WWF South Africa inputs on the draft Energy and Resource Plans

Executive summary

Energy plays a critical role in driving development and in ensuring human welfare. The Integrated Resource Plan and Integrated Energy Plan therefore play a critical role in achieving our developmental goals as set out in the National Development Plan. However, it is just as critical that developments in this sector do not undermine these same goals through negative externalities, as well as untenable expenditure on risky and costly assets.

Climate change in particular will have a devastating impact on our ability to realise our developmental goals. In order to ensure a 50% chance of limiting climate change to 2°C, no new carbon-emitting infrastructure must be built beyond what has already been procured[1]. The transition to a new, low carbon energy infrastructure will not come without challenges. However, it also presents opportunities, particularly to the developing world where access to energy is still limited. South Africa currently finds itself at a cross roads. It can either choose to invest in high-cost, risky assets which will increase the likelihood of dangerous climate change, or it can actively pursue a cleaner energy system, leveraging the industrialisation potential associated therewith, and thereby increasing the quality of life, security and income of future generations.

By fully engaging the realities of environmental impacts of the energy sector and embracing the opportunities of a shift to renewables, South Africa can realise opportunities in the just transition to a low carbon economy that will drive truly sustainable development. Given South Africa's abundant renewable energy resources, it could be a net energy exporter by 2050, including near zero-emission hydrocarbons from a power-to-liquids generation infrastructure. Moreover, the localisation of a shift to renewable energy can be a means with which to deliver much of the re-industrialisation which is a key developmental goal of the NDP. Much has been made of the potential loos of jobs associated with a transition away from coal power. However, international evidence is that renewable energy provides more, and better, jobs than other energy sources, as long as we invest in capturing the value chain.

The current iteration of the IEP and IRP falls short on vision, aligns poorly with other national guiding documents including the NDP, National Transport Master Plan and SA's proposed mitigation goals under the Paris Agreement, and does not serve the best interests of the country. It cleaves strongly to a paradigm that undermines the wellbeing of future generations: that improving livelihoods and human wellbeing is best delivered through fossil-fuel intensive development. This paradigm has been undermined both by the developmental outcomes of the last fifty years, and the critical scientific evaluations of the risks of climate change. WWF South Africa calls on the Government of South Africa to remove artificial constraints to the provision of renewable energy, to work from a base case that adheres to our national mitigation goals at the lowest cost, and to further investigate the potential for increased ambition in reducing emissions and driving national development along the lines of a low-carbon economy. We hope to work together to realise this vision of a more equitable, low cost and sustainable future.

[1] Pfeiffer et al., "The '2°C Capital Stock' for Electricity Generation."

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Introduction

"By acting now to stabilise debt, we will ensure that future generations will not pay for today's expenses, 20 or 30 years from now."

Pravin Gordhan, Budget speech 2017

WWF welcomes the long-overdue publication of the draft Integrated Resource Plan and Integrated Energy Plan for comment at this critical moment in South Africa's development. Planning the nation's energy future is one of the most important elements to enable the transition to more equitable and low carbon economy. Whilst South Africa is currently showing signs of decoupling GDP growth from increasing energy intensity, the country will need appropriate sources of power in the future to support a growing population and to achieve real developmental goals. Moreover, because the energy sector represents nearly 78% of the total national greenhouse gas emissions, it is the low-hanging fruit in terms of global mitigation. Given the reality and imminence of human-induced climate change, and the national commitment to addressing a fair share of the global mitigation responsibility, a much lower total national emissions budget will be needed.

Concerted action to decarbonise the energy sector is the most important means of realising the global ambition of limiting climate change to well below 2°C by the end of the century – a peer-reviewed global analysis of current energy generation estimates that to have a 50% chance of achieving this goal, no new carbon emitting infrastructure can be built[2] beyond what is already financially committed. Reducing both the total emissions and the relative proportion of national emissions from the sector whilst ensuring sustainable development is therefore both an opportunity and a necessity for South Africa.

At the same time, investment in nuclear energy has historically proven hugely expensive, with the IRP and IEP systematically underestimating the costs of a large nuclear build. Apart from the environmental and social risks associated with nuclear energy, there are serious questions around the disposal of radioactive waste and the cost associated therewith, something South Africa has inadequately planned for to date. Furthermore, the opportunity cost of heavy nuclear investment is extensive when compared with alternative low carbon technologies such as wind and solar power.

The global energy market is in flux as renewable energy comes to maturity, with battery prices dropping more than 60% since 2007[3] and wind and solar PV reaching price parity with conventional coal plants (even without considering the externalities associated with carbon, water and human health of old technologies). The potential for a step-change in energy consumption and production is high, and South Africa should not commit itself to costly long-term energy infrastructure projects such as nuclear power, or carbon-intensive development fuelled by coal as this transition plays out.

Smaller investments over short time horizons will protect our ability to address power needs in a cost-effective manner whilst enabling the rapid deployment of evolving low-cost climate-friendly technologies. Rolling these technologies out on a larger scale also allows us to leverage the industrialisation potential associated therewith. The paradigm of heavy fossil fuel dependence for baseload may be rapidly overturned in the next ten years, and South Africa needs to ensure that it is well-positioned to capitalise on this transition to achieve the social, environmental and developmental goals articulated in the NDP.

It is in light of this imperative that we make the following comments and recommendations for the national energy planning documents.

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[2] Ibid.

[3] Nykvist and Nilsson, "Rapidly Falling Costs of Battery Packs for Electric Vehicles."

