EIUG

Energy Intensive Users Group of Southern Africa

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EIUG COMMENT ON THE IRP2016

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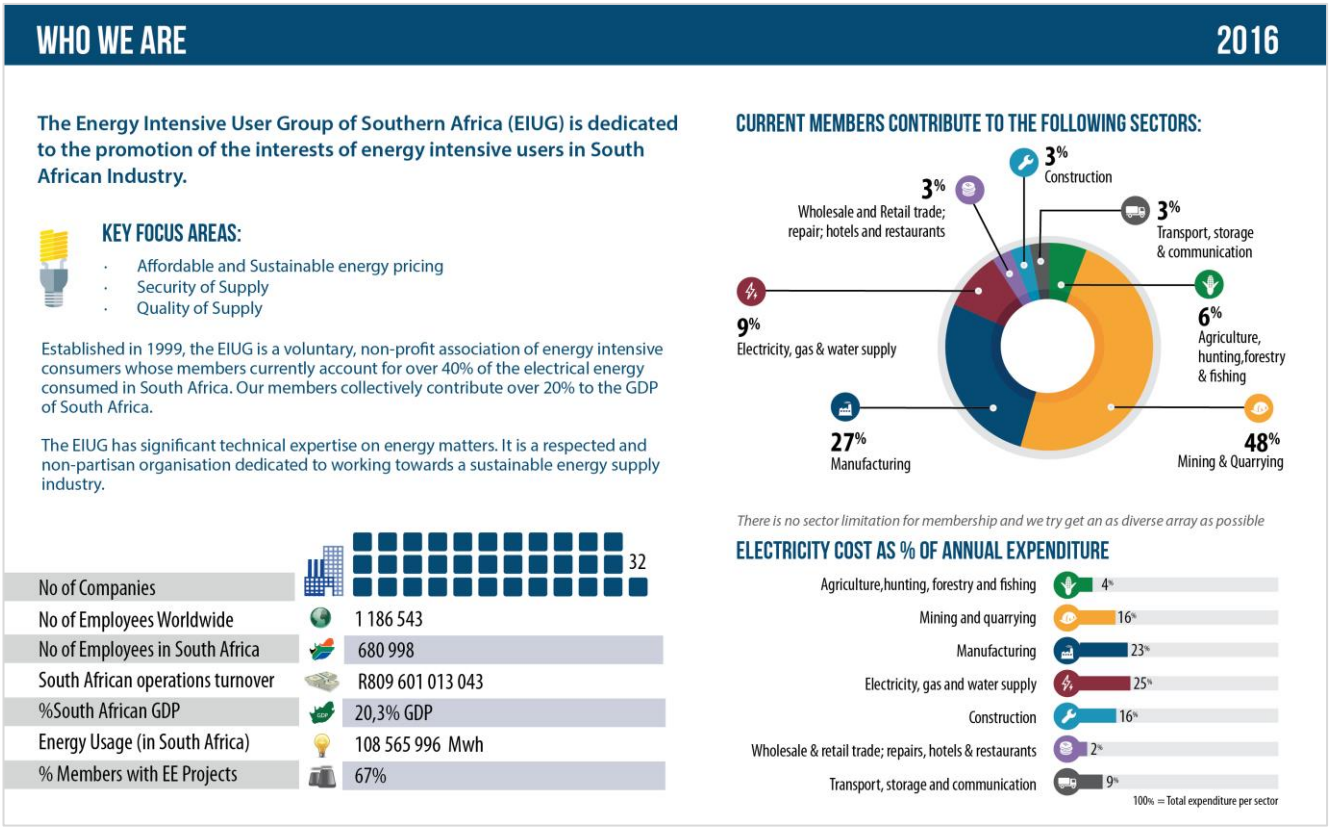
1. BACKGROUND ON THE EIUG

Established in 1999, the Energy Intensive User Group of Southern Africa (EIUG) is a voluntary, non-profit association of energy intensive consumers whose members currently account for over 40% of the electrical energy consumed in South Africa. Our members collectively contribute over 20% to the GDP of South Africa. EIUG member companies are deeply invested in the economic well-being of the country and are vulnerable to electricity price increases which can lead to lower production or closures of energy intensive industries or result in relocation to more competitively priced countries.

The EIUG is a consumer-led organisation working for the good of the country. The group strongly believes that energy is the engine for economic growth and development in South Africa. We are therefore committed to working with government and other stakeholders to ensure South Africa has energy industries which provide reliable supply at acceptable quality and competitive prices.

The EIUG seeks to influence the shape of the energy industry to ensure that reasonable and economically sound solutions are developed. The country must transition to a lower-carbon future; the EIUG aims to ensure that this is done in a manner and within a time-frame that protects and maintains the competitiveness of our economy.

Image 1: Who We Are



2. INTRODUCTION

The EIUG welcomes the opportunity to submit comments on the draft Integrated Resource Plan (IRP2016) (assumptions, Base case and observations). The draft IRP2016 and the draft Integrated Energy Plan (IEP) were published for public comment in the government gazette on 25 November 2016. The EIUG was pleased at the announcement of an extension for the submission of written comments to 31 March 2017.

The previous Integrated Resource Plan (IRP) 2010-30 was promulgated in March 2011 and was supposed to be a "living plan" which would be revised by the Department of Energy (DoE) every two years, which was not adhered to. Since the promulgation of this (2010) iteration of the IRP there have been significant economic and structural developments in the energy sector in South and Southern Africa, not least in the energy/electricity demand outlook and supply performance.

The EIUG made a presentation at the public hearings hosted by the DoE on the IRP2016 on 7 December 2016. While highlighting the unprecedented short timeframes for written comments and public hearings, the EIUG preliminary review found three key flaws in the assumptions used for the IRP2016 Base case:

- The demand assumptions
- The cost assumptions for renewable technologies
- The annual caps placed on renewable resources

The group and other associations have undertaken a more detailed review of the available information in the IRP2016 and commissioned technical work from industry experts to support our comment. The EIUG has engaged the Council for Scientific and Industrial Research's (CSIR) Energy Centre on the development of their Electricity Scenarios and commissioned Poyry, an international consulting and engineering firm to review the demand forecast used in IRP2016.

The EIUG reiterates its support for the transition to a lower-carbon economy, in a timeframe and manner which considers our developmental state and ensures competitiveness of our economy. While the country has surplus and sufficient capacity, the modernization and optimization of the electricity supply and distribution system should be addressed.

While the EIUG remains technology agnostic, the country needs reliable electricity supply at the lowest possible cost, delivered by a build plan using technologies that offer modularity and the flexibility to match the vagaries of demand. To this end, the EIUG supports the position that:

- *The Base case scenario should always be the least cost scenario against which all scenarios and sensitivities are tested.*
- *Additional scenarios should only impose justifiable and verifiable technical or policy considerations on the least cost option*
- *Electricity price paths should be calculated for each scenario to quantify the cost to the country of deviating from the least cost plan.*
- *Finally, water conservation and socio-economic impacts and costs must also be considered in the policy adjusted scenarios.*

3. CONTEXT

The IRP2016 comes at a time of significant structural changes in the electricity industry across the globe. These changes are comparable in scope and impact to the monumental changes seen in the information and communication sectors, and are not only driven by climate change imperatives, but also by new technologies with ever-decreasing costs.

The traditional electricity industry model of a public utility company building and operating large, centralised power stations worked well in the previously unconstrained world of the 20th century, where bigger was better and marginal generation costs came down because of better fuel conversion efficiencies and economies of scale. However, recently almost all aspects of the traditional approach face increasing marginal costs. This is due, in part, to increasing costs of environmental compliance (for coal) and safety (for nuclear), coupled with the institutional governance and bureaucratic processes inherent of large public utility companies. One needs look no further than the current Eskom expansion plan for examples of serious cost and schedule over-runs, and there is no evidence to show that any future mega-projects will be different.

In contrast, the costs of alternative distributed generation resources have fallen rapidly, and all indications are that these trends will continue. The developmental and economic aspirations of the country are understood and supported by the EIUG, and energy is a key enabler to achieve these aspirations. Accordingly, South Africa must draw on its abundant natural resources to supply energy at the lowest possible cost. While it is acknowledged that South Africa is rich in coal, international commitments and trends to lower carbon emissions necessitate that coal will have a much smaller share of the generation mix in any future scenario.

South Africa is likewise richly endowed with year-round solar and wind resources, which offer an alternative future of a flexible and diversified expansion plan and lower energy costs. Although certain aspects of a flexible energy mix, such as grid stability at high penetration of renewable resources still require investigation, there is adequate time to address these challenges both from a technological and a socio-economical point of view, as South African is still dominantly supplied by coal and to a lesser degree nuclear, and will be for the short to medium term.

Since 1984, nuclear generation has been part of the energy mix, supplied by the Koeberg nuclear station in the Western Cape. Nuclear is a low-carbon technology and potential suitable sites for new units have already been identified. However, the proven cost and time overruns, stringent safety requirements, inflexibility, lack of national capacity to manage large build need to be considered in the planning for the future build programme. Given the growing surplus capacity, additional megawatts coming online from committed projects – both Eskom builds and the independent power producers, as well as slow economic growth and severely reduced industrial demand for electricity, South Africa should focus on stimulating economic growth and delay the high-risk decision on such centralised baseload energy generation technology.

Against the background of a rapidly changing electricity supply business model, electricity demand growth has globally tapered off due to improving energy efficiencies and other drivers. In South Africa, the contraction in industrial demand (-6% during 2015) is largely due to high electricity price increases since 2008, as well as weak international commodity markets. This places EIUG members, who consume about 40% of the electricity generated in South Africa, in a precarious position. Some industries, notably most of the foundries and some smelters have already closed or significantly lowered production or moved to more competitive countries, and other local industries are being displaced by overseas affiliates and competitors. Should these trends continue, it is unlikely that the national electricity energy demand, which is still below 2007 levels, will grow anywhere near the rate forecasted in the IRP2016. This highlights the very real risk of over-building which will cause further price increases, and thus the spiral will continue. For the EIUG to remain internationally competitive the price elasticity of industrial demand needs to be understood, and the lowest cost and lowest risk energy mix is required. The EIUG has developed a lower demand growth outlook compared to the overly optimistic forecast used in the IRP2016. The Energy Centre at the CSIR agreed to model this demand trajectory as a sensitivity in their Electricity Scenarios work.

Should the promulgated policy adjusted IRP2016 call for major and inflexible base load investments, despite the uncertainties the country is facing, it will likely result in further price increases and a disruptive exodus of energy intensive industries, the stranding of existing coal-fired electricity generation plants, and more premature closures of mines.

