SMART ELECTRICITY PLANNING

Fast-tracking our transition to a healthy, modern, affordable electricity supply for all.

Energy is the lifeblood of a modern, employment-creating economy and society. Yet a key component of Energy supply - our current electricity infrastructure – depends on old technology and is unhealthy for people and planet.

Smart electricity planning considers the immediate needs of people, planet and economy and makes choices which future generations can live with.

This report presents key considerations for electricity planning today.

The Electricity Governance Initiative of South Africa, March 2013

Acknowledgements

We dedicate this report to the late Peet du Plooy for his considerable contribution to sustainable energy provision in South Africa. He peer reviewed this report in February 2013. We were deeply saddened by his unexpected death in early March 2013. Peet's commitment, generosity and widely respected contribution to the Energy and development sectors in South Africa will not be forgotten.

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A note to readers

This report contains many facts and figures. While we have done our utmost to verify and double-check extensively, we welcome feedback on any errors we may have overlooked.

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Preface

Partner organisations of the Electricity governance initiative of SA (EGI-SA) have cooperated to produce a report that speaks directly to the IRP2010 – the demand and supply assumptions it was based on and the needs it sought to address. Our intention is to share a strong evidence base for smarter electricity planning.

The bulk of this evidence base has relied on SNAPP – an electricity modelling tool that provides immediate graphic representations of the scenarios that are created from input data entered by modellers. Selected chapters also reflect arguments based on common justice-oriented ideals. These are the ideals required to build a more just and equitable country, where well-being is pervasive.

The motivation for doing this work is grounded in social justice values of citizen equity and wellbeing and we have actively sought to provide an evidence base for our proposals.

With this commitment to rigour and reliability in mind we have invited a wide variety of expert stakeholders to comment on our findings throughout the compilation of this report[1]. Those consulted have included a large number of academics who specialise in energy modelling and planners and modellers working in local and national government, business and industry, organised labour and community sectors.

This report is intended to directly inform key energy planning decisions being made during 2013, particularly the revision of the IRP2010.

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The Integrated Resource Plan 2010-2030 (IRP2010)

The Department of Energy's website states that:

> *"The IRP in the South African context… is a National Electricity Plan. It is a subset of the Integrated Energy Plan. The IRP is … a plan that directs the expansion of the electricity supply over the given period. The Long-term Electricity Planning goal is to ensure sustainable development considering: Technical constraints, Economic constraints, Social constraints, Externalities.* ***Its purpose is:*** *In theory - identification of the requisite investments in the electricity sector that maximise the national interest; in practice - identification of the investments in the electricity sector that allow the country to meet the forecasted demand with the minimum cost to the country"*[2].

In the IRP2010[3] promulgated by government the contribution of Coal to our electricity mix reduces from 90% to 65% of the overall electricity supply by 2030, Nuclear increases to 20%, Hydro is static at 5%, and Renewables increase to 9%. This shift in the supply mix will require that 42% of all newly built capacity be Renewable energy (RE). Using SNAPP[4] to model these investment choices, we have calculated conservatively that the proposed IRP2010 investments to 2030 would amount to approximately R 910 billion at 2010 prices). We have used the IRP2010 investment plan as the reference case for all our technical scenarios.

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[1] Draft findings were shared with: the Council for Scientific and Industrial Research (CSIR), The Energy intensive Users group (EIUG), Cambridge Programme for Sustainability Leadership (CPSL), members of parliament, Eskom and several government departments. Substantive critical comments from all informed the research.

[2] Quoted directly from the Department of Energy website: www.energy.gov.za/files/irp_frame.html

[3] The IRP2010 can be found at: www.doe-irp.co.za/content/IRP2010_promulgated.pdf

[4] See page 7 of this report for a description of SNAPP

Key messages

1. **The current electricity infrastructure** is expensive and unhealthy for people and the life-supporting natural systems that everyone is dependent upon.

2. **By phasing out fossil and nuclear power**, South Africa will remain globally relevant as it recognises and benefits from the changing international trends and attitudes around electricity production, technological advances in the field of energy, and concerns over climate change.

3. **Phasing in increasingly affordable renewable energy technology** will create jobs, reduce the country's high carbon emissions and keep the economy competitive.

4. **Electricity is vital for the development of a thriving society**, and there are many new, modern and innovative ways to provide electricity services. The electricity grid of the future is decentralised, where independent power suppliers feed electricity into a state-maintained grid infrastructure.

5. **Limiting investment:** by building more utility-scale, expensive, centralised electricity supply plants will lock the country into an increasingly outmoded, inefficient electricity system.

6. **South Africa's existing electricity plan is built on inflated electricity demand projections**. This will result in expensive infrastructure investment which will push up the cost of electricity, impacting the whole economy and further marginalising the poor.

7. With proactive electricity conservation and efficiency measures, using existing technology, **South Africa can reduce its electricity demand by 16% by 2030 without constraining economic growth**. This report shows realistic and promising opportunities for conservation and efficiency across the residential, commercial, mining and industrial sectors.

8. **Renewable energy is a viable way to meet South Africa's energy demands**. It is getting more and more affordable as technology improves, economies of scale kick in, financing mechanisms mature, practical constraints are overcome and public policy begins to take account of the negative impacts and true costs of fossil and nuclear power.

9. By tapping into South Africa's abundant wind and solar potential, **investment in renewable energy can stimulate economic growth, create abundant and sustainable new jobs, replace outmoded fossil fuel-based jobs and have positive knock-on effects**, including for the poor and for rural livelihoods.

10. **Progressive electricity tariff structures, incentives and appropriate metering** in the municipal electricity distribution side of the supply chain, can overcome some of the structural hurdles that lock local authorities into needing to generate cash flows from electricity sales.

Executive summary

Like all developing countries, South Africa faces a number of basic social, economic and environmental challenges. As we seek to forecast and plan ahead, we have a choice: we can draw only on historical information to make choices grounded in past experience, or we can also recognise the high level of uncertainty currently present, and the need for planning that is more robust and attuned to change.

At this time, an electricity planning approach is called for that has the capacity to make the necessary adjustments timeously, that seeks to address key socio-economic challenges for improved livelihoods and that sets out to protect dwindling ecosystems services.

In the context of widespread change associated with the global Energy sector, this report aims to provide a fresh look at South Africa's Electricity Demand, reviews available energy conservation and efficiency technologies for key economic sectors and seeks to debunk the outdated belief that South Africa's Electricity Supply can only be satisfied affordably and reliably using utility-scale coal and nuclear power.

Using a reliable modelling tool called SNAPP and considering our unique socio-economic realities we have used the IRP2010 investment plan as the reference case for all our technical scenarios and investigated what innovative and prudent planning should take into account.

We have prepared three Demand scenarios and two Supply scenarios. We believe these scenarios are pro-poor, promote gender equality, are achievable, will save money and will attach a greater value to the capacity of South African citizens to collectively commit to using energy more efficiently. This is a report of our findings.

There is a pressing need to re-assess how both electricity and energy planning are undertaken for the poor in South Africa. Note that electrification, though an undoubtedly important focus of energy access should be seen as only one sub-set of an integrated approach to meeting the demand for energy services. **Pro-poor energy and electricity planning must address *multiple* social and environmental objectives.**

We recognise that there is a need for further research on how to practically achieve what we show to be possible. As committed researchers and practitioners working in the Civil society sector who operate with limited financial resources, we have utilised resources available to us to highlight what smarter electricity planning can take into account. **We hope that this report will stimulate stakeholders with resources to undertake the required additional research.**

The report begins with an introduction as to **why smarter electricity planning is called for at this time**. This includes reflecting on how the Energy sector has developed over time, reviewing the current contextual factors that influence Energy choices going forward, and assessing how all of this has a bearing on Electricity planning today.

The two main chapters of the report are then introduced – **Demand and Supply**. Our work in the chapter on Demand is grounded in our informed opinion that the RP2010 was based on inflated demand assumptions. In addition, a comprehensive review of recent local and international reports and case studies on the potential of energy conservation and efficiency of all economic sectors pointed to the need for lower electricity demand forecasts as compared to IRP2010, without constraining economic growth. Using SNAPP we then modelled two Supply scenarios based on the different demand assumptions. Here we investigated what pro-poor electricity supply should take into account and the potential contribution of RE. Our research here revealed very different ideal capital investment outcomes compared to the IRP2010 investment plan.

Next we investigated the **job creation potential** from various RE supply options. **In South Africa the primary unemployment challenge is not skills or lack of them; it is that the number of people needing jobs far exceeds the number of jobs available.** RE provides many opportunities for labour intensive jobs and we provide evidence to support this assertion.

We conclude by considering the **Institutional frameworks** that are needed to support realisation of forward thinking electricity planning. We have set out to present innovative but achievable options which can fast track transition to smarter Energy planning that can benefit everyone.

It is our hope that anyone who reads this report will find it inspiring and instructive and renew their commitment to participating in the realisation of a Smart electricity future.

Using the SNAPP modelling tool

SNAPP (Sustainable National Accessible Power Planning) is a comprehensive and reputable Electricity Supply modelling tool developed in 2009 by the Energy Research Centre (ERC) at the University of Cape Town with financial support from WWF-SA. The objective of SNAPP is to assist with developing future electricity scenarios in a rigorous yet straightforward modelling framework to encourage a wider range of people to participate meaningfully in debates on our electricity future. This is achieved both through producing their own scenarios, and through learning how the electricity system responds to changes.

South Africa's electricity system faces many critical challenges, including the necessity of climate change mitigation, provision of energy services to the poor, and satisfying the electricity requirements for a growing economy. We need to be able to think creatively about future power options, while making realistic assessments of technical requirements and the economic and environmental consequences of specific choices. These considerations are traditionally accommodated through electricity planning systems which are based on complex models which are challenging, time-consuming and expensive to run. Generally only a small range of alternatives are considered because of time and other resource constraints; assumptions are usually not transparent and hence not easily tested, and the implications of many options are left unexplored.

SNAPP overcomes conventional complexity barriers by providing a transparent, spread sheet-based electricity system model which is relatively simple to use. It is a useful tool to explore the implications of specific technology choices, and provides a high degree of technical rigour to ensure modelling of plausible future electricity scenarios for South Africa. SNAPP allows users to specify generating expansion preferences and calculates the costs, investment requirements, probable impact on the average cost of generation (and thus the electricity price), and emissions implications. It includes a sophisticated reliability check to ensure that chosen investments will result in a reliable electricity system. Unlike traditional modelling frameworks, because SNAPP is a spread sheet-based tool, results are instantaneous. Users can immediately see the consequences of their choices without having to 'run' a cumbersome modelling framework.

Introduction

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"The message of the [2012] Energy Sustainability Index is clear: all countries are facing challenges in their transition towards more secure, environmentally friendly, and equitable energy systems. What makes the difference is how they set their final goals, how they balance market economics and public policies, and how they design the smartest policies in order to promote efficiency and to optimise costs, resources and investments for the long term."

- Pierre Gadonneix, Chairman of the World Energy Council

The Electricity Governance Initiative (EGI) is a global network of civil society organisations dedicated to promoting transparent, inclusive and accountable decision making in the electricity sector and is supported by the World Resources Institute (WRI).

EGI South Africa[5] is made up of a dedicated group of justice-oriented organisations and individuals focused on Electricity policy, planning and governance, who meet for working sessions with each other every 2-3 weeks and in addition have regular substantive discussions with key Energy planners and stakeholders.

We are driven by a common desire to participate in the creation of a society where our Electricity policy environment can better enable the wellbeing of people and planet.

Change rarely comes easily, and with this report, the EGI-SA ambitiously set out to make the case for a change in course that is informed by a more people-centred and innovative mind set. We are aware that our recommendations may fly in the face of traditional ways of doing things, but believe that a goal-oriented departure from historical approaches is necessary at this time.

The report is based on the best available evidence in relation to the 'triple dip recession', growing resource scarcity, and the growth of RE worldwide.

Before we broach the topic of Smart electricity planning, we review the Energy sector and emission mitigation in South Africa and then hone in on the topic of Electricity planning.

Mitigation & the South African Energy sector

South Africa's long-term mitigation strategy calls for our carbon emissions trajectory to peak in the period 2020 to 2025 at between 500 and 550 Mt carbon dioxide equivalent (CO_2 e) per annum, to remain at that emissions level until 2035, and for emissions to decline to a range of between 200 and 400 Mt CO_2 e per annum by 2050. This is referred to as the 'peak, plateau and decline' emissions trajectory.

[5] EGI-SA partners are: 350.org, Project 90 by 2030, SA Faith Communities Environment Institute (SAFCEI), Green Connection, WWF-SA, Sustainable Energy Africa, Gender and Climate Change – Women for Climate justice. Our research is supported by the Energy Research Centre at the University of Cape Town and we have regular meetings with Eskom, CSIR, the Energy Intensive Users group and other electricity stakeholders.

South Africa's current annual carbon emissions are between 520 and 540 Mt. An analysis of current and historical emissions reveals that in South Africa, most emissions have their source in the energy sector: electricity supply is consistently the largest source of emissions, followed by industry, transport and liquid fuels supply[6].

The power sector[7] in South Africa, while seeking to provide energy services for all sectors of the economy, is dirty and destructive for people and the planet. South Africa is currently estimated to be the 14th highest carbon emitter in the world[8].

The mining and industrial sectors jointly consume about half the national primary energy supplied, while the residential sector consumes about one sixth. Most (about 90%) of South Africa's electricity comes from coal, as well as a quarter of the country's liquid fuel, in a process (the Sasol coal-to-liquid process) which is at least 60% more greenhouse gas intensive than conventional oil refining. Given our dependence on coal and other fossil fuels in particular, the Energy sector is the country's principal air and water polluter and the major contributor to climate change emissions[9].

Given this, in South Africa, effective mitigation basically requires that we transform our energy mix.

Government has demonstrated its political will to take a lead towards a lower carbon and less energy intensive economy in a number of recently released strategic papers: The New Growth Path including the section on Green Economy and the National Development Plan – Vision 2030 are both geared towards economic success with a strong commitment to a changed economic structure, which takes into account that growth must come with employment and that energy intensity needs to drop.

Mitigation & Global Energy sector trends

The World Energy Council (WEC)[10] recently released their 2012 Energy Sustainability Performance Index. The Index, published within the WEC's 2012 World Energy Trilemma report, "Time to get real – the case for sustainable energy policy", finds that most countries still have not managed to balance the three major energy challenges: energy security, social equity, and environmental impact mitigation.

The WEC argues that countries must balance the trade-offs between the three challenges of the trilemma if they are to provide sustainable energy systems.

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[6] Marquard, A., Winkler, H., & Trollip, H. 2011. *Opportunities for and Costs of Mitigation in South African Economy.* (DEA report). Pretoria, South Africa: Department of Environmental Affairs. Available at: https://www.environment.gov.za/sites/default/files/docs/cost_mitigation_opportunities.pdf [2013, April 10].

[7] 'Power sector' refers here to all aspects from mining to power generation, transmission and distribution.

[8] This is in terms of total emissions as ranked by the United Nations, International Energy Agency and many other respected emissions monitoring agencies. In terms of per capita emissions, South Africa ranks about 40th in the world.

[9] Zipplies, R. 2008. *Bending the Curve,* Africa Geographic. South Africa. Available at: www.bendingthecurve.co.za/ [2013, April 10].

[10] The World Energy Council is a global forum for thought-leadership and tangible engagement committed to a sustainable energy future. The network of 92 national committees represents over 3 000 member organisations including governments, industry and expert institutions. Their mission is to promote the sustainable supply and use of energy for the greatest benefit of all. World Energy Council, The 2012 Energy Sustainability Performance Index in "World Energy Trilemma: Time to get real – the case for sustainable energy policy". Available at: www.worldenergy.org.

Of the 94 countries ranked, South Africa ranked 78th on energy security, 52nd on social equity and 53rd on environmental impact mitigation. It is noteworthy that many other developing countries ranked higher (i.e. performed better) than South Africa across all major areas assessed.

Energy analysts generally agree that the world can no longer avoid these three hard truths about energy supply and demand in the coming years[11]:

- Step-change in energy use: developing nations are entering their most energy-intensive phase of economic growth as they industrialise, build infrastructure and increase use of transportation. Demand pressures will stimulate alternative supply and more efficiency in energy use.
- Supply will struggle to keep pace: while abundant coal exists in many parts of the world, transportation difficulties and environmental degradation ultimately pose limits to growth. Alternative energy sources may become a much more significant part of the energy mix.
- Environmental stresses are increasing: even if it were possible for fossil fuels to maintain their current share of the energy mix and respond to increased demand, CO_2 emissions would then be on a pathway that could severely threaten human wellbeing. Even with moderation of fossil fuel use and effective CO_2 management, the path forward is highly challenging. Remaining within desirable levels of CO_2 concentration in the atmosphere will become increasingly difficult.

Sustainable growth recognises the importance of an inhabitable planet and a continued healthy global ecosystem.

In the context of widespread change and environmental limitations commonly associated with the global Energy sector, in the chapters that follow, we aim to provide a fresh look at South Africa's Electricity Demand and review available energy conservation and efficiency technologies for key economic sectors. We will also illustrate how the belief that South Africa's Electricity Supply can only be satisfied affordably and reliably using utility-scale coal and nuclear power generation, is becoming flawed and outdated.

Energy, the Economy and Sustainability

> "…there are steps we have to take to change the legacy we will leave our children: adjustments to our growth path we have to make as a global community, as nations working together, as citizens of a shared humanity, in response to the challenge of climate change and environmental responsibility. We are in these things together – the war on poverty, infrastructure development and financial stability, responding to global warming – we share these obligations: rich and poor, urban and rural, men and women, business and community organisations, labour and government."
>
> -Trevor Manuel, budget speech, February 2008

Today in South Africa, access to energy is seen by many decision makers and planners as inextricably linked to economic growth. But – quite apart from the widely known destructive effects of emissions caused by extracting and burning fossil fuels – **the consumption of any resource at a rate faster than its rate of formation is widely agreed to be unsustainable**. What is fundamentally unsustainable cannot be relied upon to enable sustained growth. The profound economic and ecological crises in which we currently find ourselves are inextricably linked to the political and economic structures which have ruled this planet for the past few centuries.

[11] Shell International, 2009. Shell Energy scenarios to 2050. Available at: www-static.shell.com/static/aboutshell/downloads/aboutshell/signals_signposts.pdf [2013, April 10].

2012 marked the 300th anniversary of the global energy revolution which began with Newcomen's steam engine – the first time heat and motion were combined to increase energy access. Over time, as the Industrial Revolution gathered pace, we have set about mechanising and making more convenient almost every aspect of our lives. We have done this mainly by drawing on ancient stores of fossil fuels. But, what nature has been storing over millennia, as global population has grown, we are now consuming in the equivalent of a blink of the eye.

Today all economic activity relies on energy in some way. Decisions are made on the basis of ease of control, resource availability and price. However, considerations of cost and resource availability still often exclude environmental and social impacts.

Access to modern energy services is considered to be a key aspect for improved economic development and righting inequality. While electricity access is an essential part of improving the life of the poor, rapidly rising greenhouse gas levels are challenging our traditional thinking on electricity production.

Inequality and energy access

South Africa is listed as 'medium' on global income inequality tables with its growing gap between rich and poor[12]. According to the 2007/2008 Human Development Index[13], globally the richest 20% of people access 62.2% of the income and expenditure cake while the poorest 20% only access 3.5%.

Interestingly, a United Nations[14] report recently found that "despite accelerated economic growth in Africa over the past decade, Africa's welfare has generally failed to improve. Social indicators have picked up only modestly with unemployment particularly amongst the youth remaining stubbornly high while income inequalities have widened"[15].

Earlier in 2012, the World Bank confirmed the consistent trend emerging that poverty levels "fall more slowly" in countries driven by gas, oil and minerals sectors, and in some cases, for example Gabon and Angola, "*the percentage of people living in extreme poverty has even increased as economic growth has spiked."*[16]

Energy, particularly electricity, is a key input to productivity. Increasing the price of electricity is likely to put basic energy services beyond the reach of many, including micro enterprises. Without these small-scale livelihood opportunities, people will be forced to rely more and more on the state for welfare grants[17]. Women especially, as forming the majority of the poor, as well as a disproportionate section of the informal labour market, are likely to be even more disadvantaged by tariff increases.

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[12] The Human Development Report Team. 2012. *Human Development Report 2011*. United Nations. Available at: hdr.undp.org/en/reports/global/hdr2011/ [2013, April 10]
The Human Development Index 2011 ranked South Africa 123rd (of 187 countries).
[13] Conradie, E. 2008. *The church and climatic change*: 1-104. Pietermaritzburg: Cluster Publications.

[14] United Nations 2012. *Economic Report on Africa 2012: Unleashing Africa's potential as a pole of global growth*. (p33). Available at: http://new.uneca.org/adf/publications/economic-report-africa-2012 [April 10].
[14] Polgreen, L. 2012. As Coal Boosts Mozambique, the Rural Poor Are Left Behind. *The New York Times*. 10 November. Available at http://www.nytimes.com/2012/11/11/world/africa/as-coal-boosts-mozambique-the-rural-poor-are-left-behind.html?pagewanted=all&_r=0 [2013, April 10].
[15] Economic and Social prospects for Africa, 2012, *op cit*.
[16] As Coal Boosts Mozambique, the Rural Poor Are Left Behind by Lydia Polgreen, *op cit*.
[17] Sugrue, A., Lebelo, D. 2009. Exploring energy poverty in Africa, a Cures discussion document. *Climate changew Summit 2009*. 3-5 March 2009. Available at http://www.restio.co.za/2011/08/19/exploring-energy-poverty-in-south-africa-2/

Access to energy is a key component of gender equality. The introduction of electricity reduces this burden of unpaid labour and allows women to use electricity as a substitute for labour, for instance, by using a washing machine or a vacuum cleaner. In this way energy access contributes to higher levels of gender equality. Thus a UN Women project in West Africa found that by introducing locally generated energy, women's labour hours were reduced by two to four hours a day, while positive effects were also seen on income, education and adult literacy rates[18].

As we will illustrate below, proof is mounting that a clean, people-centred RE and energy efficiency focus that promotes equality should be integral to any country's development strategy.

Given the Electricity Governance Initiative's focus on Electricity, and while we are cognisant of the broader energy environment and how all elements are interwoven, we have honed in on an aspect we are most concerned with – Electricity and more particularly, modern Electricity demand and supply alternatives.

Pro-poor Smart electricity planning – meeting immediate needs, addressing long term resilience

All countries are facing challenges in the transition towards more secure, environmentally friendly, and equitable energy systems. Setting goals for this transition, promoting the value of contributions that people can make through energy conservation and energy efficiency is important. Working to achieve sustainability today requires that we make decisions that rely more optimally on human commitment to the greater good and are grounded in wisdom and innovation.

Pro-poor Smart electricity planning is economically, socially and environmentally ethical, beneficial, durable and resilient in the face of ongoing global change.