High level comments

Desired Outcomes

1. **Climate change mitigation ambition must be met and increased**

   Addressing climate change must be a non-negotiable goal for energy plans. At present, all the emission pathways articulated in the IEP will lead to South Africa greatly exceeding the national mitigation obligation (as characterised by the "peak, plateau and decline" model, or PPD) by 2050. This is inadequate: all scenarios in both documents must at a minimum adhere to the mitigation objectives to which South Africa has committed in the Paris Agreement. Moreover, the current alignment with the upper limit of the PPD model is insufficient; South Africa's fair share of global mitigation ambition lies below the midpoint of this trajectory. Since the lowest-cost and simplest mitigation measures are available within the energy sector, South Africa should look to ensure maximum mitigation in this sector. In addition, mitigation must not be limited to "CO_2 emissions" as it is throughout the IEP, but to all greenhouse gases listed as priority pollutants under the National Environmental Management: Air Quality Act. This effectively means no investment in coal power or coal-to-liquids beyond what is already contracted can be considered.

2. **No nuclear power should be built**

   There is no technical or economic justification for the use of nuclear power, and the cost of funding it has the potential to undermine the development of future generations. At present, all scenarios have a minimum of 9.6 GW, and the IRP uses a carbon cap as a carte blanche for high rates of nuclear penetration. The assumed price points used for nuclear power are unjustifiably low, multiple national planning documents (including the National Development Plan[4], the Ministerial Advisory Committee on Energy's submission[5], and the 2013 IRP update[6]) point out that nuclear is not a viable option, and in no case is the cost of waste disposal or environmental impacts of radiation considered.

3. **Renewable energy should be prioritised in all cases**

   As a consequence of the previous two points, the best options for provision of primary energy are in the renewable energy sector. If there were significant developmental, technical or economic cases to be made against renewable energy (as there are for some sources), then these might not be good options. However, as the cheapest form of primary energy, with the lowest atmospheric emissions and the lowest consumption of water, solar photovoltaics and wind energy should be prioritised for providing the basis for national energy planning. This includes the transport sector, where there is potential to shift away from fossil-based liquid hydrocarbons as the primary energy source over the next thirty-odd years. Additional resources should be deployed as needed to ensure that these sources are bolstered as needed, and should other energy sources should therefore be complementary rather than central to the plans.

4. **Stakeholders should be engaged to ensure that the IRP and IEP are living documents**

   The IEP and IRP are critical planning documents for achieving both national climate change mitigation ambitions and realising the developmental goals of the NDP. The discussion documents presented, whilst not being final products, are very concerning both because of the driving assumptions and apparent failure to consider the broader impacts of these documents. The IEP reiterates the importance of the periodic review of the plan so that it remains relevant and accounts for significant changes. However, this also reinforces concerns about government's failure to undertake such reviews for both the IRP and IEP. Regularly updating these key planning documents assists in aligning their outcomes and in ensuring the validity of key assumptions as

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[4] National Planning Commission, National Development Plan 2030. Our Future - Make It Work.
[5] Levington et al., "Report of the Ministerial Advisory Council on Energy (MACE) Working Group on Analysis and Recommendations on the Assumptions and Methodologies Adopted in the IRP 2016 Base Case Scenario."
[6] Department of Energy, "Integrated Resource Plan for Electricity (IRP) 2010-2030 Update Report 2013."

the energy landscape changes rapidly. Moreover, the revision should include stakeholder inputs not just during the initial phase, but into the policy-adjustment process as well.

5. **The Base Case must be the cheapest option for meeting all priorities**

The IEP has four scenarios addressing potential alternative pathways, but there are systematic issues with the scenarios that need addressing. Similarly, the IRP's base case is proposed as a de facto basis for electricity delivery, upon which different scenarios can be built. This base case is problematic, since it contains erroneous data and legacy policy restrictions from the prior paper rather than focussing explicitly on technical and economic feasibility. The correct base case for discussion should be the lowest-cost option for addressing projected demand, and all alternative scenarios should then cost the price of their deviation from this base case. This position has been presented by the Ministerial Advisory Committee on Energy[7], and is standard practice for planning. It allows a clear assessment of the costs of following specific political goals, and therefore the undertaking of cost-benefit analyses of such objectives.

Incorrect Assumptions and Constraints

6. **Ensure correct levelised cost of energy for all sources**

The correct costing of different energy options is a critical element for appropriate energy planning. These documents systematically overestimate the cost of **renewable energy**, which is now the cheapest form of power available globally[8,9]. Given the rapid learning rate experienced for these technologies, we can expect these prices to drop further, but at a minimum the values submitted by the private sector to Bid Window 4 (Expedited) of the REIPPP should be used as base costs for these technologies. Failure to correctly price these costs leaves the grid at risk of the "utility death spiral"[10].At the same time, unjustifiably low costs for **nuclear power** are assumed, justified by an unreleased internal DoE report that does not agree with globally-recorded costs for the technology. This appears to be specifically designed to make nuclear power an attractive economic option, despite the significant public rejection of the technology and demonstrated costs.

Shale gas is assumed recoverable in significant volumes and competitive pricing for the local market. Based on our own research, we find the underpinning assumptions not only optimistic, but unrealistic[11]. Similarly, relatively low and stable costs are assumed for **liquid fuels** despite the cost and price stability implications[12] of the global decline in conventionally-recovered oil reserves[13]. These assumptions are key components of the fossil-fuel heavy energy mix put forward in the IEP, and must be revisited.

Finally, all costings must integrate the **environmental externalities**, including water consumption and a suitable cost for carbon in line with international best practice[14] (as recommended, and ignored, in the IEP Annexure C1 (Energy systems externalities)). In addition, the carbon tax, as a mandated mitigation measure should be included and costed separately from the carbon price. When such costs and risks are taken into account, there is no viable economic case for coal, shale gas or nuclear electricity, and a shift from liquid fuels towards electricity is an undeniably sound investment.