In this submission, the EIUG will motivate that the future direction over the short- to medium-term is clear: South Africa should take advantage of the growing surplus capacity to stimulate demand and avoid making long-term baseload investment decisions with a potential huge economic and social cost of regret. The most rational way forward is the lowest cost, least risk and lowest carbon supply mix from the new industry model of distributed generation together with the required flexible back-up generation, demand response and possible new storage technologies in the future.

4. COMMENTS

EIUG comments will focus on 6 areas of concern:

1. The IRP2016 Base case, particularly in relation to the artificial constraints on some technologies
2. Technology cost assumptions
3. Demand assumptions
4. Development of an Alternative Forecast
5. CSIR Energy Scenarios
6. Carbon Constraint
7. Other considerations

4.1. DRAFT IRP2016 BASE CASE

The draft IRP2016 base case is not a least cost scenario, but was rather extrapolated from the IRP2010 Base case. Many of the assumptions used were unchanged from the plan promulgated in 2011, however some of these assumptions were updated based on economic, environmental and technology advances.
Notably, the IRP2016 maintains the artificial constraint on two technologies, being wind and solar PV, that were imposed on the IRP2010 Base case.

It is understood that the rational for this in the IRP2010 was due to the uncertainty at the time regarding the cost and integration of renewable technologies. The same constraints are not necessary for the IRP2016 as the Renewable Energy Independent Power Producer Programme (REIPPP) as well as international experience has shown a marked decline in the cost of these technologies and proven their incorporation, reliability and flexibility.

These artificial constraints as well as the carbon constraint included in the IRP2016 Base case result in a proposed energy mix that relies heavily on large, inflexible build programmes that are characterised by long lead times and have proven time and time again to run over budget and over time.

Per analysis undertaken by the CSIRs Energy Centre, a "re-optimised" scenario which contains no limitations on Solar PV and Wind capacity additions and cost for renewables based on the latest REIPPP bid window would be R90 billion per year cheaper by 2050 than the current Draft 2016 IRP Base case.[1] The low-demand sensitivity analysis with no limitations would be approximately R20 billion per year cheaper by 2050 than the current Draft IRP Base case. This reflects the significant reductions in Renewable Energy costs observed during the four bid Windows and the implied learning rates derived from these falls in costs.

As mentioned above, the carbon constraint from the IRP2010 Base case has been included in the assumptions for the IRP2016, it is therefore not clear why a further carbon constrained scenario is listed as an additional scenario in the draft.

[1] CSIR Energy Centre; "Comments on the Integrated Resource Plan 2016 Draft" (7 December 2016), page 29.

4.2. TECHNOLOGY COST ASSUMPTIONS

As with the 2010 IRP, the Draft 2016 IRP contains some cost assumptions for each of the conventional and renewable technologies. These cost assumptions were extracted from the Electric Power Research Institute ("EPRI") studies[2], which were conducted in 2010 and 2015 for the DoE, and from the REIPPPP Bid Window 4. One of the key cost metrics EPRI computes, but is not contained in the Draft 2016 IRP, is the levelised cost of electricity ("LCOE"). This metric incorporates fuel costs, operations and maintenance ("O&M") costs as well as capital costs to arrive at an average cost per megawatt hour ("MWh"). The LCOE equates to the sum of all the costs divided by the expected MWh output over the lifetime of a plant and adjusts costs for inflation as well as discounts to account for the time value of money.[3] This metric allows for a proper cost comparison between different generation technologies, even when they have unequal lifetimes, capacity and load factors.[4]

As will be shown later in this report the modelling done by the CSIR Energy Centre illustrates that lifting the constraints on renewable technologies while leaving all other cost assumptions used by the DoE unchanged, results in the model not selecting large-scale conventional generation technologies.

However, it must be noted that the costs assumed for nuclear and renewables in the draft IRP2016 are flawed:

4.2.1. Renewable Technology Cost Assumptions

The Draft 2016 IRP provides costs for Renewable Energy technologies.[5] The two largest Renewable Energy technologies by far in terms of planned capacity additions are Wind and Solar Photovoltaic ("Solar PV"). For these technologies, the Draft 2016 IRP does not use EPRI data but instead uses cost estimates from the DoE's IPP (Independent Power Producers) office, which was based on the weighted average prices from power purchase agreements from the REIPPPP bid Window 4.

A key variable for determining the likely future costs is the learning rate, i.e. the reduction in costs arising from technology manufacturers accumulating experience. This is particularly relevant for renewable technologies, which are relatively new. The Draft 2016 IRP contains so called learning rates for Solar PV and Wind. However, given the lack of detail on how these rates are derived, there are a few concerns to be noted.

- Firstly, the learning rates in the Draft 2016 IRP are presented as ZAR per kW, whereas this variable is generally expressed as a percentage decline in the cost of production of one unit for a doubling in the cumulative installed capacity.[6] Thus, the presented learning rates cannot be verified as it is not clear how they are being used to determine future Wind and Solar PV costs.
- The reduction is ZAR per kW costs appear modest when compared to the learning rates observed from academic literature. For example, in the Draft 2016 IRP, Solar PV costs are expected to fall by only 20% and Wind by 10% over the 35 year IRP period. The learning rates derived from academic literature indicate that costs would decline by a significantly greater margin over that period.[7]
- It appears that the learning rates were derived from the DoE Renewable Bid Window 4.[8] There have been subsequent bid Windows and therefore it would be more accurate to make use of the most up-to-date cost assumptions when determining learning rates as it reflects more realistic future costs. There were significant reductions in Renewable Energy technology tariffs in the latest bid Windows.

[2] See Electric Power Research Institute (2010), Power Generation Technology Data for Integrated Resource Plan of South Africa and Electric Power Research Institute (2015), Power Generation Technology Data for Integrated Resource Plan of South Africa.
[3] Renewable Energy Advisors, available: http://www.renewable-energy-advisors.com/learn-more-2/levelized-cost-of-electricity/.
[4] U.S. Department of Energy, Office of Indian Energy, Levelised cost of energy, available: https://energy.gov/sites/prod/files/2015/08/f25/LCOE.pdf.
[5] Draft 2016 IRP, page 18.
[6] Industrial Development Corporation, Green economy report: The cost of renewable energies, August 2012, Page 8, available: https://www.idc.co.za/images/download-files/research-reports/IDC_RI_publication_Cost%20Evolution_Renewable_Energies.pdf.
[7] https://www.andrew.cmu.edu/user/ilimade/Ines_Azevedo/papers/Rubin_2015.pdf. This study established the mean learning rates (i.e. % cost reduction from doubling of cumulative installed capacity) for Solar PV as 12% and 16.5% for Wind. Given that installed capacity is expected to grow exponentially over the IRP period, the reduction in costs is likely to be significantly greater than these percentages.
[8] Draft 2016 IRP, pages 18 and 13.

For example, the Council for Scientific and Industrial Research Energy Centre ("CSIR") have been able to determine the difference in the average Renewable Energy tariffs between Bid Window 4 (used in the Draft 2016 IRP) and the latest bid Window (Bid Window 4 Expedited). These differences are shown in Table1.

TABLE 1: AVERAGE TARIFFS (ZAR/KWH) FROM IRP ASSUMPTIONS AND BID WINDOW 4 EXPEDITED

Technology	IRP 2016 assumptions (Jan 2015)	Bid Window 4 expedited (Apr 2016)
Solar PV	0.93	0.62
Wind	0.81	0.62

Source: CSIR Energy Centre (2017), Least cost electricity mix for South Africa: Optimisation of the South African power sector until 2050, page 7, available: http://www.crses.sun.ac.za/files/news/RSA%20Re-Optimisation%20-%20CSIR%20-%2016Jan2017.pdf.

Between Bid Window 4 and Bid Window 4 Expedited, average tariffs for PV and Wind fell by 33% and 23% respectively. Thus, by ignoring the tariffs in the latest bid window, the reduction in costs are not considered, resulting in Renewable Energy technology costs being artificially high. This will have implications given that the Base case scenario in the Draft 2016 IRP is meant to be a least cost model.

4.2.2. Nuclear Cost Assumptions

The Draft 2016 IRP does not use EPRI data for Nuclear technology costs. Rather, it makes use of "hybrid costs" based on a study commissioned by the DoE Nuclear Branch. This study incorporates Asian costs, which are significantly lower than the Nuclear costs observed in western countries. This study is not properly cited and it does not appear to be publicly available.[9] The Draft 2016 IRP provides no justification on why the hybrid cost data is used instead of the EPRI data.

The Draft 2016 IRP cost assumptions are significantly lower than the cost assumptions disclosed in the 2015 EPRI study, which assumes Areva Nuclear technology. Table 2 shows the differences in the detailed cost elements between the two sources.

TABLE 2: DOE AND EPRI COSTS FOR NUCLEAR TECHNOLOGY

	Unit	Draft 2016 IRP	2015 EPRI (Areva)
Rated capacity	MW, net	1,400	1,600
Total overnight cost	ZAR/kW (Jan 2010/2015 ZAR)	55,260	79,432
Lead-times and project schedule	Years	8	6
Fuel cost	R/GJ	7.35	7.35
Heat Rate	kJ/kWh	10,657	10,340
Fixed O&M Cost	R/KW/Year	885	755
Variable O&M Cost	R/MWh	34	42.4

Sources: Department of Energy, Integrated Resource Plan Update, Assumptions, Base case and observations: Revision 1, November 2016, page 16.

EPRI (2015), Power Generation Technology Data for Integrated Resource Plan of South Africa, page 8-1.