Energy services should be affordable, reliable, pose no threat to human health and safety and be environmentally sustainable. Against these objectives, different supply options (that include consideration of both the energy carrier and the appliance) may be comparatively assessed on their basis to meet the demand for energy services. These objectives need not necessarily be seen as competing and there are many win-win solutions. Energy efficient appliances are a good example that contributes to virtually all these objectives. It is recommended that energy planning for the poor in South Africa should include consideration of the following:

- A balanced and integrated approach to planning for the demand and supply of energy services for poor households that includes understanding demand profiles, the impact of access to electricity on women's unpaid domestic labour, linkages to integrated energy planning and a comparative assessment of supply options against multiple criteria;
- Energy efficiency;
- Energy planning that better reflects urban realities – inclusive targeting of all households and addressing reliability of supply in electricity distribution networks;
- Pro-poor tariffs and subsidies.

Do the electricity planning choices we make benefit the poor?

Industries, commercial businesses and residents with access to electricity have long enjoyed low electricity tariffs in South Africa. While we agree that electricity costs should better reflect

[18] Bachelet, M. 2012. Access to Clean Energy Critical For Rural Women. *Rural Women, Climate Change and Access to Energy*. 5 March 2012. Available at http://www.unwomen.org/2012/03/access-to-clean-energy-critical-for-rural-women/ [2013, April 10].

actual costs of supply and that it is also important to consider commercial viability impacts related to electricity pricing, **a socio-economic approach to setting tariffs that also supports our country's developmental agenda is critical**.

The 2011 Census revealed that 84.7%[19] of formal households[20] in South Africa are connected to the grid and use electricity for lighting. But the significant increase in the number of households connected to the electricity grid since the Census 2001 provides a one sided picture of access to electricity.

Eskom's electricity tariffs have increased on average by about 378% (3.78 times) between 2001 and 2011 and Municipalities add their increasing margins on top of Eskom's tariffs. The average household income of black African households increased over the same period by 2.7 times[21]. The poorest households spend 47.7% on food and 32% on housing, water, electricity, gas and other fuels (excluding transport)[22]. Black African unemployment is officially estimated at 35.6%.

Pro-poor Smart electricity planning and achievement of developmental goals

South Africa is committed to the achievement of the Millennium Development Goals (MDGs) and has taken steps to measure our progress toward such achievement[23]. The many economic benefits that accrue to humanity in general and the poor in particular, from access to electricity[24] are covered by a vast body of respected research[25].

These benefits include improved health, improved quality of life, access to information and reduced biodiversity loss. We now take a closer look at each of these areas of human development in relation to Electricity access.

Health and welfare

Health related benefits are linked most crucially to the reduction in air and water pollution[26], access to nutritious food due to the ability to refrigerate perishable foodstuffs and diversify nutrition options, and access to clean drinking and hot water.

Access to reliable and affordable electricity would improve the lives of families extensively. The role of women in the household energy sector, particularly poor households must be emphasised. Women are responsible for allocating household budgets, collecting wood and other biomass, purchasing fuel, and are responsible for the provision of services such as cooking, cleaning, space heating and childcare, all of which relate to energy[27]. Women and children are most exposed to respiratory illnesses from cooking with wood and paraffin

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[19] Up from 70.2% in 2001.
[20] The poorest of the poor living in informal housing or at no fixed address are of course excluded here.
[21] SA Census. 2011. Available at http://www.statssa.gov.za/census2011/default.asp [2013, April 10].
[22] Steyn, L. 2012. No food, but we have TVs. *Mail & Guardian*. 9 November 2012. Available at: http://mg.co.za/article/2012-11-09-00-no-food-but-we-have-tvs [2013, April 10].
[23] In particular for MDGs 3, 4, and 5, South Africa has a sophisticated data registration system and on MDG1, South Africa conducts regular income and expenditure surveys. In an endeavour to make the MDGs relevant to South Africa, a number of indicators were domesticated and a total of 95 indicators were identified to address all of the eight MDG goals. MDG Country Report, 2010.
[24] We distinguish between Energy and Electricity or Power throughout this report "Energy" includes all forms and sources of energy, electricity or power. "Electricity" or "Power" refers to electric energy only.
[25] Winkler, H, Simoes, AF, La Rovere, EL, Alam, M, and others. 2011. Access and affordability of electricity in developing countries, *World Development* 39 (6):1037–1050. Available at: www.erc.uct.ac.za/Research/publications/11Winkler-et-al_Access_and_affordability.pdf [2013, April 10]
[26] Commission on climate change & development, 2006.
[27] Annecke, W. 2009. Still in the shadows: Women and gender relations in the electricity sector in South Africa; in *Electric Capitalism - Recolonising Africa on the Power Grid.* D. McDonald, Ed. first ed. London Cape Town: Earthscan HSRC press. 288

indoors. Along with lack of access to healthy nutrition, it is estimated that in the year 2000 this was responsible for an alarming 2.7% of the global disease burden. Projected deaths from indoor smoke pollution for sub-Saharan Africa are 1.8 million children and 1.7 million adult women between 2000 and 2030[28]. Access to electricity can mitigate the demand for health services and reduce the burden of health care currently being borne by citizens through chronic ill health, lost earning power and stunted development.
Forward thinking electricity planning will seek to ensure that future generations are not required to bear the dual consequences of social inequality and lack of access to energy due to outdated planning in South Africa.

Quality of life and access to information

In poor households, cooking accounts for the major share of household energy demand. Women are still primarily responsible for finding fuel for cooking and/or space heating. These activities still often require walking many kilometres and communities report the need to walk increasingly greater distances to find firewood. This trend will worsen as existing wood sources are used up and predicted climatic drying effects in certain regions take their toll.

Household lighting extends the time available for reading, studying and working. Access to electricity enables the use of technology, thereby enhancing information access and potentially the ability of a person to productively participate in our economy[29]. In 2011, only 8.6% households could access the Internet from home, with over half of households (64.8%) having no access at all.[30]

Biodiversity and ecosystem preservation

Reliance on wood fuel can lead to deforestation and the eventual destruction of biodiversity, leading to other environmental impacts such as; increased floods, erosion, loss of fertile soil etc. Access to fuel-efficient cooking technology, the use of the sun to heat water (solar water heating), and the use of rainwater collection tanks can directly benefit poor households and enable them to take an active part in repairing and conserving diminishing natural resources and deteriorating ecosystems.

Achieving developmental goals through Smart electricity planning is a challenge, tied to rich rewards

Since our first democratic elections, over 4 million homes have been connected to the electricity grid. This has increased the proportion of formal households on the grid to about 84.7%[31], a remarkable achievement. But connecting homes to the country`s electricity grid is becoming very expensive especially in rural areas. Alternative forms of electricity access have become critical.

Ironically as electricity prices have risen, residents are choosing to not use electricity even when they have the physical access, because such usage is becoming unaffordable[32].
For reasons of affordability, households continue to use a diverse range of fuels despite an assumption that as families moved into formal housing, they would shift to using electricity only[33].

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[28] International Energy Agency. 2012. *Key World Energy Statistics 2012*. Available at: www.iea.org/publications/freepublications/publication/name,31287,en.html [2013, April 10].
[29] Saghir, J. 2005. Energy and Poverty: Myths, Links, and Policy Issues. *World Bank Energy Working Notes*. Available at: http://siteresources.worldbank.org/INTENERGY/Resources/EnergyWorkingNotes_4.pdf [2013, April 10].
[30] SA Census, 2011, available at http://www.statssa.gov.za/census2011/default.asp [2013, April 10].
[31] SA Census, 2011, available at http://www.statssa.gov.za/census2011/default.asp [2013, April 10].
[32] Direct feedback to civil society organisations from residents of poor communities attending workshops during 2011 and 2012 in Western & Eastern Cape.

If we accept the premise that electricity is vital for the development of a thriving society, the provision of basic electricity services to the marginalised and vulnerable should be seen as a social investment and not purely approached from a cost-recovery intention, as has been proposed in South Africa. **Smart Electricity planning can enable long term progress in poverty alleviation and gender equity and achieve national economic development goals.**

True cost: what is considered when we compare the costs of energy provision?

Sustainability recognises the inextricable links between the natural world and people. It will aim to fairly consider the value of ecosystems preservation for ongoing human development. When environmental and social welfare costs of electricity provision outweigh the benefits of electricity access, we have to reconsider the cost comparisons we make. If we look at across the full value chain, we may well see the benefit of making different Energy choices. In Eskom's MYPD3 proposal to NERSA in November 2012, Eskom stated that electricity *needs* to move to a cost-reflective tariff[34]. But what are the true costs that should be considered?

Ecosystems services

Human industrial activity generally relies on nature for providing a number of services, regulating such services (e.g. water purification, climate control) and supporting services such as decomposition of organic materials and the ongoing provision of habitat.

The only costs generally reflected in planning have been the costs of extracting these items from the natural world. **The real cost is not reflected, which would be the cost of reproducing these services for future generations**.

From the perspective of ecosystems services costing, global warming is a sign that the world economy has hit the limit of the eco-system's ability to provide free services.

Incorporating externalities properly is illuminating

Perhaps the most common type of externality is pollution. Pollution increases the costs of healthcare and degrades the quality of life of humans and organisms. But generally, companies causing the pollution do not contribute to healthcare and quality of life costs. Instead their pollution is subsidised by others through growing poor public health, reduced economic productivity, sickness and suffering, and even death (which economists do strive to price). In this sense, externalities are a social subsidy and it is widely acknowledged that fossil fuel (and Nuclear) subsidies dwarf anything solar or wind power has ever received.[35] **But who pays for the social subsidies not covered by government**?

The 1998 White Paper on Energy Policy recognises that "the production and consumption of energy has many undesirable impacts on the environment, often resulting in external costs, also known as negative externalities"[36]. Since South Africa has a carbon-intensive power sector *and* historically low levels of electrification and housing in poor areas, many communities have had to face a double burden of lack of electricity and poor air quality from neighbouring Eskom power plants and coal mines. Recognising the environmental impacts of fossil fuels and the social benefits of improved energy services, the White Paper aimed to better incorporate external costs into energy prices, since that would remove some of the distortions that make RE appear more costly than conventional fuels.

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[33] Cousins, T., Mahote, F. 2003. *A Final Report Containing A Compilation And Analysis Of The Social Survey Data*. City Of Cape Town. Available at: cdm.unfccc.int/UserManagement/FileStorage/FS_123598248 [2013, April 10].

[34] Eskom. 2013. MYPD3 application to NERSA, part 1 revenue application page 5/144; Available at: www.Eskom.co.za/content/MYPDFinalX3.pdf 2013, April 10].

[35] http://cleantechnica.com/2013/02/07/energy-subsidies-clean-energy-subsidies-fossil-fuel-subsidies/

[36] Department of Minerals and Energy. 1998. White Paper on the Energy Policy of the Republic of South Africa. Pretoria: Government Printer. Available at: http://www.info.gov.za/view/DownloadFileAction?id=142157 [2013, April 10].

The inclusion of 'quantifiable externalities' in energy prices is key to reflecting the costs and benefits of different technologies more accurately; especially since conventional fuel prices have not historically included these negative (or even positive) impacts, and have also benefitted from high levels of subsidies.

Let us return now to the topic of Smart electricity planning. How do the assumptions we make about future demand impact the investment choices we then commit to?

Demand

Author: Robert Fischer

Contributors: Saul Roux, Oliver Stotke

In summary:

The IRP2010 is based on high economic and electricity demand growth predictions. Lower than the assumed growth in electricity demand has been experienced in the two years since the IRP2010 promulgation and local and global economic growth is predicted to be low for years to come.

While it is too early to conclude that these short term lower demand growth trends will continue into the long term future, high growth assumptions present their own risks. In a context like South Africa where abundant natural energy resources exist, where unemployment figures are high and household incomes are dwindling, inflated energy demand projections that automatically lead to inflated investment in expensive generation technologies that don't provide significant numbers of jobs is just not smart.

Based on the best available information, including international and local research, the potential for reduced electricity use in diverse sectors has been examined and from this examination alternative scenarios for future electricity demand in South Africa have emerged.

Given these alternative demand scenarios, new supply scenarios were then developed. These are presented in the next chapter on electricity supply.

We have found that – based on current demand levels, through effective energy efficiency and conservation strategies and following existing best practice examples in the sector – **residential sectors could reduce their electricity demand by up to 40%, commercial sectors up to 25%, mining and industries between 15% and 20%.**

We conclude that by achieving the overall National Energy Efficiency Strategy target of 12% and continuing with a very moderate energy efficiency programme until 2030, an overall electricity demand reduction of 16%[37] by 2030 is easily achievable without constraining economic growth.

South Africa's power sector today

The power sector[38] in South Africa is dirty and unhealthy. It is the country's biggest air polluter and contributor to climate change. It directly uses about 2% – and pollutes much more – of national water resources and contributes about 59% of our CO_2 emissions[39].

Eskom dominates the South African power sector. The energy intensity of our economy has been historically high compared to developed countries, but is also higher than other emerging economies like China, Brazil or India. It is encouraging that recent trends show a slow drop of energy intensity in South Africa and new policies, like the New Growth Path (Green Economy) are geared to accelerate such changes of the economic sectors of South Africa.

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[37] Compared to the 4% energy efficiency potential taken into account in the IRP2010

[38] 'Power sector' refers here to all aspects of power provision from mining to generation, transmission and distribution.

[39] Zipplies, R. 2008. *Bending the Curve,* Africa Geographic, South Africa, available at: www.bendingthecurve.co.za/ [2013, April 10].

More coal, nuclear power, gas and a small variety of RE technologies are currently on the country's policy roadmap toward a future energy mix in South Africa.

With the IRP2010 and especially with the Renewable Energy Independent Power Producers' Procurement Programme (REIPPPP), Government has for the first time demonstrated its political will to support innovation in the power sector. Opening the power sector up to players other than Eskom will lead to healthy diversity. However, it is of concern that so far these emerging reforms appear to have been primarily designed so as not to present a threat to our old, centralised power system.

An independent system and market operator (ISMO), which has full control over transmission assets ('the grid'), is being planned and the accompanying legal framework and regulations are being drafted. The final chapter of this report on Institutional governance delves further into the power sector's legislative and regulatory frameworks.

As has been pointed out in the previous chapter, increasing electricity demand is still seen by many conventional decision makers and planners as inextricably linked to economic growth. But – quite apart from the widely known destructive effects of emissions caused by extracting and burning fossil fuels – it is clear that as global construction and transport costs steadily rise, and public perceptions of energy usage change, the common view of what constitutes sustainable electricity demand and supply is changing.

Electricity planning in South Africa – the IRP2010

South Africa's first National Integrated Resource Plan (NIRP1) was completed in 2002. An updated plan (NIRP2) was completed in 2004 and NIRP3 was completed in 2008. The current IRP2 or IRP2010 was promulgated in May 2011. Previously Eskom used to develop Integrated Strategic Electricity Plans (ISEPs), which provided strategic projections of supply-side electricity options to be implemented to meet Eskom's long-term electricity load forecasts.

So far all so-called 'Integrated' resource or electricity plans have been rather one-dimensional and follow classical planning approaches where the electricity demand and its growth is taken as a given input factor – and in hindsight the demand assumptions are often wrong, namely too high. The plan then seeks to create supply scenarios, which fulfill multiple criteria, but where lowest-cost and sufficient reserve generation capacity are the dominant factors.

In addition, the IRP2010 is not based on an Integrated Energy Plan, which would allow the electricity sector to be truly integrated within the entire energy sector.

The IRP2010 based its proposed roadmap for new-build generation on Eskom's System Operator (SO) department's moderate demand forecast[40] which assumes a doubling of electricity demand in the next 25 years[41].

Taking an overly cautious stance, the IRP2010 moderate forecast considered only a fraction of the potential contribution to reduce demand with effective Energy Efficiency and Demand side Management (EEDSM). It is important to point out that **the IRP2010 Energy efficiency targets did not include existing national energy efficiency targets of 12% (in general) and 15% (for industries), but only propose a 4% demand reduction by 2030 through EEDSM measures**.

[40] Also called SO Moderate or SO-Mod; SO moderate is the chosen IRP2010 scenario modelled by Eskom, SO-High and SO-Low are other scenarios modelled by Eskom but not chosen.
[41] The actual 2012 electricity demand is likely to be about 10% below the SO-moderate forecast for 2012.

Possible reduced demand reductions of electricity users in response to consecutive high tariff increases ('price elasticity') were only factored in indirectly by considering income effects on GDP growth[42] and substitution effects, which would directly impact on electricity demand[43].

Alongside this, an overly optimistic GDP growth forecast pushed the projected electricity demand in the IRP2010 to an expected annual growth-rate of about 2.9% from 2010 onwards (see **Figure 1a and b** on page 26), with major demand assumed likely to come from industry sectors and municipalities.

Forecasting and choosing the most appropriate scenario to plan around is difficult, particularly when multiple factors come together, such as global uncertainty and the impacts of price increases. However, **when sufficient evidence surfaces to indicate that assumptions were inflated, our legislated periodic planning reviews allow for flawed assumptions to be revisited**.

Was the IRP2010 based on overly inflated demand projections?

The IRP2010 based its modelling for future supply options on historical data and a so-called moderate demand forecast developed by Eskom and its System Operator department (SO), which in fact reflects a business as usual approach. This SO-moderate forecast assumes a 2.9% annual increase in electricity demand for the entire planning horizon 2010-2030.

Electricity consumers of all sectors are feeling the effects of tariff increases in a context of global economic slowdown and many attempts have been made to reduce energy consumption. This is reflected in a significant drop in electricity demand over the past two years.

While it is too early to conclude that this lower demand growth trend will definitely continue in the long term, it is sufficiently different from the projection for South Africa's many expert energy modellers to consider the likely over-investment impacts should such a trend continue.

A number of submissions in the public consultation process for the IRP2010 questioned the choice of the SO-moderate forecast as a sound basis for the modelling exercise and asked for the demand estimates to be lowered; pointing out the significant potential of energy efficiency and demand-side management (EEDSM) to reduce electricity demand, especially with consideration of public reaction to high electricity tariff increases[44]. Without reasons provided, these submissions were widely ignored and the modelling for the new-build plan in the IRP2010 was finally based on the SO-moderate forecast[45].

Eskom reported in its interim results for 2012 a drop in electricity demand of 2.9% for the period January to September 2012 as compared to the same period of the prior year[46]. Note that in the same period South Africa's GDP rose 2.5%[47]

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[42] Price increases generally reduce disposable income, particularly in the case of poor households.
[43] IRP input parameters: D5 = Price Elasticity of Demand - IRP2010 Input Parameter. Price elasticity is captured in GDP-growth assumptions and in future electricity intensity. In future iterations of the IRP the effects of price elasticity should be considered as directly impacting on the demand forecast models.
[44] Submissions from civil society referring to the inflated forecast and too conservative EEDSM considerations include: ASSAf, Idasa and Electricity Governance Initiative – South Africa.
[45] At the time IRP2010 was in development, Eskom also invited CSIR to model a demand forecast. The CSIR-forecasts largely matched the SO's low demand scenario. Later on in the process Eskom and DoE dismissed CSIR's forecasts without transparent justification and continued to use the SO-moderate forecast.
[46] Eskom. 2012. Media Statement. Available at: http://www.eskom.co.za/content/MediaRelease_interimResults2012~1.pdf [2013, April 10].

The influence of popular, people-centred and values-driven programmes to reduce energy consumption[48], a slow shift toward an economic structure that is less energy intensive, rapidly growing public awareness of climate change impacts and further effects of price elasticity, are all new and significant factors in the power demand context.

In October 2012 Eskom applied to NERSA for their third Multi Year Price Determination (MYPD3). Significantly, Eskom based the MYPD3 on a revised demand forecast of 1.9% annually. A 1.9% annual increase would double the electricity consumption in 36 years as opposed to the 25 years assumed in the SO-moderate forecast. At the very least, these recent declines in the electricity demand urgently need to be analysed in order to assess whether the IRP2010 build programme will lead to unaffordable overcapacity and whether the entire IRP2010 actually will need to be reviewed.

Important questions to ask at this time are:

- What are the consequences of overly-conservative energy efficiency estimates (i.e. too low) and overly-optimistic (i.e. too high) economic and electricity demand growth estimates?
- Do we really need all the new-build capacity as proposed in the IRP2010? Can we afford expensive stranded infrastructure investments?
- How are further price increases likely to impact on demand? What would happen to the demand forecast and the related need for new-build if the potential of EEDSM is taken more seriously?
- Why is DOE delaying the review process for the IRP2010?

Making better assumptions

The South African electricity system, which largely relies on power generation from carbon-intensive coal and oil plus some nuclear power (uranium), was and is dominated by a tight relationship between the power giant Eskom and all big industrial sectors, which together consume about 70% of South Africa's available electricity.

This relationship also determines the demand projections, where Eskom historically has developed future supply plans and based these mainly on industrial forecasts – the Integrated Strategic Electricity Plans (ISEPs). These ISEPs have informed the National Integrated Resource Plans 1-3, developed by NERSA. (The last ISEP (ISEP12) was not finalised, because it was replaced by the first IRP and later with the current IRP2 or IRP2010.)

For 2012, the peak demand forecasts in IRP2010 were: SO-moderate forecast (SO-Mod): 40 GW, SO-low forecast (SO-Low): 39 GW and CSIR-Mod: 40 GW. Eskom's most recent system status bulletins[49] report peak demands in the winter months of below 36 GW – respectively 10% less than SO-Mod and 8% below SO-Low.

Eskom and DoE's concerted efforts to promote energy efficiency coupled with electricity users' reaction to price signals and the ailing economy have all contributed to the drop in demand (both peak and energy), which was also reported in Eskom's interim results for the first six months of 2012.

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[47] Mantshantsha, S. 2013. Electricity use drops 'due to price increase'. *Business Day Live*. 27 February 2013. Available at: http://www.bdlive.co.za/business/energy/2013/02/27/electricity-use-drops-due-to-price-increase [2013, April 10].

[48] Awareness Campaigns like 49M, SWH and Heat Pump rollout programmes, the replacement of lighting energy technologies and household appliances with low energy options, the Energy Efficiency Accord (A voluntary agreement from a large group of South African industries in support of the National Energy Efficiency Strategy).

[49] Eskom. 2013. *System status bulletins*. Available at: http://www.eskom.co.za/c/199/system-status-bulletins/ [2013, April 10].

Besides all the efforts undertaken to conserve energy, to improve energy efficiency and to reduce peak demand, the globally weak economy and local factors such as prolonged strikes in the mining sector have also contributed to a lower demand – but exactly which factor has had how much effect is currently not clear.

With this in mind and with the informed belief in the significant potential of energy conservation and efficiency efforts across all sectors, we have rigorously analysed electricity demand and how it could develop with updated and more ambitious targets for the efficient use of energy. Given that economic growth is frequently linked to security of Electricity supply, we will begin with a look at Gross Domestic Product (GDP).

GDP

The Gross Domestic Product (GDP) in South Africa dropped to a low 1.2% in the 3rd quarter of 2012. Prior to this, between 1993 and 2012, South African GDP Growth Rate averaged 3.26% reaching an all-time high of 7.60% in December of 1994 and a record low of -6.30% in March of 2009[50].

