	2640	1500	0	0	0	23920	37700	23430	0	144690	0	77059	87.8	13.1	269.1
2046	23900	0	1500	690	2900	0	0	0	0	0	6700	19170	2640	1500	0	0	0	24430	38100	23980	0	145510	0	77841	86.9	11.6	268.5
2047	22100	0	1500	690	2900	0	0	0	0	0	6700	20590	2640	1500	0	0	0	24790	38100	24320	0	145830	0	78603	85.5	10.2	271.4
2048	19100	0	1500	690	2900	0	0	0	0	0	9700	20590	2640	1500	0	0	0	24930	38100	24770	0	146420	0	78969	85.4	9.8	270.7
2049	17900	0	1500	690	2900	0	0	0	0	0	10450	20590	2640	1500	0	0	0	25000	38100	25090	0	146360	0	79640	83.8	8.5	272.1
2050	16120	0	1500	690	2900	0	0	0	0	0	11950	20590	2640	1500	0	0	0	25000	38100	25280	0	146270	0	80163	82.5	7.5	272.0

Table 43 – Details of Learning Curve Sensitivity scenario

Year	Existing/Committed										New											Total Capacity (excl DR)	Total DR	Peak demand	Reserve Margin (Total)	Reserve Margin (Reliable)	CO_2 emissions
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other						
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	45660	2560	38280	27.8	21.1	256.1
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	48150	2560	38924	32.4	21.4	257.4
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	51610	2810	39703	39.9	26.8	264.7
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	54710	3060	40608	45.7	31.9	266.6
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	56850	3060	41679	47.2	33.7	273.0
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	58280	2060	42485	44.2	33.6	277.3
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	140	0	0	0	59130	2060	43713	42.0	31.5	283.7
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	280	0	0	0	58990	2060	44977	37.5	27.0	291.3
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	490	0	0	0	58630	2060	46481	32.0	21.6	302.8
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	1050	0	0	0	59305	2060	47952	29.2	18.0	305.8
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	1610	0	0	0	59610	2060	49442	25.8	13.9	308.8
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	750	710	0	1500	0	0	0	2270	0	0	0	61280	2060	50895	25.5	12.6	314.1
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	2200	2840	0	1500	0	0	1600	2990	0	0	0	65290	2060	52593	29.2	15.3	275.0
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	2200	2840	840	1500	0	0	1600	3550	0	0	0	65300	0	52995	23.2	12.0	275.0
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	2200	2840	2640	1500	0	0	3200	4110	0	0	0	67960	0	54745	24.1	12.3	275.0
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	2200	2840	3600	2060	0	0	4800	4670	0	0	0	70220	0	56482	24.3	11.8	275.0
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2700	2840	3840	2060	0	0	6400	5230	0	0	0	72720	0	58547	24.2	11.2	275.0
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	3840	2060	0	0	8000	5790	0	0	0	75090	0	60509	24.1	10.6	275.0
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2950	2840	4200	2060	0	0	9600	6350	0	0	0	77590	0	62159	24.8	10.8	275.0
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	3700	2840	5400	2060	0	0	9600	6910	0	0	0	78940	0	63463	24.4	9.7	270.1
2033	34460	3120	1500	690	2900	1860	1070	300	1300	640	5200	2840	5400	2060	0	0	11200	7470	0	0	0	82010	0	64969	26.2	11.1	272.8
2034	33880	3120	1500	690	2900	1860	1070	300	370	640	5200	2840	6000	2060	0	0	12800	8030	0	0	0	83260	0	66210	25.8	11.0	270.4
2035	33880	3120	1500	690	2900	1860	1070	300	0	640	5200	2840	6360	2060	0	0	14400	8590	0	0	0	85410	0	67414	26.7	11.8	267.8
2036	33410	3120	1500	690	2900	1860	1070	300	0	280	5200	2840	6600	2060	0	0	16000	9150	0	0	0	86980	0	68341	27.3	11.7	272.9
2037	32940	1020	1500	690	2900	1860	1070	300	0	280	7450	2840	8760	2060	0	0	16000	9710	0	0	0	89380	0	69621	28.4	12.3	270.8
2038	32470	1020	1500	690	2900	1860	1070	300	0	280	7450	2840	9120	2060	0	0	17600	10270	0	0	0	91430	0	70777	29.2	12.6	274.2
2039	30960	1020	1500	690	2900	1860	160	300	0	280	8200	2840	9120	2060	0	0	19200	10760	0	0	0	91850	0	71736	28.0	12.3	274.4
2040	28680	1020	1500	690	2900	1860	20	300	0	280	8200	4260	9120	2060	0	0	20800	11320	0	0	0	93010	0	72495	28.3	12.1	271.5
2041	27540	1020	1500	690	2900	1860	0	300	0	0	8200	6390	9120	2060	0	0	20800	11880	0	0	0	94260	0	73599	28.1	11.4	271.4
2042	27540	1020	1500	690	2900	1860	0	300	0	0	8200	6390	9120	2060	0	0	22400	12440	0	0	0	96420	0	74482	29.5	12.2	275.0
2043	26820	1020	1500	690	2900	1860	0	300	0	0	8200	6390	9120	2060	0	0	24000	13000	0	0	0	97860	0	75368	29.8	12.1	273.2
2044	26820	1020	1500	690	2900	0	0	200	0	0	8200	7100	9120	2060	0	0	25600	13490	0	320	0	99020	0	76112	30.1	11.6	270.0
2045	25650	1020	1500	690	2900	0	0	0	0	0	8200	7810	9240	2060	0	0	27200	13910	0	550	0	100730	0	77059	30.7	11.8	269.1
2046	23900	0	1500	690	2900	0	0	0	0	0	8950	8520	9240	2060	0	0	28800	14260	0	550	0	101370	0	77841	30.2	11.1	268.5
2047	22100	0	1500	690	2900	0	0	0	0	0	8950	9940	9240	2060	0	0	28800	14260	0	550	800	100990	800	78603	29.8	9.8	271.4
2048	19100	0	1500	690	2900	0	0	0	0	0	11950	9940	9240	2060	0	0	30400	14190	0	550	0	102520	0	78969	29.8	11.0	270.7
2049	17900	0	1500	690	2900	0	0	0	0	0	11950	11360	9240	2060	0	0	30400	13950	0	550	0	102500	0	79640	28.7	10.4	272.1
2050	16120	0	1500	690	2900	0	0	0	0	0	12700	12780	9240	2060	0	0	30400	13450	0	550	0	102390	0	80163	27.7	10.1	272.0

APPENDIX E – REVIEW OF TRANSMISSION IMPACT OF IRP UPDATE SCENARIOS

E.1. This is an assessment report on the potential impact on the future Transmission Grid of three IRP 2010 update scenarios considering the likely spatial allocation of the future generation of these scenarios.

E.2. The three scenarios considered are:

- Moderate Decline Scenario
- Weathering the Storm Scenario
- Big Gas Scenario

E.3. The geographical allocation of each type of generation is discussed separately with an overview of the main impacts of each scenario on the Transmission Grid design.

E.4. Recent long term strategic transmission planning studies and interaction with external stakeholders have identified five main Transmission Power Corridors that will be required to be developed. The assessment of the transmission impact of the IRP 2010 update scenarios indicates that these identified Power Corridors will be required to enable all three generation scenarios. The five main Power Corridors are known as the Solar Corridor; the Western Coastal Corridor, the Eastern Coastal Corridor; the Central Corridor and the Northern Import Corridor.

E.5. The advantages of less transmission infrastructure requirements with a large distributed generation strategy in terms of PV as well as gas should be taken into consideration when developing the new policies for generation. However the strategy must also account for the associated risks of large power transfer swings between day and night flows that will result with the installation of large amounts of distributed PV and the replacement generation for the evening peak. Whichever future generation scenario unfolds and wherever the new generation will be finally located, the five main Transmission Power Corridors will play a major role in their successful integration. The investment in and the development of these Power Corridors will provide flexibility of implementation and faster connection schedules for all three IRP 2010 update scenarios or a completely different IRP scenario in the future.

System Peak Demand

E.6. As both the Moderate Decline and Big Gas scenarios are using the Green Shoots Demand Forecast, they have the same Peak Demand which is higher than the Weathering the Storm Peak Demand as shown in Table 44 below. This will have an impact on the timing of the transmission projects as the Weathering the Storm Scenario 2050 demand is only slightly higher than the 2030 demand of the other two scenarios. However it is the location of generation that has the major impact on the design of the Transmission Grid.

Table 44 - Peak Demand (MW) for the three scenarios

Peak Demand (MW)	2020	2030	2040	2050
Moderate Decline Scenario	46759	61187	72495	80163
Weathering the Storm Scenario	44040	51557	58083	63553
Big Gas Scenario	46759	61187	72495	80163

Generation Options: Coal

E.7. The coal generation consists of two components, namely the existing fleet (including Medupi and Kusile) and the allocation of New Coal generation.

E.8. *Existing Fleet:* The existing fleet now includes life extension option. The locations of existing fleet are known and this component is common to all three scenarios. There is no major impact from these units other than extended use of the existing Transmission Grid due to longer life.

E.9. *New Coal:* The New Coal plant consists of three components, namely Coal FBC, Coal Imported (i.e. imported as electricity) and Coal PF. The Coal FBC is considered to be 250MW units and these have been allocated to potential locations based on previous consultations with coal generation experts. The Coal Imported is a proposed plant of 1200MW in Botswana which is considered to be imported into the North West Province in the area where the MTS Watershed is located. The Coal PF is considered to be 750MW units which make up large power station with a maximum size of 4500MW. They are mainly in Limpopo near Lephalale, with one located in the Bothaville area in the Free State (3000MW) and one in the Majuba area (2250MW) in northern KwaZulu Natal.