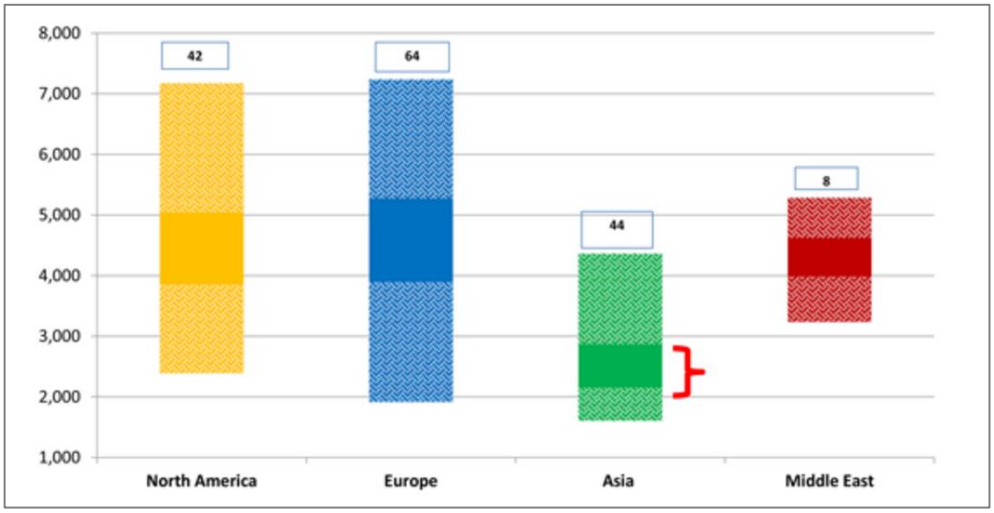
The Draft 2016 IRP assumes significantly lower overnight capital cost and variable O&M costs. Although LCOE estimates are not provided, the differences in the above cost components will mean that the LCOE derived using the Draft 2016 IRP assumptions would be significantly lower than the LCOE derived using EPRI data. This would be problematic if the Draft 2016 IRP assumptions are not applicable to South Africa, and the Base case scenario will incorrectly infer that Nuclear technology is a cost optimal solution.

As explained above, Nuclear technology costs derived from Asia are generally lower than the Nuclear costs derived from the West.[10] This is illustrated in Figure 1, which shows the range of overnight capital costs by

[9] Draft 2016 IRP, page 9.
[10] Draft 2016 IRP, page. 9.

region, in 2013 US dollars, and was constructed from data from publications and studies covering a period from 2008 to 2014.

FIGURE 1: OVERNIGHT CAPITAL COST FOR NUCLEAR POWER PLANTS (2013 USD/KW)



Source: World Nuclear Association (2017), The Economics of Nuclear Power, available: http://www.world-Nuclear.org/information-library/economic-aspects/economics-of-Nuclear-power.aspx.

Lovering, Yip and Nordhaus (2016) collected historical Nuclear reactor-specific overnight construction cost ("OCC") data for 349 reactors in the US, France, Canada, West Germany, Japan, India, and South Korea, encompassing 58% of all reactors built globally.[11] The historical data shows that costs have not evolved in the same way in different countries. While OCC has increased in some countries over time (the US being an extreme case of this), some countries have shown stable costs over the long term while some have even experienced cost declines.

This difference in historical costs may motivate the use of hybrid costs. However, in using costs from various countries, it is also important that the reasons for the differing costs are considered. As observed by Lovering et al., the evolution of costs over time depends on different regional, historical, and institutional factors. Even with the same reactor technologies, there is a large variance in cost trends over time. This implies that cost drivers other than learning-by-doing have a significant impact. Lovering et al. suggests that some of the cost drivers include utility structure, reactor size, regulatory regime, and international collaboration.[12] Thus it is not sufficient to only take the costs into consideration, without accounting for the factors that drive these costs.

Importantly, the Draft 2016 IRP has not taken delays and cost overruns into consideration when determining the predicted cost of Nuclear technology. This is especially important given South Africa's lack of experience with Nuclear power plants relative to some countries that may make up the hybrid cost estimates derived by the DoE. Nuclear technology has a history of delays and cost overruns.[13] An extreme example is the Watts Bar Unit 2 Nuclear reactor in the US which only neared operation in 2015 after construction began in 1973.[14] Also, in their World Nuclear Industry Status Report for 2016, Schneider and Froggatt found that Nuclear plant projects were delayed in 9 of the 14 countries analysed, and most of these were delayed by several years. These delays have occurred in countries such as China, Russia, US, Japan, France, Finland, Brazil and India.[15]

[11] Lovering, J.R., Yip, A. and Nordhaus, T., (2016), Historical construction costs of global Nuclear power reactors, Energy Policy volume 91, pages 371-382.
[12] Ibid, page 380.
[13] Carbon Connect (2014), Future electricity series part 3: Power from Nuclear, page 5.
[14] Bulletin of the atomic scientists (2015), Watts Bar Unit 2, last old reactor of the 20th century: a cautionary tale, 8 October 2015, available: http://thebulletin.org/watts-bar-unit-2-last-old-reactor-20th-century-cautionary-tale8783.
[15] Ibid, page 28.

Hossen, Kang and Kim suggests that the LCOE increases by 8%-10% for every year that a Nuclear project is delayed.[16] Delays and cost overruns have already been experienced in South Africa with the Medupi and Kusile plants, where costs grew from an estimated R69 billion and R80.6 billion in 2007 to R154.2 billion and R172.2 billion for Medupi and Kusile respectively.[17]

4.2.3. Conclusions on Cost Comparisons

A cost comparison analysis will show that conventional technology costs have increased since the publication of the 2010 IRP. For Nuclear specifically, the LCOE derived using the Draft IRP2016 assumptions are likely to be significantly lower than the LCOE derived using EPRI data, which means that the Base Case scenario will incorrectly infer that Nuclear technology is a cost optimal solution.

Conversely, the costs for renewable technologies have fallen to the level where they have become cost competitive with conventional technologies. As will be shown later in this report, correcting costs for the actual bids received in Bid Window 4 Expedited and assuming only modest further learning will result in a mix of renewables and gas as the least cost option for the country.

The EIUG therefore argues that there is a significant asymmetry in the risk of cost overruns between short-lead time technologies and long-lead time technologies such as nuclear, and this should be factored into the modelling in search of a least cost (and least risk) energy mix.

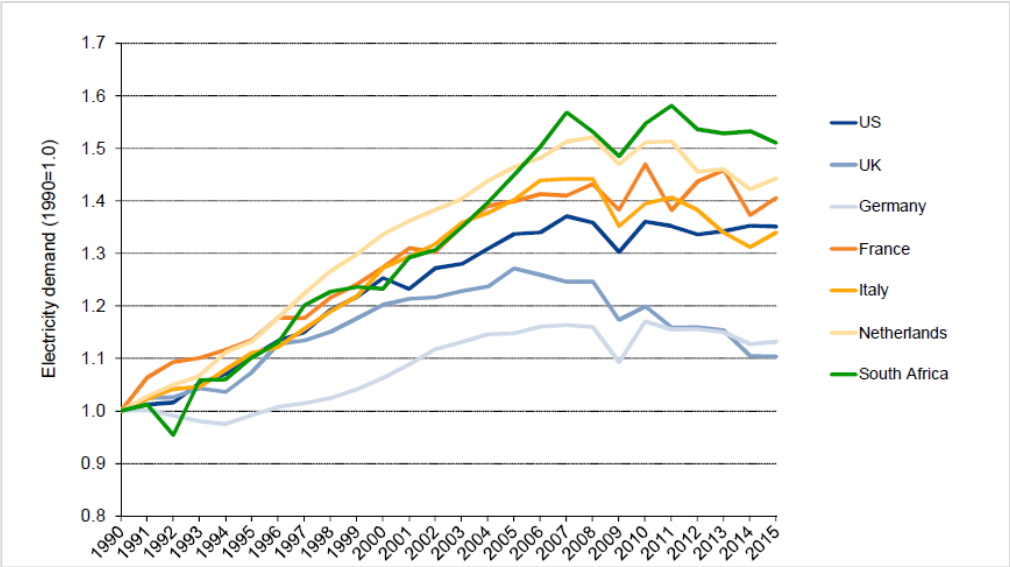
4.3. DEMAND ASSUMPTIONS

The demand forecast used in the IRP2016 Base case is unrealistic. South Africa's electricity demand has not grown since 2007, due largely to significant price increases, structural (not cyclical) changes in commodity markets, weak economic growth and improved energy efficiency. The lack of generation capacity was **not** the main reason for the drop off in demand, meaning the availability of new capacity will not automatically cause renewed demand growth.

Internationally, there has been a clear slow-down in demand growth in many parts of the world since 2007. Figure 2 presents the historic demand for selected countries, including South Africa for comparison. This was initially driven by the economic downturn in 2008 and higher energy prices, but the return of economic growth has not lead to a return in demand growth due to a greater focus on energy efficiency and a continuation of higher retail prices for electricity.

[16] Hossen, M.M., Kang, S., and Kim, J., (2015), Construction schedule delay risk assessment by using combined AHP-RII methodology for an international NPP project, Nuclear Engineering and Technology volume 47 (3), page 363.
[17] Mail and Guardian, Sinking into Eskom's black hole, 6 February 2015, available: https://mg.co.za/article/2015-02-05-sinking-into-eskoms-black-hole%20%5b2016.

FIGURE 2: HISTORIC DEMAND IN SELECTED COUNTRIES



Although the IRP has a long-term outlook, the initial 2.6% average year on year demand growth assumption, starting from 2016, is too optimistic. At the current energy intensity of the economy it translates to a GDP growth of close to 5%. We already know the GDP growth in 2016 was only 0,5%, and it may increase to 1,5% in 2017. Over-building, leading to over-capacity will result in severe price increases, stifling further growth and triggering a negative spiral, where above inflation price increases and falling demand feed on each other.

Coupled with the overly-optimistic demand forecast used in the modelling of the IRP2016 Base case, there is a high risk of overbuilding, leading to overcapacity which will result in higher electricity price increases that the country can ill afford. Demand is likely to remain low into the medium term, and there is currently an over-supply of electricity, which is also likely to hold into the medium term. There is sufficient time therefore, for a robust planning process to take place that ensures the least-regret investment decision is made for the country.