In order to close the GDP per capita gap with OECD-countries South Africa would need to grow at a much higher rate, but in the current global financial context is this likely to happen?

The SO-Mod demand forecast was based on a 4.5% annual growth in GDP and a 2.9% growth in electricity sales. This would translate to a doubling of electricity demand in just 25 years.

The SO-Low forecast, assumed a 3.5% GDP and a 1.9% electricity demand growth. Eskom in its latest MYPD3 application based its 5-year pricing model on a 1.9% annual electricity demand forecast and a 4% GDP-growth rate respectively over the next 5 years.

The SO-Mod forecast – if realised – would lead to a very challenging situation: **South Africa would need to double its existing fleet[51] by 2035** – or in the medium term it would need to invest heavily in the extension of the lifetimes of the ageing plants.

In the case of a real demand growth following the SO-Low forecast the replacement of power plants would still need to happen, but additional capacity of only about 15 GW would need to be commissioned by 2035.

The high demand assumptions pose a tremendous challenge, which has resulted in the promulgation of a rather overwhelming plan to build expensive centralised Coal and Nuclear power stations and a small amount of large-scale RE power plants within the next 25 years to meet the assumed, and we believe inflated, forecasted need.

South Africa's Power Sector – a different tomorrow

Historically the planning preference for large-scale centralised coal-fired and nuclear power generation has partly been due to the technology limitations of the day, the availability of cheap coal, the guaranteed free access to water and the nuclear ambitions of the Apartheid government. This has happened within a system where it is assumed that security and adequacy of grid-based Energy supply and Economic growth are always linked.

Technology advances and the recognition of the need for transition away from energy-intensive industry lead us to ask: does such an approach still make sense?[52] A smarter approach to electricity planning can enable a transition to a modern, diversified and distributed Power sector.

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[50] Bank De Binary. 2013. South Africa GDP. Available at: http://www.tradingeconomics.com/south-africa/gdp-growth [2013, April 10].
[51] Eskom. 2012. Eskom's generation plant mix. *COP 17 fact sheet* . Available at: http://www.eskom.co.za/content/Generation%20Mix.pdf [2013, April 10].
[52] Many OECD countries are decoupling economic growth and grid-based energy use.

Why do we think that the current electricity planning approach is not sufficiently smart?

Today, electricity planning in South Africa tends to prepare for uncertainties with an approach in favour of overcapacity in order to avoid the worst case – unmet demand or rolling blackouts.

Such an approach has its advantages but can also turn out to be excessively costly and financially risky. This is especially true when much of the investment is likely to be spent on inflexible, large scale, dirty power stations, where the likelihood of construction delays are high, cost estimates subject to common overruns and where future risks and costs of fuel and waste management are unpredictable. Delays would mean that assumed future demand cannot be met and if the demand growth should not materialise as expected, the power stations would need to operate below capacity or have to be mothballed, as happened in the past – both very costly practices.

By comparison, **most RE technologies favour modular construction so that the risk of over-investment in such technologies is far lower and new-builds are less financially and environmentally risky**.

Uncertainties in forecasting our future cannot be overcome, but we can apply smarter approaches to how we deal with such uncertainty. For example, **allowing Eskom under its current sales-driven regime to predict its own future can only result in demand forecasts and supply scenarios which do not sufficiently take into account the contribution of ambitious electricity savings drives, socio-economic and environmental impacts of fossil fuel based power generation, and which discount the potential of decentralised supply solutions**. In short, asking the dominant electricity provider, which is heavily invested in a centralised grid, to apply innovation in its demand and supply mix is likely to have limited success.

More practical, innovative and integrated approaches can include determined strategies to foster diversified and efficient generation of electricity, widespread use of our RE resources and accessible options for using coal-based electricity more wisely and efficiently. These approaches can also result in more equitable economic wellbeing without destroying our planet.

What has changed to materially influence change in the power sector?

Eskom's existing fleet of power plants have an average age of 30 years, the oldest one – Komati – is 49 years old[53]. This leads to high maintenance needs and an increased frequency of plant failures affecting system availability[54]. Given this, is planning for further investment in large power plants with unpredictable costs, which will only come online in 10 to 15 years prudent?

While global economic downturn effects are clearly a significant consideration in any analysis of global contextual change, these are difficult to apply directly to the local context. So we will focus on some key local contextual factors that have produced significant change and which therefore should influence our planning choices more.

These are:

1. The electricity tariffs through two MYPD cycles of three years each have been increased aggressively. An application for a third and again steep electricity tariff increase cycle – MYPD3, has just been rejected by NERSA.
2. As electricity consumers in all sectors are pressurised by hiked tariffs – awareness of the need to reduce electricity consumption is becoming common knowledge. More

[53] Eskom. 2012. *October 2012: Quarterly Update: State of the Power System*. Available at: http://www.eskom.co.za/content/20121012OctStateSystemediabriefMaster_v7final.pdf [2013, April 10].
[54] Availability is the probability that a system will work as required when needed.

and Smart Energy efficiency Demand-side Management (EEDSM) solutions for households, commercial buildings, manufacturing, heavy industries and mining are by comparison becoming economically feasible as electricity tariffs continue to increase, thus potentially improving end-use efficiency and reducing demand.

3. We have technologies available today which can enable anyone to participate in the power sector, not merely as an electricity consumer, but also as a supplier. Many supply options are today available off the shelf, such as: Solar PV options to suit rich and poor, bigger rooftop and ground installations of Solar PV and wind turbines on farms and commercial buildings which can range from a few kW to some MW without disturbing the intended use of the land or the land operations and without polluting the environment.
4. Investment in R&D for small and large-scale storage solutions – to support a wider deployment of intermittent RE solutions – has increased significantly in the past few years. Prices for energy storage have started to drop and new improved technologies have begun to appear in pilot and commercial applications.
5. Large scale RE generation capacity can be added with a lead time of a year or two (in the case of Solar PV or wind), instead of 10 years or more needed for large scale coal or nuclear options. Small scale embedded generation can be installed within weeks (e.g. Solar PV).

While in the early days of democracy there was an implicit assumption that electricity would be available to and affordable for everyone, ironically as electricity prices have risen, poor households frequently end up not using electricity even when they have the physical access. This is because electricity is becoming increasingly unaffordable[55]. This has negative consequences for gender equality as previously discussed and is likely to increase the inter-generational transfer of poverty.

Given these local circumstances and the fact that electricity demand growth has followed a decreasing trend, there is an urgent need to sensibly review the electricity demand forecast and related investment planning choices made in the IRP2010.

Taking energy conservation and efficiency potential seriously

Projecting mid- and longer term developments of energy conservation and energy efficiency require that the impacts of further factors should be taken into account, such as:

- Continued increased electricity tariffs (price elasticity of demand).
- Going beyond 'low hanging fruit' and using best available technology options for energy efficiency interventions in all sectors; moving from 'component optimisation' to 'system optimisation'.
- Mining and industrial investment in process and system changes, which can lead to 40-50% reduction of energy use.
- The introduction of new building regulations (SANS 10400-XA: Energy Usage in Buildings)[56].
- SANS 10400-XA is only a first step. The Nearly-Zero-Energy Building Standard by 2020 for the countries in the European Union is mandatory – this can happen in South Africa too.
- Provision of incentives for energy improvements to existing buildings.

[55] Frequent direct feedback to civil society organisations from members of poor communities attending workshops during 2011 and 2012 in Western & Eastern Cape & Gauteng.

[56] SABS. 2011. *The application of National Building Regulations. Part XA: 10400-XA: Energy usage in buildings.* Available at: https://www.sabs.co.za/webstore/SetaPDF/Demos/Encryptor/genpreview.php?stdsid=1400025021&pid=12481 [2013, April 10].

- Promotion of recycling which reduces energy consumption significantly in aluminium, steel, glass, plastics and paper production – South Africa could set more ambitious targets and implement these.
- The availability of natural gas for cooking and heating (although this will require significant gas infrastructure development).

As already stated, we believe the targets of the National Energy Efficiency Strategy of 12% in total and 15% by 2015 for mining, industries and commerce are achievable and targets way beyond that are feasible. Going beyond reducing energy consumption at the point of use by conservation and efficient solutions and on-site power generation has additional potential to reduce electricity demand from the national grid. Here are some examples:

- The availability of natural gas for applications such as combined heat and power on large, small and micro scale will impact all sectors, including electricity generation.
- Mining and industries implementation of own- and co-generation wherever suitable, including investments in RE supply.
- Utilisation of commercial, industrial and residential potential of biogas from waste water and bio-degradable waste.
- Development of landfill gas and other waste-to-energy technologies.
- Exploiting the potential for solar thermal applications to satisfy commercial and industrial cooling and process heat requirements.
- Competitive costs of Solar PV driving implementation for industry, commerce and residential sectors.
- Commercial buildings supplying themselves with electricity from the sun, geo-thermal and combined heat and power. Many examples already exist. Such initiatives can be accelerated and rolled out broadly.
- Cutting the red-tape and allowing and assisting citizens, communities and enterprises to participate in the electricity market as suppliers. Proper incentives can kick-off an accelerated roll-out of Solar PV rooftop installations.
- Low income homes can successfully participate in Solar PV rooftop programmes, considering the costs for Free Basic Electricity (FBE) and the real costs for distributing electricity to these households. Enabling this participation will call for innovative financial models for small-scale embedded power generation in poor communities.
- Energy storage solutions are under development worldwide and are becoming more cost-effective. Solar PV is already competitive in off-grid situations and often also when compared to grid extensions. The International Energy Agency (IEA) predicts that RE and especially Solar PV WITH storage will be competitive with conventional power before 2030.
- The introduction of electrified surface transport would have an upward effect on electricity demand. Such an intervention would need to be analysed in close conjunction with other energy sectors, such as coal or gas-to-liquid (which currently supply 40% of South Africa's liquid fuels). The overall efficiency (mine to wheel) of our current system is 12%, whereas the efficiency of an electrified transport system, based on coal or gas fired power generation is about 30%[57].

Our scenario modelling outcomes

To adopt the SO-moderate forecast (SO-Mod) would suggest that we do not trust in the likelihood of energy efficiency gains, that policies on economic restructuring will not be successful and that the global and local economy will start to return to high growth-mode. We feel that this is unduly conservative.

[57] Kendall, G. 2008. *Plugged In. The end of the oil age*. WWF. Available at: http://www.electricdrive.org/index.php?ht=a/GetDocumentAction/id/27921 [2013, April 10].

Instead, we have assumed more ambitious and achievable energy saving potentials into our proposed demand forecasts. These allow for economic health and realistic, achievable energy saving options.

South Africa's energy intensity has started to drop and is likely to continue to do so with the successful development and implementation of the New Growth Path (NGP) and the recommendations of the National Development Plan (NDP).

For our proposed demand scenarios we have used two baselines: firstly we applied the energy savings potential to the SO-Moderate forecast and secondly to the SO-Low forecast. You will recall that as indicated above, the differences between these two forecasts originated mainly from the assumed GDP-growth rates (4.5% for SO-Mod & 3.5% for SO-Low).

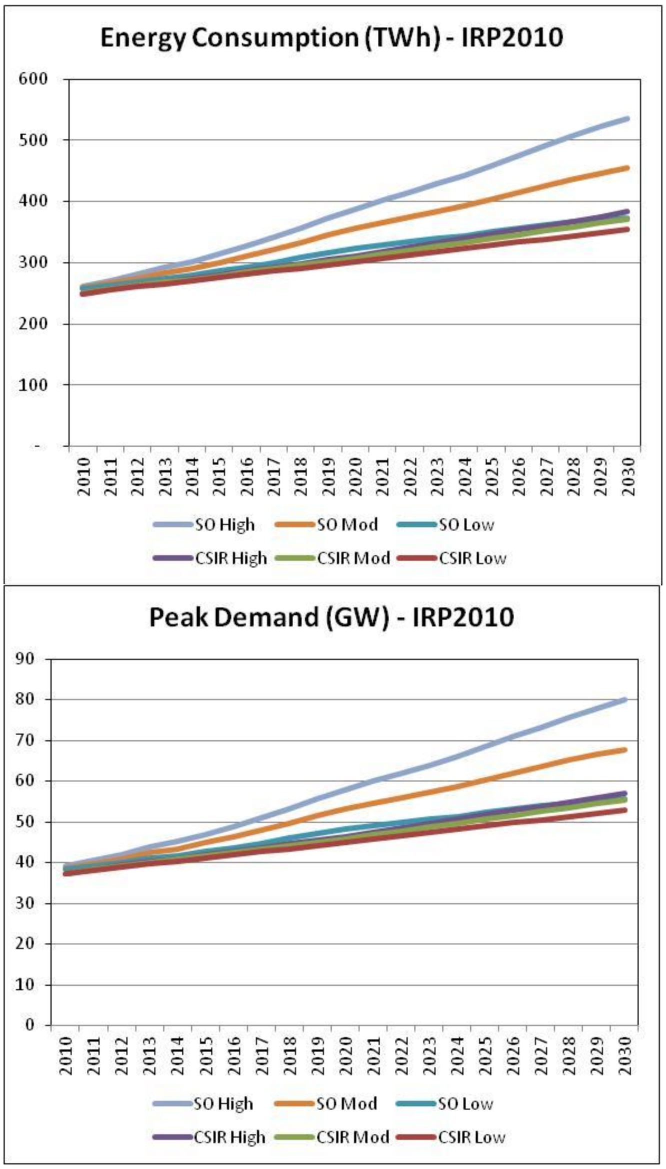

Figure 1a & b: IRP2010 – Electricity Consumption Forecasts[58].

[58] SO: System Operator – An Eskom department. Mod: Moderate; Eskom. 2010. *IRP2010-Energy Forecast Revision 2 Report*. Available at: http://www.energy.gov.za/IRP/irp%20files/SO_IRP%202010%20Energy%20Forecast%20Final%20Report.pdf [2013, April 10].

Based on publicly available information, including international and local sources and case studies, we examined the potential of electricity savings in different sectors and this led us to alternative scenarios for future electricity demand in South Africa.

First, let us remember that it is a seldom considered fact that in most cases, centralised energy supply cannot avoid major transmission losses before reaching the point of final use.

Energy chain losses

The industrial sector is a major energy and electricity user in South Africa. Electricity requirements in this sector are mainly determined by activities such as: compressed air, lighting, cooling, process heat, HVAC, electric motors and drives for pumping, fans, etc. System-wide energy losses for a water pumping activity can amount to more than 90%.

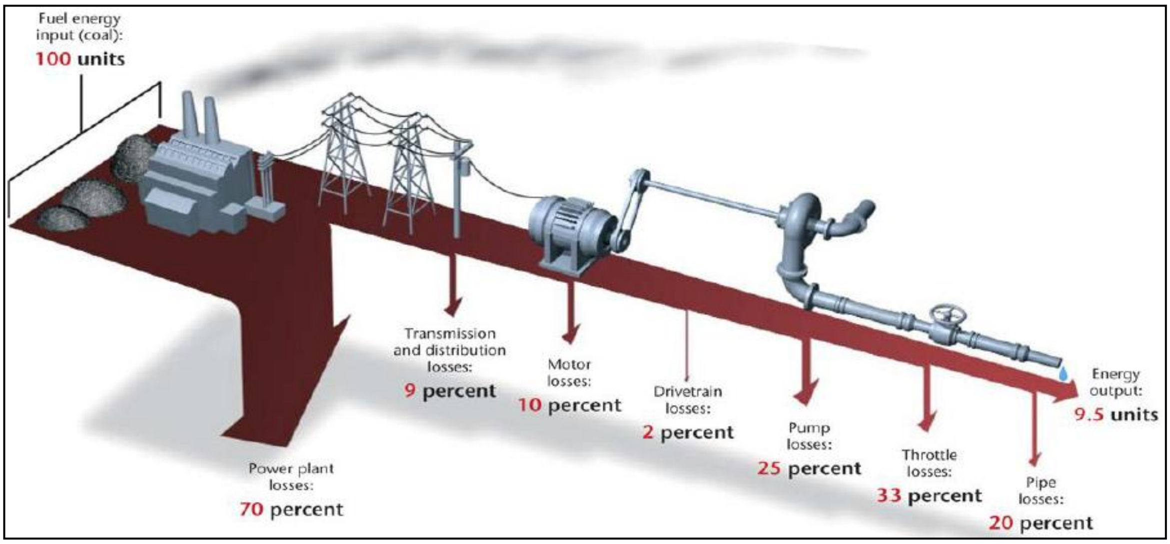

Figure 2: Energy losses: More than 90% of energy extracted from the ground is commonly wasted before it reaches the final point of use[59].

And then there is the wastage at the point of use, for instance, lighting in all sectors is most wasteful when incandescent light bulbs are used. The energy chain efficiency in this case is less than 1%, when the primary energy source is coal. 30% of the total energy-chain losses are attributable to the use of the incandescent bulbs in the building itself.

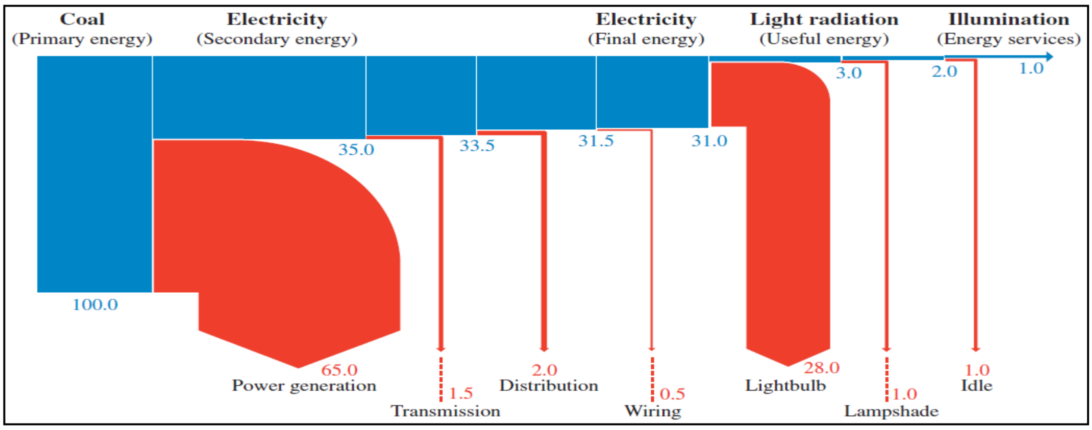

Figure 3: Energy chain efficiency for incandescent lighting[60].

[59] The World Business Council on Sustainable Development (WBCSD).

The examples above demonstrate the common, wasteful use of energy within a centralised electricity supply system and the contribution to losses at the point of use respectively. Note that the energy input for coal mining is not considered in the examples we provide. This would use about 5% of the primary energy generated and hence increase the total losses even more.

Decentralised and RE supply can avoid such massive losses of primary energy conversion and distribution.

Using a few examples we now highlight how the four major energy-use sectors of South Africa's economy contribute to electricity demand and then work out what potential for savings can be unlocked in each sector when the right incentives are put in place.

Potential contributions: energy conservation, efficiency and peak demand management
This study has analysed the potential of electricity saving in the different sectors and so has looked at the potential contributions of energy conservation, energy efficiency and peak demand management in four respective sectors[61] using the following commonly understood benchmarks for energy conservation and efficiency:

- **Current energy use**: The average energy usage in the sector, including energy use and peak demand.
- **Best practice:** The energy consumed by a sector-member with above average energy efficiency.
- **Practical minimum:** The energy that would be required after implementing substantial improvements in energy usage, based on state-of-the-art and emerging technologies.

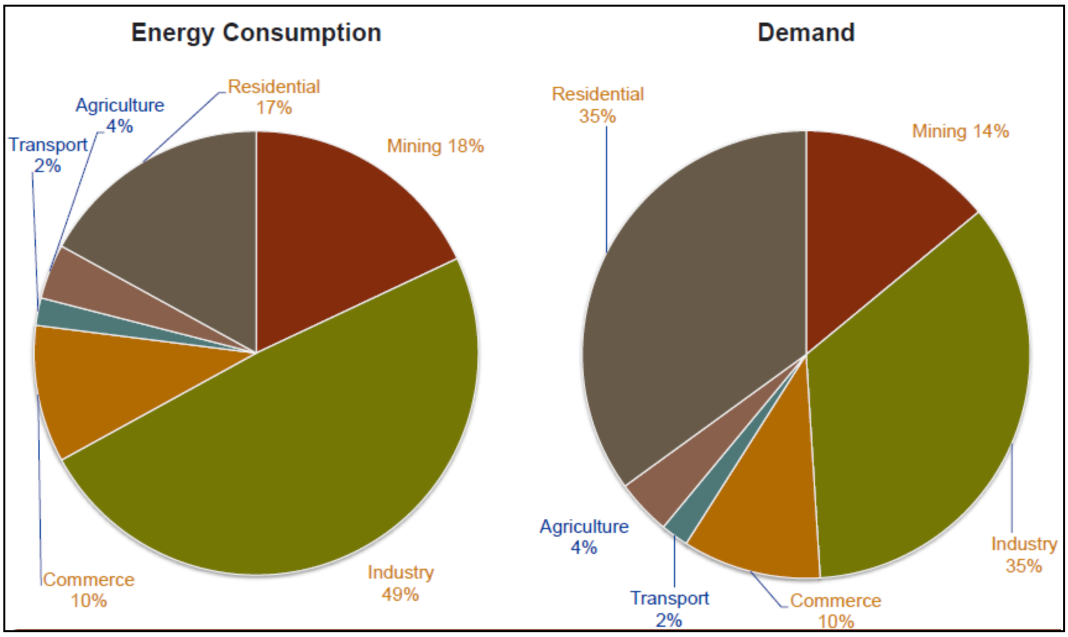

Figure 4: Electricity Consumption and peak demand per Sector in South Africa 2012 (Eskom).

As illustrated in **Figure 4** above, **mining and industry combined use 67% of South Africa's electricity and are responsible for 49% of peak demand.**

[60] GEA. 2012. *Global Energy Assessment – toward a Sustainable Future*. Cambridge University Press, Cambridge UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria. E-book available at: http://www.cambridge.org/gb/knowledge/isbn/item7107122/?site_locale=en_GB [2013, April 10].
[61] The four sectors analysed: Mining; Industry (energy intensive); Other industry; Residential.

The residential and commercial sector together use 27% of electricity and are responsible for 45% of peak demand.

Agriculture and transport consume 4% and 2% respectively of South Africa's electricity. Future developments in the transport sector, which will include electrified public transportation and electric cars and bicycles, will definitely have an impact on demand.

Recall that the overall target of the National Energy Efficiency Strategy (NEES) is 12% savings and the target of the industrial signatories to the Energy Efficiency Accord is a 15% saving below business as usual by 2015.

The NEES targets are minimum targets, which are achievable by attending to 'low hanging fruits' such as: component optimisation in the areas of electric drives, ventilation, pumping, compressed air systems, etc. Investment needs in such measures are relatively low and usually pay back in a period of less than two years.

Going beyond these easily achievable targets requires a more committed approach known as 'system optimisation', where entire processes are analysed and re-engineered in order to achieve an average potential of 40-50% energy saving across all industrial sectors[62].