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[7] Levington et al., "Report of the Ministerial Advisory Council on Energy (MACE) Working Group on Analysis and Recommendations on the Assumptions and Methodologies Adopted in the IRP 2016 Base Case Scenario."

[8] As of 2015, solar photovoltaic (PV) and wind energy are the cheapest bulk energy services available globally. They have been shown to be economic locally at 62c/kWh for solar and PV provided to the grid (through bids provide din the REIPPPP's Bid Round 4 Expedited), and global prices for PV have hit bid levels of 2.9 USc (~40c South African) in 2016.

[9] Sanders, "Chile Energy Auction Gives Bachelet a Success to Boast About."

[10] The lower lifetime costs of renewables compared to increasing electricity grid can incentivise higher LSM households to remove themselves from the grid. Since consumption from these relatively higher users subsidises grid maintenance, costs will rise to compensate, driving more off grid. To decouple this feedback effect, it is necessary for utilities to develop feed-in tariffs, capture the low-cost associated with RE and sell it on to householders.

[11] Fakir, "Framework to Assess the Economic Reality of Shale Gas in South Africa."

[12] Murphy, "The Implications of the Declining Energy Return on Investment of Oil Production."

[13] Fustier et al., "Global Oil Supply: Will Mature Field Declines Drive the next Supply Crunch?"

[14] US EPA, "Social Cost of Carbon"; Shindell, "The Social Cost of Atmospheric Release."

7. **Remove artificial restrictions on renewable energy and electric vehicles**

Artificial restrictions related to the use of renewable electricity generation and electric vehicles (EVs) must be corrected. The IRP document states that these restrictions are policy positions carried over from the IRP 2010[15], and therefore they have no place in a base case scenario. The Department of Energy has put forward the rationale in public meetings that high renewable energy penetration rates will lead to grid instability and that the cost of grid upgrades to address renewables is prohibitive. Both these issues have been addressed and disproved by the CSIR, and South Africa would in any case be committed to significant grid construction and modification to enable the connection of projected new capacity by 2050. Similarly, much of the automotive industry anticipates that the cost effectiveness of EVs[16] and the rapid reduction in price of key components[17] could lead to rapid uptake by the mid-2020s, which has significant impacts on both electricity and liquid fuel demand. This would significantly shift the balance of electricity and liquid fuel demands, and consequently uptake assumptions should rather be aligned with industry guidelines and other national investment strategies to ensure correct modelling of demand.

8. **Use realistic growth and economic assumptions**

Realistic assumptions for economic growth are critical in determining the energy demand of the country. The assumptions in these planning documents are very high (all scenarios assume a minimum of 2.8% GDP growth per annum, which is higher than in nearly five years), especially compared to global growth estimates and therefore run the risk of significantly inflating the projected demand. This risk is compounded by the simple linear correlations that have been used to extrapolate demand based on historical growth, despite the demonstrated decoupling of economic growth and energy demand in recent years. In addition, committing the nation to costly infrastructural builds and carbon-intensive development (shale gas, coal- and gas-to-liquid plants and new coal power plants) runs a serious risk of stranded assets[18] and wasted expenditure when demand is not realised or fossil fuels cannot be accessed[19]. These will in turn negatively impact local development, when investment in capturing the full value chain for renewable energy represents a real opportunity for reindustrialisation.

9. **Prevent Eskom capturing the political process**

Eskom's consistent meddling in the determination of the energy mix must be prevented, and the utility should be split into separate entities mandated respectively with generation and transmission of electricity. The current structure inevitably leads to Eskom's unnecessary predilection for a coal-based baseload-heavy generation structure dominating the debate, rather than capitalising on low-cost, cleaner renewables linked with dispatchable (quick ramp-up) power. Eskom's repeated refusal to sign agreements with DoE-approved IPPs is a case in point, as is the repeated and unjustified repetition of the assertion that renewable energy cannot be connected to the grid because of instability and cost. Both criteria have been examined by the CSIR and demonstrated through high temporal-resolution modelling and grid analysis (respectively) to be false. The Department of Energy has maintained during stakeholder engagements that grid analysis and development falls exclusively under the domain of Eskom,

[15] *"The Base Case maintains a number of policy positions imposed in the IRP 2010-30 in particular an annual build limit of new capacity for wind (1600 MW) and photovoltaic (1000 MW)".* IRP2010 update, pg 13

[16] In the Polokwane stakeholder consultation, the Department of Energy disingenuously argued that the model selected only petrol/diesel vehicles based on cost-efficiency. However, the IEP's Annexure A (Technology Assumptions) specifically points out that the model projected that private transport would be exclusively electric as a result of their "assumed low total discounted cost" despite the imposition of a 30% premium for their purchase. In fact, the low rate of EV penetration by 2050 is a result of a specific choice to limit the rate to 20% of the current national pool size per annum.

[17] Nykvist and Nilsson, "Rapidly Falling Costs of Battery Packs for Electric Vehicles."

[18] Since achieving globally-agreed climate mitigation targets requires that the bulk of discovered fossil fuel reserves are not exploited, investments dependent on these reserves will likely not realise their projected returns. The risk of such "stranded assets" has been termed the "carbon bubble", and prudent risk assessment should guide investment towards low-carbon alternatives. More realistically and responsibly it should dictate a trajectory towards complete decarbonisation.

[19] Fulton and Weber, "Carbon Asset Risk: Discussion Framework."

and it therefore takes Eskom's word on the grid issues. This untenable position must be addressed; electricity development cannot be undertaken without integrated planning.