The EIUG engaged Pöyry Management Consulting to do a review of the demand assumptions used in the IRP2016 analysis[18]. This review is based on the information presented in the January 2016 report "*Forecasts for electricity demand in South Africa (2014 – 2050) using the CSIR sectorial regression model".*
This review is included here:

4.3.1. The Macro-Economic Assumptions Used Are Optimistic

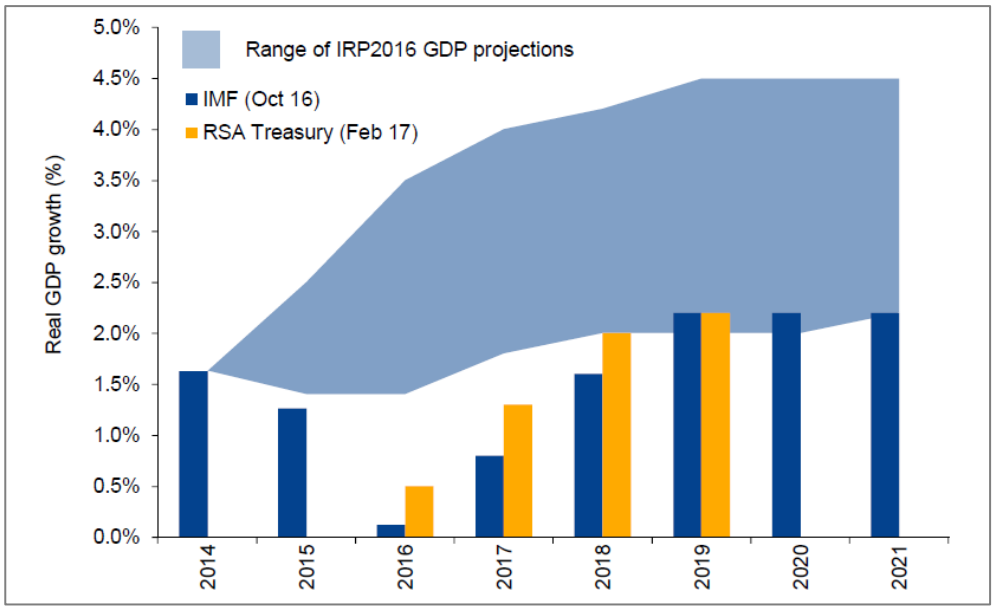
The source for the GDP and FCEH (final consumption expenditure by households) projections are not stated in the document. These are the key drivers of future demand growth and transparency over the source and date of forecast for these assumptions would be beneficial.

A widely-used benchmark forecast for GDP growth is the IMF GDP projection which is updated bi-annually. The latest IMF GDP projection is presented in Figure 3 alongside the GDP growth projections that were used in the development of the IRP2016 demand forecast scenarios. The assumptions used in the IRP2016 analysis are significantly higher than the latest IMF GDP forecast.

The February 2017 GDP growth numbers published as part of the 2017 South African budget also indicate a lower GDP growth rate more reflective of the IMF level than the level used in the CSIR forecast.

[18] Poyry: A Review of the Demand Forecast Used in IRP2016 (2017)

FIGURE 3: COMPARISON OF IRP2016 GDP PRJECTION AND IMF PROJECTION



Note: IMF forecast taken from their October 2016 WEO update

4.3.2. The Choice of a High GDP Growth Scenario for the IRP2016 Base case is Unusual

The demand forecast scenario for the IRP2016 Base case was selected to be the high economic growth scenario including an adjustment which reflects the trend towards less intensive consumption pattern in the commerce and manufacturing sector – the "*High (Less energy intensive)*" scenario.

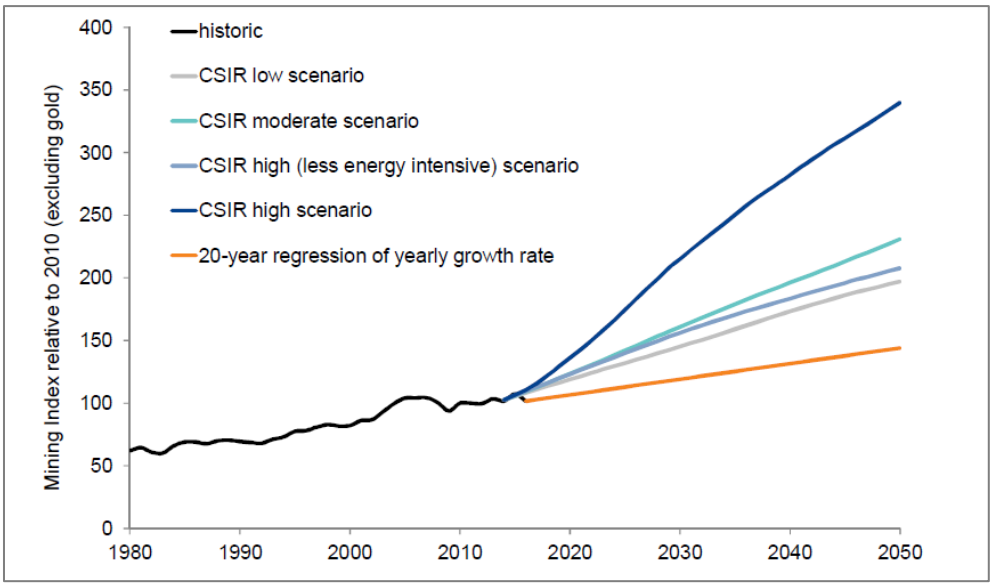
The most rational scenario for the IRP2016 Base case would have been a scenario which used the Central GDP growth assumption and reflected the trend towards less intensive consumption pattern in the commerce and manufacturing sector. This scenario has not been included in the demand forecast scenarios that have been developed.

4.3.3. Mining Index Assumptions are Optimistic

We believe the historic data for mining trends do not justify the projected increases used in the forecasts (shown in Figure 4). In all four of their scenarios, the expected growth rates are far higher than would be expected based on a continuation of the historic growth rate.

We believe it would be prudent to consider a scenario of no growth given the stagnation in the mining index in recent years.

FIGURE 4: EVOLUTION OF MINING INDEX IN SOUTH AFRICA



Source for historic data: Statistics South Africa

4.3.4. The historic data used to develop the regression relationships spans too great a period

The historic data from 1972 is presented in the CSIR document. It is not stated in the document, but our analysis suggests that data back to approximately 1990 has been used to develop the regression relationships. This allows many data points which is beneficial. However, there are other factors that are likely to outweigh this benefit:

- the nature of economic activity within each sector has changed dramatically over the last 25 years; and
- the technology that is used in each economic activity has in almost all cases changed dramatically over the last 25 years.

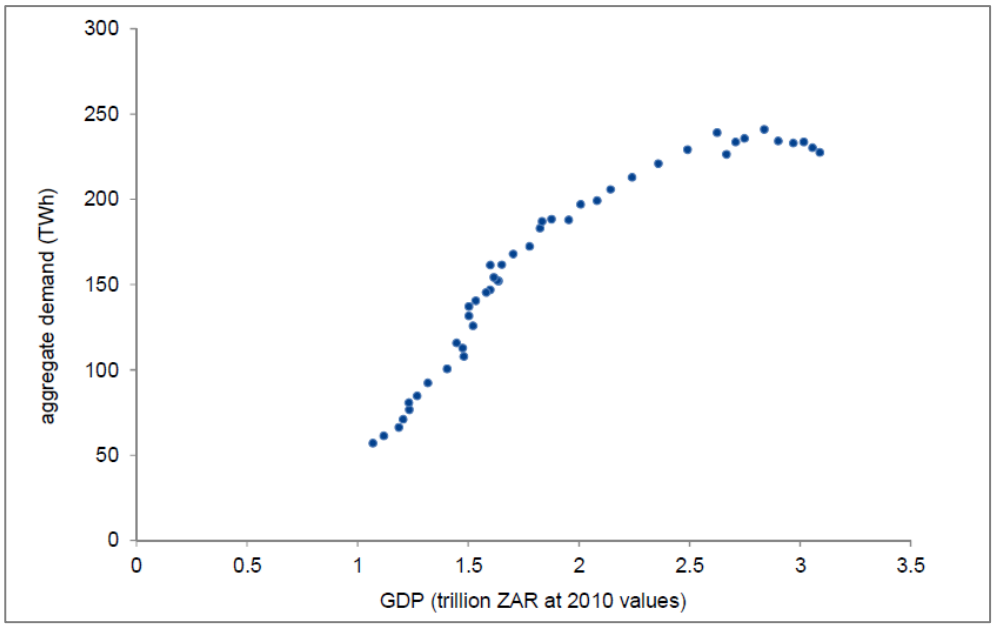
These factors mean that the relationship between electricity consumption and factors such as GDP and household consumption will have changed over time. The changing relationship between GDP and demand can be seen in Figure 5.

This is not reflected in the approach. Regression points that are 20 to 25 years old carry the same weight in the regression as data from 2013.

A shorter period which minimises the impact of these factors while still allowing enough data points for the regression relationship to be deemed significant would be more appropriate.

When a short period is used to develop the historic regression significantly different results can be observed and in some cases (such as in the transport sector) the regression relationships that have been developed almost completely disappear.

FIGURE 5: RELATIONSHIP BETWEEN GDP AND ELECTRICITY DEMAND IN SOUTH AFRICA



4.3.5. The impact of higher electricity tariffs and domestic and agricultural efficiency improvements are likely to be understated

Energy efficiency measures have changed the relationship between economic activity and demand across many countries.

This has been no different in South Africa. The South African government has launched a range of initiatives to improve energy efficiency. This began with the launch of the National Energy Efficiency Strategy of South Africa in March 2005.

In addition to this, the retail tariff in South Africa has increased dramatically and has more than doubled in real terms between 2007 and present. There will be both short-term and long-term impacts of higher tariffs. The short-term impacts will be a shift towards less electricity intense activities. The longer-term impact will be to amplify this shift by a change in investment patterns.

The regression analysis attempts to reflect the efficiency gains in the manufacturing and industrial sector to reflect the impact of efficiency improvements. However, no explicit accounting for energy efficiency has been accounted for in other sectors.

4.3.6. Scenarios do not reflect the future uncertainty in energy efficiency gains

The CSIR document presents four scenarios for the future electricity demand in South Africa. The key differentiator across the scenarios is the macroeconomic conditions (represented by factors such as GDP and FCEH). The High scenario is additionally differentiated by a shift in economic activity towards less intensive forms of economic activity.

The approach is based on a continuation of historic trends. The uncertainty over the long-term impact of greater energy efficiency on demand growth is not properly explored within the scenarios. Given the high level of uncertainty, we believe this should also be considered as a scenario driver. One way to do this is to explore differing lengths of regression period to add greater weight to more recent years where a marked change between economic activity and demand has been observed.