The IRP2010's SO-moderate forecast only included an energy saving potential of 4% by 2030.

The current approach is not sufficiently smart, because it does not reflect confidence in the capacity of people in South Africa to use energy more wisely or draw on our natural resources sufficiently. Most critically it requires massive financial resources and discounts a range of environmental impacts.

Beside these arguments, a smarter approach which includes the potential for energy savings at the very beginning of the planning process would require a lot less by way of financial investment. While energy conservation and efficiency initiatives also require investment, such costs generally do not come close to the scale of investment required for new power generation.

At the public participation process for the second review of the National Energy Efficiency Strategy in January 2013 Eskom reported that during the MYPD2 period a total investment of R5.4 billion resulted in a peak demand saving of 1 037 MW, which means that Eskom has proven that **1 MW saved currently costs R5.2 million**. **According Eskom's Integrated Report 2012 the average overnight investment costs – based on 2010 figures - for Medupi are R17.7 million/MW and R18.5 million/MW for Kusile**.

At the recent second review of the National Energy Efficiency Strategy municipalities provided examples of energy efficiency implementation costs ranging between R1.4 million per MW and R4 million per MW.

From this we can conclude with reasonable certainty that investing in energy efficiency is much cheaper than investing in new power generation build. The range of energy efficiency costing compared to new power plant investment is between a factor 3 to 12, depending on who is responsible for implementing EEDSM measures and where such saving options are implemented.

[62] Mckuur, G. 2011. Industrial Energy Efficiency Project South Africa. *SAATCHA Conference*. South Africa 20-30 August 2011. Available at: http://www.saatca.co.za/DNN/LinkClick.aspx?fileticket=FRXx-Cc70MA%3D&tabid=106 [2013, April 10].

Our findings for potential energy savings in four key sectors when the right incentives are present:

1. The Mining Sector:

The South African mining sector has historically been a significant contributor to the country's GDP. In the last decade it accounted directly for 6.1% of GDP in real terms. The contribution of the mining sector in real terms currently shows a declining tendency - from 7.2% in 2002 to 5.2% in 2011.

The mining sector – independent of raw materials and conditions for production – shows widely varying energy intensity. Energy use in the mining sector (6% of SA's overall energy use) closely follows production volumes.

The sector's electricity use was about 15% or about 37 TWh of the total demand in 2011[63].

The growth outlook in the mining sector provides a mixed picture. Reflecting on the last decade we see that production increased in some sub-sectors (aggregate and sand, chromite, iron ore, manganese, coal, PGM) and declined in others (copper, diamond, gold, silver, uranium).

As the global economy slowed down, production increases also slowed down. Decline of production has accelerated in recent years and figures only indicate slow recovery to pre-crisis levels. An overall relatively static outlook for the mining sector is also reflected in the outlook for the sector's electricity demand taken as input parameter for the IRP2010 demand forecast.

Energy use in mines (after exploration) is determined by following processes:

- Extraction – Drilling, blasting, digging, ventilation, dewatering.
- Materials Handling – Transport of ore and waste to the mill or disposal area (diesel: trucks, loaders, bulldozers; electric: load-haul-dump machines, conveyors, pipelines, hoists).
- Beneficiation and processing – Beneficiation: Crushing, grinding, separations (physical, chemical); Processing: roasting, smelting and/or refining.
- Auxiliary operations – offices, lighting, water treatment, bath houses and workers' quarters.

Of these processes drilling, digging, ventilation, dewatering, materials handling, crushing, grinding and processing demand the major share of electricity consumption to produce the final mined product.

Auxiliary operations use a significant share of energy in the mining of metals and minerals. Underground mining requires more energy than surface mining due to greater requirements for hauling, ventilation, water pumping, lighting and other operations.

Research has found that the electricity saving potential in this sector is extensive and ranges between a suggested minimum of 8%[64] and 20%[65]where a broader range of interventions are considered, including energy audits and the introduction of energy management at mines.

These are our findings for electricity saving potential in the mining industry:[66,67]

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[63] Eskom. 2012.
[64] Stotko, O. Environmental Engineer at Carbon & Energy Africa (Pty) Ltd.
[65] DME. 2003. Capacity Building in Energy Efficiency and Renewable Energy. Report No. – P-54126, Energy Efficiency savings projections.
[66] DME. 2003. Capacity Building in Energy Efficiency and Renewable Energy. Report No. – P-54126, Energy efficiency savings projections.
[67] BCS Incorporated. 2007. *Mining Industry Energy Bandwidth Study*. U.S. Department of Energy. Available at: http://www1.eere.energy.gov/manufacturing/resources/mining/pdfs/mining_bandwidth.pdf

SA Mining Industry Electricity Use and Saving Potential	
Current Energy Use	100%
Best Practice	-21%
Practical Minimum	-53%

Table 1: Mining electricity use and saving potential.

The largest potential for energy savings resides in the metal mining industry (62%), followed by coal mining (48%) and other minerals (42%) – when considering the difference between the current energy use and the practical minimum. The biggest allocations for electricity use result from grinding, ventilation and pumping.

According to a 2003 Department of Minerals and Energy study on energy efficiency, it is expected that energy intensity in industrial sectors will gradually improve with modernisation of practice and equipment. The gold mining sector stands out as an exception, where the energy intensity will increase due to the increase in mining depth and decrease in ore quality, whereas other mining energy intensity will be kept constant due to gradual modernisation of practice and equipment.

The mining industry depends heavily on a reliable and affordable energy and electricity supply. Whereas other governments, in North America and Australia, require their mining sectors to generate their own electricity, in South Africa mines are supplied through the national grid. Mining industries globally are investing in RE faster than other industries and Bloomberg has predicted that this sector will account for 1.8% of global clean-power spending in 2012[68].

Case studies from several local mining industry leaders highlight the successful implementation of such initiatives and at the same time shed a light on the significant potential of saving energy in this energy-intensive sector[69]. These case studies can be found at the end of this report.

Comparing the many case studies we have located with the actual savings potential as revealed in the DME, 2003 Study and the US-Study (DoE-US, 2007)[70] clearly shows that the mining industry of South Africa could contribute more – much more – than the existing industrial target of 15% to national energy saving efforts.

Our conclusion: the South African mining industry could definitely achieve its current 15% energy saving target by 2015, provided the entire sector were to merely follow the many successful examples within its fold.

Beyond 2015 our modelling illustrates that an updated energy efficiency strategy could provide more ambitious targets for the industry and aim for what we have benchmarked as 'the practical minimum' potential of about 50% savings below current use by 2030.

2. The Industrial Sector (Energy intensive):

[68] Bloomberg, London: 9th Dec. 2012.
[69] Energy Efficiency Accord, report and case studies available from www.nbi.org.za and company websites.
[70] BCS Incorporated. 2007. *Mining Industry Energy Bandwidth Study*. U.S. Department of Energy. Available at: http://www1.eere.energy.gov/manufacturing/resources/mining/pdfs/mining_bandwidth.pdf

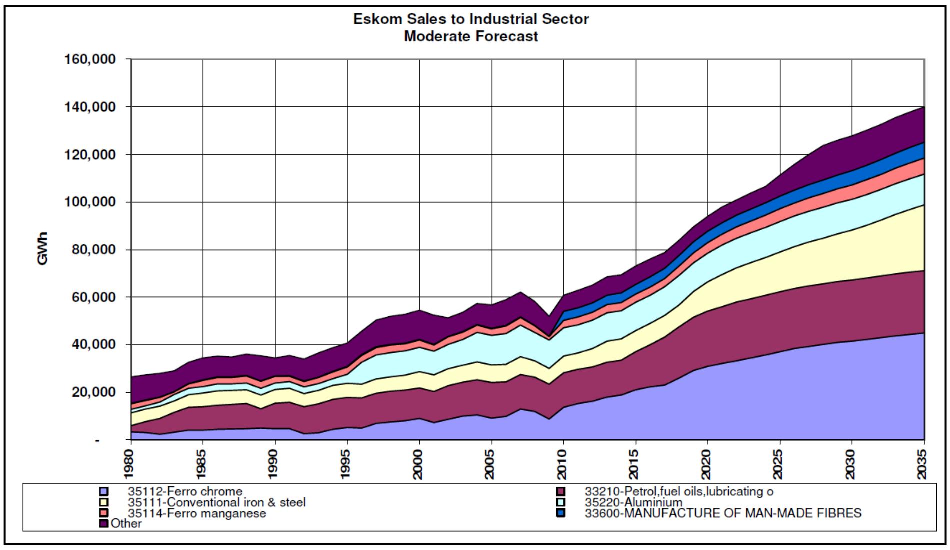


Figure 5: Eskom Sales to Industrial Sector, moderate forecast, IRP2010.

Eskom categorises the industrial sector as follows: ferro-chrome; conventional iron & steel; ferro manganese; petrol, fuel oils, lubrication; aluminium; man-made fibres and others.

As Eskom's and IRP2010's demand forecast for the industrial sector shows, it is anticipated that most energy users in this sector are expected to grow their electricity needs by 4% annually, which is above the historic average. Earlier in this chapter we had a look at global growth developments, which suggest a low growth reality was clearly not taken into account in the IRP2010 assumptions.

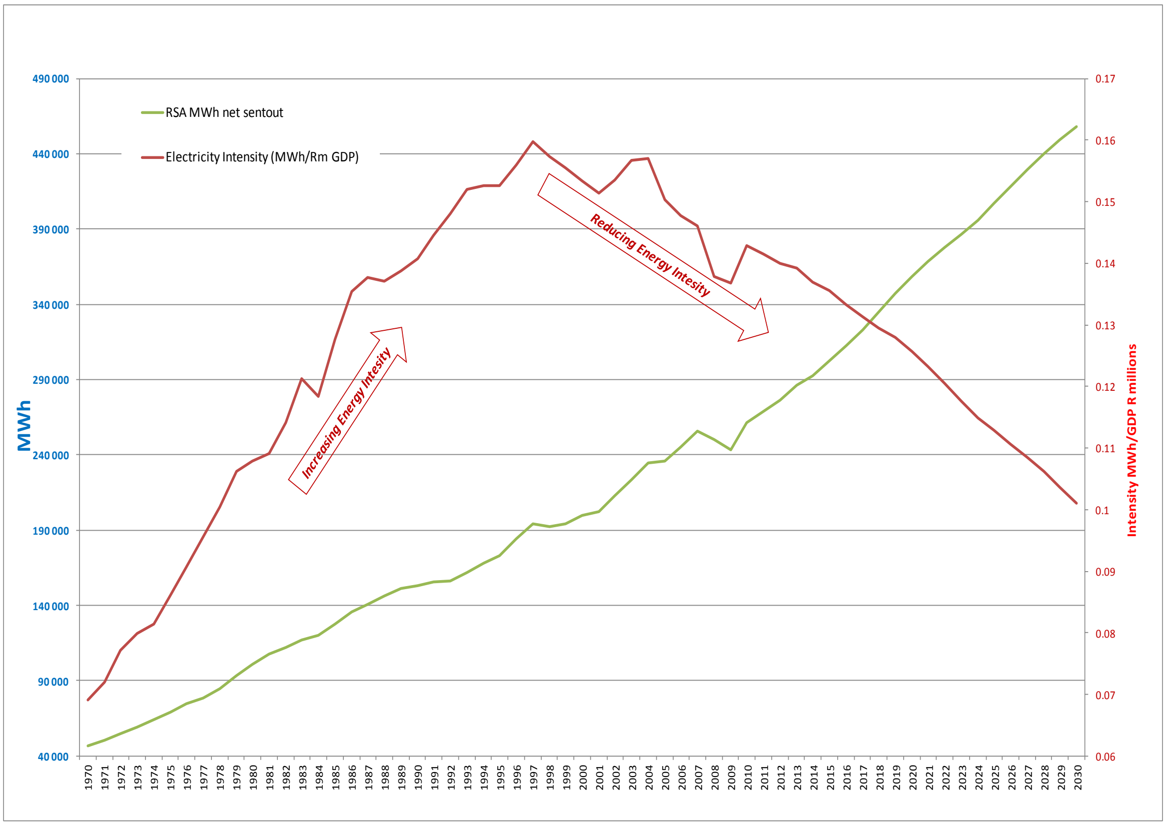


Figure 6: Energy intensity in South Africa showing a decline from 2000 onward (MWh/Rm GDP).[71]

In addition to a more likely lower expected global growth rate, as **Figure 6** above illustrates, **South Africa's economy is already on a path towards a less energy-intense economic structure.**

An important group within the industrial sector is The Energy Intensive User Group (EIUG) of Southern Africa. **EIUG is an association of energy intensive consumers whose members currently account for approximately 44% of the electrical energy consumed in South Africa.** Membership of the EIUG is made up of large industry in the fields of mining, materials beneficiation and materials manufacturing.

The EIUG's primary concerns include: the shortfall of generation capacity, the security of supply crisis, the above inflation price rises anticipated and the costs of energy efficiency as it is presented on EIUG's website. EIUG's chairman has mentioned frequently in the recent past that industrial electricity tariffs are reaching a 'tipping point', which could force industries to relocate to other countries or simply close down business. But for many of these industries relocation is not an option due to locally available raw materials and huge infrastructure investment. **Energy efficient solutions have been proven to be feasible for some members of the group and more reluctant members will soon need to follow such examples.**

Some EIUG members have published case studies presenting significant achievements in electricity savings, e.g. Arcellor Mittal, Exxaro Group, SAB Miller and Xstrata. Some of these case studies are included at the end of this report. The Second review of the National Energy Efficiency Strategy continues to work towards an overall energy efficiency target for mining and industries of 15% by 2015.

Sector case studies show that a 30% reduction per produced unit in selected foundries was achieved in the last three years and another 15% from that level is about to be implemented (in total from the 2009 baseline: 38% savings realised).

Incentives such as subsidised loans and other financial and tax offers, intended to enable industries to invest in energy saving measures, will help industries to keep their operations profitable and contribute to lower the forecasted steep demand increases. This will lead to the reduced need for new power generation.

Local and international case studies show that **the most efficient companies in a sector usually use about 20% less energy than their competitors.** Using best available technology in a sector, which mainly looks at component replacement, results in energy savings of above 20%. Going beyond that requires more capital expensive process and system changes, but savings of 40-50% are deemed possible and feasible [72],[73].

Our conclusion: Similar to the mining sector, the South African heavy industries could definitely achieve its current 15% energy saving target by 2015. Improved energy intensity beyond that to a level of 20% savings is achievable by using best available technologies. To achieve targets of up to 40-50% will require higher capital investment in process and system changes, but these options are possible and feasible.

3. **Other industries, the commercial sector and municipalities**:

Here we find major sub-sectors such as: non-food manufacturing, textiles, food and beverage and others. End-use electricity is distributed differently in these sectors, but major

[71] Energy Intensive User Group. 2012. Presentation to PCE: Second review of National Energy Efficiency Strategy (NEES). Available at: http://irp2.files.wordpress.com/2011/10/eiug-2012-nees-presentation.pptx [2013, April 11].
[72] Mckuur, G. 2011. Industrial Energy Efficiency Project South Africa. *SAATCHA Conference*. South Africa 20-30 August 2011. Available at: http://www.saatca.co.za/DNN/LinkClick.aspx?fileticket=FRXx-Cc70MA%3D&tabid=106 [2013, April 10].
[73] IEA, Energy Technology Perspectives 2010.

components are: electric drives, process cooling/refrigeration, process heating, compressed air, lighting, heating, ventilation & air conditioning, electrochemical processes and electronic equipment. The share in costs of operations might be lower compared to energy intensive industries; subsequently the pressure to reduce these increasing costs is less felt here.

The potential for savings through energy efficient solutions is similar to that of other sectors. The NEES suggests a 15% energy efficiency target for the commercial and public building sector. The NEES also states that the proposed sector targets comprise a conservative estimate.

For industries and the commercial sectors (except buildings) most studies propose energy efficiency targets in the range of 10-15%, which can be achieved through the implementation of 'low hanging fruit' options[74] .

The Green Building Council of South Africa (GBCSA) is an important promoter of improvements in the commercial building sectors. A number of relevant case studies can be found on the GBCSA website and some were presented at the NEES review. Selected examples from these presentations state that new commercial buildings in South Africa have been built with energy savings way above what the newly launched building standard SANS10400-XA suggests. **For example:**

- NDPW Agrivaal Office, Pretoria: 35% below SANS 10400-XA.
- Manenberg Contact Centre, City of Cape Town: 80% below.
- KZN DPW Sisonke District Offices: 80% below.
- ABSA Towers West, Johannesburg: 60% below.
- Vodafone Site Solution Innovation Centre, Midrand: 200% below (i.e. it is an 'energy plus' building).

For the purposes of this study we have looked at some of the most recent information on energy use from selected municipalities:

The City of Cape Town (CoCT) study – Energy Scenarios for Cape Town - was developed in close cooperation with the University of Cape Town (UCT) and concluded in 2011. This provides a representative example with the majority of electricity consumers in the residential and the commercial sector.

The study for the Department of Local Government and Housing of the provincial government Gauteng - **Assessment of Energy Efficiency and Renewable Energy Potential in Gauteng and Associated Long Term Energy Planning Implications** was finalised in 2010. The Gauteng province has a significantly higher share of industrial electricity consumers as compared to the Western Cape.

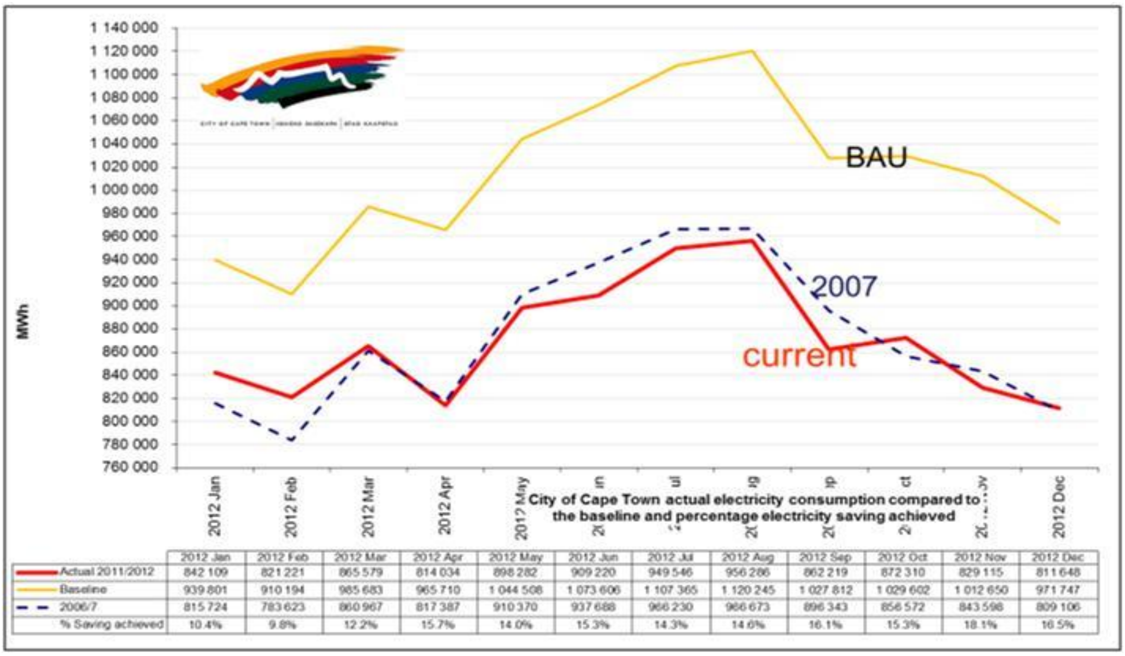
We have also looked at the **Energy & Climate Change Strategy of the City of Ekurhuleni**.

Local government itself is a direct and often significant consumer of electricity. Most municipalities in South Africa, but especially Cape Town in the Western Cape and urban areas in Gauteng are faced with high population growth rates[75] due to people moving into these areas with the hope of establishing improved livelihoods. Such developments pose immense challenges to municipalities, which are obliged to deliver basic services such as

[74] These include: improved compressed air systems, efficient lighting, use of high efficient electric motors and variable speed drives for fans, motors and pumps, improvement in heating ventilation and cooling installations, better maintenance programmes and the introduction of energy management systems. The term 'low hanging fruits' commonly refers to low investment costs and a short pay-back time) of less than one to two years.
[75] SA Census. 2011. Available at http://www.statssa.gov.za/census2011/default.asp [2013, April 10].

water, sanitation, electricity or other forms of energy, health and education facilities and affordable means of transport to all residents.[76]

In spite of continued urbanisation, the City of Cape Town and other municipalities have reported more or less steady electricity consumption over recent years:



	2012 Jan	2012 Feb	2012 Mar	2012 Apr	2012 May	2012 Jun	2012 Jul	2012 Aug	2012 Sep	2012 Oct	2012 Nov	2012 Dec
Actual 2011/2012	842 109	821 221	865 579	814 034	898 282	909 220	949 546	956 286	862 219	872 310	829 115	811 648
Baseline	939 801	910 194	985 683	965 710	1 044 508	1 073 606	1 107 365	1 120 245	1 027 812	1 029 602	1 012 650	971 747
2006/7	815 724	783 623	860 967	817 387	910 370	937 688	966 230	966 673	896 343	856 572	843 598	809 106
% Saving achieved	10.4%	9.8%	12.2%	15.7%	14.0%	15.3%	14.3%	14.6%	16.1%	15.3%	18.1%	16.5%

Figure 7: CoCT reduced electricity consumption by 14.4% compared to business as usual[77].

<u>Our conclusion:</u> Industries within municipalities can easily achieve the 15% NEES target by 2015. Going beyond that will become more attractive, especially with the financial pressure coming from Eskom's determination to increase tariffs to reflect 'real costs'. Going beyond 15% up to above 100% in the case of energy-plus buildings is possible within the next ten to twenty years.

4. The residential sector:

The Cape Town study referred to above (Energy Scenarios for Cape Town), shows that in 2007/2008 about 94% of just under one million households have been electrified within the Cape Town metro. These households consumed an average of 617 kWh per month in 2008. Low income households use 220 kWh per month and households with very high income use on average 1 033 kWh per month. In medium and higher income households, water heating accounts for the major share of electricity demand – most of these households utilise geysers electrified by the grid.

The residential sector is a major contributor to morning and evening peak demand in the daily electricity demand profile. As people return to their homes in the evening all activities including cooking, lighting, cooling, heating, personal hygiene, entertainment and communication contribute to the surge in residential consumption during these hours.

As women tend to be the household energy managers, involving them in planning and funding energy efficiency can achieve surprising results. When two women founded *The Riot for Austerity* movement in North America in 2008, they managed to reduce their household

[76] UCT's African Centre for Cities has found that urbanisation in South Africa is lower than the rest of the continent.