Table 45 – Coal generation for the three scenarios

COAL Generation (MW)	2020	2030	2040	2050
Existing Coal - Common	45750	37410	28950	12280
New Coal - Moderate Decline Scenario	0	2450	8200	14950
New Coal - Weathering the Storm Scenario	0	2200	10450	26200
New Coal - Big Gas Scenario	0	1200	1200	1200

E.10. *Impact:* The coal generation values are shown in Table 45. For the Big Gas Scenario the impact on the Transmission Grid is minimal. For the Moderate Decline Scenario some additional power corridors will be required from the north-western Limpopo after 2030 but in line with the IRP 2010 transmission planning considerations. However for the Weathering the Storm Scenario significant transmission reinforcement from the same area of Limpopo will now be required to evacuate the power.

Generation Options: Hydro / Pumped Storage / Hydro Imported

E.11. All the existing hydro and pumped storage generation and the new Ingula pumped storage are considered in service for the entire period up until 2050 for all three scenarios. Cahora Bassa is considered to be importing 1500MW for the entire period at same location, Apollo, for all three scenarios. Mpanda Nkua is considered to start importing with 1125MW and in 2022 for the Moderate Decline and Big Gas scenarios and in 2023 in the Weathering the Storm Scenario, with 1500MW for the following years up to 2050 for all three scenarios. The Mpanda Nkua power is considered to arrive in Maputo via HVDC where it will first offset the Mozal load and remaining power will cross the border in the Komatipoort border area.

E.12. *Impact:* There is minimal transmission impact from the IRP 2010 considerations regarding hydro generation. The only potential risk is Mpanda Nkua, if it does not materialise provision will have to be made to keep supplying the increasing Mozambique load in the Maputo area. Similarly if Mpanda Nkua does happen and the Mozal load is no longer there, provision must be made to import the available power. Therefore a reinforced South Africa-Mozambique transmission power corridor must be planned for any future scenario.

Generation Options: Nuclear

E.13. Koeberg is considered operational until 2043 for all three scenarios. No new nuclear is considered for the Weathering the Storm and Big Gas Scenarios and therefore have no impact. A new nuclear fleet up to 20800MW is considered for the Moderate Decline Scenario. They consist of 1600MW units and these have been allocated to the three nuclear sites already under consideration in preferred transmission integration order. The maximum size per site is 4800MW with an additional unit added at Duynefontien after Koeberg is decommissioned. Thus a fourth site is required and this was selected as one of the existing West Coast nuclear sites that Eskom already owns.

E.14. *Impact*: The rollout of a large nuclear fleet of 20GW as proposed in the Moderate Decline Scenario will have a major impact on the transmission system. Currently the only sites under consideration are along the Cape coastline. Combined with other generation in the Cape provinces this implies that most of the power will have to be exported to the north and to KwaZulu Natal which will require significant transmission infrastructure, including several high capacity HVDC schemes, over long distances. This results in a very skewed power transfer from south to north. It is highly recommended that if such a large nuclear fleet is committed then alternative sites be identified, e.g. in KwaZulu Natal or decommissioned coal power station sites, and considered to reduce the amount of new transmission infrastructure that will be required.

Generation Options: Gas

E.15. The proposed Gas generation consists of three components, namely imported gas (i.e. imported as electricity), CCGT units and OCGT units. The imported gas will be imported from both Namibia and Mozambique, crossing the borders in the Oranjemund and Komatipoort areas respectively. All the CCGT and OCGT units are considered to be installed at the five main port areas of Saldanha, Mossel Bay, Port Elizabeth (Coega), Durban and Richards Bay. This is to either import the gas as LNG initially or as a result of massive shale gas resources to collect the gas in the port areas for generation or shipping out as LNG. The ports are thus considered as “Gas Hubs” for the collection and redistribution of any gas resources.

Table 46 – Gas generation for the three scenarios

GAS Generation (MW)	2020	2030	2040	2050
Moderate Decline Scenario	3480	10510	15350	18140
Weathering the Storm Scenario	3480	7660	12380	13520
Big Gas Scenario	3480	20880	45690	67770

E.16. *Impact*: The gas generation in the Moderate Decline and Weathering the Storm scenarios will be mainly used to manage the system with increased renewable generation and after 2030 will start to require significant additional transmission infrastructure to move the power out from the port areas. This should be in line with the normal development of the Transmission Grid with an emphasis on more transmission lines in the power corridors out of the Cape. However in Big Gas Scenario there are significant amounts of gas generation added with around 20GW in service by 2030 which will require a significant amount of new transmission capacity in the power corridors to evacuate the power, particularly from the Eastern Cape. By 2050 the installed gas generation will have more than tripled to around 67GW. This will require significant investment in transmission infrastructure, to more or less one and half times the existing transmission infrastructure.

E.17. For every 4000MW of generation the likely transmission infrastructure needed to link this to a remote load centre and meet the Grid Code requirements will be either a complete new 4000MW HVDC scheme, three 765kV HVAC lines or six 400kV HVAC lines. All are very expensive solutions when distances start to exceed 500km. It is highly likely that transporting large amounts of gas around the country will become more attractive as the gas can be used for other industrial and residential uses. Then it would be more beneficial to locate the gas generation plant closer to the load centres and reduce the burden on the Transmission Grid.

Generation Options: Solar CSP

E.18. The Big Gas Scenario has no CSP allocation and therefore no Transmission impact. The Moderate Decline and Weathering the Storm scenarios have CSP generation allocated with a storage capacity of either 6 hours or 9 hours to help meet the system peak. These CSP plants are assumed to be large groupings of 100MW units spread across the Northern Cape, Free State and North West in areas already identified as potential “Solar Parks”. Some CSP has been allocated to a potential “Solar Park” area in the Limpopo province. The Moderate Decline Scenario has 4700MW allocated by 2030 increasing to 10100MW by 2050 while the Weathering the Storm Scenario only has new CSP allocated after 2030, reaching 5300MW by 2050.

E.19. *Impact*: The nature of CSP operation means that the volatility of the output is controlled and the transmission system can be designed to transfer a smaller and more controlled range of power flows than with other renewable energy generation such as wind and PV. As there is no significant load in the CSP “Solar Park” areas additional transmission infrastructure will be required to transport the power to where it is required, particularly in the Northern Cape. However this is in line with the proposed transmission “Solar Corridor” linking the Northern Cape to the North West province. There is thus no significant impact on the Transmission Grid design other than enabling the development of this new power corridor.

Generation Options: Wind

E.20. The successful bidders from REBID Rounds 1 and 2 and the Eskom Sere site are allocated with a lifespan of 20 years. New wind has been allocated on a spatial basis in five broad areas around an identified Wind Atlas test mast. However these values have been reallocated to more likely “Wind Areas” previously identified in transmission planning studies and interactions with the Wind association, SAWEA. This will provide a more appropriate spatial allocation of the wind generation for Transmission Grid planning considerations. The maximum wind allocation is around 16GW by 2050 in the Moderate Decline Scenario and 13GW in the Weathering the Storm Scenario with only 2280MW in the Big Gas Scenario.

E.21. *Impact*: The total amount of wind allocated in the three scenarios is in the order of or less than the allocation in the IRP 2010. Thus they will have no significant change in impact on the Transmission Grid design taking the IRP 2010 as a base. The impact remains the intermittence of the wind generation and therefore the range of power transfers that will need to be accommodated. The higher the wind generation the larger the range of potential power flows related to that particular wind area. The biggest impact will be under the Moderate Decline Scenario in the Eastern Cape and Western Cape where combined with high nuclear generation they will trigger additional transmission infrastructure to evacuate the excess power from these two provinces to the load centres to the north and further up the east coast.

Generation Options: Solar PV

E.22. The Transmission Grid does not consider Solar PV as a demand source as it is not available during the System Peak Demand in the evening, and is only considered as an energy source. However with large amounts of PV generation as proposed in the three scenarios, they will have an impact on the Transmission Grid during the day when the system is both highly loaded during the week and lightly loaded over the weekends. The

PV has been allocated around seven major centres, either large metros (Bloemfontein, Cape Town, Durban, Johannesburg and Port Elizabeth) or good solar zones (De Aar and Upington). Accordingly the PV allocation for these centres has been spread into five municipal areas around these centres. In the case of the metros the areas are on the outskirts of the cities and in the case of the solar zones the areas are those identified as potential areas for "Solar Parks". The totals for PV are shown in Table 47.

Table 47 - PV generation for the three scenarios

PV Generation (MW)	2020	2030	2040	2050
Moderate Decline Scenario	1350	9940	18890	25000
Weathering the Storm Scenario	1070	7660	16610	24720
Big Gas Scenario	1140	6520	12460	19010

E.23. *Impact*: As already stated the main impact will be the local integration of the PV generation into the local Transmission and Distribution networks rather than across the main power corridors and care must be taken to minimise the creation of power flow bottlenecks. A bigger impact will be if the large amounts of PV are not distributed in these seven assumed areas and instead are highly concentrated in the Northern Cape and North West province. This will result in more excess power that has to be evacuated and the further loading of the proposed "Solar Corridor" between these two provinces to move the power to the main load centres.

E.24. Solar PV is a generation option that can be used to create a large distributed generation pattern which, if correctly sized and located within the distribution networks relatively close to large load centres, can reduce integration costs in terms of less new infrastructure (both distribution and transmission) and lower system losses. Again care must be taken to avoid power flow bottlenecks within the distribution and transmission networks and overstressing them during the daylight hours. However there is a trade-off for the widely distributed PV generation in that the Transmission Grid must also be designed to facilitate large power transfer swings between the day and night flows to accommodate the replacement generation for the evening peak. The larger the amount of PV installed the more transmission infrastructure will be required. The great advantage of PV is that it is relatively portable and viable anywhere in the country. It is recommended that new policies and incentives for PV to avoid future congestion on the Transmission Grid should be given serious consideration.