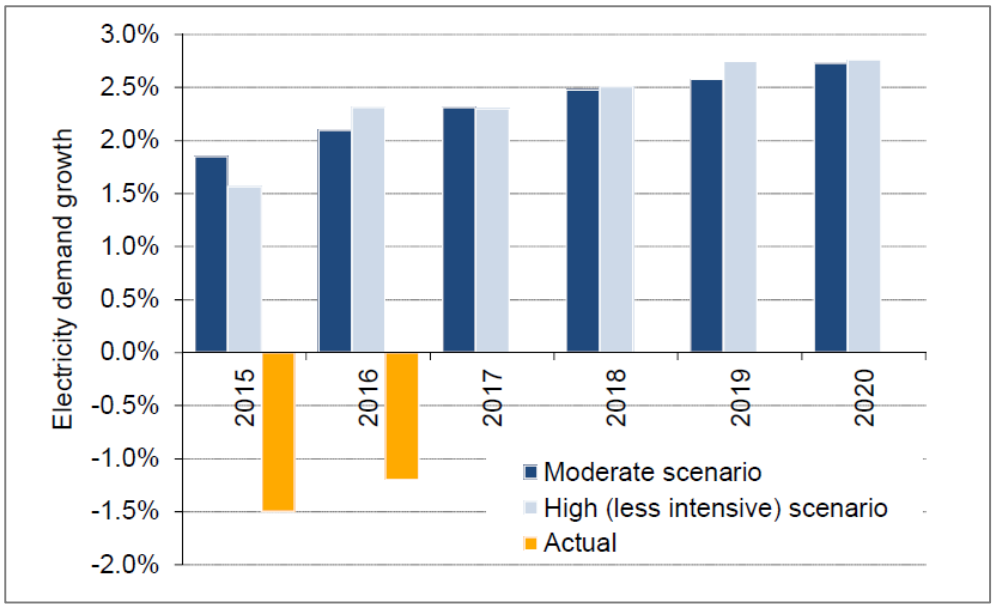
Eskom's low scenario in their capacity adequacy assessment shows close to no growth over the coming nine years which is designed to explore a continuation of the low growth seen since 2008[19]. A similar scenario in the IRP2016 analysis is essential in our view.

4.3.7. The forecasting model has significantly over-forecasted demand growth in 2015 and 2016

A key test of any forecasting model is how it against available out-turn data. The CSIR document includes a demand forecast for 2015 and 2016 which can be compared against the actual outturn values. Figure 6 present the forecast from the moderate and High (Less Intensive) scenarios against the actual outturn demand growth.

While the CSIR regression predicted an increase in demand growth, there has been a fall in the past two years. There should be analysis or discussion as to why this has occurred.

FIGURE 6: ACTUAL ELECTRICITY DEMAND GROWTH COMPARED TO SCENARIO FORECASTS



Source: StatisticsSA and CSIR

4.3.8. The starting point for the forecast does not reflect the recent

The first year of the demand forecast prepared by CSIR is 2015. This means that actual demand data for 2015 and 2016 is not reflected in the model.

The impact of this is that the current level of electricity demand is 6.7% below the forecast used in the IRP2016 Base case. At a minimum, the IRP2016 Base case should be updated to reflect this lower starting point.

4.3.9. Other Comments

- **Losses**: The CSIR document assumes that energy losses increase from 8.5% to 11.5% in the coming five years. This seems too aggressive given that total energy losses in the last five years were reported by Eskom were around 8.5%.
- **Data provision**: The CSIR document flags the lack of quality sectorial level data on energy consumption. We absolutely concur with this concern. The provision of accurate sectorial demand data would be a low-cost activity that would add transparency to the area of electricity demand analysis and enhance forecasting.

[19] Eskom, 'Medium-term System Adequacy Outlook 2016 to 2021'

- **Statistical significance**: The adjusted R-squared value for the overall regression is reported. The statistical significance of each regression variable is not reported and would be a beneficial addition to the report.
- **Normalisation**: The historic demand has not been normalised for temperature or load shedding that occurred.
- **Peak demand**: The forecast is only a forecast of the future volume of electricity demand and not the change in the pattern of consumption across the year and the level of peak demand that may be experienced. The government is separately undertaking a range of initiatives that will lead to greater demand-side participation that could have the effect of slowing peak demand growth relative to volume demand.

4.4. DEVELOPMENT OF AN ALTERNATIVE FORECAST

4.4.1. Poyry Forecast

Pöyry has developed a spread sheet electricity demand model, which is based on the economic relationships between demand growth and changes in GDP. Underlying the model is an econometric 'error correction' model capturing the effect of GDP on aggregate power demand. Estimates are based on historical correlations between power demand and both the absolute value of GDP and its rate of increase. This procedure gives a long-term relationship between aggregate demand and GDP, together with short term corrections associated to changes in GDP growth.

The form of regression that is used is as follows:

$$\Delta\, power\ demand_t = \alpha + \beta * \Delta\, gdp_t - \gamma * (power\ demand_{t-1} - \delta * gdp_{t-1})$$

The model has the capability to take additional optional economic indicators, such as assumptions on population growth, increases in energy efficiency gains and the deployment rate of electric vehicles. We have not activated these elements.

Figure 7 shows a short-term recovery from the dip in demand observed since 2011 followed by a stabilisation into a long-term trend. The long-term trends in the Central and High scenarios differ between the models due to the following factors:

- The Low scenario represents a continuation of the stagnation in demand growth that has been seen in the past 10 years.
- This scenario is characterised by lower GDP growth along with a shift from heavy industry to less intensive service focused industries.
- In 2030, our Low scenario consumption is 3.8 MWh per capita.
- This is a similar level to the consumption level to the current level in Poland (3.9), Hungary (3.9), Chile (3.9), China (3.8) and Croatia (3.8).
- These countries have a significantly higher GDP per capita than South Africa.

We therefore believe that the Low scenario is credible and explores the potential for economic development that is focused on less energy intensive activities.

FIGURE 7: DEMAND PROJECTIONS FOR SOUTH AFRICA (REVISED CSIR PROJECTIONS)

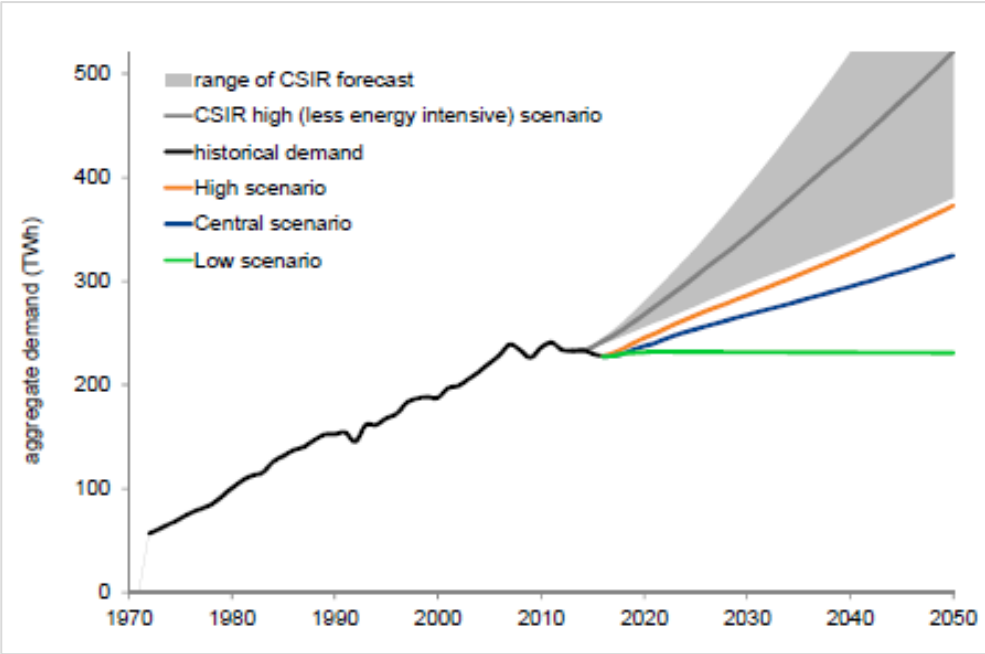
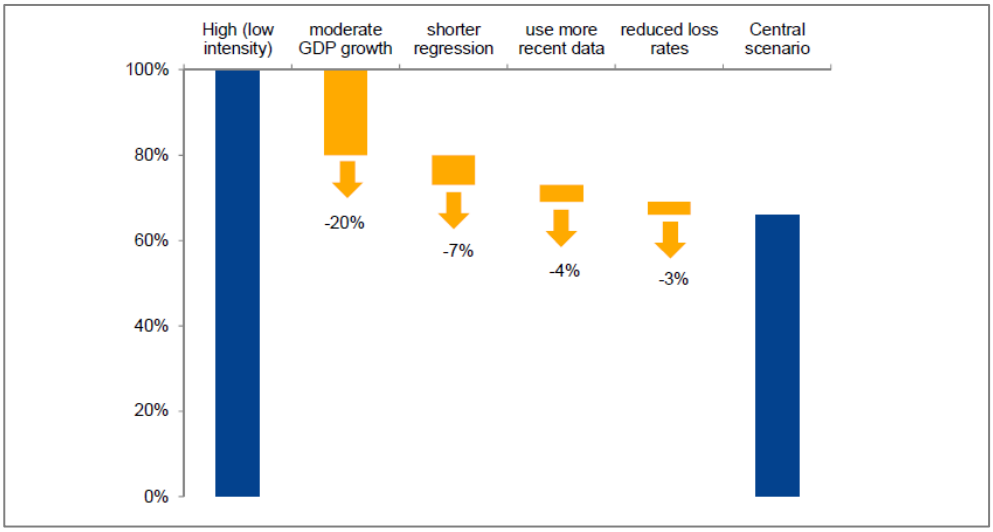


FIGURE 8: MAIN FACTORS ACTING TO REDUCE CSIR DEMAND PROJECTIONS



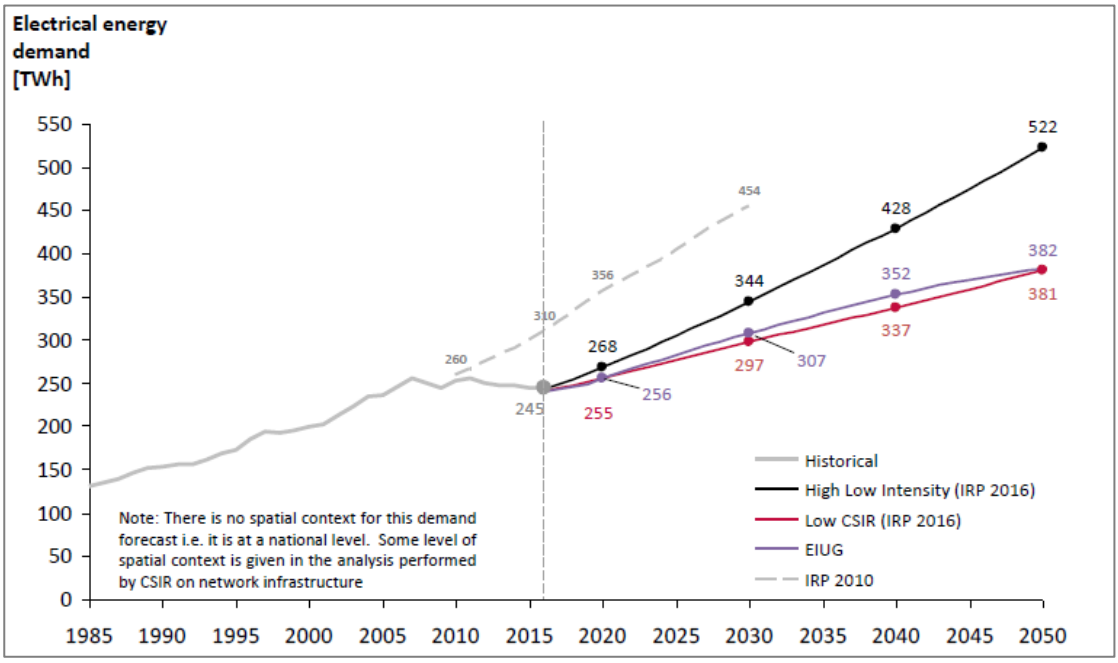
4.5. CSIR ENERGY CENTRE SCENARIOS

Given the relative good fit of Poyry' s "High Scenario" to the IRP2016 "Low Scenario", the EIUG requested the CSIR Energy Centre team to model the IRP2016 "Low Scenario" as the sensitivity in their Electricity Scenarios work. The CSIR Energy Centre team used the exact same Plexos software for the system modelling, as well as the identical input assumptions used by the DoE, except for specific items as mentioned below per scenario.