[77] CoCT Presentation to PCE: Second Review of NEES.

carbon emissions by almost 80% in a year.[78] A huge barrier to energy efficiency investment is simply knowledge – when women were informed of energy efficiency options, they readily availed themselves of the opportunity to save money.[79]

All residential sub-sectors can contribute to electricity savings by installing solar water heating or heat-pumps and water-saving shower heads, efficient lighting and more efficient household appliances. Behaviour changes in the use of energy also contribute to reduced electricity consumption.

Government-led programmes aim to roll out such measures in residential buildings, along with financial incentives, such as the distribution of free energy efficient light bulbs and SWH and heat pump rebates. Better standards for household appliances and electronic equipment improve energy use gradually as people replace these over time. Improved and mandatory building standards, such as the SANS 10400-XA, which include insulation, improved windows and doors, the use of SWH or heat-pumps for water and space heating need to be rigorously implemented for new buildings and new ways have to be found to allow a gradual upgrade of old buildings to such standards[80].

The potential of electricity savings in the residential sectors has been analysed in many studies – internationally and locally. Already in a 2003 DME-study, the savings potential in residential electricity use was estimated to be 38%. This was through a roll-out of SWHs and energy efficient lighting only, without considering any other measures.

The Gauteng study mentioned above targets savings in the residential sector of 13% by 2014 and 37% by 2025, matching the DME 2003 findings. The City of Ekurhuleni applies energy efficiency targets as set by NEES.

The European Union's target of 'nearly zero energy' buildings from 2020 onwards and the actual experience from the GBCSA can inform South Africa's developers of building standards and provide direction for future updates to the further potential of energy saving in the commercial and residential building sector.

Our conclusion: The most urgent need in the residential sector is to reduce the peak demand. SWHs, heat pumps, using timers for pool pumps and water features, efficient lighting, ceiling insulation, informing poor women about the availability of better and safer designs of fuel efficient stoves, fuel switches to LPG or biofuels for cooking and heating and behaviour change are all simple and low cost measures with guaranteed, immediate and sustained reductions of peak demand and energy consumption.

Energy savings per sector: our overall conclusions

Our findings very clearly point out that a projected future demand growth can potentially be significantly different from what is currently modelled in the IRP2010. **Just by considering the so far ignored NEES targets for 2015, which are deemed by the NEES itself as conservative estimates, South Africa can change tack and accelerate the decoupling of electricity demand growth from GDP-growth.** Going beyond 2015 with continued moderate EE-targets is

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[78] Astyk, S. 2008. *Depletion and AbundANCE: Life On the New Home Front*, Gabriola Island, Canada: New Society Publishers. p. 20.

[79] Energia Africa. 2010. *Capacity-Building In Energy Efficiency For Households and Forum For Energy Service Providers.* p. 15. Available at: http://www.energia-africa.org/where-we-work/zambia/capacity-building-in-energy-efficiency-for-households-and-forum-for-energy-service-providers-zambia-2010/ [2013, April 11].

[80] 80 SABS. 2011. *The application of National Building Regulations. Part XA: 10400-XA: Energy usage in buildings.* Available at: https://www.sabs.co.za/webstore/SetaPDF/Demos/Encryptor/genpreview.php?stdsid=1400025021&pid=12481 [2013, April 10].

feasible and necessary. Depending on key drivers, such as electricity tariffs and climate change, more ambitious targets for energy savings will become economically feasible without constraining South Africa's economy.

Within the timeframe of the IRP2010, i.e. up to 2030, we can conclude that feasible energy saving potentials in all sectors are well above the current targets as set in the NEES Second review.

Alternative demand scenarios

Using the IRP2010 forecasts for electrical energy consumption and peak demand as a reference case and applying Smart choices for reduction of electricity use, we now propose three alternative scenarios.

We have re-assessed the IRP2010 SO-Moderate and SO-Low electricity demand forecasts and applied different levels of energy-saving ambition for the proposed scenarios. We included only energy-saving potentials at the point of use. Our proposed scenarios exclude on-site power generation in whatever form. **On-site power generation would further contribute to reduction of electricity demand from the grid.** Efficiency potentials for power generation, transmission and distribution, including impacts of a Smart grid are also not considered. All scenarios proposed in this study consider the achievement of a nation-wide 15% energy efficiency gain by 2015.

With the exclusions noted above, we have modelled the following three scenarios:

Scenario 1: Smart track

Beyond the 15% targets by 2015 this first Smart scenario – 'Smart track' - continues with very moderate efficiency gains in the following years up to 2020 – in total an additional saving of 5% is expected (1% per year until 2020). After 2020 this scenario just follows forecasts for SO-Moderate or SO-Low.

Scenario 2: Smart intrepid

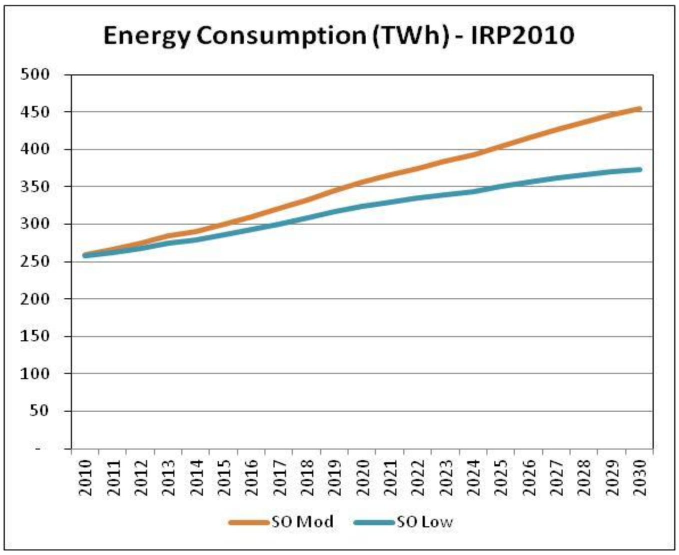
Beyond the 15% targets by 2015 this second scenario – 'Smart intrepid' continues with an additional 15% reduction until 2030 (i.e. 1% per year) as compared to the baselines of SO-Mod or SO-Low. The Smart intrepid scenario implements the potential gains through achieving best practice energy use in all sectors and goes slightly beyond that towards 2030.

Scenario 3: Smart Max

Beyond the 15% targets by 2015 the third scenario – 'Smart max' is more ambitious until 2020 with an additional 10% until 2020 (2% per year) on top of the 15% policy target and from 2020 to 2030 another 10% (1% per year), which means that the 'Best Practice' levels are reached faster and by 2030 it reaches an overall energy efficiency target of 35%.

In the graphs below we have included the following forecasts from the IRP2010:

- SO-Low forecast (SO-Low) – assuming 3.5% GDP and 1.9% electricity growth.
- SO-Moderate forecast (SO-Mod) – assuming 4.5% GDP and 2.9% electricity growth.



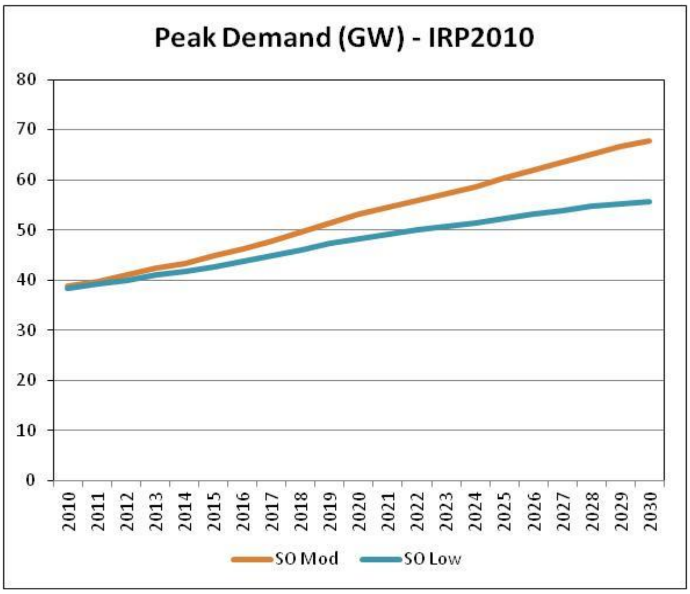


Figure 8a & b: IRP2010 forecasts: SO-Moderate (SO-Mod) and SO-Low (SO-Low).

Using the SO-Moderate and the SO-Low forecasts respectively as our baselines we have applied our three Smart Energy Efficiency scenarios as follows:

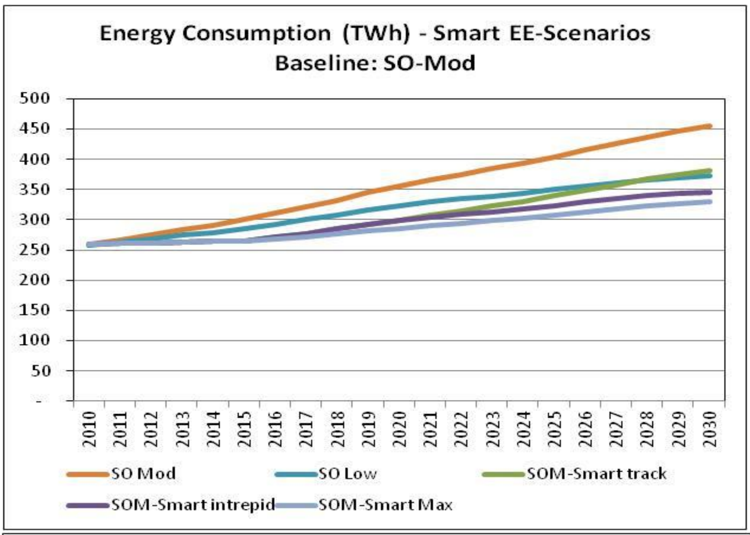
- SOM-Smart track: Using SO-Mod as baseline. Achieving EE-Policy by 2015 and continuing with conservative EE-gains until 2020.
- SOM-Smart intrepid: Using SO-Mod as baseline. Achieving EE-Policy by 2015 and continuing with moderate EE-gains following best practice in all sectors and slightly beyond until 2030.
- SOM-Smart Max: Using SO-Mod as baseline. Achieving EE-Policy by 2015 and continuing with ambitious EE-gains until 2030.

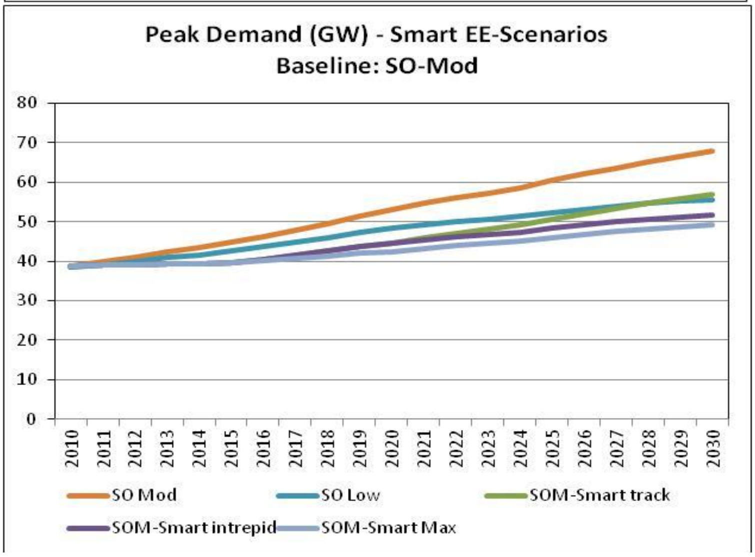
And – the same as above, but using the SO-Low forecast as baseline:

- SOL- Smart track: Using SO-Low as baseline. Achieving EE-Policy by 2015 and continuing with conservative EE-gains until 2020.
- SOL- Smart intrepid: Using SO-Low as baseline. Achieving EE-Policy by 2015 and continuing with moderate EE-gains following best practice in all sectors until 2030.

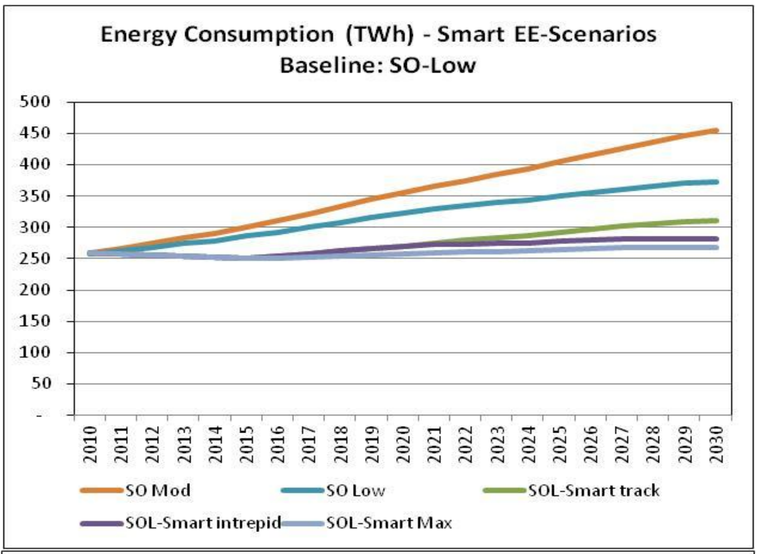
- SOL-Smart Max: Using SO-Low as baseline. Achieving EE-Policy by 2015 and continuing with ambitious EE-gains until 2030.

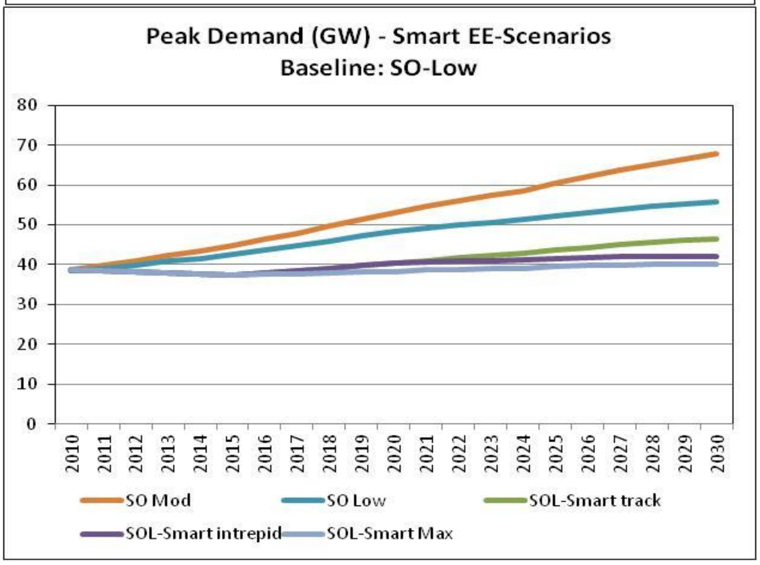
Our modelled findings are presented in the following graphs:





Figures 9 & 10: Smart EE-Scenarios with SO-Mod as baseline.





Figures 11 & 12: Smart EE-Scenarios with SO-Low as baseline

One important outcome of this modelling exercise is that it is clearly shown that by **simply taking into account achievement of the moderately adjusted 15% existing National energy efficiency strategy target by 2015 the future demand development changes significantly.**

To achieve this target (and exceed it) would give South Africa a great head-start in reducing its energy requirements. To begin **would simply require that we take our existing energy efficiency targets seriously.**

The EE-pathways as calculated, following the SO-Moderate or the SO-Low baseline, create a rather wide band for the energy consumption and peak demand in 2030:

Electricity Consumption In 2030	IRP2010 SO-Mod	Smart track	Smart intrepid	Smart Max
Energy Consumption (TWh)	454	382	346	330
Peak Demand (GW)	68	57	52	49
Percentage less from SO-Mod baseline		16%	24%	27%

Table 2: Electricity Consumption: Comparing SO-Mod and Smart EE-scenarios by 2030.

Electricity Consumption In 2030	IRP2010 SO-Low	Smart track	Smart intrepid	Smart Max
Energy Consumption (TWh)	373	311	282	268
Peak Demand (GW)	56	46	42	40
Percentage less from SO-Low baseline		16%	24%	27%

Table 3: Electricity Consumption: Comparing SO-Low and Smart EE-scenarios by 2030.

Conclusion

Slower global economic growth, the on-going implementation of energy efficiency measures and other factors such as raised awareness and the reaction of all electricity consumers to tariff hikes all contribute to the lower electricity demand - to which extent each factor contributes to the overall reduced demand is not clear.

We have analysed national policies and on-going efforts to achieve demand reductions and have concluded that achieving an energy efficiency target of 15% by 2015 for ALL sectors of the economy is possible. This is especially true when considering that the measures needed to be implemented to reach this goal are low-cost and no-cost interventions, as well as those higher-cost measures with short payback periods as spelled out in the country's energy efficiency strategy - commonly referred to as 'low hanging fruits'.

Based on this and added minimal energy efficiency efforts beyond 2015 we have defined a new demand scenario and simply named it 'Smart track', which results in a demand reduction of 16% by 2030.

Going beyond the less ambitious Smart track EE demand scenario, we followed the strong challenge of the National Climate Change Response White Paper to implement more aggressive energy efficiency and demand-side measures and a sound understanding that more than 'low hanging fruits' are necessary and possible. This scenario we have called 'Smart intrepid'. In this scenario we considered best available technologies, which forward thinking companies and other electricity consumers can already access today. **The 'Smart intrepid' scenario brings the electricity demand down by 24% by 2030.**

We have also looked at highly ambitious efficiency gains, which studies refer to as the 'practical minimum'. These calculations have been included as **'Smart Max' scenario resulting in electricity savings of 27% by 2030.**

We have applied the Smart demand scenarios on the two baselines SO-Mod and SO-Low in order to estimate electricity consumption scenarios. These results were then fed into the Supply chapter of this report to identify Supply options that speak to these outcomes. Read on to see what we found.

Key references utilised throughout the research for this chapter:

- DoE-US, 2007: Mining Industry Energy Bandwidth Study. June 2007. Prepared by: BCS, Incorporated. For: U.S. Department of Energy – Industrial Technologies Program.
- Trollip, H., Walsh, V., Mahomed, S., Jones, B. 2012: Potential impact on municipal revenue of small-scale own generation and energy efficiency. Submitted to the South African Economic Regulators Conference to be held in Pretoria on the 21 & 22 August 2012.

Supply

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In summary:

RE prices are declining as technology improves, economies of scale kick in, financing mechanisms mature, and public policy begins to take account of the negative impacts of Coal and Nuclear dependence. As part of our country's commitment to addressing and responding to climate change, as well as our commitment to sustainable development, we can transition towards an integrated planning approach that regards social justice and the careful use of natural resources as paramount.

The level of uncertainty present in the global economy, climate change impacts and the considerable energy efficiency potential as described in the previous chapter, together imply that our electricity supply planning should be – and can be - far more modern, nimble and robust.

In this chapter we present smarter Supply scenarios. These scenarios assume a portion of energy efficiency as is normal practice in IRP planning. Supply scenario 1 - the Smart track - assumes a low degree of energy efficiency as proposed in the Smart track demand scenario in the previous chapter.

The second Supply scenario we present - Smart intrepid - assumes a higher level of energy efficiency and is based on the Smart intrepid demand scenario presented in the previous chapter. The resulting scenarios suggest that very different choices around Supply investment can be made.

Both lower demand growth scenarios based on Smart energy efficiency (EE) choices would require a slower pace for the implementation of new power generation capacity and allow for a meaningful increase in the deployment of RE technologies.

A Smart approach to planning for supply of pro-poor energy services

In any developmental context it is a fact that the provision of energy services is not only about the technical provision of the service. The developmental outcomes relating to health, education and economic development enabled by such services are equally important. Making sure that electricity planning has considered supply options that can ultimately contribute to the achievement of developmental outcomes is integral to Smart planning.

A balanced and integrated approach to planning should incorporate the consideration of several aspects. Firstly such a planning process should commence with an evidence-based understanding of demand and usage profiles of low-income households, having due regard for the gendered aspects of energy decision-making. Starting with an understanding of the demand profile gives insight into preferences and also how people consume different energy services. This serves as a basis for understanding which, of a range of different energy technologies, is suitable to meet different energy services such as cooking, lighting, water heating, space heating, refrigeration and media and communication.

The application of energy services in poor households is nuanced and so even for a single energy service such as cooking, households often prefer to use different energy types for different meal types depending on perceived utilities of different fuels[81]. It is essential that these realities are taken into account when considering supply options. Current energy planning 'for the poor' does not reflect many of the realities of poor household energy demand such as multiple fuel use. Moreover, there has been insufficient consideration of the gendered impact of higher electricity tariffs.

On the supply side, a Smart planning process should then identify a suite of potential supply solutions that could meet the varying demand for overall household energy services. These supply solutions must include consideration of the energy type generally preferred by citizens and the preferred end-user technology or appliances. All of these facets make up the system of supply and are essential to providing safe, environmentally sustainable and affordable energy services. The various supply options should then be assessed on the basis of their contribution to multiple social and environmental criteria.

A one-sided supply-side approach to energy planning for the poor is a one of the key weaknesses in South Africa's current planning approach. It is difficult to even explore alternative supply solutions on an equal basis in the policy sphere due to the domination of electricity as the preferred supply option for poor households. In the absence of an integrated approach that takes into account and considers both demand and supply perspectives it is not possible to fairly evaluate different supply options. It may well emerge that electricity is the best carrier to supply energy services. However in the absence of a balanced comparative assessment of different options this cannot be reliably asserted. For illustrative purposes **Table 4** below lists a suite of supply-side options for different household energy services that can be incorporated within a Smart electricity planning approach.

Energy Service	**Range of options that are safe, affordable, low carbon alternatives**
Lighting	Electricity (grid, mini-grids, Solar PV) with CFLs or LEDs
	LED solar lanterns
	Coke bottle lights
Cooking	Electricity (grid, mini-grids) and efficient stoves
	Wonder bags
	LPG offers a lower carbon and safer alternative to paraffin for those households (particularly urban) who are not able to use electricity for cooking (e.g. backyard dwellers)
	Biogas offers a solution for both cooking and sanitation
	Fuel-efficient wood cook stoves use less wood and reduce indoor air pollution, reduce emissions and lessen deforestation impacts
Water heating	SWHs
Space heating	Electricity (grid, mini-grids, Solar PV) with efficient heating appliances
	Building design and insulation – for both formal and informal housing
	Efficient biomass stoves for space heating

[81] Cowan, B. 2008. *Alleviation of Poverty through the Provision of local Energy Services*. Available at www.ecn.nl/publications/PdfFetch.aspx?nr=ECN-C--05-043 [2013, April 11]

Refrigeration	Electricity (grid, mini-grids, Solar PV) with efficient appliances
Communication and media	Electricity (grid, mini-grids, Solar PV) for cellphones, radios, television, computers etc.

Table 4: Options available per energy service

Our reference case: IRP2010's new generation build plan

The IRP2010 has been lauded for its commitment to RE choices, but a closer examination of the policy-adjusted scenario adopted to inform investment choices in the IRP2010 shows that by 2030, trailing global RE Supply choice trends, South Africa will only have 9% of its electricity derived from renewable sources (excluding large hydro)[82].

Although this is a significant increase in RE from what is close to zero at this moment, South Africa has far greater potential for power generation from renewable sources.