Overview of the impact on Transmission Grid

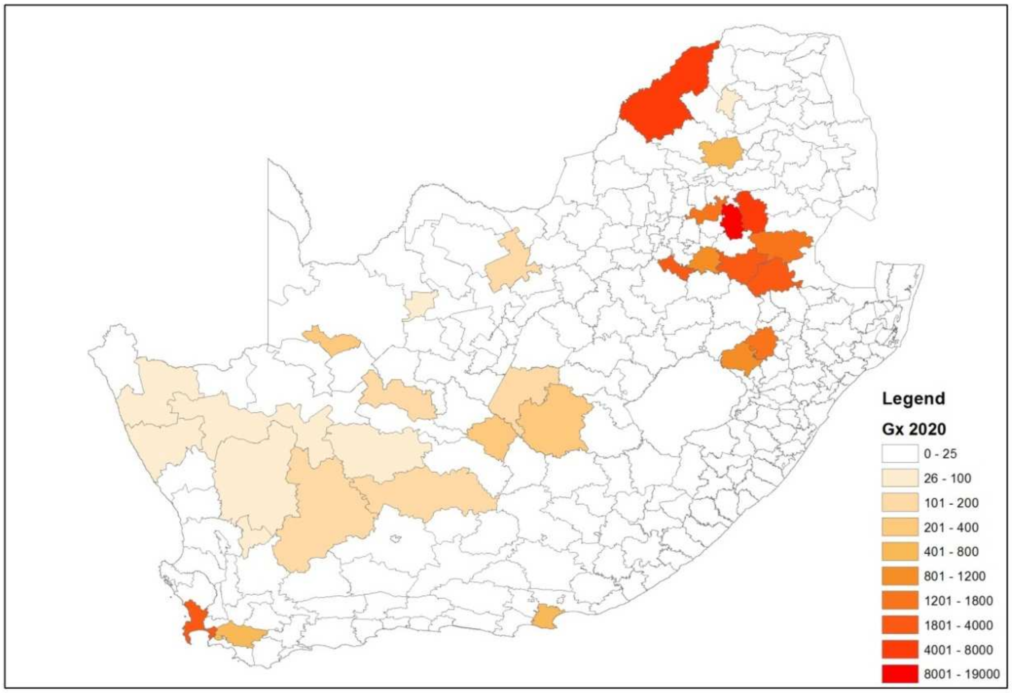
E.25. The best way to appreciate the potential impact of the three IRP 2010 update scenarios on the development of the Transmission Grid is to spatially map the generation and compare it to the spatial spread of the system demand. Based on the above allocations and assumptions of location of generation for the different types of generation in the scenarios the following sets of maps indicate the generation "heat maps" of the country. The first map is for the anticipated 2020 spatial spread and then the possible spatial spread by 2040 for the three scenarios under discussion and an extension of the IRP 2010 baseline scenario.

E.26. A recent transmission planning assessment study considered what the requirements for the 2040 Transmission Grid would be, based on an extension of the IRP 2010 up to 2040. The year 2040 thus gives a good impression of how the spatial spread of the generation will differ between the scenarios and from the potential IRP 2010 spatial spread. The year 2050 is very far in the future and many variables will make it very difficult to give a reasonable estimation of the spatial spread. However the 2040 spatial spread can be reasonably allocated and already gives a good indication of the potential changes and impact of the generation if the scenario is extended to 2050.

E.27. Figures 45 through 49 each have two maps to indicate the concentration of generation across the country. The first map shows the installed generation located within the magisterial districts (referred to as a map area) of the country. The second shows the summation of the total installed generation within each province with the figure indicating the value on 2040 and a bar chart showing the change for each decade, i.e. 2020, 2030, 2040 and 2050. The darker the red shading of a map area or province, the more generation of any type that is located within that area.

E.28. Figure 45 indicates the expected generation spread by 2020 based on the IRP 2010 which can be considered as a baseline and the second map the provincial totals by 2040 form the extended IRP 2010. Figures 46, 47 and 48 are the same two maps indicating the generation allocation by 2040 for all three scenarios. As can be clearly seen there is a dramatic shift of generation to the Cape provinces which will drive the need for more transmission infrastructure within the main power corridors to evacuate the excess power to the north.

Figure 45 – Map of the generation magisterial district spread by 2020 based on IRP 2010 and the 2040 provincial spread based on the extended IRP 2010



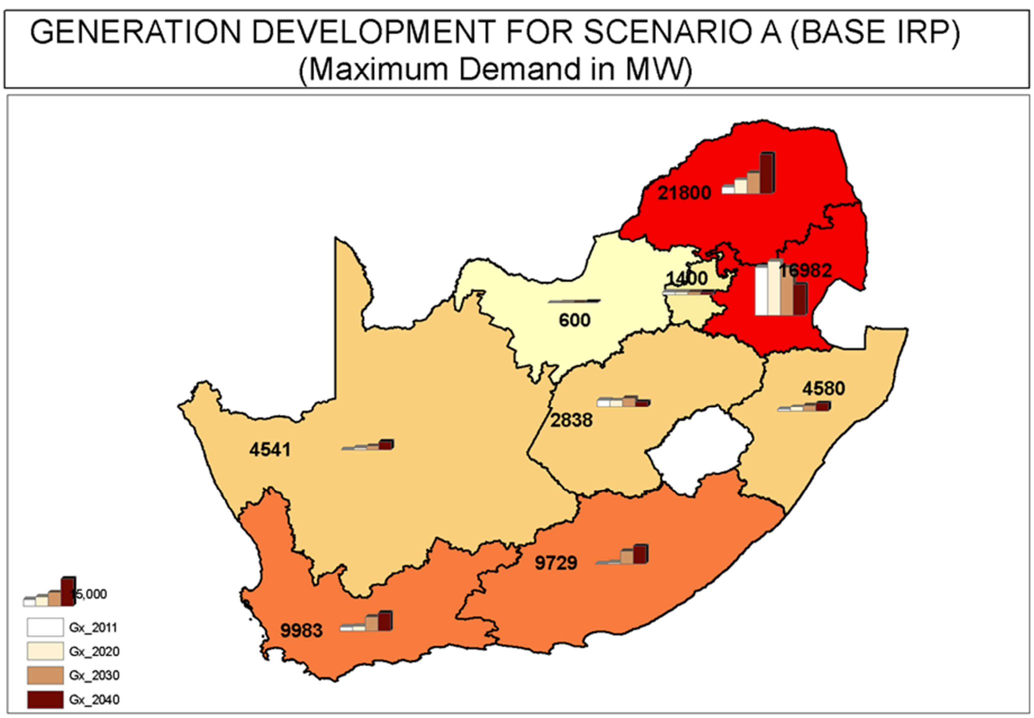
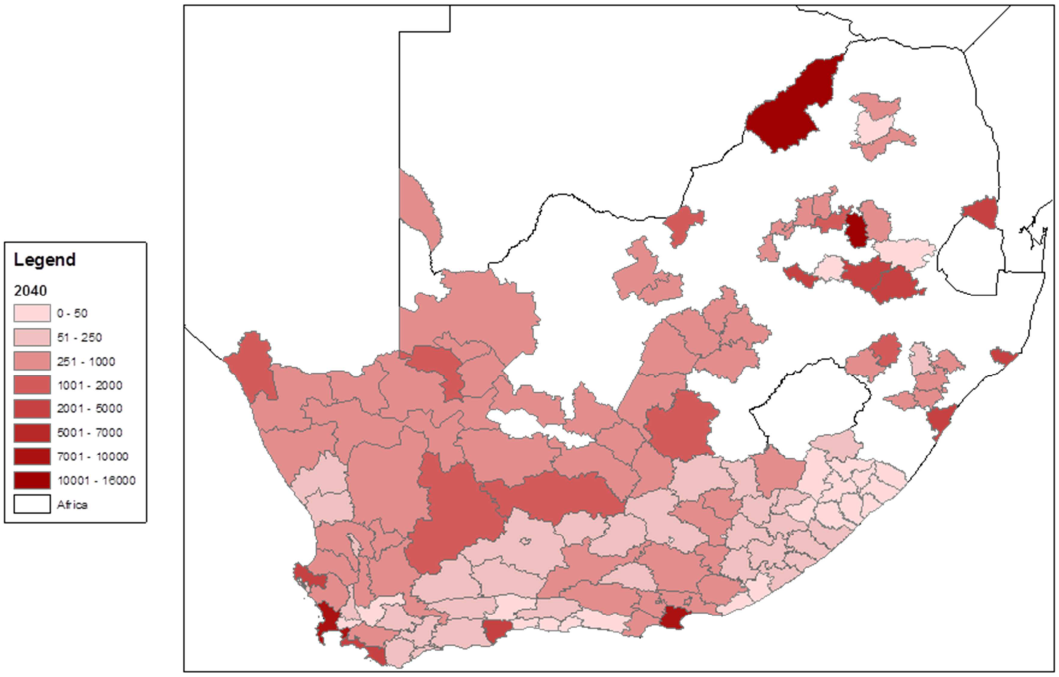


Figure 46 – Map of the generation spread by 2040 for the Moderate Decline Scenario