While the EIUG concurs with Poyry's Central scenario, the Poyry High scenario (or the IRP2016 Low scenario), ending up at 380 TWh per year by 2050, is seen by the EIUG as "erring on the side of caution" and building rather too much than too little. It limits the risk of over-building and triggering a death spiral where excessive new capacity cause drastic price increases, leading to low or negative growth, grid defection and the stranding of existing assets. The IRP "low-demand" forecast is used as the EIUG demand forecast.

Figure 9 indicates the good fit of the EIUG demand growth forecast with the IRP2016 Low forecast used for the draft IRP2016 Base case.

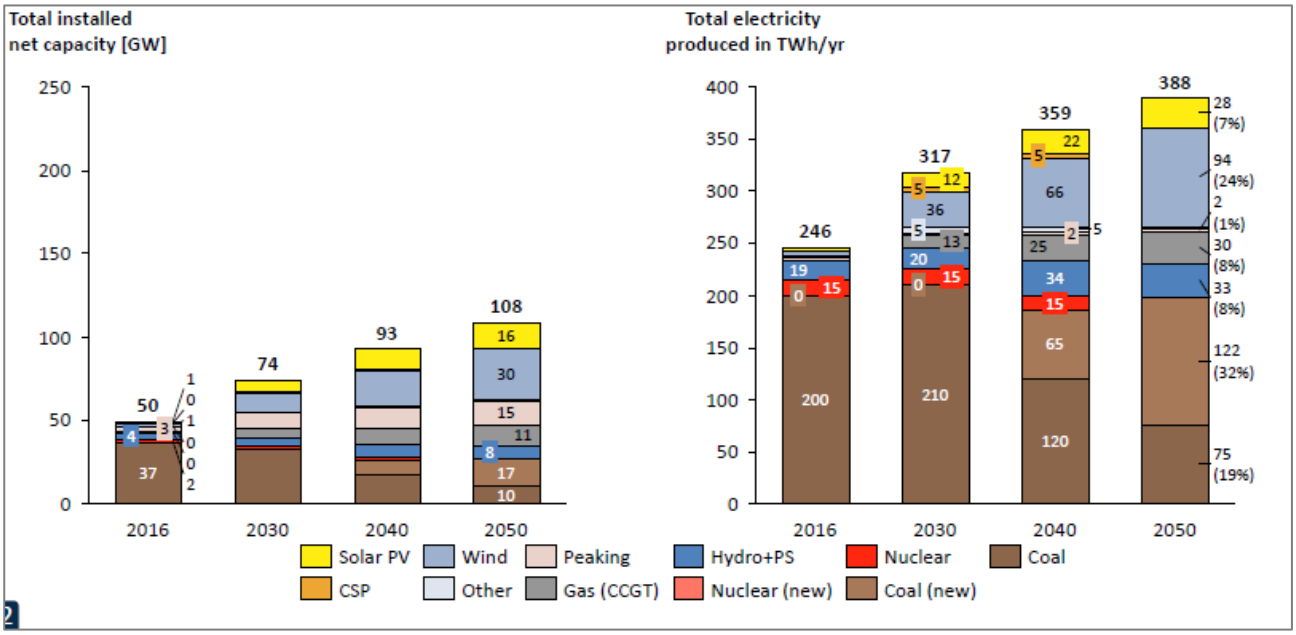
FIGURE 9: DEMAND FORECASTS



Source: CSIR Analysis

The results of the CSIR Energy Centre Team modelling with the EIUG growth assumption for the IRP Base case scenario is shown in Figure 10. As can be seen the model will not select nuclear but build more coal beyond 2030, since the low demand growth will maintain the emissions profile below the Peak Plateau Decline limitation.

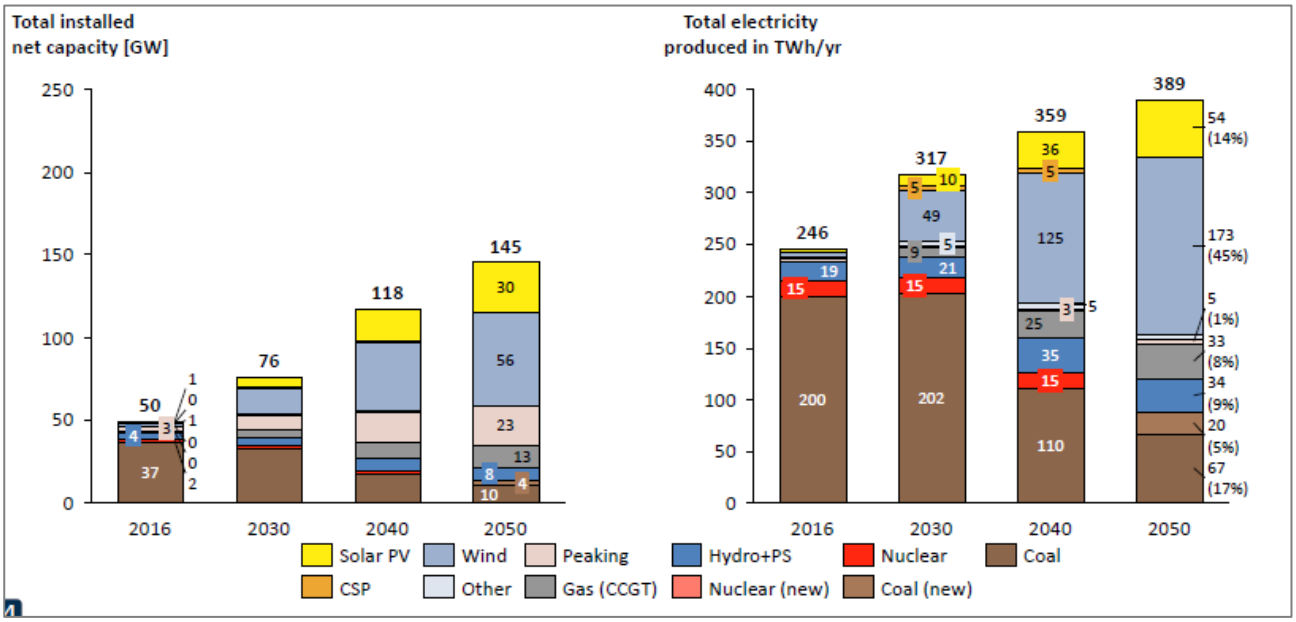
FIGURE 10: BASE CASE: LOW DEMAND



Source: CSIR Analysis

In Figure 11 the results are shown for the Low demand growth scenario without any limitation on renewables. The model therefore builds more renewables and no further coal beyond Kusile and the committed coal IPP.

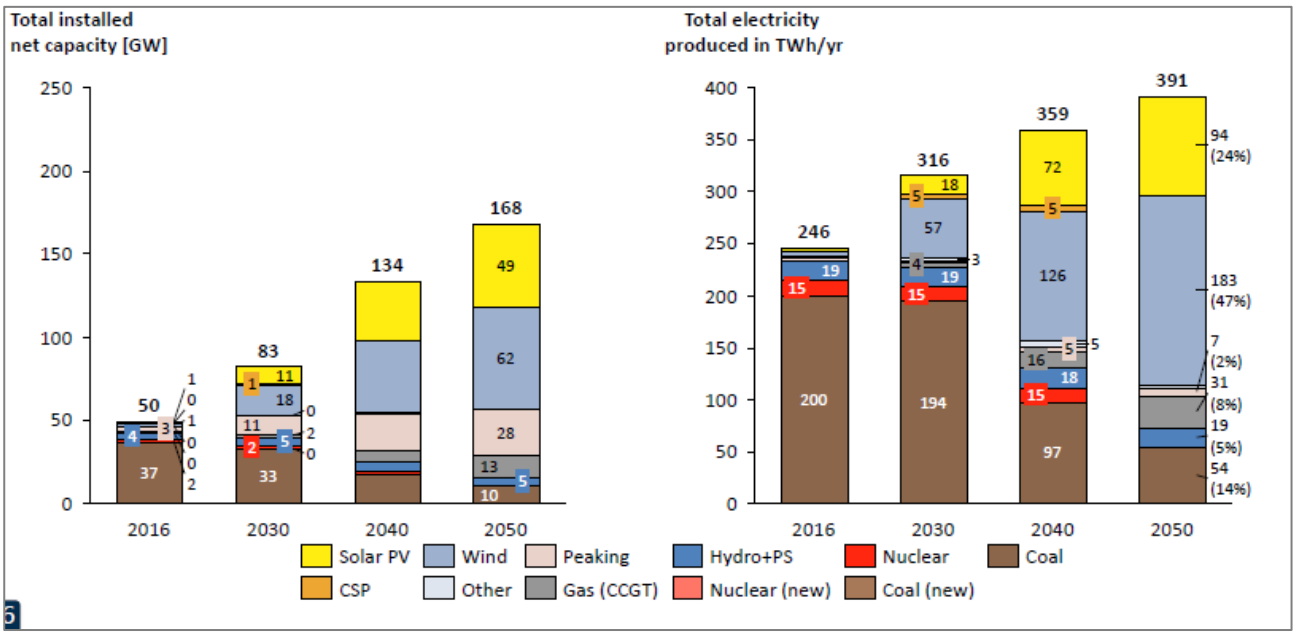
FIGURE 11: UNCONSTRAINED BASE CASE: LOW DEMAND



Source: CSIR Analysis

Finally, the modelling results of the Low demand scenario with the costs of renewable technologies based on the REIPPP bid window 4 Expedited results is presented in Figure 12. As can be expected, the optimal mix will contain more renewables and gas, but will result in the lowest LCOE.