IEP specific comments

The NDP targets both the impacts of climate change on one hand, and the elimination of poverty and eradication of inequality on the other. Of the 8 objectives of the IEP (ensure security of supply; minimise cost of energy; promote job creation and localisation; CO2 and pollutant emissions; water consumption; diversity of supply and primary sources; energy efficiency; and energy access) the majority fall under the umbrella of these two objectives. Integrating these, it follows that any decisions about the future energy mix of the country should be guided by two principles, with cost as an independent variable. In the first instance, we should target the cleanest energy mix in order to effectively address the country's high carbon emission profile, and secondly we must choose energy pathways that can enable industrialisation and create employment in a manner that drives a low carbon transition of the South African economy. In other words, the 8 objectives are not equal; while some will permit trade-offs (diversity of supply, cost, jobs), others have hard minimum limits (security of supply, water consumption, CO_2 and pollutant emissions) and others still will be driven largely by indirect aspects of the plan (energy intensity). Moreover, the interpretation of these objectives depends to a large extent on the assumptions and parameters that feed into the model. This document appears to have a number of incorrect assumptions or to ignore the evidence of some of the background data – an oversight which must be addressed.

Detailed comments on specific issues and sections are included in Annexure 1: Detailed comments on the IEP

IRP specific comments

The IRP as presented is completely insufficient. The base case bears no relationship to a real lowest-cost option because of the imposition of artificial restrictions on the rate of inclusion of renewable energy, and the already-detailed erroneous costing assumptions. The lack of technical and economic justification for such deviations (and the lack of commentary on such) provides a clear indication that the process is being driven by concerns unrelated to the stated goals of achieving a low-cost sustainable and diversified electricity mix. To remedy this, a true lowest-cost base case in line with the CSIR Least Cost scenario should be used, and any deviation from the least cost scenario should have both a justification and explanation of the cost implications of such deviation.

No rationale has been cited for these constraints, although mention has been made of the capacity of the grid to absorb new renewable capacity. Again, a preliminary assessment by the CSIR indicated that there is still considerable capacity to accept additional power along the main backbone. Moreover, the likely cost of grid upgrades is small in comparison to expensive new build – and would be necessary in any case to accommodate increasing power generation from any source. See also the point below in respect of a grid commission study. Coupled with existing coal in the mix and a target for reducing carbon emissions, these upper limits to RE mean that nuclear power is presented as the only option that can deliver the desired carbon reduction.

Despite having commissioned no large renewable integration study to support their contention, Eskom cites potential grid instability as the main reason not to increase the penetration of renewable energy - a position reiterated by Acting Eskom CEO Matshela Koko in the public stakeholder forums. The 2016 CSIR study examining the potential for increased RE uptake appears to be the only study examining this instability and variability, and it concluded the opposite. Using real-time demand linked with wind and solar data across the country, the studied showed that distributed RE linked to small amounts of dispatchable power can provide a more stable, lower cost energy supply than the IRP2010 base case.

Consequently, the imposition of constraints on the inclusion of RE into the grid do not represent either a technical or economic constraint, and must therefore be a political consideration, which should therefore be explored through a scenario.

Stakeholder consultation on the IRP must include further interaction once the proposed scenarios have been developed, and once the assumptions have been corrected. In the absence of such, this document will not have a suitable popular mandate for implementation.

Detailed comments on each section are provided in Annexure 2: Detailed comments on the IRP 2016 Update.

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Annexure 1: Detailed comments on the IEP

Section 2.1.5 (Renewable energy sources)

On biomass availability: the IEP states that the harvesting of the sugar crop in South Africa results in approximately 7 Mt of bagasse available for energy generation. The South African Bioenergy Atlas puts this figure at 5.3 Mt, substantially less. At the same time, switching from the current harvesting technique where much of the cellulosic material is simply burnt to green harvesting would significantly increase the amount of bagasse available.

Wind energy: The IEP document still references the dated 1995 wind potential assessment from the Department of Mineral and Energy Affairs to describe the potential for generation wind power in South Africa[20]. The SANEDI Wind Atlas of South Africa supersedes that assessment, and provides a much better accuracy and precision of wind potential. Moreover, it has become clear that the wind potential for South Africa is far from limited to the coast and the Drakensberg foothills; The evidence is that South Africa has some of the best onshore wind potential of any country in the world[21] and that moderate wind conditions pervade across much of the country. Combined with modern wind generation technologies, this can enable wind generation to be distributed widely, addressing many of the problems associated with local variation in wind generation. The document and model assumptions should be updated to reflect this reality.

Section 3.1 (Macroeconomic assumptions)

The IRP2010 is listed as one of the sources for GDP growth assumptions. This is inadequate, as the IRP2010 is widely acknowledged to be based on outdated and over-optimistic growth rates.

The GDP growth factors assumed in Table 0-1 appear to be too high, especially for the low growth scenario. There is also no reason to differentiate the three scenarios for the past 3 years for which actual (or better estimated) growth rates are available. This implies that demand is typically too high in most scenarios, potentially driving unnecessary investment in power, or unwarrantedly increasing the energy intensity of the economy.

Section 4 (Scenarios)

- While the electricity generation in the different scenarios aligns with the upper bound of the "peak, plateau and decline", the total emissions of the energy sector exceed the national commitment in all cases. This is not commensurate with a national fair share of international mitigation action. The most moderate level of mitigation commitment that should be considered is adherence to the mid-point of the trajectory range, and a more realistic budget would see SA's emissions drawing down towards the lower trajectory of the range.
- The choice of moderate growth rate for the base case scenario is inadequate, as all evidence suggests that what is currently referred to as the "low growth scenario" is actually closer to a "moderate growth scenario" and the persisting low-growth outlook as published by most major macroeconomic forecasts for South Africa is not captured at all. The current choice of growth rate projects unrealistically high energy demand projections, which in turn result in an over-capacitated and uneconomic energy system.
- It is problematic that all the four scenarios in the draft IEP include the implementation of the 9.6 GW new nuclear build programme, not just the base case scenario. This means the authors of the IEP see the nuclear build as given, which it is not. By its own admission – it is only the "Nuclear relaxed" sensitivity run that allows the model to optimise the least cost energy system by considering alternative options. This means that the draft IEP deliberately breaches its objective

[20] Diab, "Wind Atlas of South Africa."
[21] SANEDI and Department of Energy, "WASA."

no 2 (to minimise the cost of energy) at the onset. In addition, this is not in alignment with the draft IRP, which does not consider the 9.6 GW of new nuclear by 2030 in all its scenarios.