According the promulgated IRP2010, the power generation capacity to be built by 2030 to satisfy the assumed SO-Mod demand forecast amounts to about 55 GW, including Medupi and Kusile. This will result in an overall installed capacity of 89 GW - almost doubling the current power generation capacity of about 45 GW.

The SNAPP (Sustainable National Accessible Power Planning) tool

As previously mentioned, we rely in our modelling choices on the SNAPP tool, which enables the modeller to ensure that there is sufficient supply to meet projected demand, that the loss of load probability (LOLP) is zero, the reserve margin at least 15% and the unmet demand is zero.

The University of Cape Town (UCT), working with the Worldwide Fund for Nature (WWF) have developed SNAPP - an energy supply modelling tool that enables citizens to model a variety of energy investment choices that can lead to reliable and stable Supply.

Given that money always needs to be borrowed to build new power stations, and that these loans will need to be paid back over time with interest, the amount of investment required based on Supply choices made can provide an indication of the costs that will probably be passed on to electricity consumers in future years[83].

SNAPP enables some modelling of the likely costs of Supply – expressed as the levelised cost per unit of electricity produced. It also shows the related investment requirements over time and can model the cost impacts of a carbon tax.

SNAPP is currently being upgraded to enable modelling up to 2040, but for our report, the 2011-2012 version of SNAPP has been used. **UCT provided the authors with a version of SNAPP which models the IRP2010 assumptions, costs, environmental impacts and build programme exactly and allows for running parallel alternative demand and supply scenarios.** For the comparisons that follow, the promulgated IRP2010 policy-adjusted scenario, precisely adopted and modelled by SNAPP, has been used as the reference case.

The IRP2010 - what has changed since 2010?

There are several key realities in the Energy sector that have changed since 2010 and that can have a direct bearing on Supply investment.

[82] Large hydropower is often excluded from renewable energy due to the social and environmental impacts of large dams. The Global Renewable Energy Investment Outlook 2012 provides investment figures for renewable energy for two cases, excluding and including large hydropower.
[83] Although actual energy cost is one aspect of the price of electricity, other factors such as the cost of finance, levies and taxes, subsidies and depreciation all contribute to the overall electricity tariff.

Firstly, as Eskom itself has informed us, the current trend for electricity demand growth is far below the demand assumptions of the IRP2010.

As stated in the previous chapter, the IRP2010 based its proposed roadmap for new-build generation on Eskom's System Operator (SO) department's moderate demand forecast[84] which assumed a doubling of electricity demand over the next 25 years. Eskom's MYPD3 application revealed a revision of these demand assumptions with a 1.9% per year demand increase for the five year period projected until 2018, coupled to an estimated 4% growth of GDP.

In 2012 electricity demand actually dropped by 2.6% (compared to 2011) and was more than 10% below the IRP2010 forecast for 2012[85].

The 1.9% electricity demand increase as forecasted by Eskom in MYPD3 matches the SO-Low forecast, which was also prepared for the IRP2010, but not utilised. SNAPP allows us to model some of the impacts of such a reduction in the demand forecast.

SNAPP illustrates that **the IRP2010 new generation build programme with an electricity demand growth following the SO-Low assumption will result – when implemented as planned – in a reserve margin of 40% in 2030**, far above the required level of 15%.

Secondly, several key costs have changed: direct and associated Coal, Nuclear and other fossil fuel costs continue to rise and Solar and Wind costs continue to drop.

To illustrate this point: we know that the full capital expenditure for the IRP2010 build programme which was based on 2010 cost assumptions, amounted to over R900 billion at the time. **Yet in January 2013, in its MYPD3 application, Eskom presented the capital expenditure for just the proposed 9.6GW nuclear build at R914 billion**.

By comparison, according to the Bloomberg global trends report (2012)[86], over the last two years to the first quarter of 2012, **the Levelised Cost of Energy (LCOE)[87] for Solar PV and onshore wind fell by 44% and 7% respectively.** Over the same time period, CCGT and coal-fired electricity generation costs rose by 6% and 7% respectively.

Eskom expressed the need in its MYPD3 application for Government to intervene and cap the expected annual local coal price increase at 10%.

Estimates for the cost of nuclear power have generally risen in recent years.[88]. Nuclear costs in the IRP2010 were corrected upwards by 40% in the final version of the IRP2010, following international trends.

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[84] Also called SO Moderate or SO-Mod; SO moderate is the chosen IRP2010 scenario modelled by Eskom, SO-High and SO-Low are other scenarios modelled by Eskom but not chosen.

[85] STATSSA. 2012. *Table 2 – Annual percentage change in electricity available for distribution in South Africa: 2008–2013.* Available at: http://www.statssa.gov.za/publications/P4141/P4141February2013.pdf [2013,April 11].

[86] Bloomberg. 2012. *Global Trends in Renewable Energy Investment 2012*. P. 34. Available at: http://fs-unep-centre.org/sites/default/files/publications/globaltrendsreport2012final.pdf [2013, April 11]

[87] LCOE: the price at which electricity must be generated from a specific source to break even over the lifetime of the project. It is an economic assessment of the cost of the energy-generating system including all the costs over its lifetime: initial investment, operations and maintenance, cost of fuel, cost of capital, and is very useful in calculating the costs of generation from different sources.

[88] U.S. Energy Information Agency. 2012. *Annual Energy Outlook 2012*. Available at: http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf [2013, April 11].

The South African REIPPPP currently underway[89] has received an overwhelming response from RE developers, and over the two first bidding windows, it has been revealed that, following global pricing trends, the costs of renewables are consistently decreasing.

Technology	Average price window 1	Average price window 2
Solar PV	R2.75 /kWh	R1.65 /kWh
CSP	R2.68 kWh	R2.51 /kWh
Wind	R1.14 /kWh	89c /kWh

Table 5: Average prices quoted in the REIPPPP in window 1 and window 2[90].

Smart electricity planning would take note of clearly changing key energy sector assumptions and prudently reconsider investment plans at regular milestone intervals.

Even though considering updated costs would further support our case, for reasons of robust, irrefutable comparability and consistency with the chosen reference scenario of the IRP2010 we will continue to use the cost assumptions from 2010 throughout our own scenarios. When we refer to and consider current cost developments this will be pointed out separately.

While we are on the subject of costs, let's briefly take a look at Externalised costs in relation to Electricity supply.

True cost: South African power supply and externalities

In 2010, academics at the University of Cape Town compiled this estimate of external costs for electricity generation as part of the Integrated Resource Plan 2010. **These costs were not incorporated into the model utilised by the Department of Energy (DOE) however, and the impacts are therefore not allowed for in the final IRP2010 policy-adjusted plan.**

Table 6 below is by no means a definitive analysis of the impacts of different generation choices, and the authors have acknowledged that further research is required. The costs of acid mine drainage in particular may have been significantly underestimated, and water impacts have not been accounted for at all for nuclear or gas-fired power. The health costs have been estimated based on updating older studies.

The true costs of health care would also need to be evaluated bearing in mind that almost all the health care taking place in the home is through women's unpaid labour. Thus studies have shown that women's care work increased during the HIV/AIDs crisis.[91] Similarly where people get sick through, e.g. air pollution or unclean water, this will have a negative impact on women's unpaid labour hours.

More recent work has examined the externalised costs of power from the two major centralised power plants currently being built in South Africa – Medupi and Kusile – only[92].

[89] The REIPPPP targets the procurement of 3 725 MW of power to be generated from renewable energy by 2015. So far, bidding windows one and two constitute 2 460 MW of this target.
[90] Aphane, O. 2012. Engineering News, p. 25 June, 2012.
[91] Avert. 2012. *HIV and AIDS Home Based Care.* Available at: http://www.avert.org/aids-home-care.htm [2013, April 11].
[92] For example, Riekert & Koch (2012), Nkambule & Bliganut (2012) in Journal of Energy in Southern Africa, 23, 4, November 2012, "…the opportunity costs of investing in Medupi and Kusile in terms of damages caused by carbon emissions and water use, and found that there would be significant costs associated with investments in coal-fired power stations (Blignaut 2012; Inglesi-Lotz & Blignaut 2012) when compared with renewable energy technologies."

All the technologies have a positive externality of 18c/kWh – since at its point of use electricity is clean burning, and the benefits of electrification on education, productivity and health are positive (as discussed in detail above). The key finding is the substantial negative external costs associated with fossil fuel-based power, with gas externalities adding 30c/kWh in unaccounted for costs; diesel generators adding 50c/kWh, and coal-fired power adding a significant 55c/kWh.

Best estimate of external costs for electricity generation technologies in South Africa

Units: c/ kWh (2009 cents ZAR)	*Coal*	*Nuclear*	*Gas – CCGT*	*Diesel –OCGT*	*Biomass (incl biogas)*	*Hydro (small)*	*Wind*	*CSP*	*PV*
POWER GENERATION									
GHG emissions	48 (25 – 71)	0.3 (0.2 - 0.4)	27 (11 – 32)	45.5 (24 – 67)	4.3 (1.8 – 5)	0.15 (0.1 - 0.2)	0.8 (0.4 - 1.2)	0.7 (0.3 - 1.1)	2.8 (1.6 - 4.4)
Health impacts	1.35 (1.0 - 1.7)	0.03	0.34	0.22	0.39	0.05	0.09	0.09	0.19
FUEL (Production & Transport)									
Acid mine drainage	2.1* (0.4 - 3.9)	?	?	?	-	-	-	-	-
Biodiversity loss	0.7 (0.6 - 0.8)	0.1	0.39	0.9	0.13	0	0	0	0
Health impacts	0.36 (0.02 - 0.7)	0.15	0.14	0.15	0.05	0	0	0	0
GHG emissions	2.3 (1.3 - 3.3)	0.45	2.8	2.8	1.5	0	0	0	0
TOTAL EXTERNALITY COST (estimate)	~ 55	~ 1	~ 30	~ 50	~ 6	~ 0.2	~ 0.9	~ 0.8	~ 3
Benefits of electrification – positive externalities	18 (4.7 - 24.2)	18 (4.7 - 24.2)	18 (4.7 - 24.2)	18 (4.7 - 24.2)	18 (4.7 - 24.2)	18 (4.7 - 24.2)	18 (4.7 - 24.2)	18 (4.7 - 24.2)	18 (4.7 - 24.2)
* A presentation by the Federation for Sustainable Environment (Pretorius, 2009) estimates the water damage externality from Eskom's coal mining needs at about R cents 38/kWh.									

Table 6: Edkins M, Winkler H, Marquard A, Spalding-Fecher R. External cost of electricity generation: Contribution to the Integrated Resource Plan 2 for Electricity. 2010. Department of the Environment and Water Affairs.

Once the negative externalities of coal are properly accounted for, it is apparent that RE technologies will start to become competitive with fossil fuels relatively soon. For example, in the REIPPPP the average Round 1 bid price in 2011 for wind power was R1.14kWh, and for round 2 in 2012 it was 89c/kWh. At a current average electricity price over 40c/kWh and coal externalities estimated at about 55c/kWh, wind power appears a lot more attractive as a socially optimal investment.

It is also worth noting that Eskom's current estimates of new coal generation are 97c/kWh which with an additional 55c/kWh would make coal unattractive even at current RE prices[93].

To date most studies investigating the monetisation of impacts in the South African context have largely focused on air pollution, health and climate change impacts.

A tendency to ignore the interconnectedness of the energy system is further demonstrated by the fact that water pollution, crop and bio-diversity losses have always been represented as low costs. Similarly, many studies have drawn on international estimates and **there is a need for further research on the impact pathways and precise local impacts of different**

[93] Donnelly, L. 2012. Eskom grilled on power price. *Mail and Guardian.* 24 August. Available at: http://mg.co.za/article/2012-08-24-00-eskom-grilled-on-power-price [2013, April 11].

energy choices. At present there are no studies that have directly addressed the environmental and social impacts of coal and gas conversion to produce synthetic fuel, even though this process accounts for a significant portion of South Africa's liquid fuels supply.

There are very few examples of social impacts being included in conventional cost valuations and South Africa is no exception.

Furthermore, emerging technologies like Carbon Capture and Storage are part of the energy discourse in South Africa, but as yet their financial, energy and externalised costs have not been accounted for. While South Africa has indicated it will move forward with a carbon tax as of 2015 (Budget speech 2013), which is intended to internalise part of the externality of carbon emissions, there is no policy certainty on how this will be rolled out. Similarly, the current environmental levy placed on coal-fired electricity in South Africa partly attempts to address the associated externalities, but at 2c/kWh is clearly not high enough to adequately internalise the costs of coal-fired power.[94]

The externalities of electricity supply technologies

Below is a brief discussion of the negative externalities of the electricity supply sector for the most common technologies. Since important socio-economic externalities are frequently overlooked, it is crucial that there is further research undertaken to analyse the impacts and deepen understanding of the externalised social and economic costs on society of various technology choices.

Externalities of coal-fired power

Coal-fired power is polluting along the entire value chain, from mining to cleaning coal, to combustion, to disposal of contaminated ash and other waste. Carbon emissions are the most well-known example of environmental impacts (since combustion of coal is considerably more carbon-intensive than other fossil fuels) but there are many others, especially impacts on water resources, air pollution and health.

Impacts on water resources, particularly from Acid Mine Drainage (AMD), threaten groundwater supplies and riverine systems. Wide-spread water impacts include the destruction of river habitats and fish stocks, resulting in negative agricultural impacts and affiliated livelihoods. There are several examples of strongly degraded water catchment areas and rivers in South Africa, including the Olifants and Vaal rivers, and much of this can be attributed to contamination of water by AMD[95]. Furthermore, water systems are contaminated by sludge/slurry pools where waste from coal washing is stored.

Atmospheric air pollution during combustion

Besides carbon dioxide emissions, combustion of coal contributes to the release of other greenhouse gases (for example methane), particulate matter (e.g. black carbon or soot), sulphur dioxide, nitrous oxides, mercury and other heavy metals and carcinogens (lead, hexavalent chromium, arsenic, nickel)[96].

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[94] Eskom. 2012. 3rd Multi-year Price Determination application. Available at: http://www.eskom.co.za/c/article/1744/multi-year-price-determination-mypd/ [2013, April 11].

[95] Council for Geoscience. 2010. *Mine water management in the Witwatersrand Gold fields with special emphasis on acid mine drainage*. Expert Team of the Inter-Ministerial Committee. Pretoria: IMC. Available at: http://www.info.gov.za/view/DownloadFileAction?id=142259 [2013, April 11]

[96] Riekert, J.W. & Koch, S.F. 2012. Projecting the external health costs of a coal-fired power plant: The case of Kusile. *Journal of Energy in Southern Africa.* 23 (4), November 2012. This gives a detailed analysis of the impact pathway methodology for Kusile power station. The air pollution health impacts of Kusile in the eMalahleni municipality are estimated at 0.09c/kWh-6.08c/kWh, over and above the direct costs of production (and other externalised costs).

Coal and its emissions are responsible for respiratory diseases and a major contributor towards the bio-accumulation of neurotoxins such as highly toxic mercury in people and other living organisms. Coal-fired power stations produce over half of the world's 2 190 tonnes of mercury that are pumped into the atmosphere every year[97].

Waste disposal, besides contamination of water by slurry, fly ash heaps also spread particulate matter.

Although not discussed here due to the major stated focus of this report, there are further externalities associated with mining and the transport of coal.

Externalities of nuclear power

As with coal, nuclear power externalities exist along the full fuel cycle: from mining/milling, through the conversion of uranium, enrichment, fuel fabrication, electricity generation, interim spent fuel storage, (possibly) reprocessing, and finally high level waste disposal. The impacts from mining for uranium are more severe than those from mining for coal, and include noise, air pollution, greenhouse gas emissions, and contamination of water.

Other stages in the nuclear fuel cycle do not apply in South Africa, which does not yet fabricate fuel or reprocess spent fuel, for example. There are serious externalities associated with waste disposal and decommissioning of nuclear plants, especially given the very long time frames associated with radioactive waste. Although these costs should be included in the costs of production, there are examples of decommissioning funds disappearing (as happened during privatisation in the UK), and there is a real risk that the costs of decommissioning may exceed the funds that have been set aside. Since decommissioning costs are not accurately known, future taxpayers will in all probability have to cover these expenses[98].

In South Africa, the subsidisation of nuclear power and fabrication of fuel constituted a 'fiscal externality' for many years, though this practice has declined in recent years [99].

Like the rest of the world, South Africa has no waste disposal site for high level waste or used fuel and the costs of building such a site are therefore unknown[100]. Such costs will need to be borne by future generations and such sites will need to be maintained and monitored for hundreds of thousands of years.

The most serious externalities are associated with the potential for nuclear accidents. Although the likelihood of accident is low, the impacts in the case of accident – on the environment and people's health – can be catastrophic. According to Kessides[101], "It should also be noted that the original risk analysis of nuclear power might have underestimated the true probability of reactor meltdown. And while modern reactors are claimed to achieve a very low risk of serious accidents, this needs to be assessed as it is dependent on 'best practices' in construction and operation. Therefore, all developments in the literature on the

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[97] Greenpeace. 2008. *The True Cost of Coal: How people and the planet are paying the price for the world's dirtiest fuel.* Amsterdam: Greenpeace. Available at: http://www.greenpeace.org/international/Global/international/planet-2/report/2008/11/true-cost-of-coal.pdf [2013, April 11].

[98] Thomas, S. 2010. *The economics of nuclear power: an update*. Belgium, Brussels: Heinrich Boell Stiftung. Available at: http://boell.org/downloads/Thomas_UK_-_web.pdf [2013, April 11].

[99] Spalding-Fecher, R. & Matibe, D.K. 2003. Electricity and externalities in South Africa. *Energy Policy*. 31(8): 721-734. Available at: http://ideas.repec.org/a/eee/enepol/v31y2003i8p721-734.html [2013, April 11].

[100] Currently high level waste is kept on-site at Koeberg nuclear power station in the Western Cape.

[101] Kessides, I.N. 2010. Nuclear power: Understanding the economic risks and uncertainties. *Energy Policy*. 38(8): 3849-3864. Available at: http://www.sciencedirect.com/science/article/pii/S0301421510001680 [2013, April 11].

probabilistic risk assessment of nuclear safety and proliferation need to be carefully reviewed, as well as the estimates and approaches of existing credible studies"[102].

In the event of a nuclear accident, the costs of environmental clean-up and human health impacts will fall on the state (and thus the taxpayer).

Externalities of shale gas

Although South Africa does not currently rely on gas for direct electricity generation, there is increasing focus on the potential for hydraulic fracturing ('fracking') to provide an alternative to coal in South Africa's economy (in the National Planning Commission's National Development Plan, for example). In addition, South Africa is considering importing liquefied natural gas (LNG), for instance from Mozambique, into a future re-gasification terminal near Mossgas. Sasol already imports natural gas by pipeline from Mozambique.

Currently, the externalities associated with the use of Open-Cycle Gas Turbines include air pollution (for example sulphur dioxide and other volatile organic compounds - such as benzene - from the refining process), water pollution and land degradation during the oil extraction phase, externalities associated with transporting the fuel, and emissions from combustion. Large-scale electricity generation will probably use Closed-cycle Gas Turbines, which are somewhat more benign to the environment due to their higher efficiency.

Although the size of the shale gas resource in the Karoo is not yet known, and it is not clear whether, if there is a sizeable resource, what it will be used for, we include a brief discussion here of some of the impacts of hydraulic fracturing because **the presence of shale gas is likely to influence future electricity supply choices**.

The fracking debate has become highly polarised, but there will undoubtedly be significant impacts from the process, as has been witnessed in other countries.

These could include:

Land degradation, water and air pollution and noise from multiple tanker and other vehicle journeys to and from well sites will have negative impacts on local areas, and there will be ongoing costs associated with road maintenance (as has been seen in coal mining areas in South Africa). If the shale gas is to be distributed by pipeline and liquefied for export then there will be a need for considerable additional infrastructure, which will have its own impact on the environment.

Greenhouse gas emissions or hydrocarbons, (depending on the nature of the gas), from fugitive methane and volatile organic compound emissions, and from carbon emissions will contribute to South Africa's overall emissions picture[103].

Geological impacts or when fracking fluid does not flow back to the surface, or through surface spillages and waste water contamination are important risks that if quantified, would put fracking into a very different cost segment.

Smart electricity supply choices – can we exclude Nuclear energy?

Much has been written and said about the negative impacts of nuclear energy[104] and its inappropriateness as an energy choice.

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[102] Kessides, I.N. 2010. Nuclear power: Understanding the economic risks and uncertainties. *Energy Policy*. 38(8): 3849-3864. Available at: http://www.sciencedirect.com/science/article/pii/S0301421510001680 [2013, April 11].

[103] Department of Mineral Resources. 2012. *Report on investigation of hydraulic fracturing in the Karoo Basin of South Africa*. Pretoria, South Africa: Working Group on hydraulic fracturing.

[104] Harding, J. 2007. Economics of New Nuclear Power and Proliferation Risks in a Carbon Constrained World. *The Electricity Journal*. 20(10):65-76.; Lovins, A.B. 2006. *Nuclear power: competitive economics and climate-protection potential.* Columbia, USA: Rocky Mountain Institute, www.rmi.org; Fig, D. 2005.

Nuclear energy costs are on the rise and commonly extended construction periods add on to such cost developments through escalating financing costs[105]. While South Africa was involved in the nuclear industry for military purposes in the apartheid era, it is unclear why the current South African government promotes nuclear energy.

According to the National Energy Policy approved in 1998, government foresaw the need for new generation but on these conditions: ***"Whether new nuclear capacity will be an option … will depend largely on the environmental and economic merits of other energy sources relative to nuclear and its political and public acceptability, construction lead-times and load characteristics."*** [106]

The IRP2010 modelling for the least-cost energy plan resulted in initial exclusion of new nuclear energy from the plan on the basis that the modelling programme recognised it was too expensive. It was later manually brought back, into the Policy-Adjusted Plan, with the DOE stating that this was for 'energy security' reasons[107].
Our Smart electricity demand and supply scenarios illustrate that we do not need Nuclear power to keep our electricity system stable and reduce our carbon emissions. This means we can also safely avoid the high risks of a nuclear accident, the problems with storage of radioactive waste, and the very high (and continually escalating) costs of building new nuclear plants[108].

Is reliance on RE feasible?

South Africa's Department of Environmental Affairs provided an answer to this question back in 2008: "Although coal is by far our largest non-renewable energy resource with an impressive energy resource potential of 1,298,000 PJ[109], it is far less than our largest RE resource, namely solar with an energy potential of 8,500,000 PJ/year"[110]. We repeat: the total coal reserve is 1 298 000 PJ, while the annual solar resource potential is 8 500 000 PJ.

Thus, our total coal reserves are only equal to around 15% of the solar energy available to us every year.

But if this endorsement of South Africa's solar energy potential is not sufficiently convincing, consider the following:

Uranium Road. South Africa: Jacana.; Heinrich Boel Stiftung, 2004; Moody's US nuclear sector analysis; Environmental Health Perspective, 2007 .
http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1867971

104 http://www.nrc.gov/info-finder/decommissioning/power-reactor/peach-bottom-atomic-power-station-unit.html

105 *World Nuclear Industry Status Report 2010-2011*. Available at: http://www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-51.html [2013, April 11].