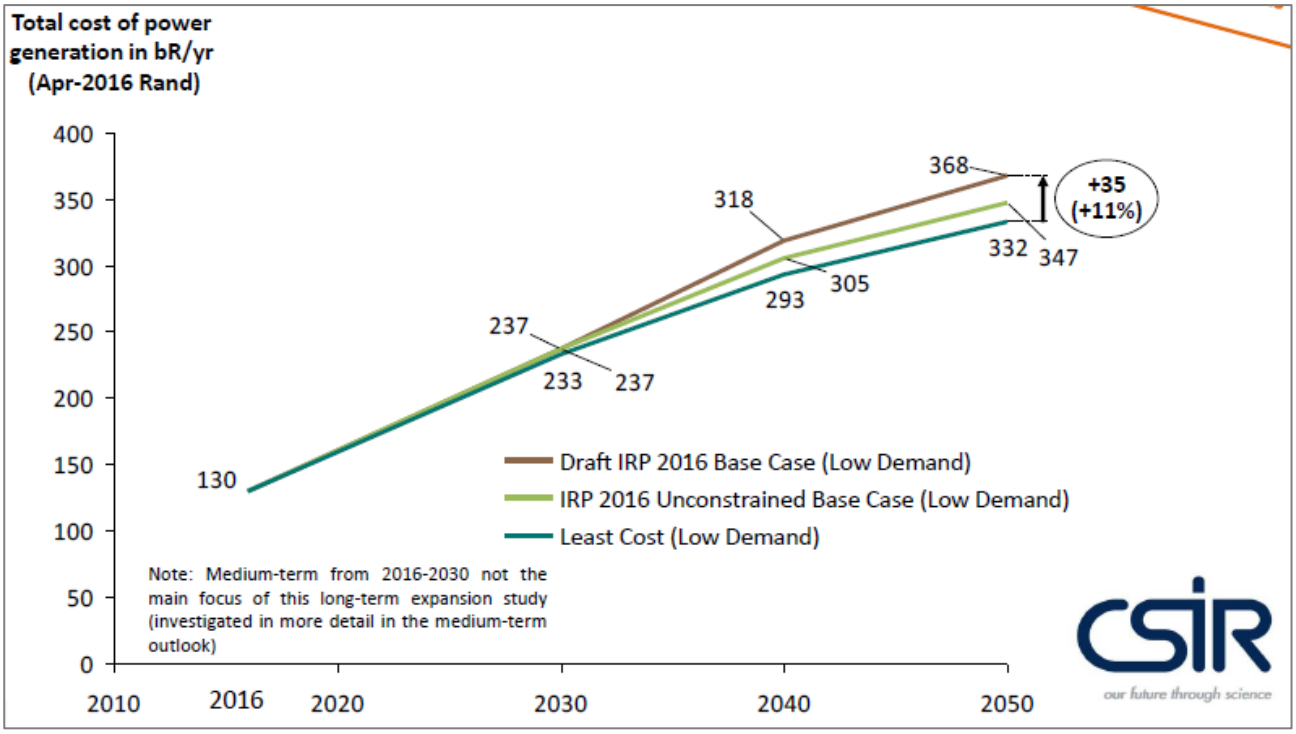
FIGURE 12: LEAST COST: LOW DEMAND



Source: CSIR Analysis

Figures 13 and 14 show the total cost of generation as well as the average tariff (without cost of CO_2) for the three above scenarios.

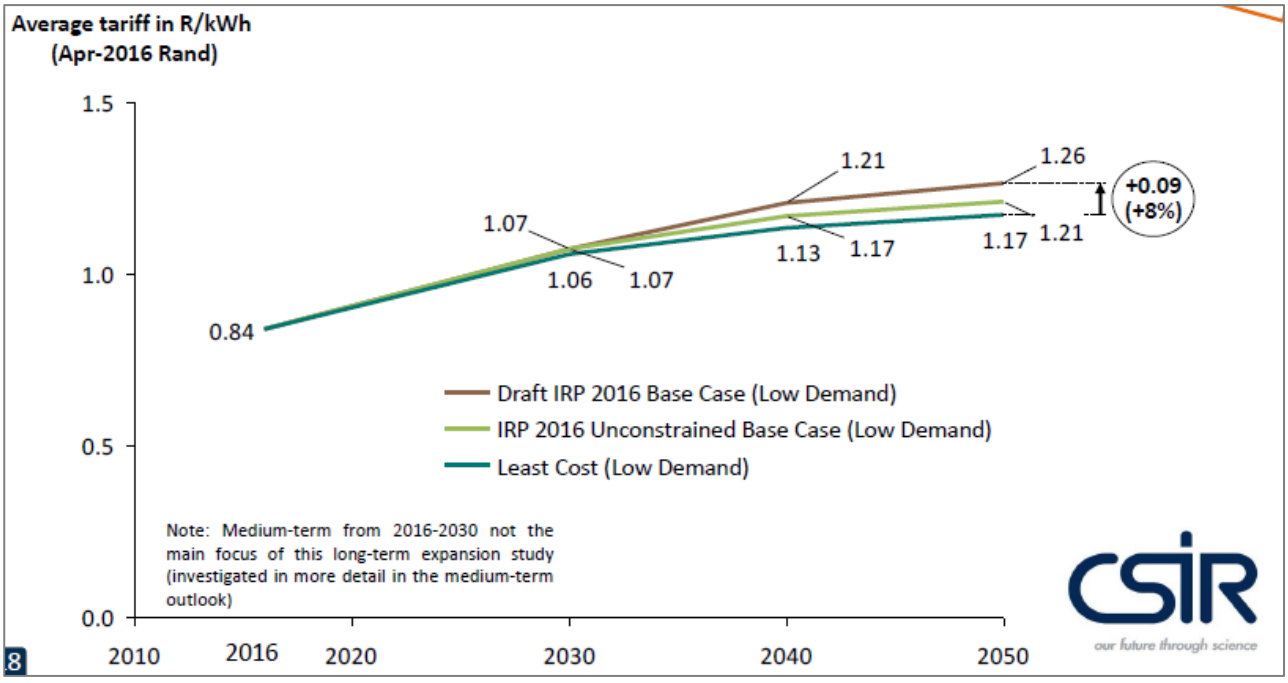
FIGURE 13: TOTAL COST OF POWER GENERATION: LOW DEMAND BASE CASE



Source: CSIR Analytics

≈R35 bn/year more expensive by 2050 than Least Cost (without cost of CO^2)

FIGURE 14: AVERAGE TARIFF (WITHOUT COST OF CO2)

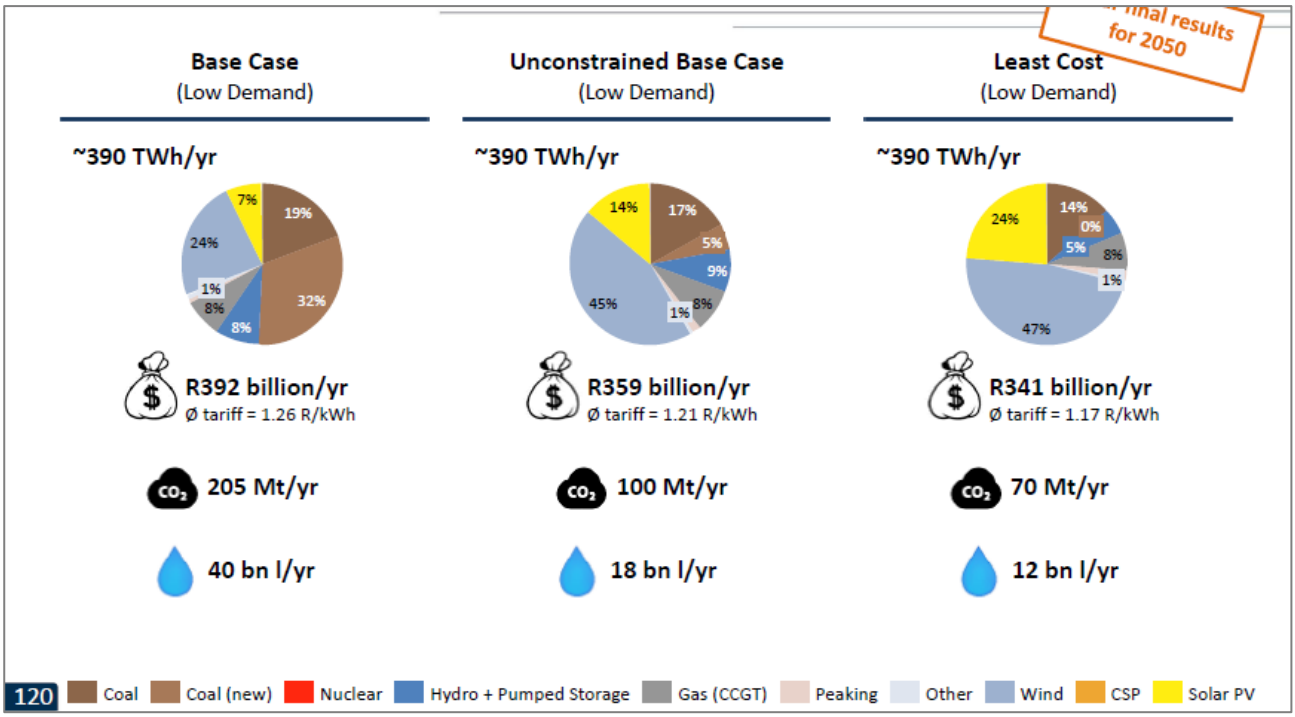


Sources: Eskom on Tx, Dx cost; CSIR analysis

Note: Average tariff projections include 0.30 R/kWh for transmission, distribution and customer service (today's average cost for these items)

Base case tariff 9 cents/kWh higher than Least Cost by 2050

FIGURE 15: COMPARATIVE ANALYSIS OF LOW DEMAND SCENARIOS



Sources: Eskom on Tx, Dx cost; CSIR analysis
Note: Average tariff projections include 0.30 R/kWh for transmission, distribution and customer service (todays average cost for these items)
~R20 billion/year cheaper by 2050 than IRP 2016 Base case

The modelling results of the CSIR Energy Research team for the optimal build plan to meet the EIUG demand forecast (like the IRP2016 Low Demand) indicates that:

- *The country is moving into an over-supply situation with new base load capacity only required beyond 2030 (in the IRP2016 Base case scenario with constrained renewables)*
- *No nuclear is selected in any of the scenarios. This concurs with the EIUG view that nuclear is not part of the least cost mix over the medium term, and may lock the country into a very expensive long-term liability and strand existing coal fired capacity.*
- *South Africa is in the fortunate position that the electricity supply industry has a negative carbon abatement cost, meaning that the least cost supply mix going forward has also the lowest carbon footprint and uses the least amount of water.*

4.6. CARBON CONSTRAINT

The use of the term "carbon budget" in the context of the electricity sector is not understood as carbon budgets are a mitigation instrument imposed on individual entities not on sectors.