- Similarly, the four core scenarios also assume an optimistic outlook on the role of shale gas in the South African economy, which again implies the development of South Africa's shale gas resources as a given, which it is not. Two main comments on this:
    - Based on our own research, we find the underpinning assumptions that economically recoverable volumes of shale gas are extracted and that shale gas is competitively priced and available to the local market are not only optimistic, but unrealistic[22]. See also comment on shale gas extraction costs under comments to Annexure A.
    - In addition, the extremely large water requirements of shale gas extraction, assuming large-scale development of shale gas resources is in direct contravention of the IEP objective to minimise water consumption in the energy system[23]. No externality cost for this water use has been included in the cost calculations.
- No carbon tax is assumed in the scenarios, despite the fact that the Department of Environmental Affairs and National Treasury have made it clear that this is a key component of the mix of national mitigation measures. At the same time, calculating the external costs of carbon emissions by using the proposed carbon tax value as proxy is too low. Please see the section on Annexure C1 for more detail.

Section 4.5 (Scenario summary)

In the Environmental Awareness scenario there is no carbon externality cost assumed post 2019. Although more targeted investments may reduce the total externalities, given the long operational life of electricity generation infrastructure one would expect continued externalities, as well as an increased carbon tax cost.

Section 5 (Demand analysis)

This section states that there is paucity of energy consumption data at an energy end-use level. That is not correct - several studies have been conducted on energy use in South Africa, down to the energy use per energy service (cooking, lighting, water heating etc). There is indeed therefore data available to extrapolate, or at least calibrate the model for residential energy use.

Section 5.1 (Energy use in agriculture)

This section has at least two mistakes:

- The following statement is problematic: "*diesel is the most used energy carrier, mainly because the sector is characterised by traction which accounts for 66.71% of energy use and that this trend is likely to continue due to the Biofuel Industrial Strategy, which targets new and additional land which is approximately 1.4% of arable land in South Africa (DME, 2007).*" This implies more traction in the sector and therefore an increase in diesel consumption, which confuses the drivers of an absolute increase in demand for an energy carrier with the reasons for its relative importance in the energy mix within a sector. While bringing additional land into production will almost certainly increase the demand for diesel in absolute terms, this says nothing of its relative contribution (expressed in percentages) to the energy mix of the agriculture sector, which depends on diesel prices and availability of alternatives.
- The respective overall average reductions in energy intensities in the sector are reported to be slightly more than 1.1%, 2.2% and 2.1% over the modelling period for the different scenarios. This cannot be correct – from the graph it looks like these might be *annual reductions* over the modelling period?

[22] Fakir, "Framework to Assess the Economic Reality of Shale Gas in South Africa."
[23] Bole-Rentel, "Shale Gas 101: Introduction to Water Impacts."

Section 5.2 (Energy use in the commercial sector)

- This section specifies that "energy efficiency reductions" that have caused energy consumption in the commercial sector to soar between 1993 and 2010. Please provide some examples of these activities, to help both clarify and to enable potential action in reversing the trend.
- There is no good explanation offered for the counter-intuitive substantial increase in energy intensity of the commercial sector between 2015 and 2025 for the Green Shoots scenario. Whilst this scenario represents rapid growth of the sector, international trends have been towards lower energy intensity as sectors grow. This is driven partly by improvements in technology, and partly by the competitive advantage gained by reducing per-unit energy consumption.

Section 5.3 (Energy use in the industrial sector)

- No renewable heat is assumed in meeting even a small part of total energy demand in the industrial sector. Solar thermal technologies and biomass co-firing (or stand-alone) are well-established options for the generation of renewable process heat, which could partly replace the projected demand for coal in the sector. Such approaches may achieve traction independently as costs of certain technologies decrease, but they should also be incentivised through government action as a means to reducing total national emissions.

Section 5.5 (Energy use in transport)

- Despite the biofuels blending targets set forth in Government's Mandatory Blending Regulations promulgated on 23 August 2012, no biofuels are assumed as part of energy consumption of the transport sector. While it is true that the enforcement of the blending mandates is being delayed, there is no reason for ignoring them in long-term projections, unless there is new information that the regulations have been scrapped altogether[24]. In addition, South African Airlines has publicly stated their ambition to procure 500 million litres of sustainable bio jet fuel by 2023/24. Together, the biofuel targets for land transportation and air transport should represent a recognisable amount of fuel switch from traditional mineral based fuels to biofuels in the projections of transport sector energy use. WWF strongly supports limiting the provision of biofuels exclusively to the aviation sector as an interim means of reducing total emissions, whilst transitioning towards lower impact artificial fuels.
- The penetration rates assumed for electric vehicles and the potential for a shift away from liquid fuels appears to be very low. Please see the comments on Annexure A for more detail.

Section 6 (Supply side options)

- See comment on Section 5.5 – despite the biofuel blending targets set in the Government's Mandatory Blending Regulations (2012) and South African Airlines' declared biofuel ambitions, there appears to be no biofuel supply mandated over the IEP period.
- As production of biofuel feedstock is very labour-intensive, neglecting to include biofuels in the liquid fuel supply also has significant implications for the energy system job estimates in Section 6.3.