106 Department of Minerals and Energy. 1998. White Paper on the Energy Policy of the Republic of South Africa. Pretoria: Government Printer. P. 63. Available at: http://www.info.gov.za/view/DownloadFileAction?id=142157 [2013, April 10].

107 Department of Energy. 2010. *Integrated Resource Plan for Electricity 2010-2030 Revision 2, final Report.* Pretoria: Department of Energy. Available at: http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf [2013, April 11].

108 Thomas, S. 2010. *The economics of nuclear power: an update*. Belgium, Brussels: Heinrich Boell Stiftung. Available at: http://boell.org/downloads/Thomas_UK_-_web.pdf [2013, April 11].

109 Our Uranium reserve is far less than our coal reserve at 157,853 PJ, i.e. it is only 12% of our coal reserves (Lukey, 2008).

110 Lukey, P. 2008. Possible challenges to the implementation of Cabinet's directions related to renewables. *WWF National Renewable Energy Conference*. 7 November 2008. Available at: http://awsassets.wwf.org.za/downloads/cheaper_electricity_with_renewable_energy.pdf [2013, April 11].

- Aside from runaway overnight and operational costs of coal and nuclear energy supply, it is also common practice to externalise the bulk of environmental impact costs from such technologies. RE technologies such as wind or solar in particular, have zero fuel costs and low or no externalised costs. In addition, overnight costs do not escalate since construction phases for renewables are far shorter than for coal and nuclear and the costs of renewable technologies will continue to drop[111].
- The REIPPPP initially planned for 3 725 MW over a period of 3 bid windows, 2 460 MW have already been absorbed, leaving 1 165 MW available for the remaining bid windows. The enthusiastic response with which RE IPPs have responded to the REIPPPP process indicates that South Africa could easily procure more renewables, when needed. The Minister responded positively to this development and announced that 3 200 MW additional RE would be procured by 2020[112].
- Amory Lovins from the Rocky Mountain Institute has researched a number of alternatives for how the USA might meet its energy needs, and concluded that by 2050: "*a future U.S. electricity system in which renewables—mostly at utility scale—provide at least 80% of electricity by 2050 [is possible]. There is widespread adoption of energy efficiency and participation in demand response programs, valued for their ability to complement generation from variable renewable sources. The increased energy efficiency flattens electricity demand growth, probably leading many regulators and utilities to challenge the current business model with new value propositions*"[113].
- The Worldwide Fund for nature's (WWF) energy study from 2011 – The Energy Report – illustrated clearly how globally100% RE supply by 2050 is within reach[114].

The challenges to RE

As wind and solar are intermittent (albeit abundant) energy sources in South Africa, it is essential to deal with the issue of intermittency of supply. It is worth noting here that the Renewable Energy Policy Network (REN21) concluded in its 2013 Global Futures report that "Utilities have contended with variability since the dawn of centralised power networks, although mostly in terms of demand variability than supply variability."[115] The report added that utilities are already finding ways to manage large shares of renewables and that integration of renewables into the grid is not just about hardware but also about how power markets function. The report states that 'more than a dozen' different options are available to utilities to balance variable renewables. Options to smooth out peak household demand by involving women as household energy managers in reducing peak hour demand, should also be explored.

South African appropriate approaches that we have found can support the widespread deployment of RE include:

- Distribution of renewable generation widely throughout the country rather than high concentration in one region.
- Solar power and solar thermal solutions for increasing cooling requirements of residential and commercial buildings and industrial purposes match the cooling demand profile in South Africa perfectly.
- Residential and commercial hot water and heat demand can be matched with existing hot water storage and solar thermal energy.

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[111] REN21. 2013. *Renewables Global Futures Report 2013*. Renewable Energy Policy Network for the 21st Century. Available at: http://www.ren21.net/Portals/0/REN21_GFR_2013_print.pdf [2013, April 11].
[112] Government gazette of 19 Dec 2012.
[113] Lovins, A, 2012. *Electricity* scenarios. Colorado, USA: Rocky Mountain Institute. Available at: http://www.rmi.org/RFGraph-Electricity_scenarios [2013, April 11].
[114] WWF. 2011. *The Energy Report. 100% renewable energy by 2050.* WWF. Available at: http://assets.panda.org/downloads/the_energy_report_lowres_111110.pdf
[115] REN21. 2013. Global futures report, 2013. *Op cit.*

- Small scale battery storage solutions, including electric vehicles, increase the load factor of distributed Solar PV significantly and can also contribute to reduce peak demand in residential buildings.
- Overcapacities of wind or solar can be used to generate hydrogen or methane, which can be stored and used to e.g. power fuel cells or gas turbines whenever the load profile demands it.
- The challenge of the short-term intermittency of wind power can be overcome on-site by fly-wheels, super-capacitors or also battery based solutions. Also, the more widely geographically distributed the wind farms are, the less intermittent is their collective contribution to the grid[116].

Electricity grid technology (smart grids) and energy storage systems are now seen by Venture Capitalists and Private Equity financiers as "the next big thing"[117].

As South Africa is effectively starting from zero, on-grid RE and most of the technology needed to overcome intermittency challenges is either already commercially available or rapidly evolving, there is no doubt that RE can be integrated into the South African national grid with a moderate deployment rate. Read on to see our evidence for this view.

Using our natural resources wisely

In South Africa, while we have an abundance of RE options in various forms, estimates differ as to feasibility. For example, Eskom estimated in 2006 that there is only about 1 000 MW wind power available along the coast[118]. However, the recently independently published **SA wind atlas[119] indicates a minimum of 10 000 MW with a 30% load factor, and 20 000 MW with a 20% load factor**.

In 2008 the Department of Environmental Affairs shared these graphics on the potential solar and wind resources for South Africa[120]:

[116] Marquard, A., Merven, B. & Tyler, E. 2008. Appendix 3 – New assessment of wind resources for South Africa. *Costing a 2020 Target of 15% Renewable Electricity for South Africa*. Cape Town: UCT ERC. Available at: http://www.erc.uct.ac.za/Research/publications/08-Marquardetal-costing_a_2020_target.pdf [2013, April 11].
[117] http://www.energyandcapital.com/articles/energy-storage-systems/3134
[118] African Wildlife 2006, page 40
[119] SANEDI n.d. *Wind Atlas for South Africa (WASA).* Available at: http://www.wasaproject.info/ [2013, April 11].
[120] Department of Environmental Affairs. 2008. *WWF National Renewable Energy Conference.* 7 November 2008. *Op cit.*

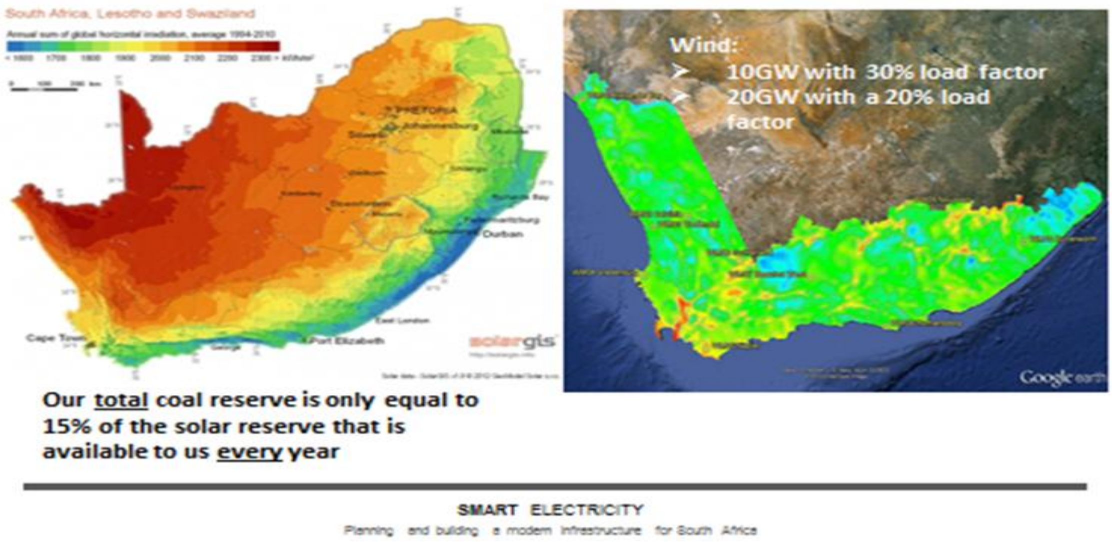

Figure 13: Solar and wind resources for South Africa, Dept Environmental Affairs, 2008

While there are a variety of RE technologies available to us, the Smart energy planning team focused mainly on solar and on-shore wind options as these are the most commercially viable options for South Africa at this time.

Solar Photovoltaic

Solar photovoltaic (Solar PV) systems capture the energy in sunlight and convert it directly into electricity. Banks and Schaffler[121] proposed in 2006 that up to 14% of South Africa's electricity could be supplied by Solar PV by 2050, based on the costs for Solar PV in 2006.

The price of solar PV modules has dropped significantly: from $6 per watt in 2000 to $1 per watt by the end of 2011. Beyond cost reductions of PV-modules further opportunities for cost reductions can be pointed out: higher efficiency rates, thin film modules and lowering costs for 'balance of system' components[122].

In addition to large scale Solar PV, the growing uptake of rooftop PV installation throughout the world suggests that such a trend may well become common here, provided financial and institutional barriers are removed.

Small scale Solar PV systems are doing well with 21 GW of the 28 GW installed worldwide in 2011 in the "sub-1 MW category"[123].

Solar thermal energy

Solar energy transformed in SWHs to hot water can significantly contribute to reducing demand on the grid, especially in the residential sector. On a larger scale energy from the sun can be collected and focused with mirrors or in parabolic troughs to create a high

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[121] Banks, D., Schäffler, J. 2006. *The potential contribution of renewable energy in South Africa*. DANIDA and Earthlife Africa. Available at: http://www.nano.co.za/PotentialContributionOfRenewableEnergyInSAFeb06.pdf [2013, April 11].
[122] The balance of system (BOS) encompasses all components of a photovoltaic system other than the photovoltaic panels. This includes wiring, switches, support racks, an inverter, and batteries in the case of off-grid systems. In the case of free-standing systems, land is sometimes included as part of the BOS.
[123] Bloomberg investment finance 2012.

intensity heat source that can be used to generate electricity by means of a steam turbine or heat engine[124]. From 2006 to 2011, installations of concentrated solar power (CSP) plants increased annually by about 37%, albeit from a low base[125].

A great potential for the utilisation of solar thermal energy in commercial and industrial cooling processes exists, but has not yet been exploited in South Africa.

Wind

Wind turbines harness the energy of moving air in order to generate electricity. Globally, in 2011, wind power installations increased by 20% to a total capacity of 238 GW[126]. A number of countries and states significantly increased their share of wind power from 2010 to 2011 including Denmark, where wind provides nearly 26% of electricity demand, Spain (15.9%), and Portugal (15.6%); four German states met almost half of their electricity needs with wind; the state of South Australia generated 20% of its demand from wind; and the U.S. states of South Dakota and Iowa respectively produced 22% and 19% of their power from wind in this year[127].

Renewables are proving an attractive investment in developing countries. REN21 reported in 2012 that "India displayed the fastest expansion in investment of any large renewables market in the world, with 62% growth", while China and India were ranked first and 5th respectively, in terms of the world wind energy capacity[128].

Using energy wisely

The Department of Energy's National Energy Efficiency Strategy (NEES) of 2008 set an overall energy efficiency target of 12% by 2015, with a 15% target for the industrial sector. The Second Review of the NEES in 2012 reiterated these targets, however it is not yet known to what extent the implementation of the NEES has contributed to the national electricity demand drop in 2012.

As we have illustrated, according to the Smart track demand scenario, with moderate effort, it would be possible to save 16% of total electricity demand by 2030 when compared to the IRP2010 baseline.

If this was to be met, the projected IRP2010 peak demand of 68 GW in 2030 would be reduced to 57 GW, a total saving of 11 GW.

Using SNAPP to model the SO-moderate demand forecast, with a limited 16% savings by 2030, we can then calculate what the reserve margin would be if we continued to build the power stations planned in the IRP2010.

If the Smart track energy efficiency target we propose were to be met, using the IRP moderate demand annual growth rate of 2.9 % SO-moderate demand forecast as baseline, SNAPP shows that such a scenario would result in a reserve margin of 27% if we implement the IRP2010 new generation build programme as is. In other words, we would be building 12% more generation capacity than is needed to retain system stability.

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[124] Department of Minerals and Energy. 2003. *White paper on renewable energy.Pretoria: Department of Minerals and Energy*. Available at: http://unfccc.int/files/meetings/seminar/application/pdf/sem_sup1_south_africa.pdf [2013, April 11].
[125] REN21. 2013. Global futures report, 2013. Page 3. *Op cit.*
[126] REN21. 2013. Global futures report, 2013. Page 5. *Op cit.*
[127] REN21. 2013. Global futures report, 2013. Page 4. *Op cit.*
[128] REN21 2013. Global futures report, 2013. *Page 7. Op cit*

	IRP2010	Smart track
Peak demand in 2030	68 GW	57 GW
Savings by 2030	3.4 GW – with moderate EE, as proposed in IRP2010	10.8 GW
Reserve margin, including imported capacity	13%	27%
Percentage over-supply (with 15% reserve margin as accepted standard)	-2%	12%

Table 7: Final 2030 peak capacity needed – IRP2010 compared to the Smart track demand.

As has been pointed out above, if the SO-Low demand forecast is adopted by Eskom and DOE, South Africa's power system would have a reserve margin of 40% with the current build plan.

Changes in assumptions for energy planning are common and changes to key assumptions can be taken into account with timeous reviews of strategies and investment choices. **The IRP2010 was concluded in 2010. Its assumptions were based on information dated back to 2008 and earlier.** Given the changes highlighted above, a review of the IRP2010 needs to be undertaken urgently.

Smart planning for a renewable energy-strong Supply future

The Smart supply scenarios adopt the Smart track and Smart intrepid demand scenarios as their foundational demand forecast assumptions. Including Energy Efficiency (EE) potential in demand forecast is in keeping with an integrated energy planning approach and therefore 'smarter' than the supply-focused approach as used in the IRP2010.

Taking into account conventionally externalised costs of the different technologies would be another facet of an integrated approach - this step however requires investigation which we were unable to undertake within the scope of this report.

Using SNAPP to model the IRP2010, we can illustrate the effects of the timing for bringing a range of different electricity generation choices on to the grid. As already stated, for the IRP2010, SNAPP shows a reserve margin of 13% by 2030 and a loss of load probability (LOLP) of zero.

> *"The reserve margin is a known and accepted deterministic indicator of the reliability of a system. However, it does not take into account some system characteristics which also affect the reliability of a system, such as the size of the individual units that make up a system in relation to the size of the system and their individual outage rates; random weather fluctuations that may affect both demand and supply.*
>
> *Reliability assessments are then done by using probabilistic approaches/indicators such as LOLP (Loss of load probability). ….Parameters are then adjusted, the model re-run and iterated until the desired level of reliability according to these indicators, are achieved. LOLP is a reliability index that indicates the probability that some portion of the load will not be satisfied by the available generating capacity".*[129]

[129] Marquard, A., Merven, B. & Tyler, E. 2008. *Costing a 2020 Target of 15% Renewable Electricity for South Africa*. Cape Town: UCT ERC. Available at: http://www.erc.uct.ac.za/Research/publications/08-Marquardetal-costing_a_2020_target.pdf [2013, April 11].

Key indicators considered in the Smart electricity plan

For this study, the key indicators that were assessed by using SNAPP were:

- Loss of Load Probability (LOLP), an assessment of the reliability and stability of the grid, an indicator of reliability of power generation.
- Reserve margin, including imported capacity (which indicates spare capacity should one power station have an emergency and have to shut down).
- Investment required for building new generation plant.

For this modelling exercise, SNAPP allowed us to use pumped storage as a proxy for storage in general. Storage options need to guarantee a certain level of availability in order to be used as an adequate storage option. SNAPP has modelled pumped storage with 73% efficiency and 28% availability, regarded as a reasonable approximation for future storage[130]. Over the next twenty years, it is assumed that new forms of storage would have surpassed current levels of commercial viability.

The aim of the scenarios is to stimulate discussion and influence our electricity planning and therefore a more pragmatic approach has been adopted. Given that Medupi and Kusile power stations are already under construction we have opted to include both in the Smart supply energy mix.

Bear in mind that a reserve margin of about 15% is assumed (regarded as reasonable in the electricity generation industry), the IRP2010 policy adjusted scenario predicted that a peak capacity of 89 532 MW would be needed by 2030[131] to meet a peak demand of 67 810MW.

The models we present here aim to be comparable with the IRP2010.

Smart track is a new-build Supply plan for what has been described in the previous chapter by the same name, which assumes that electricity demand growth continues to be slower than SO-Mod, as the NEES energy efficiency targets are implemented and achieved by 2015 and moderate energy efficiency measures are implemented up to 2020. Beyond 2020 it is assumed that the electricity demand will recover and ramp up to the SO-Mod levels of 2.9% annual increase. As has been shown, in total the Smart track forecast results in a 16% lower demand by 2030 as compared to the IRP2010 baseline of SO-Mod.

Smart intrepid is a new-build Supply plan for what has been described in the previous chapter by the same name. It assumes that the NEES targets are achieved and the slow growth trend in electricity demand will remain through successful implementation of additional energy efficiency targets beyond 2015. As has been shown, in total the Smart intrepid scenario results in a 24% lower demand by 2030 as compared to the IRP2010 baseline of SO-Mod.

Results of our Supply modelling

The **Smart track scenario** mix of electricity Supply is based on the availability of RE resources. Data is drawn from previous research. The Banks and Schäffler study of 2006 is a robust technical report which has yet to be improved upon, a comprehensive analysis of the amount of energy available in South Africa.

Their *progressive renewable scenario* was calculated to provide about 13.3% RE by 2020 and 70% by 2050. We have used the progressive renewable scenario from the Banks et al report,

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130 Andrew Marquard (Personal communication, 2012).

131 Department of Energy. 2010. *Integrated Resource Plan for Electricity 2010-2030 Revision 2, final Report.* Pretoria: Department of Energy. Available at: http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf [2013, April 11].

as well as the *RE scenario* from the WWF Energy review 2010 report[132] and adapted these scenarios to take into account recent RE trends. All scenarios meet LOLP=0 and a reserve margin of at least 15%.

Table 8 below provides a comparison of the projected new-build RE 2030 scenario from the Banks and Schaffler study, the WWF 2010 scenario, the IRP2010 and our Smart track scenario that replaces most of the planned new Coal and Nuclear build with RE.

Investment plan - new-build (in GW)	Banks et al 2006[133]	WWF 2010	IRP2010	Smart track RE
Fossil peak (Open Cycle Gas Turbine, Closed Cycle Gas Turbine, Integrated Gasification Combined Cycle)	4.8	1.2 + 1.5 + 1.7	4.9 + 2.4	1 + 2.4
Pressurised Water Reactor Nuclear	0	0	9.6	0
Hydro[134]	2.6	0	0.1 + 2.6	0.1 + 2.6
Landfill gas	0.2	0.2	0.1	0.1
Biomass	1.9	0.6	0	2.7
Super critical Coal/ Fluidised Bed combustion coal	7.6	4.8	12.7 + 2.3	8.7
Wind	19.9	9.5 + 12.7	9.2	10.0
Wave and other	0.9	1	0	0
CSP tower and trough	10.3	33.2 + 2.4	1.2	7.9
Solar PV	3.9	0.4	8.4	10.5
Storage	6.1	2.7	1.3	5.5
RE-total (GW and % of total)	43 (72%)	62.5 (83%)	20.1 (37%)	36.6 (71%)
Total (GW)	60.12	75.1	54.8	51.5

Table 8: Comparison of new-build requirements in GW: Banks and Schaffler, WWF 2010, IRP2010 and Smart track scenarios[135].

The results of SNAPP modelling of the Smart track generation scenario are shown below. Significantly, the system remains stable, with LOLP equal to zero.

The Smart track investment plan requires less capital as it is not necessary to build as many large power stations as was envisaged in the IRP2010. According to the costs modelled in SNAPP, 18% of the overnight capital requirements can be saved with the Smart track new-build generation plan. SNAPP does not calculate financing costs. It is worth noting here that according to Eskom just the financing charges for Medupi and Kusile are estimated to amount to R25 billion and R40 billion respectively[136].

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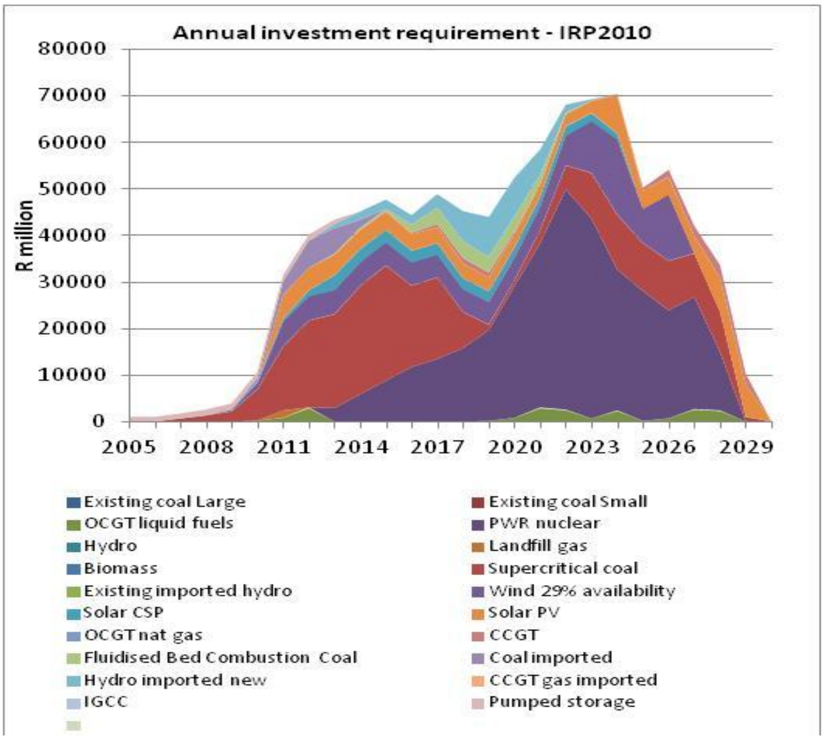
[132] WWF. 2010. *50% by 2030 Renewable Energy in a Just Transition to Sustainable Electricity Supply*. South Africa: WWF-SA. Available at: http://www.energy.gov.za/IRP/irp%20files/WWF_SA.pdf [2013, April 11].
[133] Banks, D., Schäffler, J. 2006. *The potential contribution of renewable energy in South Africa*. DANIDA and Earthlife Africa. Available at: http://www.nano.co.za/PotentialContributionOfRenewableEnergyInSAFeb06.pdf [2013, April 11].
[134] Hydro not included in RE basket.
[135] WWF later added that "the choice of CSP over PV as solar option in this study was for illustrative purposes, with CSP including storage; it did not reflect a technology preference or lack of faith in PV for multiple GW".