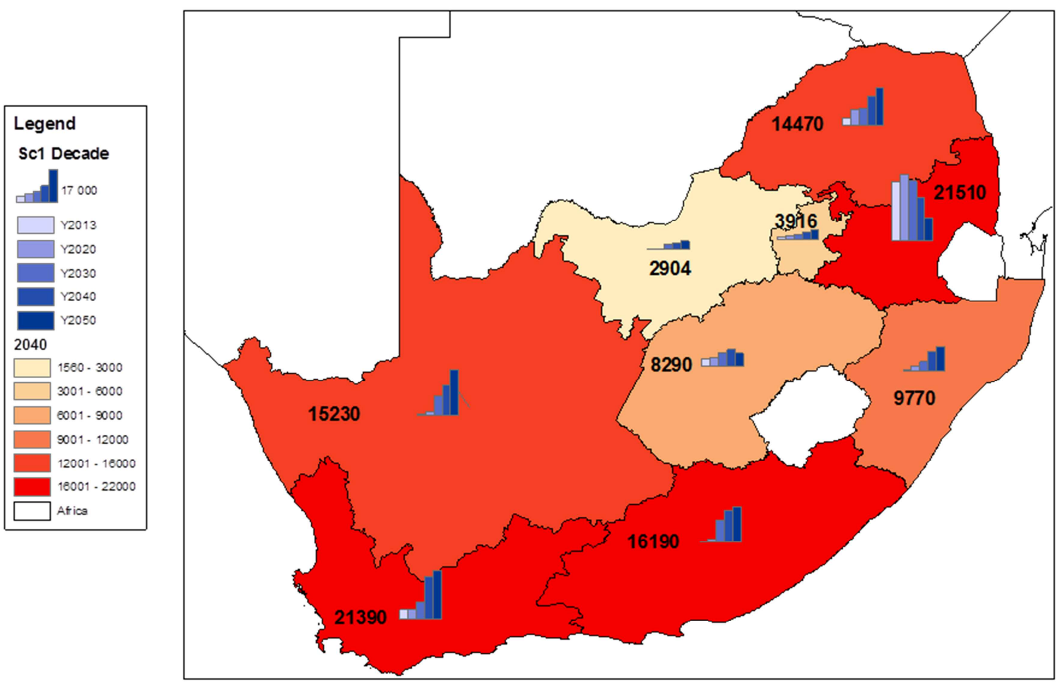
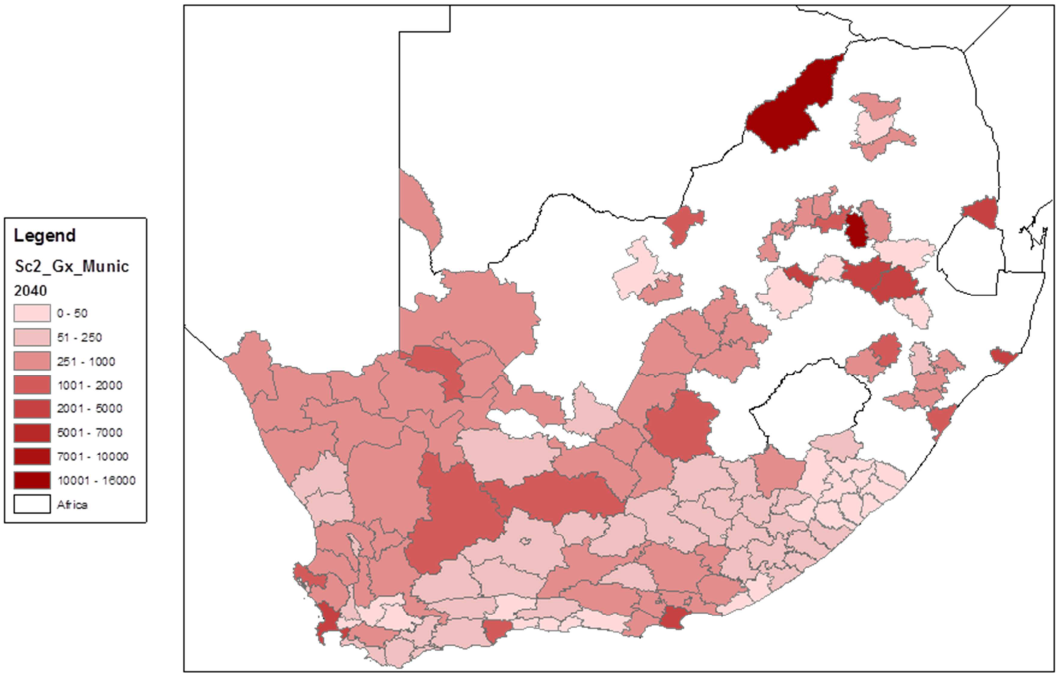


Figure 47 – Map of the generation spread by 2040 for the Weathering the Storm Scenario



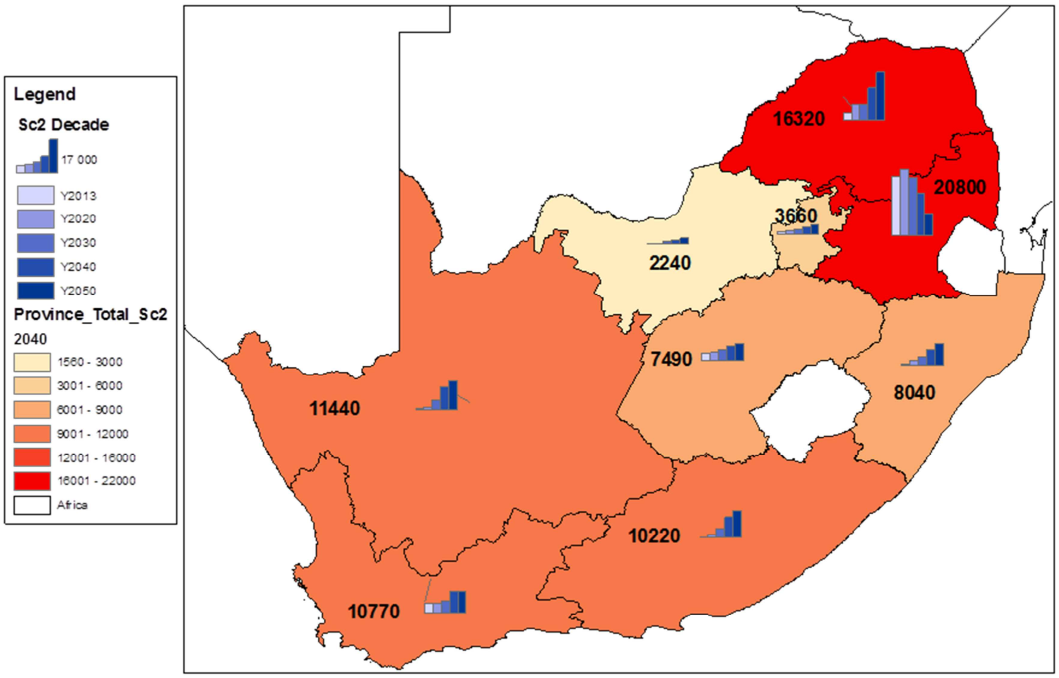
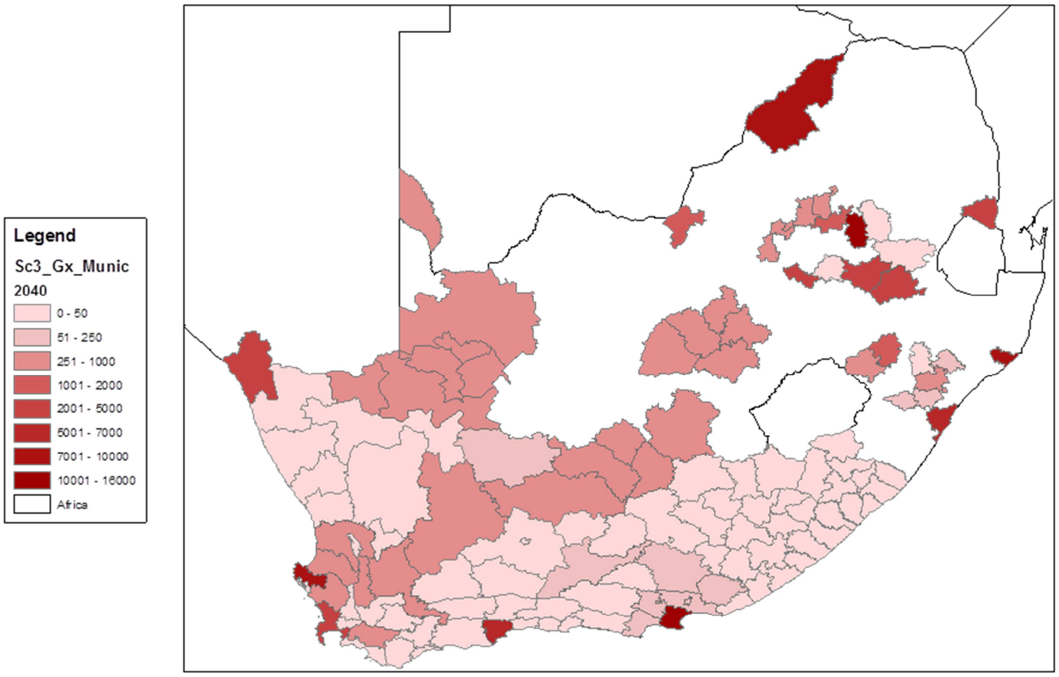
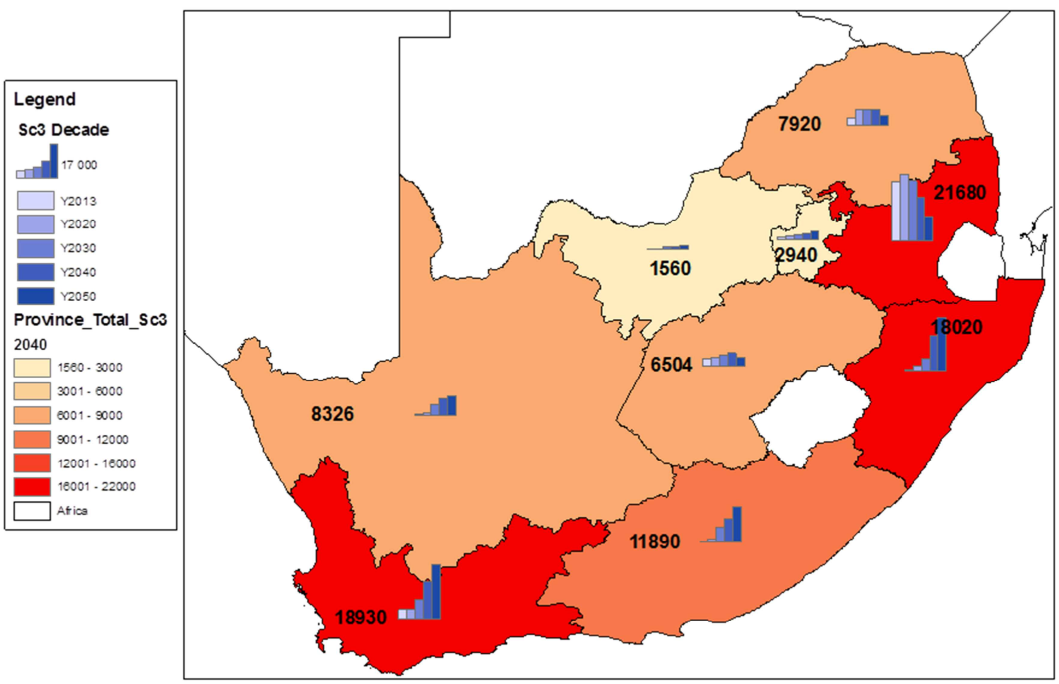