Section 6.1 (New capacity requirements)

The electricity scenarios detailed in this section do not align with the IRP Update 2016. More specifically, whilst it is reasonable for the scenarios should differ from the base case, one would at least expect the base case in the IRP and IEP to align. The inclusion of nuclear power in all scenarios is, as previously noted, not aligned with the recommendations of multiple national planning documents. In addition, biomass-based electricity generation in the IEP is recognisable at 1 GW, whereas there is almost none in the IRP.

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[24] If this is the case, WWF would like to prevail upon the Department of Energy to publish this clarification as soon as possible.

Section 6.1.2 (Liquid fuel supply)

- The IEP considers biomass only for use in the stationary sector. However, Government's Mandatory Blending Regulations (2012) pertaining to blending of biofuels with conventional fuels will direct significant biomass resources into the production of liquid fuels for transport, which is not considered at all.
- The assumptions driving the increase in liquid fuel supply must be questioned. Again, the potential for transition of the transport sector towards electricity as the primary means of generation by 2050 is underestimated. Demand for liquid fuel in the IEP is entirely contingent on the coupling of land transport to a fossil-fuel hydrocarbon chain, which is extremely undesirable. Indeed, given the current cost of delivered energy from RE, and the current learning rate, there is potential for a significant portion of the transport energy requirement to be delivered either directly through electricity, or indirectly through power-to-liquids technology.
- The text in this section specifies that new Coal to Liquid (CTL) plants are unlikely in all scenarios, but Figure 0-6 clearly indicates the inclusion of new coal-to-liquid plants after 2040 in three of the four scenarios. Any consideration of new CTL plants should not be embarked upon. As a particularly high carbon emission form of fuel provision, coal to liquid plants undermine any commitment to achieving the Paris Agreement's goals of limiting dangerous climate change to below 2 degrees.
- Similarly, the supply of liquid fuels from gas-to-liquid (GTL) appears to be largely dependent on the assumption of cheap reliable gas supply, which is unlikely to be valid.

Section 6.2 (Costs)

The application of different externality rates for different scenarios makes no sense. The externality cost borne by society is the same regardless of the societal perception of such. Moreover, the rate chosen for carbon dioxide emissions in even the "Environmental Awareness" is significantly lower than either the rate recommended in Annexure C1 or international best practice. Inclusion of externality costs should be a real consideration when calculating energy system costs, and should be consistent in all cases.

The IEP also fails to consider the externality costs related to the disposal of radioactive waste. This must be included in all cases – South Africa's current management processes for radioactive waste are insufficient given the long lifetime of waste, and a full costing of safe disposal must be calculated.

Section 6.2.1 (Electricity generation costs)

The potential for renewable energy to undermine the current baseload-heavy paradigm for electricity generation has not been taken on board. The cited electricity generation costs are heavily dependent on policy positions that have not been formally made – the base case should be a least-cost option that has no policy constrains on electricity generation.

Biomass accounts for less than 1% of new generation capacity by 2050 (at 1 GW, as shown in Figure 0.4 in Section 1.1.1) but over 10% of total discounted costs of electricity generation. This is a result of the very high estimates of the cost of biomass electricity. Based on the existing cost assumptions, the inclusion of any amount of biomass-based electricity into the mix at such a high cost, compared to solar and wind generation options, strongly violates the cost-effectiveness mandate of the IEP process. WWF strongly recommends that these cost assumptions be revisited, and if valid, then commitment to integration of biomass should be left to private sector enterprise, which appears to be able to bring biomass into the energy mix at a lower cost.

Section 6.3 (Jobs)

The assumptions around job creation for the shale gas scenario appear to be inordinately large. The CSIR's scientific assessment of shale gas potential in the Karoo estimates 2575 direct jobs in the "big Gas" exploitation scenario, and warns that it "should not be assumed that indirect and induced impacts in terms of jobs in the study area would reach the same level as direct impacts"[25]. The IEP's assumption of more than 1.4 million direct jobs from shale gas extraction (Figure 0-38) is three orders of magnitude, and hard to fathom. This is particularly true in light of an unproven and potentially uneconomical resource

Section 6.4 (Emissions)

- From Figure 0-19 it is evident that none of the development scenarios aligns with the "peak, plateau and decline" trajectory to which South Africa has committed in the Intended Nationally-Determined Contribution to the Paris Agreement. This is a binding commitment, and as such it must be a hard political boundary for the total carbon dioxide emissions. Moreover, since the energy sector (particularly electricity) represent the least-cost means of addressing national emissions, the "Green Shoots" and "Environmental Awareness" should look to reduce emissions considerably below the midpoint of the PPD.
- Emissions from electricity generation and energy production in the "Environmental Awareness" in the models are well below the actual emissions in 2014-2016. Building a model on the basis of invalid historical data is pointless and unuseful.

Section 6.5 (Water use)

- It would be appropriate to show a breakdown of water use by technology, which will show how highly water intensive coal and shale gas are, compared to renewables. Presenting just the total water use in the primary energy sector per scenario doesn't show these large differences in water requirements by different technologies.
- It is important to also integrate the externality cost of water into the cost calculations for each technology, to enable more nuanced decision-making within and between scenarios.