The recently released report on the proposed post-2020 national mitigation system[20] make this clear. It is suggested that the approach set out in this report be used as the basis for developing the carbon constraint that should be imposed on the sector.

It should be noted that if either the least-cost Base Case, or a carbon constraint scenario will meet governments carbon reduction obligations, as defined by policy, there is then no need for an additional carbon price in the form of a carbon tax.

[20] DNA Economics, The Green House, Development [of] South Africa's climate change mitigation system: Updated Interim Report.v5 (2017)

Under a Base Case scenario with no artificial technology constraints, the least-cost scenario is also the lowest GHG emission scenario. There is therefore no need for the inclusion of a carbon constraint in the Base Case. If the least-cost Base Case scenario does not meet the emission reduction trajectory defined by government policy, an additional sensitivity with the required carbon reduction constraint should be modelled as a policy adjusted scenario.

4.7. OTHER CONSIDERATIONS

Although not strictly in scope for the IRP2016 the EIUG wishes to deal briefly with the following issues:

4.7.1. Network Challenges

The DoE and Eskom have indicated in public consultations and in the media, that there are grid capacity constraints for Renewable Energy capacity additions. Per the DoE, the issue with connecting Renewable Energy capacity to the national electricity grid is that Renewable Energy projects tend to be in isolated places with insufficient connection points.[21] Further complications arise because of delays in securing sites and servitudes as well as obtaining the necessary environmental and other statutory approvals, which have been highlighted in Eskom's latest Transmission Development Plan ("TDP").[22]

The EIUG wishes to point out that the low demand growth outlook will require a slower roll out of renewable generation and that distributed generation often can be connected into existing infrastructure, while new mega scale base load power stations require substantial connection facilities. It should therefore be possible to accommodate the roll out of distributed generation with proper grid planning, allowing for the least cost energy mix to be achieved.

4.7.2. System Stability

The premise that Renewable Energy technologies are unreliable and unstable in South Africa has been challenged in a recent study by the CSIR.[23] This comprehensive study examined Wind and Solar PV resources across the country and made the following observations:

- Wind and Solar resources across the country are both "extremely good", and Wind resources are better than previously believed[24];
- Wind and Solar PV are on a par in terms of magnitude and cost competitiveness;
- Wind and Solar PV can be built as complementary technologies, as Wind supply peaks typically in the evening and Solar PV in the middle of the day;
- There is low seasonality in both Wind and Solar resources in South Africa;
- Wind farms should be located across the country, as short term fluctuations in the aggregated Wind power feed-in are significantly reduced by wide spatial distribution".[25]

The CSIR modeling indicates that a portfolio of Wind and Solar PV, combined with flexible gas fired generation will provide reliable and stable electricity at a levelised cost of energy comparable to that of traditional technologies such as coal and nuclear.

[21] See for example Greve, N. (16 February 2017) Playing dirty with clean energy: How government is putting jobs and investment at risk", Finweek.
[22] Eskom (2016) Transmission development plan 2016-2025, pg. 3: http://www.eskom.co.za/Whatweredoing/TransmissionDevelopmentPlan/Documents/TransDevPlan2016-2025Brochure.pdf.
[23] Knorr et al (2016) Wind and Solar PV Resource Aggregation Study for South Africa: Final Report: https://www.csir.co.za/sites/default/files/Documents/Wind%20and%20Solar%20PV%20Resource%20Aggregation%20Study%20for%20South%20Africa_Final%20report.pdf. This study conducted by the CSIR in collaboration with the South African Energy Development Institute, Eskom and the Fraunhofer Institute for Wind Energy and Energy Systems in Kassel, Germany.
[24] More than 80% of South Africa has enough Wind for high load factors.
[25] Dr. Stefan Bofinger, Britta Zimmermann, Ann-Katrin Gerlach – Fraunhofer IWES, Dr. Tobias Bischof-Niemz, Crescent Mushwana – CSIR (3 March 2016) "Wind and Solar PV Resource Aggregation Study for South Africa: Public presentation of results." http://www.wasaproject.info/docs/PVWindAggregationstudy.pdf.

System stability aspects such as frequency control, system inertia and reactive power control require further work if deep penetration of renewables is to be achieved. The South African power system is however still very much dominated by coal and nuclear generation and the addition of further renewables will not take the country close to stability limits for many years. South Africa therefore has the time to witness and learn from the progress made in countries such as Ireland, which is also on an island grid and achieves levels of renewable generation of up to 60% lately without causing grid instability.

4.7.3. Embedded Generation (including Co-Generation)

The requirement for embedded generation, such as co-generation amongst others, to be included in the IRP as a licensing pre-condition, is problematic. The EIUG proposes that the requirement be removed, since generation behind the meter cannot effectively be centrally planned. It will be more practical to allow the host facility (be it an industrial plant or commercial building) to invest in embedded generation if the business case for such an investment meets its financial criteria, provided obviously that all technical requirements are met and the facility is registered or licensed with NERSA.

Assuming embedded generation is registered with NERSA, the amount of embedded generation across all technologies would be known for planning purposes.

4.7.4. Socio-Economic Impacts

Whatever form the future energy mix takes, there will be an impact on jobs and the shape of the economy. The decommissioning of the current Eskom coal-generation stations is certain as they come to end of life, however there is time to manage the jobs lost in this this sector if this transition is properly planned. While it may well be that there is space for coal in the future energy mix, its share is guaranteed to be low, given the international commitments made by South African to lower the carbon emissions (in the absence of viable carbon capture & storage).

The EIUG also concedes that there may be many so-called green-jobs in the future, however the numbers currently quoted are highly disputable. In addition, a key consideration missing from the numbers and debate is that the skills of workers in the current economy, are not transferrable to the different economy. This again can be managed. It is not the role of the IRP, or the DoE necessarily to deal with these consequences of the IRP; the EIUG's recommendation to government is to have socio-economic assessments run against the main scenarios developed in the final IRP2016, and to then ensure that concerns raised in these assessments are addressed.

Though there may be jobs lost and gained depending on the shape of the energy generation directly, job creation should take place in the overall economy, not in the power sector. Or put another way, electricity should be an enabler for development and employment, rather than a massive direct employer itself. This can be achieved by ensuring that the least-cost electricity generation plan is developed.

5. CONCLUSION

Analysis of the Draft IRP2016 has shown that the demand forecast used by the DoE is far too optimistic. The EIUG has shown that demand growth has leveled off internationally after the 2008 economic meltdown, and the return to economic growth in many countries has not led to a return in demand growth due to a focus on energy efficiency and higher retail prices. In South Africa, the phenomenon is even more pronounced due to structural changes experienced in international commodity markets. The DoE demand forecast used too optimistic macro-economic and mining index assumptions, and used regression relationships spanning too great a time. Thus, the current level of electricity demand is already 6,7% below the forecast used in the IRP2016 base case.

The EIUG developed an alternative demand outlook with the assistance of a reputable international consulting firm. The EIUG demand outlook has a good fit with the IRP2016 Low Demand scenario, and the CSIR Energy Research team agreed to model it as a sensitivity in their Electricity Scenarios work. The results of the study indicate that the lowest cost supply mix for the country is a combination of renewable technologies and gas fired generation. South Africa is in the fortunate position that it has a negative carbon abatement cost for de-carbonising the power grid, meaning that the lowest cost technologies are also the cleanest (and have short lead times).

Under a Base Case scenario with no artificial technology constraints, the least-cost scenario is also the lowest GHG emission scenario. There is therefore no need for the inclusion of a carbon constraint in the Base Case. If the least-cost Base Case scenario does not meet the emission reduction trajectory defined by government policy, an additional sensitivity with the required carbon reduction constraint should be modelled as a policy adjusted scenario.

While the EIUG remains technology agnostic, the country needs reliable electricity supply at the lowest possible cost, delivered by a build plan using technologies that offer modularity and the flexibility to match the vagaries of demand.

Given the current uncertainties and vagaries of demand it will be very risky to embark on new base load investment over the short to medium term. Correcting the country demand growth outlook to a more realistic level shows that we are entering a period of significant over-capacity, and forcing in a long-lead time and inflexible nuclear investment decision can lead to unaffordable price increases, the stranding of significant coal capacity and early closure of mines.

6. RECOMMENDATIONS

In general, the document contains numerous statements and approaches which are not substantiated. It is recommended that all decisions made as part of the methodology in the final version of the IRP should be substantiated in a transparent way that allows stakeholders to follow the reasoning.

The Base case scenario should always be the least cost scenario against which all scenarios and sensitivities are tested. These additional scenarios should only impose justifiable and verifiable technical or policy considerations on the least cost option. As well as the development and publication of reliable electricity price paths for each scenario. Finally, that water conservation and socio-economic impacts and costs must also be considered in the policy adjusted scenarios.

The EIUG recommends that there must be consultations on the outputs of all current, proposed and accepted scenarios modelling work, and the potential basis and parameters for 'policy adjustment' to produce an actual plan. At least 60 days must be afforded for input on the scenarios. Once the draft policy-adjusted IRP is available, the public must have at least 30 days to provide comments thereon.

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U.S. Department of Energy, Office of Indian Energy, Levelised cost of energy, available: https://energy.gov/sites/prod/files/2015/08/f25/LCOE.pdf.
https://www.andrew.cmu.edu/user/ilimade/Ines_Azevedo/papers/Rubin_2015.pdf. This study established the mean learning rates (i.e. % cost reduction from doubling of cumulative installed capacity) for Solar PV as 12% and 16.5% for Wind. Given that installed capacity is expected to grow exponentially over the IRP period, the reduction in costs is likely to be significantly greater than these percentages.