Figure 48 – Map of the generation spread by 2040 for the Big Gas Scenario

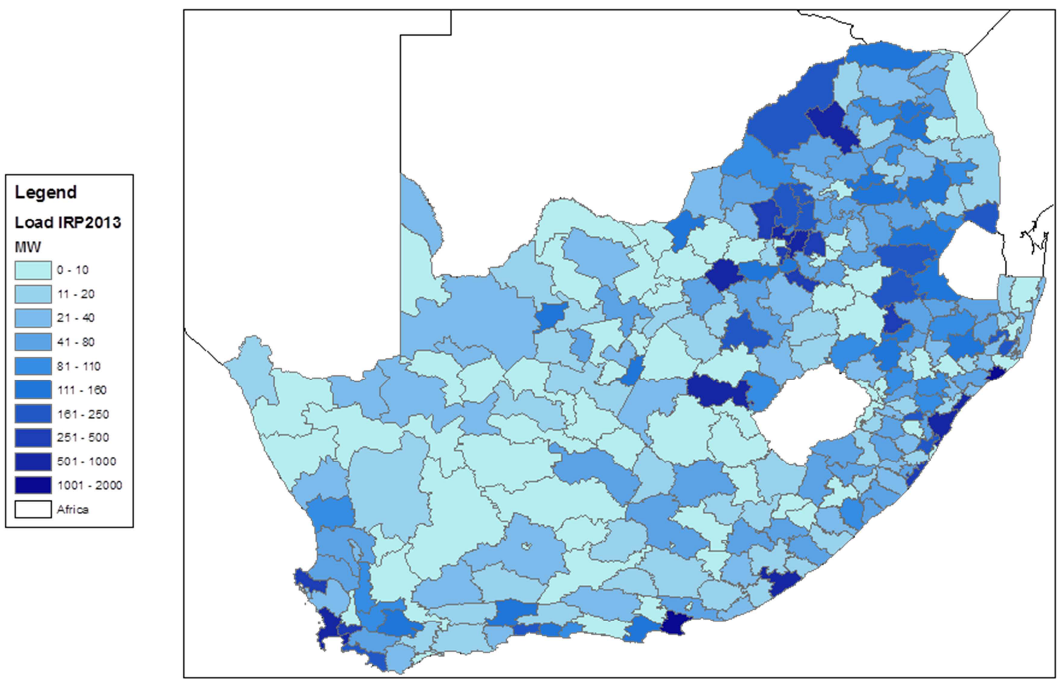




E.29. More insight can be gained by comparing the spatial spread of the demand across the country against the generation spatial spread. By comparing the expected demand within a magisterial district or map area with the allocated generation to that area the overall power deficit or excess (Demand Balance) of that area can be determined. These can then be summated within the provinces to determine the overall Demand Balance of the nine provinces. Note that an expected typical generation pattern of the installed generation at time of system peak was used for all the Demand Balance calculations. The resultant values will indicate where future transmission power corridors are likely to be required to move the excess power to the areas where there are power deficits.

E.30. The map in Figure 49 shows the spread of the demand within the magisterial districts map areas across the country for 2040 for the higher demand forecast for the Moderate Decline and Weathering the Storm scenarios. The dark blue areas indicate the major load centres and these are not expected to change significantly over the period to 2050 for any generation scenario.

Figure 49 – Map of the spatial spread of electricity demand by 2040 for the Moderate Decline and Weathering the Storm scenarios



E.31. The maps shown in Figures 50 through 53 indicate the overall Demand Balance values by the relative shading of the provinces. Red indicating excess power or generation and blue a power deficit, the darker the shading the larger the value. Figure 50 is the Demand Balance map at time of system peak for the year 2040 based on an extension of the IRP 2010 up to 2040 (referred to as Scenario A) which was undertaken in a recent transmission planning assessment study. This can be used as baseline to compare the impact of the three new scenarios. Figures 51, 52 and 53 are the same provincial Demand Balance maps at time of system peak for the year 2040 for the three scenarios.

Figure 50 – Map of the provincial demand balances by 2040 based on the extended IRP 2010

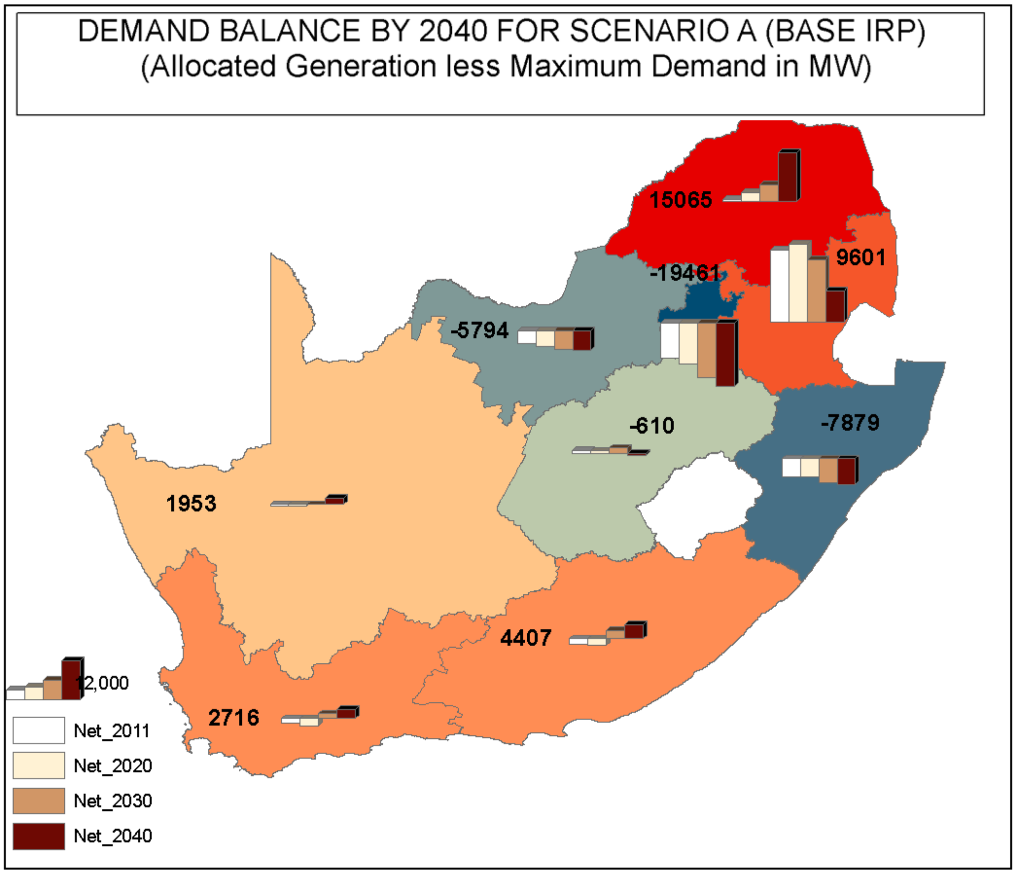


Figure 51 – Map of the provincial demand balances by 2040 for the Moderate Decline Scenario

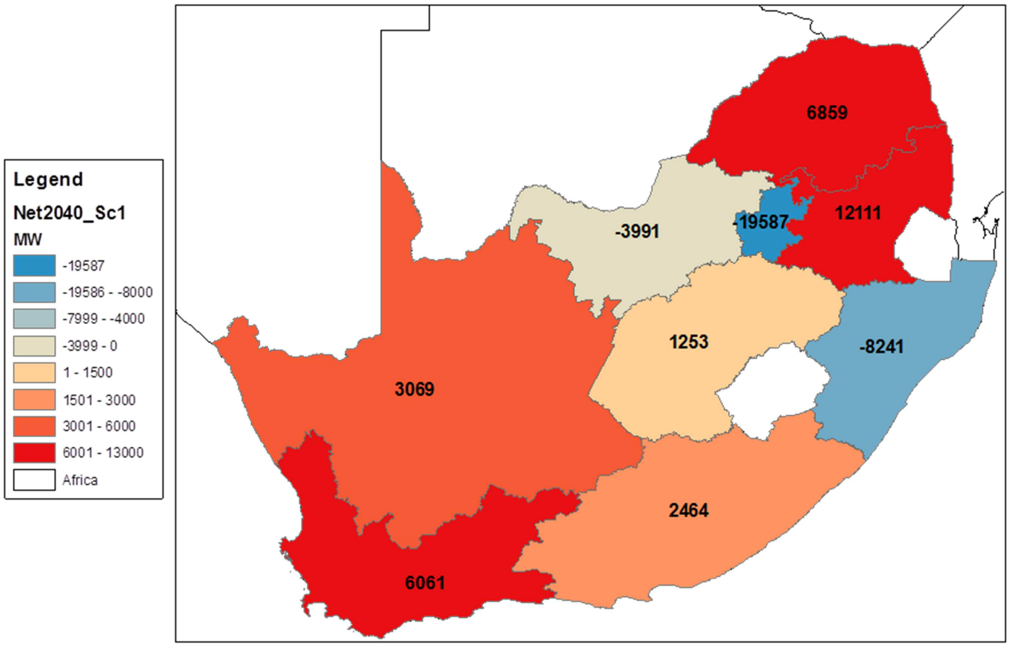


Figure 52 – Map of the provincial demand balances by 2040 for the Weathering the Storm Scenario