IEP Annexure A (Technology assumptions)

- Section 3.4 on Sources of primary energy: The fixed and capital costs for the extraction of shale gas, assumed to be R378m/PJ/annum based on estimates from extraction in the US because no local estimates are available are highly likely a significant underestimate of the extraction costs the industry would face in South Africa, for a number of reasons, as discussed in the WWF report on the economics of shale gas[26].
- Table 10 in Annexure A showing emission factors for electricity technologies: The categories "Bagasse forestry residues", "Bagasse GEN" and "Bagasse Municipal Solid Waste" don't seem to make sense. Bagasse is a biomass residue, but not from forestry (as the dry pulpy residue left after the extraction of juice from sugar cane it is usually classified as an "agricultural" residue). Similarly, it doesn't have much to do with municipal solid waste. It is possible that here the words "biomass" and "bagasse" were mixed up. Besides the mislabelling, the CO2 emission factor for biomass from forestry seems rather high, as if it only accounted for the emission at the point of combustion but not on a life-cycle basis, which includes carbon sequestration by the biomass during its growth period.

Section 3.2.2 (Transport technologies)

The potential for electric vehicles to overturn expectations in the transport sector is very large, and is overlooked in both the IRP and IEP. This is problematic, because it have potentially very significant impacts on both these documents, increasing the efficiency of the sector and driving a significant transition away from dependence on liquid fuels for transport to electricity. Moreover, a significant shift in transport to battery electric vehicles (BEVs), combined with smart grids and time-of-use metering enables better grid load balancing by promoting off-peak dynamic charging. It is notable that the annex says "In preliminary model runs the model selected busses and electric vehicles exclusively for private and public transport vehicles respectively due to their assumed low total

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[25] Scholes et al., *Shale Gas Development in the Central Karoo: A Scientific Assessment of the Opportunities and Risks*.

[26] Fakir, "Framework to Assess the Economic Reality of Shale Gas in South Africa."

discounted cost." This is in stark contrast to the stakeholder consultation in Polokwane, at which the "DoE argued that the model only picked up petrol / diesel vehicles based on cost-efficiency"[27] – a comment which might charitably be characterized as deeply misleading.

WWF strongly recommends that at the very least a scenario looking at a potential rapid transition to electric vehicles, informed by expert inputs, be considered. Some of the problematic assumptions made in the IEP include:

- Price differential and learning rate: The IEP assumes a 30% premium for electric vehicles, and no learning rate. This is deeply unlikely, given that the price of batteries (by far the most expensive component of BEVs) has dropped more than 80% since 2006. The learning rate for batteries is therefore between 8% and 14% per annum[28]. Current industry estimates for price parity with conventional vehicles are between 2023 and 2030, at which point it will be cheaper to own and run a BEV than an internal combustion engine vehicle.
- Vehicle types: market penetration in the IEP is limited exclusively to domestic light vehicles. Whilst much of the market development to date has focused on this market segment, EVs will likely penetrate other areas in short order. At present, SUVs, long haulage vehicles and busses are already being manufactured, and in China at least, more than 10% of busses produced are battery powered[29].
- Penetration rates: The rationale for limiting the rate of penetration as the industry ramps up production is sound. However, the rate selected underestimates the potential for industrial shift – whole industries have been built in fifteen years (mainstream mobile phones only rolled out in the late 1990s, and were pervasive worldwide within ten years), and such a transition is quite possible. Global EV sales have increased by 42% to 162% since 2010, at which rate they could comprise 80% of vehicle market sales by 2030. Most car manufacturers anticipate BEV to reach at least 25% of the total volume of sales over the next 10 years (from a current base of less than 1%). In light of this, it seems that the penetration rates put forward in the IEP are very low, as well as being inconsistent with the NATMAP target rate and the DTI's Electric Vehicle Industry Roadmap.

As Africa's largest producer and assembler of vehicles, the localisation potential for an EV transition in South Africa is high, and represents a key opportunity that could be missed if it is not considered in national planning documents. Moreover, given that the Nationally Determined Contribution to the Paris Agreement projects incremental costs of US$513billion between 2010 and 2050 for electric vehicles[30] (with another US$488 billion for 20% hybrid electric vehicles by 2030), some plan to channel this expenditure through incentivising local uptake and production of EVs is needed.

Section 3.3 (Electricity generation)

The assumptions for costs and grid stability here are derived from the EPRI data and the IRP2010, and consequently the critiques are the same as for the IRP, as detailed below.

IEP Annexure B (Macroeconomic assumptions)

Whilst in principle WWF agrees with many of the macroeconomic assumptions, or at the very least does not have evidence to dispute them, there are certain assumptions that seem odd.

- The use of a very high discount rate for energy investments cannot be justified. The recommended rate of 8.4% is based exclusively on economic opportunity cost, and is justified "as the IEP discounts future costs and does not calculate the cost benefit or Net Present Value"[31]. Apart from being a circular argument and therefore meaningless, the basic

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[27] Public notes from the IEP/IRP Public Consultation Workshop, African Climate Reality Project, Noelle Garcin (25 January 2017).
[28] Nykvist and Nilsson, "Rapidly Falling Costs of Battery Packs for Electric Vehicles."
[29] Research and Markets, "China Bus Industry Report 2016-2020."
[30] Government of the South Africa, "South Africa's Intended Nationally Determined Contribution (INDC)."
[31] IEP Annexure B: Macroeconomic Assumptions, page 11.

assumption here is that the future impacts of energy choices are negligible. This is evidently wrong, given the multi-generational impacts of carbon dioxide emissions, and the long-term environmental and health impacts of pollution from coal plants. The implications of such a choice are that investments with high initial costs but long term savings (such as renewable energy) are discouraged, and investment to reduce the impacts of climate change do not make sense. Since South Africa has committed to reduce emissions, climate change reduction investments are a given, and it is incumbent on the government to ensure that these are made at the lowest cost – which is demonstrably the energy sector.

- The GDP assumptions high in all scenarios, which impacts demand and therefore all investments. Even the low development trajectory in the CSIR guidance document significantly exceeds real growth experience in the last five years, and given the South African economy's heavy dependence on mineral resources (including coal, for which long-term global demand continues to decline), it is unlikely that this lower boundary is a more realistic projection of future growth.