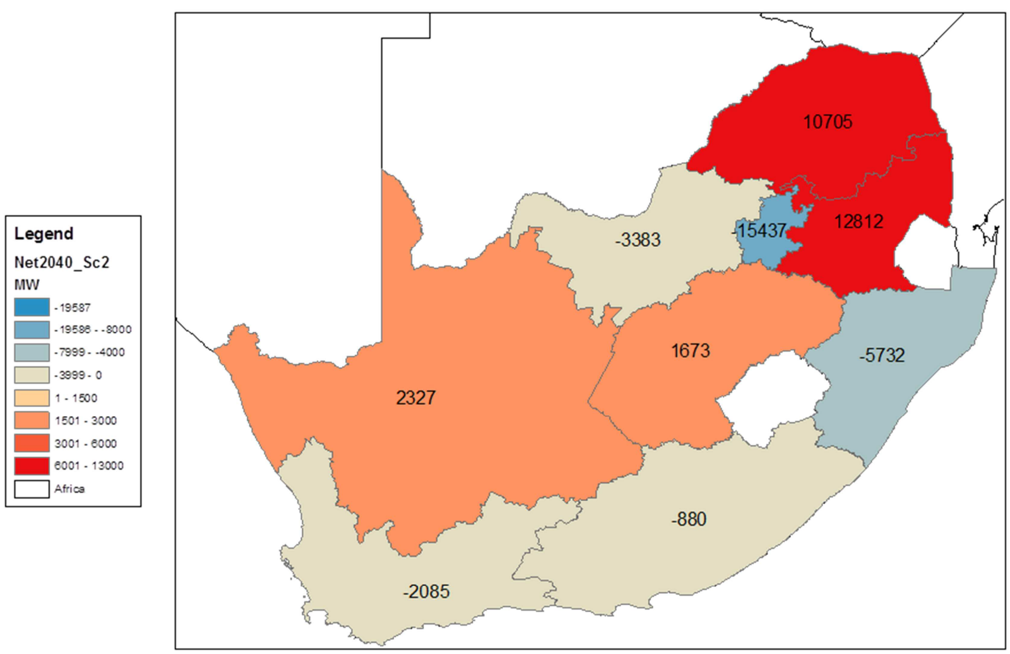
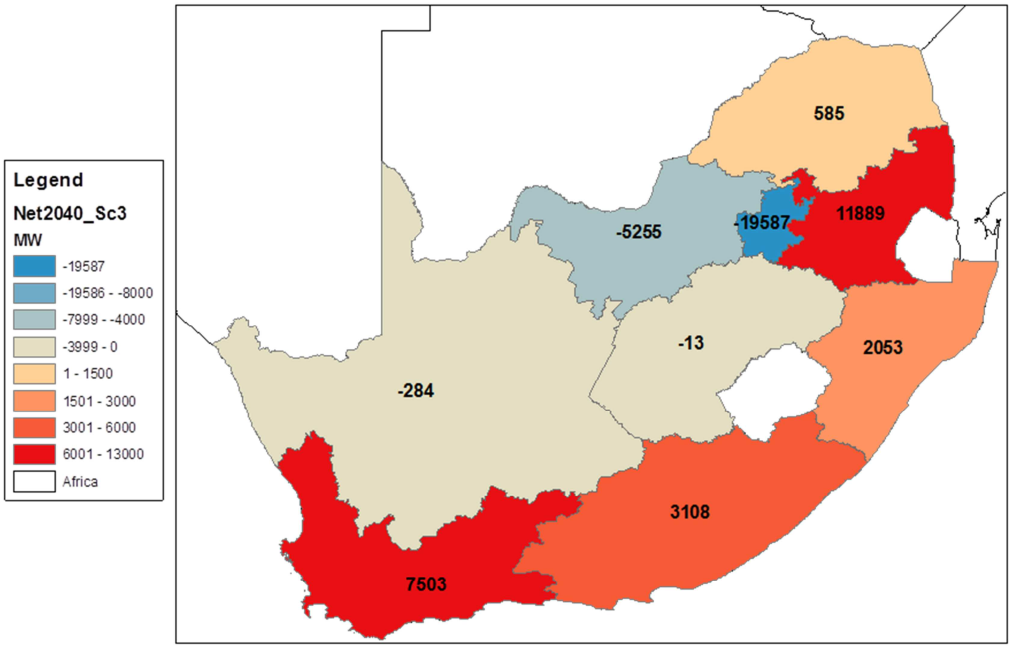


Figure 53 – Map of the provincial demand balances by 2040 for the Big Gas Scenario

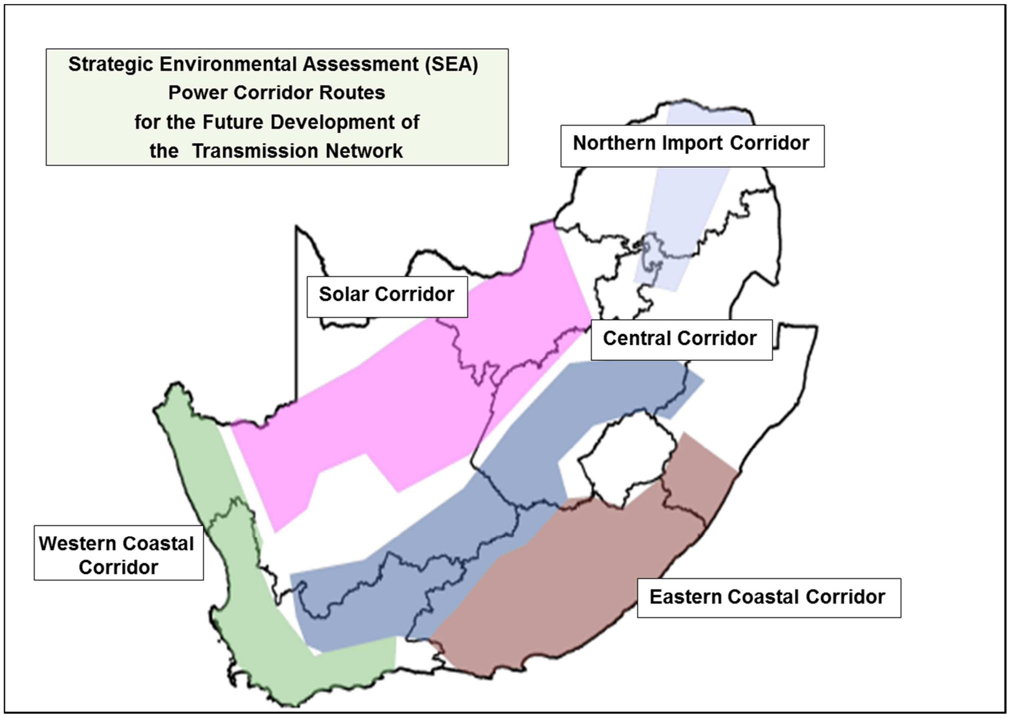


E.32. The maps clearly show that for both the Moderate Decline and Big Gas scenarios there will be a need for massive transmission infrastructure to evacuate the power out of the Cape provinces. This further reinforces the need for both the "Eastern Coastal Corridor" running from the Eastern Cape into KwaZulu Natal as well as for a. "Solar Corridor" along the Northern Cape into the North West Province. The "Central Corridor" capacity will need to be steadily increased to cope with the power transfers out of the Cape areas. Despite these new power corridors major bottlenecks are still anticipated that will require significant transmission infrastructure to relieve. Effort should be undertaken to either identify alternative sites (nuclear) or transportation of the resource itself (gas) to reduce the transmission infrastructure requirements.

E.33. The Weathering the Storm Scenario has a better match in terms of new generation in both the northern parts of the country (coal in Limpopo) and in the southern parts (gas and renewables in the Cape provinces) combined with the existing capacity of the "Central Corridor" of around 5GW. What is not clear from the Demand Balance map for the evening peak is the potential need to evacuate large amounts of PV, wind and gas generation that will be installed in the three Cape provinces as can be seen in the installed generation map in Figure 48. The power flows during daylight hours with good wind conditions will require power corridors to evacuate power rather than import power. Thus the variance and size of the potential power transfers still indicate the need for the "Solar Corridor" and the "Eastern Coastal Corridor" transmission routes.

E.34. A recent transmission planning assessment study considering what the requirements for the 2040 Transmission Grid would be, based on an extension of the IRP 2010 up to 2040 as well as two other generation scenarios, identified a number of main power corridors that will be required to be developed for the future. These corridors have shown to be in alignment with the needs of several other stakeholders outside of Eskom through interactions and discussions. They formed part of the input for the SIP10 project of the Department of Environmental Affairs to undertake Strategic Environmental Assessment projects for these transmission main power corridors. There are five corridors in total and they are indicated in the map in Figure 54.

Figure 54 – Map of the SEA Power Corridors for the future Transmission Grid



E.35. The assessment of the three IRP 2010 update scenarios indicates that the identified five Transmission Power Corridors will be required to enable all three generation scenarios. The main difference is the physical amount of transmission infrastructure within these corridors and their timing. The transmission impact assessment has been based on the reasonable spatial location of the future generation taking into account current knowledge and information. Therefore there is still opportunity to consider better generation location strategies in the longer term.

E.36. One generation strategy that can provide advantages in terms of reducing the network integration costs and minimising system losses is to consider a large distributed generation network with more appropriately sized units. These would be smaller sized plants that can be integrated into the distribution networks utilising their infrastructure and reducing the loading of the Transmission Grid. Initially this can be achieved with PV but later extended, with the associated transport infrastructure, to gas and even coal plants located near large loads or major load centres.

E.37. The wide distribution of significant PV generation does have trade-off transmission risks in terms of large day to night power transfer shifts to accommodate the PV replacement generation for the evening peak. Regarding the gas and coal option, if it proves uneconomical to transport then allowance will have to be made for significant transmission capital expenditure to accompany the integration of the future generation in the general areas assumed for this assessment report.

E.38. Whichever future generation scenario unfolds and wherever the new generation will be finally located, the five main Transmission Power Corridors will play a major role in their successful integration. Investment in and the development of these Power Corridors will provide flexibility of implementation and faster connection schedules for all three of the generation scenarios or a completely different IRP scenario in the future.

E.39. Serious consideration should be given to managing the distribution of the future generation to minimise the very skewed distribution in order to gain the maximum transmission capacity and flexibility to transport the power to where it is needed for the minimum transmission investment.

APPENDIX F – ADEQUACY ASSESSMENT STUDY

Executive Summary

F.1. The IRP2010 Update has been tested for adequacy to ensure that the security of supply is not compromised. The adequacy assessment models the South African electricity supply system on an hourly basis for the period 2019 to 2028. The method to assess the system adequacy is to model the Supply-Demand Balance, in other words the system's (existing, committed and new plant build in the IRP 2010 Update scenarios) ability to meet customer energy demand within a set of adequacy metrics at the lowest possible cost. The Supply-Demand Balance results are compared to the Generation Adequacy Metrics.

F.2. This report summarizes the findings from testing three of the IRP2010 Update scenarios for adequacy, namely "Weathering the Storm", "Moderate Decline" and "Big Gas". The most significant input parameters for an adequacy type study are the plant performance metrics, the load forecast and the plant in commercial service.

F.3. The results for the Weathering The Storm scenario show high annual load factors (above adequacy threshold of 50% per annum) of the expensive base load stations in the last two years of the study horizon, indicating that there may be a slight shortage of base load capacity in these years.

F.4. The results for the Moderate Decline scenario show high annual load factors of the expensive base load stations as well as unserved energy above the Adequacy Metric thresholds in 2023, 2024 and 2028. This indicates that there may be shortage of base load and peaking capacity in these years.

F.5. The results for the Big Gas scenario show high annual load factors of the expensive base load and OCGT stations as well as unserved energy above the Adequacy Metric threshold in 2023, 2024, 2027 and 2028. This indicates that there may be shortage of base load, mid-merit and peaking capacity in these years.

F.6. The aspects mentioned in the Conclusion must be noted when contemplating these conclusions.

Introduction

F.7. The optimisation process in IRP2010 Update is based on minimisation of "Total Cost to Customer" and obeying system and entity (for example generator) constraints. The only uncertainty addressed in this optimisation is the distribution of unplanned outages, by means of the equivalent load duration curve approach. The traditional adequacy metrics (like reserve margin, unserved energy) are primarily an outcome of this process[6].

F.8. The intent of the IRP2010 Update Adequacy Assessment is not to address long-term uncertainties (for example different long-term load growths or substantial delays in commercial operation dates of new plant). These are to be addressed as part of the main IRP process. The IRP2010 Update Adequacy Assessment rather interrogates the adequacy of a plan should that future (the supply and demand assumed for the plan) materialize. This assessment is only done for certain plans and years.

[6] The quantum of unserved energy does play a role in the cost minimisation by virtue of the total cost of unserved energy being included in the objective function.

F.9. The Medium-term Outlook (MTO) risk assessment studies have been carried out for a number of years[7]. The purpose of a MTO is the assessment of system adequacy for the next five years. The MTO results inform management decisions regarding existing fleet performance and the implementation of additional short to medium-term measures to improve system adequacy.

F.10. The intent of the IRP2010 Update Adequacy Assessment and the MTO is thus the same. The adequacy criteria developed for the MTO have been adjusted for use in the IRP 2010 Update Adequacy Assessment and are shown in Table 48. The power system is considered adequate when it meets all these Generation Adequacy Metrics.

Table 48 – Adequacy Metrics

Adequacy Metric		Threshold	Detail
AM1: UE GWh	Unserved Energy (UE)	< 20 GWh per annum	The amount of energy in a year that could not be supplied due to system supply shortages.
AM2: GLF (OCGT)	Open-cycle Gas Turbine (OCGT) Load Factor	< 6% per annum	The Gross Load Factor (GLF) of the combined OCGT plant in operation in a year.
AM3: GLF (EBLS)	Expensive Base Load Stations (EBLS) Load Factor	< 50% per annum	The Gross Load Factor (GLF) of the combined expensive Base-load Stations (Majuba Dry and Majuba Wet) in a year.

Adequacy Metrics

Capacity Adequacy

F.11. The first two Adequacy Metrics – Unserved Energy and OCGT Load Factors - look primarily at the capacity adequacy. Historically for the MTO, OCGT load factors were included to give a financial sustainability indication. The combined load factor of all the OCGTs (including the new OCGTs) was used in the IRP2010 Update Adequacy Assessment. Capacity inadequacy will be flagged when the threshold of any one of these Metrics is exceeded. The likelihood that the system will be unable to meet the load during a capacity type contingency is then unacceptably high.

F.12. Capacity type contingencies are typically unexpected load increases (sudden or earlier than expected cold weather) or co-incident unplanned failure of a number of generating units. These short duration type events (typically hours) are considered capacity contingencies.

F.13. When may the system be capacity inadequate? When there is just sufficient total plant capacity to supply the load during high demand hours under the expected supply and demand situation. The plant then has insufficient capacity reserve to cater for a capacity type contingency should it occur. The capacity shortfall will then result in unserved energy for a few hours.

Energy Adequacy

F.14. The third Adequacy Metric (the Gross Load Factor (GLF) of the combined expensive Base-load Stations) looks primarily at the energy adequacy. Historically for the MTO, Camden, Grootvlei and Komati were considered the expensive Base-load Stations. The IRP2010 Update uses Majuba (Wet and Dry) as the Expensive Base-load Station (3 843 MW). Majuba comes to end-of-life in 2045 which is beyond the years tested for

[7] For example the MEDIUM TERM RISK MITIGATION PROJECT FOR ELECTRICITY IN SOUTH AFRICA (2010 TO 2016), Appendix E, INTEGRATED RESOURCE PLAN FOR ELECTRICITY 2010-2030.

adequacy. The use of CCGTs for this Adequacy Metric is not supported as the time required to increase fuel supply to the CCGTs will be unacceptably long. Energy inadequacy will be flagged when these load factors get too high, meaning the system response to an energy type contingency may not be sustainable.

F.15. What is an energy type contingency? The occurrence of a significantly higher than forecast load growth or the loss of a large source of supply (for example the loss of Cahora Bassa) for a prolonged period. These long duration type events (weeks/months) are typically considered an energy contingency.

F.16. When may the system be energy inadequate? When there is just sufficient base-load plant to supply the load on a continuous basis under the expected supply and demand situation. All base-load plant thus operates at high load factors under normal circumstances. The base-load plant then has insufficient energy reserve and/or fuel to cater for an energy type contingency should it occur. The energy shortfall will then require base-load type generation from peaking plant (mostly OCGTs). This may not be financially sustainable should it even be possible from a fuel supply perspective. The probability of extended rolling "blackouts" will then be unacceptably high.

Thresholds

F.17. The specific uncertainties considered when determining the thresholds are:

- short-term demand forecast
- distribution of forced outages
- stochastic nature of Wind and Solar PV generation
- loss of a large generator for an extended period

F.18. The first two uncertainties are addressed internally in the model and pertain (mostly) to the Capacity Adequacy Metrics (Unserved Energy and OCGT Load Factor). The thresholds for these Capacity Adequacy Metrics are set at minimum total cost to the customer when including the uncertainties.

F.19. The threshold for the Energy Adequacy Metric (Load Factor of Expensive Base-load Stations) is set by calculating the energy reserve needed to cater for an energy event. The event used in the analysis for the MTO was the loss of the Cahora Bassa supply for a continuous period of three months. In the analysis this event does not occur simultaneous with the uncertainties pertaining to the Capacity Adequacy Metrics.

F.20. The IRP2010 Update Adequacy Assessment can at best be seen as a "first pass" assessment. It must be stressed that should the adequacy assessment indicate inadequacies it is not automatically indicated to adjust the IRP Plan. A full quantitative assessment should then be performed to determine the plan that yields the least total cost to the customer given the uncertainties indicated.

Modelling Parameters

F.21. The modelling parameters assumed for the IRP2010 Update Adequacy are summarized below.

F.22. It is assumed the current demand-side provision of **Instantaneous Reserve** will not continue and the availability of Interruptible Load emergency resources will diminish. The reserves were split in to Instantaneous, Regulating and 10-minute. The Instantaneous Reserve requirement was set at 600 MW until New Nuclear plant (1 600 MW per unit) is built and increased to 1 000 MW from this date. The Regulating Reserve is set at 600 MW as per the present requirement and to cater for the "peak-within-the-peak".

F.23. The fuel resources in the IRP2010 Update model were removed and a Fuel Price was used as input. To ensure the **merit order** does not change and for faster model execution, the Heat Rate Base and Heat Rate Increments were removed and replace with Heat Rate. The merit order used is as follows:

- Renewable Plant
- Hydro Plant
- Base-load Plant
- Five units of Coal_PFwFGD_Gen (if needed)
- Mid-merit Plant (Co-gen, MTPPP, new CCGTs)
- Majuba (Dry and Wet)
- 10-minute Reserve
- Demand Response
- Peaking Plant (OCGTs)
- Acacia and Port Rex
- Instantaneous Reserve
- Unserved Energy
- Regulating Reserve

F.24. The existing coal-fired power stations have practical limitations on their **maximum load factors**. It is assumed this will also be the case for new coal-fired plant. A conservative maximum weekly load factor of 95% was included for all base-load coal-fired plant.

F.25. The **commitment** of units was included for all generators not capable of two-shifting, except for Majuba (dry and wet).

F.26. **Minimum stable generation** levels were set at practical values for all the generators.

F.27. **Capacity profiles** were used for the existing nuclear generators (Koeberg) and planned outages for new nuclear generators were assumed to occur once every 18 months (i.e. assume refuelling regime is the same as Koeberg).

F.28. Realistic minimum and maximum weekly/monthly/annual **load factors** were assumed for these generators:

- Emergency Resources
- For the Demand Response measure the maximum capacity factors were assumed as:
  - Max Capacity Factor Day: 9%
  - Max Capacity Factor Week: 6%
  - Max Capacity Factor Year: 1.4%

F.29. The energy demand and the photovoltaic (PV) profiles were modelled stochastically. The wind profile as an endogenous stochastic variable introduces too much variability and it was rather inputted directly using multiple profiles (bands).