The price point for shale gas seems extremely low, as previously mentioned, and the assumption of a 43bn cubic feet output per annum is very ambitious. Similarly, the potential for job creation in the case of shale gas is optimistic, given the economics of the case.

IEP Annexure C1 (Energy systems externalities)

WWF welcomes the inclusion of externalities into the calculations of the total cost and viability of different energy options for South Africa. The inclusion of externalities is a good first step towards a realistic accounting of the value and impacts of the current economic paradigm, and will help in transitioning towards a more realistic planning and budgeting process for a low-carbon and equitable economy. However, the fact that certain of the recommendations on pricing and including the externalities has been ignored in the IEP is highly problematic.

Specifically, the document refers to the fact that the carbon tax price should not be used as a proxy for the negative externalities of carbon. Globally published externality costs for carbon dioxide emissions range from \$5 to \$120/tCO_2e, with a common standard is the US Environmental Protection Agency's \$46/tCO_2e[32], recommended in this annex. The full social cost of carbon depends both on the discount rate assumed and the scope of impacts, and a full global accounting of damages for coal being something of an outlier[33]. Regardless, the proposed national carbon tax rate of R48-R120/tCO_2e is not a valid measure of the real costs, but rather a weak incentive to shift behaviour. Since the implementation of the tax is highly contingent, it is not possible to determine what the rate would be on a single activity in a given year[34]. Consequently, as recommended in this annex, a more realistic rate for calculating the social cost of carbon should be used, and the cost of carbon tax (as a fiscal incentive) should be calculated on top of that.

WWF calls on the government to undertake a stakeholder engagement to better determine the real social cost of carbon in the South Africa context.

[32] US EPA, "Social Cost of Carbon."
[33] Shindell, "The Social Cost of Atmospheric Release."
[34] Viz. the tax may be applied only at the margin when a budget cap is exceeded or on all eligible emissions; the current tax-free allowances may stand or change in the next phase; entities are liable for different rebates depending on their activities; many activities fall below the emissions threshold and are therefore not taxed; the rate itself is subject to ministerial determination and increments in line with proposed policy; and the current baseline rate of R120 ins not a rate that would motivate change (in line with the Long Term Mitigation Scenarios) but rather a revised price point that is more amenable to business interests than policy recommendations from stakeholder analysis.

Annexure 2: Detailed comments on the IRP 2016 Update

Several annexes that were specified as being circulated for public commentary in the IRP Update Report have not been circulated. These include the determination of the social discount rate, technology learning rates and "additional assumptions report". In the absence of these, it is clear that the purpose of the stakeholder briefing document (to assess and critique the assumptions driving the base base) cannot be met. Further stakeholder consultation once these documents are available and the proposed scenarios have been developed is necessary.

Section 3.4 (Eskom plant life)

The timelines within the document reflect original timing for the retirement of coal plants, and include the period for fitting and refurbishment in line with NEM:AQA emission guidelines. It is evident from this that the timelines for refurbishment are not in line with Eskom's environmental compliance timelines, and should be updated in light of this. Repeated postponement of compliance is not adequate in terms of meeting national emissions commitments.

Already the bottom 5 plants' retirement timelines have been brought forward in light of the slowing of national electricity demand, the necessity of compliance with emissions standards, and the potential costs of retrofitting. All scenarios should reflect these updated assumptions.

Section 3.6 (Greenhouse Gas Emissions Trajectory)

A full carbon budgeting approach is necessary for integration energy sector emissions. Moreover, the assumption that electricity should continue to retain a 45% share of the national emissions budget should not hold: as the sector with the potential for the least-cost mitigation within the country, the rate of emissions decline within the electricity sector should be much higher than that of the country as a whole.

Section 4 (Results and observations from the base case)

The base case as it stands is inadequate for its role, and has previously mentioned, should be revised to reflect the least-cost technically feasible option for provisioning electricity in line with projected demand. Many of othe assumptions that inform this model are problematic. POf particular concern is the assertion that the base case maintains a number of policy positions, particularly a restriction on the rate of inclusion of renewable power that is not justified thourhg any technical or economic reason.

IRP Annexure A (EPRI report)

We have already detailed issues with the costings for renewable energy in the IRP. The costs for nuclear energy within this document are better aligned with international experience, and should therefore be used when calculating the cost of nuclear power. However, the costings within the IRP are obtained from a further documentary study commissioned by the Department of Energy. We would request that this additional document be released for public consultation, since it contains key assumptions driving the determination of the proposed electricity mix.

The LCOE costs for renewable energy in this document are woefully outdated with respect to both the national and global experience. Whilst it is appreciated that the ERPI values have not been used for calculation of LCOE for PV and wind energy, WWF still recommends that the values obtained in bids for the REIPPPP Round 4 (Expedited) be used as the baseline cost for these technologies, since the price point has been established through realistic market discovery mechanisms.

IRP Annexure B (Demand Forecasts)

The demand forecasts developed in this document are heavily reliant on historical trends, and are dependent on correlative regression models that do not link strongly to drivers. For instance, the linkage of transport to the mining index assumes systematic economic drivers within the mining sector that impact overall transport. Whilst this may be the case for mining and affiliated industries (admittedly a large driver of the diesel consumption) it is likely merely correlative with other transport energy demands such as the private transport sector.

More importantly, whilst some cognisance is made of the decoupling of GDP and energy demand (reducing energy intensity), a historical trend focus does not take cognisance of potential trend disruptors. Two of these, renewables and electric vehicles, have a high likelihood of causing significant energy shifts over the period 2015-2050, and should be factored into demand forecasts.