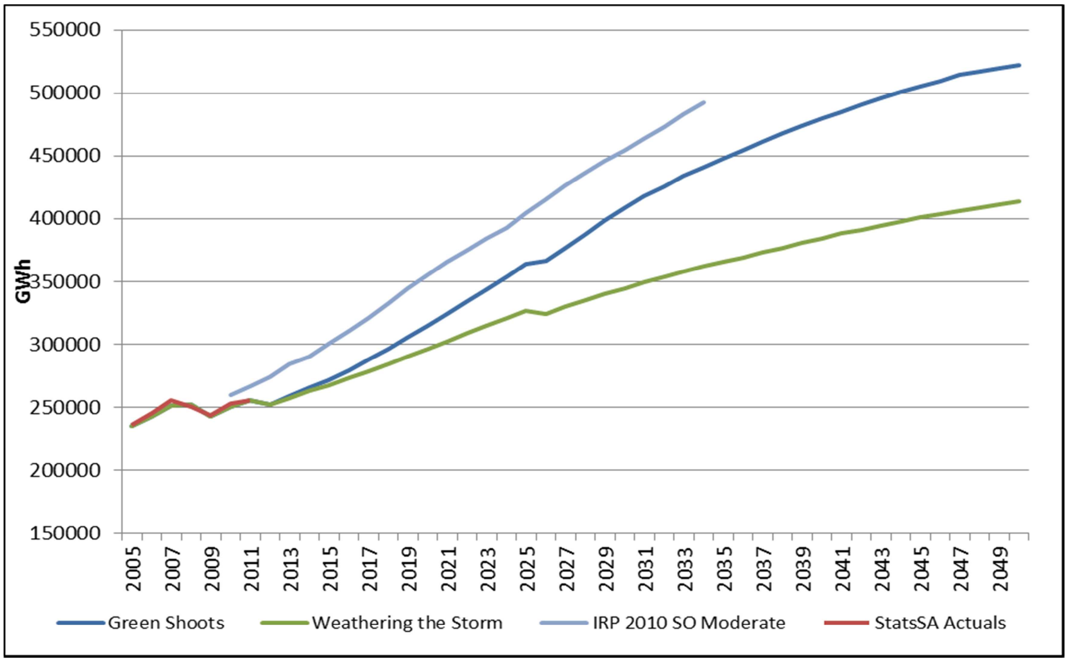
IRP2010 Update Scenarios tested for Adequacy

F.30. Three of the IRP2010 Update scenarios were tested for adequacy for the time horizon 2019 to 2029, namely “Weathering the Storm”, “Moderate Decline” and “Big Gas”. The scenario descriptions are detailed in Appendix D.

IRP2010 Update Assumptions

F.31. Demand Forecast: The CSIR Green Shoots demand forecast, used in the Big Gas and Moderate decline scenarios, as well as the Weathering the Storm demand forecast, used in the Weathering the Storm scenario, are shown in Figure 55. The IRP2010 Moderate forecast as well as the recorded actual demand is shown for reference.

Figure 55 – IRP 2010 Update demand forecasts



F.32. Supply-side options: Table 1 (of the main report) indicates the policy-adjusted plan and the results of the Ministerial Determinations (in 2011 and 2012) which identified the capacity to be procured from independent power producers (IPPs). In addition 800 MW of co-generation capacity was added to that preferred in the IRP plans. Of these determinations the Renewable Bid Programme has already contracted 2470 MW of renewable capacity and the contracts with the DoE OCGT peakers have been finalised. The assumed commercial operation dates for Eskom's new build plant are summarized in Table 49.

Table 49 – Eskom new build commissioning dates

Power Station	1st unit Commercial Operation Date
Medupi	1 February 2014
Kusile	1 January 2015
Ingula	1 August 2014
Sere	1 May 2014

F.33. **Life Extension**: beyond the return to service stations the coal-fired power stations are all expected to be decommissioned at the end of 50 year plant life. The IRP2010 Update however considered refurbishment options for the life of these power stations to be extended by another ten years, providing a mechanism to defer new capital expenditure and contain electricity price increases. The coal-fired power stations which were chosen for life extension in the IRP2010 Update scenarios tested for adequacy are shown in Table 50.

Table 50 – Coal-fired power stations which undergo life extension

Weathering The Storm	Moderate Decline	Big Gas
• **Duvha** • **Kendal** • **Kriel** • **Lethabo** • **Majuba (Wet & Dry)** • **Matimba** • **Matla** • **Tutuka**	• Duvha • Kendal • Kriel • Lethabo • Majuba (Wet & Dry) • Matimba • Matla • Tutuka	• Duvha • Kendal • Kriel • Lethabo • Matimba • Matla • Tutuka

F.34. **Demand Side Options**: The IRP 2010 Update considered only the Eskom projects for energy efficiency demand side management (EEDSM) as was indicated in the MYPD3 application.

F.35. **Plant Performance**: Since the 2008 electricity supply crisis Eskom was able to meet electricity demand through delaying maintenance on the generation fleet. This has led to the deterioration in performance of the aging fleet, exacerbating the current crisis but also incurring a longer term impact on the effectiveness of the fleet to meet future demand. The IRP 2010 assumed the fleet to have an average availability of 86% but actual performance, however, declined to less than 80%. Consequently to avoid continued stress on the fleet Eskom has proposed a new generation maintenance strategy that aims to ensure the required maintenance is carried out on key identified generators, regardless of the demand-supply balance. The final objective is to arrest the decline in performance and return the average availability factor of the current fleet to 80% over the next ten years. The Eskom generation five-year maintenance plan for the current fleet (the "80:10:10" strategy) is used as the basis for the planned maintenance and unplanned outage probabilities in all scenarios. This maintenance schedule for the Eskom's existing fleet includes additional interventions to comply with the air quality requirements for existing generation facilities. The Base Case also includes the additional outages required to retrofit flue gas desulphurisation at each of the large coal-fired generators (excluding the return to service stations which will be decommissioned between 2020 and 2029).

Results

F.36. Weathering the Storm: The results in Table 51 show high annual load factors (above adequacy threshold of 50% per annum) of the expensive base load stations in the last two years of the study horizon, indicating that there may be a slight shortage of base load capacity in these years.

Table 51 – Results from Weathering the Storm adequacy test

Adequacy Metric	Threshold	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
UE (GWh)	< 20 GWh	0.00	0.00	0.00	0.02	0.00	0.28	0.46	1.46	6.09	2.39
GLF (OCGT) %	< 6 %	0.03	0.04	0.23	0.37	1.05	1.53	1.22	0.99	3.21	3.19
GLF (EBLS) %	< 50 %	4.2	4.4	9.1	15.9	26.7	32.0	36.7	36.2	50.9	52.2

F.37. Moderate Decline: The results in Table 52 show that all adequacy metric thresholds for unserved energy and OCGT load factors are violated in 2023 and 2024. The annual load factors of the expensive base load stations are also above the adequacy threshold from 2023 to 2028. This indicates that there may be a shortage of mid-merit and peaking capacity in 2023 and 2024 and a shortage of base load from 2023 to 2028.

Table 52 – Results from Moderate Decline adequacy test

Adequacy Metric	Threshold	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
UE (GWh)	< 20 GWh	0.00	2.00	5.80	10.88	35.31	59.03	3.80	11.80	10.18	6.55
GLF (OCGT) %	< 6 %	0.58	1.09	3.17	4.13	9.72	10.48	2.40	2.92	5.53	6.97
GLF (EBLS) %	< 50 %	14.3	20.1	33.2	37.6	49.9	52.6	49.4	53.8	59.7	62.6

F.38. Big Gas: The results in Table 53 show that unserved energy is above the adequacy threshold from 2022 to 2024. The annual combined OCGT load factors are also above the adequacy threshold in 2023 and 2024. The annual combined load factors of the expensive base load stations are above the adequacy threshold from 2023 to 2028. This indicates that there may be a shortage of mid-merit and peaking capacity from 2022 to 2024 and a shortage of base load from 2023 to 2028.

Table 53 – Results from Big Gas adequacy test

Adequacy Metric	Threshold	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
UE (GWh)	< 20 GWh	0.07	1.42	8.22	24.93	132.94	108.45	1.11	12.59	5.23	4.34
GLF (OCGT) %	< 6 %	0.65	1.12	3.74	5.33	14.44	13.67	2.01	2.59	2.32	2.03
GLF (EBLS) %	< 50 %	14.1	20.5	33.4	42.4	54.8	59.4	56.4	58.4	53.5	54.2

Conclusion

F.39. The results for the Weathering The Storm scenario show high annual load factors (above adequacy threshold of 50% per annum) of the expensive base load stations in the last two years of the study horizon, indicating that there may be a slight shortage of base load capacity in these years.

F.40. The results for the Moderate Decline scenario show that the annual amount of unserved energy and the OCGT load factors are above the adequacy thresholds in 2023 and 2024. The annual load factors of the expensive base load stations are also above the adequacy threshold from 2023 to 2028. This indicates that there may be a shortage of mid-merit and peaking capacity in 2023 and 2024 and a shortage of base load from 2023 to 2028.

F.41. The results for the Big Gas scenario show that the annual unserved energy is above the adequacy threshold from 2022 to 2024. The annual combined OCGT load factors are also above the adequacy threshold in 2023 and 2024. The annual combined load factors of the expensive base load stations are above the adequacy threshold from 2023 to 2028. This indicates that there may be a shortage of mid-merit and peaking capacity from 2022 to 2024 and a shortage of base load from 2023 to 2028.

F.42. The following aspects must be noted:

F.42.1. System adequacy is very sensitive. For example, an increase of some 150 MW in base load capacity for the Big Gas Case will remove the inadequacies indicated in 2027/28.

F.42.2. The system is expanded by adding discrete generating units, some with a capacity of up to 1 600 MW (Nuclear).

F.42.3. The system is expanded by minimising present value costs over the planning horizon. For example, the "tighter" system adequacy in all three Cases in 2023/24 is mainly due to low demand growth in the years immediately following – the optimisation is "waiting" for sustained growth to build more capacity.

F.42.4. The expansion optimisation is based on minimising total cost to customer over the planning horizon. The thresholds for the Adequacy Metrics used in the analysis were determined in 2010 for the system in 2010. These thresholds might change due to the changing plant mix, different plant costs and performance and changes in load shapes.

F.43. Based on these considerations, it is stressed this IRP2010 Update Adequacy Assessment can at best be seen as a “first pass” assessment. The inadequacies stated in the adequacy assessment do not automatically indicate an adjustment to the IRP Plan is required. A full quantitative assessment should be performed to determine the plan that yields the least total cost to the customer given the uncertainties.