[136] Donnelly, L. 2012. Eskom grilled on power price. *Mail and Guardian*. 24 August. Available at: http://mg.co.za/article/2012-08-24-00-eskom-grilled-on-power-price [2013, April 11].



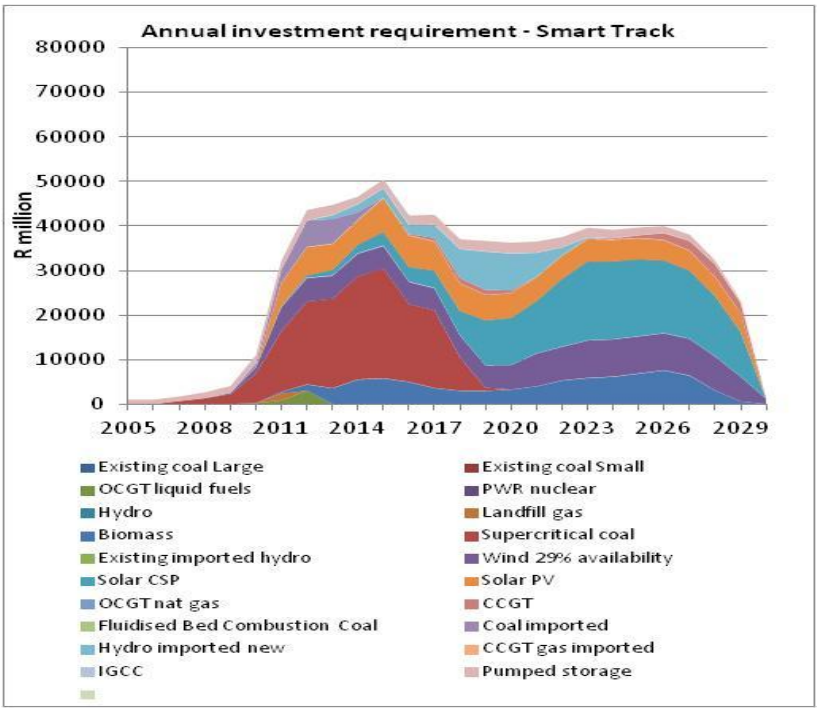


Figure 14: Annual investment requirements compared: IRP2010 vs Smart track.

The comparative generation mix is shown in **Figure 15** below.

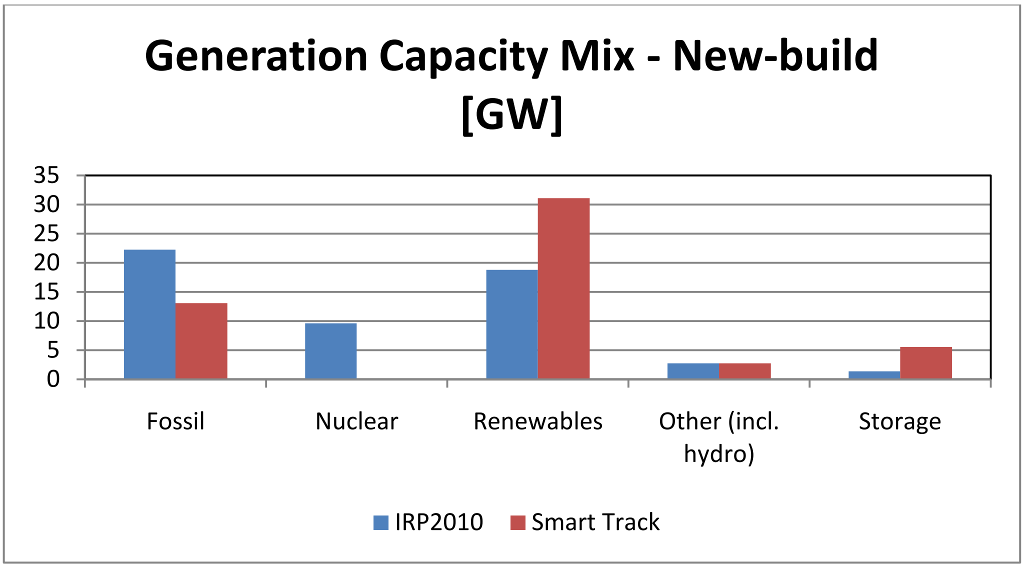


Figure 15: Comparison of the generation mix for the IRP2010 vs Smart track.

The Smart intrepid scenario

The Smart intrepid scenario assumes that the NEES targets are achieved and the slow growth trend in electricity demand will remain through implementing additional energy efficiency targets beyond 2015. In total the Smart intrepid demand forecast results in a 24% lower demand by 2030 as compared to the IRP2010 baseline of SO-Mod. The Smart track demand was 16% below SO-Mod. Using SNAPP, a Smart intrepid scenario was then modelled for this report. The results compared to the IRP2010 are shown below.

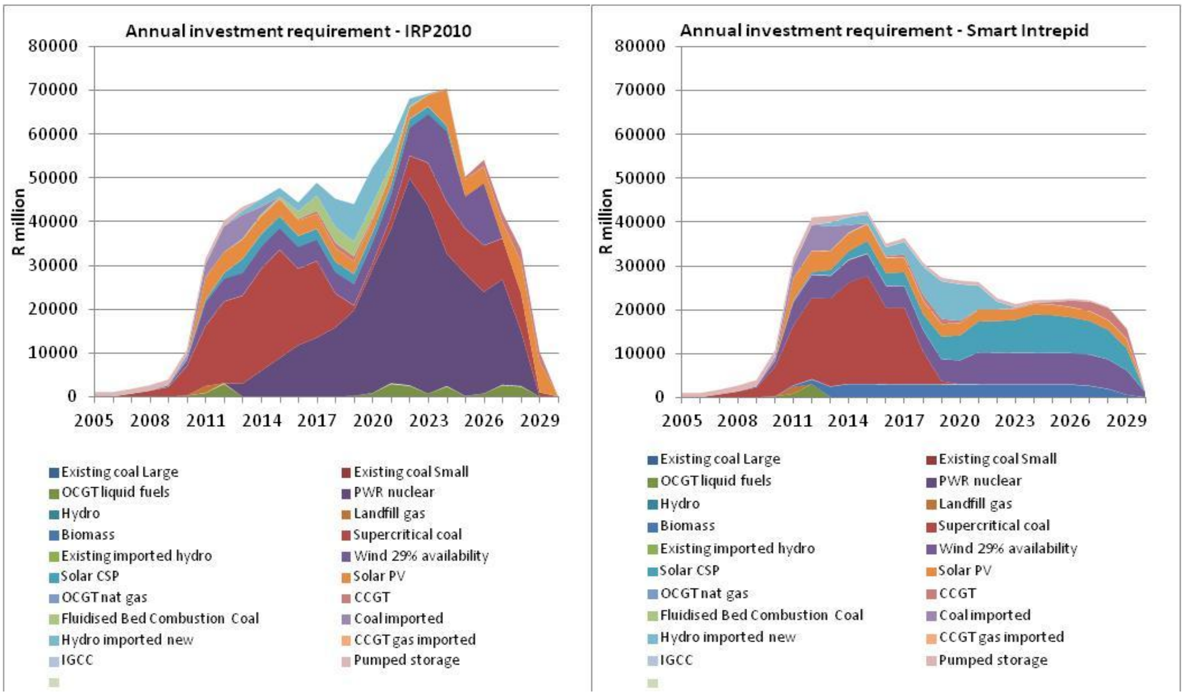


Figure 16: Annual investment requirements compared: IRP2010 vs Smart intrepid.

This reveals the fact that (excluding the comparatively low costs of energy conservation and efficiency) the investment requirement for the Smart intrepid scenario would be R560 billion[137], a 39% reduction in investment when compared with the IRP2010.

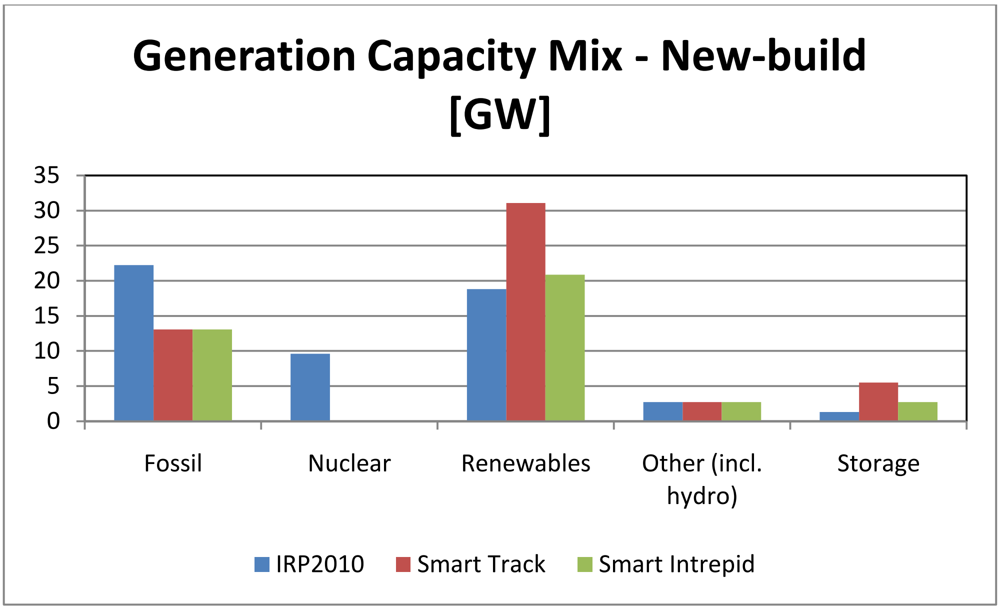


Figure 17: comparison of the generation mix for the IRP2010 compared to the Smart track and Smart intrepid scenarios

Key factor	IRP2010	Smart track	Smart intrepid
Investment costs	R 910 billion	R 749 billion	R 560 billion
Reserve margin	13%	19%	16%
LOLP	*0.0%*	*0.0%*	*0.0%*

Table 9: A comparison of key indicators for IRP2010 vs Smart track vs Smart intrepid

The levelised cost of electricity (LCOE) in 2030 will remain roughly the same with all scenarios. Earlier retirement of old and less efficient power plants may become an increasingly attractive option as coal and other fossil fuel prices continue to rise and stronger commitments to carbon emission reductions come into play. South Africa's carbon tax, as proposed for implementation by 2015 could also trigger such developments[138].

Emissions[139] forecast comparisons: IRP2010 and Smart scenarios

- **IRP2010:** plateau with 300 Mt CO_2e in 2020-2021, starts to drop slowly thereafter to 274 in 2030. Accumulated from 2010-2030: 5 660 Mt CO_2e

137 Using the IRP2010 as a reference case, our calculations are also based on 2010 prices.
138 Pravin, G. 2013. *Minister of Finance Pravin Gordhan presents the 2013 Budget Speech.* Pretoria: South African Government Information. Available at: http://www.info.gov.za/speech/DynamicAction?pageid=461&sid=34533&tid=99785 [2013, April 11].
139 Emissions expressed as CO_2e or CO2e.

- **Smart track:** reaches maximum in 2021 with 245 Mt CO_2e (18% less than IRP), drops to 234 Mt in 2024 and rises again to 242 in 2030 (12% less than IRP). Accumulated from 2010-2030: 4 995 Mt CO_2e (**12% less than IRP**).
- **Smart intrepid:** very similar to Smart track in 2021: 249 Mt CO_2e (17% less), drops to 235 Mt in 2030 (14% less IRP). Accumulated: 4 999 Mt CO_2e (**also about 12% less IRP2010**).

Locally manufactured RE technologies and investment in energy efficiency will further stimulate local job creation – as is outlined in detail in the next chapter.

Smart Electricity planning & the national grid

Eskom is planning to spend about R149 billion over the next ten years to improve grid reliability and ensure that the proposed new generation can be integrated into the system, with a further 12 700 km to be added to the existing 28 000 km of network[140].

Although it will be necessary to continue some upgrading of the transmission infrastructure to allow for large scale solar parks and wind farms across the country, Smart electricity planning would ensure that the grid can manage the introduction of decentralised small-scale suppliers.

Smart electricity planning does not favour mega-projects. Instead decentralised approaches to energy supply are treated as more favourable to pro-poor energy access and are actively supported.

As urban populations grow many municipalities are challenged by huge capital expenditures needed to strengthen and extend the electricity distribution infrastructure within their boundaries. A focus on energy efficiency incentives will help to delay capital investments into the formal distribution system.

The Independent Systems and Market Operator (ISMO), is a state-owned enterprise that would own the national transmission grid and would provide open access to a transmission service which does not discriminate against independent suppliers. Once the ISMO is established we anticipate that it would become possible for customers to choose their suppliers and potentially avoid carbon tax by choosing RE suppliers.

Do the current tariff structures support the Smart approach?

Currently, municipalities add on varying surcharges onto their electricity tariffs in order to finance the municipal distribution grid and to cross-subsidise other services. In many cases this approach has resulted in tariffs, which are unaffordable for the urban poor, triggering service delivery protests. Municipal industrial tariffs have also been strongly criticised and industrial customers tend to close down operations, save costs through reducing the number of jobs offered, consider relocating to cheaper municipalities, or, if they are sufficiently powerful, insist that Eskom take over the direct electricity provision in these areas[141].

Electricity distribution by municipalities has traditionally been regarded as a revenue generating activity to cross-subsidise other basic services.

[140] Creamer, T. 2013. National rewiring – big changes in store for SA's transmission network as generation mix evolves. *Engineering News.* 9 November. Available at: http://www.engineeringnews.co.za/article/big-changes-in-store-for-sas-transmission-network-as-generation-mix-evolves-2012-11-09-1 [2013, April 11].

[141] PMG. 2012. Restructuring of Electricity Distribution Industry: public hearings. *Parliamentary Monitoring Group*. 25 July 2012. Available at: http://www.pmg.org.za/report/20120725-edi-doe-eskom-cogta-salganersa-national-treasury-fcc-and-dbsa-publi-0 [2013, April 11].

Without the municipal surcharge, Eskom electricity is cheaper to the end user. But, while Eskom customers receive roads, sanitation, water services from their municipality, their electricity payments avoid contributing towards cross-subsidising these services as they are Eskom customers[142]. This then leads to a further burden on the municipal electricity customers. Surcharges of up to 700%[143] are experienced. This is clearly not a sustainable situation.

A thorough re-evaluation of municipal revenue generation, involving all urban citizens such as women and the poor, should also be considered. **The current funding model of providing many local government revenue needs through electricity surcharges originated during *apartheid* and may be out of step with modern approaches.** The situation where municipalities depend heavily on the surcharges on electricity tariffs for revenue generation poses a significant barrier to the implementation of effective energy saving and energy efficiency programmes led by municipalities.

The same context is valid for small-scale embedded generation: decreasing electricity consumption through SWHs and other energy saving measures and own generation through for example rooftop Solar PV systems would cut deeply into the revenue base of municipal distributors with current residential tariff structures.

Municipalities are aware that cost-effective energy saving programmes and rooftop Solar PV options will become increasingly attractive to consumers. We will most likely see the extension of fixed daily network or service charges in municipal and Eskom tariffs to residential users in order to allow for the grid-connection of small-scale embedded generation and make up for revenue losses.

Other approaches are to increase property rates while still achieving cost-reflective tariffs for other services and thus reducing the need for cross-subsidisation. Such changes in tariff structures will be under pressure to not discourage the uptake of energy saving measures and rooftop Solar PV installations on the one hand and on the other hand somehow avoid the erosion of the revenue base needed for the upkeep of the electricity distribution system.

Supplying affordable electricity to poor households will remain a challenge whatever tariff structure is applied. However, including the poor and women in energy planning processes allows them to be agents of their own lives, as opposed to the current model where electricity pricing decisions are made in spaces generally still inaccessible to them.

What if we experience rapid increases in economic growth?

As previously stated but worth repeating, the global economic crisis of 2008 and continuing volatility including low-growth outlooks, both domestically and internationally, mean that it is prudent to have a range of flexible options in the new-build plan. This will ensure that resources are not wasted in building power plants that may turn out to be unnecessary because effective energy conservation and efficiency strategies are being implemented. Lower economic growth tends to result in lower electricity demand.

The flexibility of RE technologies and the significantly shorter lead times for RE projects make them well-placed to respond to increases as well as decreases in demand.

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[142] PMG. 2012. Restructuring of Electricity Distribution Industry: public hearings. *Parliamentary Monitoring Group*. 25 July 2012. Available at: http://www.pmg.org.za/report/20120725-edi-doe-eskom-cogta-salganersa-national-treasury-fcc-and-dbsa-publi-0 [2013, April 11].

[143] EIUG. 2012. *Municipal tariff study*. *Energy Intensive User Group*. Avail at: http://www.eiug.org.za/projects/ [2013, April 11].

What are the risks of continuing with business as usual?
Energy security is of paramount importance to any country. The IEA defines energy supply to be *'secure' if it is adequate, affordable and reliable*. On the other hand, the IEA defines ***energy insecurity*** as *"the loss of economic welfare that may occur as a result of a change in the price and availability of energy."*[144] We would argue for the addition of 'sustainable' to the definition of a 'secure' energy supply system.

Conclusion

Using SNAPP, we have shown that, with a moderate amount of electricity savings – as proposed in the Smart track demand scenario – i.e. 16% below the demand of the SO-Mod baseline by 2030, it is possible to supply all the electricity we require by shifting our electricity generation from nuclear and coal to wind and solar. Such an electricity plan would enhance environmental quality, provide jobs (see next chapter for details), address energy poverty and reduce overnight investment required by about 18%, compared to the current IRP2010 policy-adjusted scenario.

The Smart intrepid scenario follows more ambitious energy efficiency targets – towards and beyond current best practice resulting in 24% less demand by 2030 – and reduces investment requirements by about 39% compared to IRP2010.

Historically, South Africa has enjoyed low electricity tariffs, which resulted in the wasteful use of our valuable resources. As Eskom pushes towards cost-reflective tariffs more and more energy saving and investment in energy efficiency and other demand managements measures have become economically feasible in all sectors. Fossil fuel prices will continue to rise, including coal, directly impacting on South Africa's electricity tariffs due to the huge dependence of coal and other fossil fuels in the current energy mix. Independent of global and local economic growth rates it just makes sense to save energy. The megawatt saved also costs much less than the megawatt generated.

Energy Efficiency and Demand-side Management contribute to decouple electricity demand from economic growth. A transition away from energy-intensive economic sectors as envisioned in the National Development Plan, will further reduce the energy intensity of our economy. Such a lower growth in electricity demand will allow South Africa to replace the majority of coal-, fossil fuel-based and nuclear power supply plants as they retire with RE technology. Following the proposed scenarios Smart track or Smart intrepid will accelerate the deployment of RE in South Africa.

Over-investment in new centralised power stations would not be in the interests of the state, nor of its citizens, particularly the poor and marginalised, who are likely to suffer both from continued rising electricity tariffs required to pay for the new-build and compromised service delivery in other sectors, as a larger proportion of treasury revenue would need to be allocated to meet rising energy supply costs.

An economy with lower energy intensity and timeous investments in RE is more resilient against foreseeable cost escalations of fossil fuels. RE technologies are more flexible and modular, faster to build, reduce financing costs and risks, create more local jobs and incur lower adverse externality impacts.

If we compare the annual investment needed to provide electricity as per the IRP2010 compared to our modelled outcomes that would grow the green economy and provide jobs, we see that these scenarios will need less investment, thereby incurring less debt and lower

[144] Ölz, S., Sims, R. & Kirchner, N. 2007. *Contribution of Renewables to Energy security, International Energy Agency information paper*. OECD/IEA. Available at: https://www.iea.org/publications/freepublications/publication/so_contribution.pdf [2013, April 11].

interest rates, and this ultimately can result in an electricity price which is lower than current tariff trends suggest.

In a nutshell, these are the features, benefits and challenges of Smart Electricity supply planning that we propose:

Smart electricity planning features	Benefits	Challenges
Reliable supply	Ensures adequate reserve margins and enables economic success	Integrating into outdated grid[145]
Efficient use	Increase productive & effective use of existing supply	Perverse incentives in Eskom and local municipalities undermine effectiveness of efficiency campaigns
Cost-effective	Reduces Operations & Maintenance and fuel costs. Stabilises electricity prices	Understanding appeal of high capital expenditure; growing appeal of low operating expenditure financing
Encourages Foreign Direct Investment	Grow RE industry in line with global trends, especially local manufacturing	IRP currently not geared toward growing RE demand
Jobs	Provides diversity of jobs to improve short and long term employment for many	Some technical skills shortage
Poverty eradication	Enables access to affordable energy services, improves wellbeing, stimulates small businesses - all of which would also promote gender equality	The view that energy services can only be supplied by limited and outdated means
Environmental quality	Reduce pollution of dwindling water resources. Reduce risk of carbon-related trade penalties. Improved air quality	Integrating traditionally externalised costs meaningfully into electricity planning decisions

[145] REN21, 2010, provides great ideas for handling grid integration.
REN21. 2010. *Renewables Global Status Report 2010*. Renewable Energy Policy Network for the 21st Century. Available at: http://www.ren21.net/Portals/0/documents/Resources/REN21_GSR_2010_full_revised%20Sept2010.pdf [2013, April 11].

Job creation potential

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In summary:
RE projects can be beneficial for job creation in South Africa and their full potential as agents of economic growth can be fully realised if they are tied into a larger manufacturing sector growth plan for the country. Failure to do this will result in very few sustainable permanent jobs and perhaps leave a legacy of large capital intensive projects with little job creation potential beyond initial construction jobs.

Job creation in the RE industry is not only about replacing coal jobs with renewable ones. There are also likely to be positive knock-on effects on rural livelihoods and job creation.

Government programmes can drive growth in RE technology manufacturing activity directly. Rebates for SWHs, financial credit schemes through rates bills or electricity bills, properly lifting the cap on RE beyond IRP2010, local funded energy conservation and efficiency programmes, bylaws and national standards, can all stimulate such growth. There is a general need to develop skilled South African technicians and engineers in order to maximise local employment; stimulating the RE sector can both address job creation and provide energy security.

South Africa has abundant and widespread wind, sun and human resources – for us distributed RE generation is the future. Citizen- and community-owned small- scale embedded generation, own- and co-generation in enterprises and industries – all labour intensive options – can be realised in a modern, clean and just energy future.

Historically, given our minerals wealth, large numbers of people have been employed in coal mines and coal-fired electricity generation plants. This number has declined drastically in the post-apartheid era, with both coal mining and conventional electricity generation jobs decreasing. As climate change impacts make themselves felt in South Africa and around the world, it is necessary to rethink South Africa's high commitment to coal.

In general, **the extremely high levels of unemployment in South Africa are approaching crisis point.** Even those who are employed often face employment insecurity and a lack of decent working conditions. South Africa has faced steady de-industrialisation of the economy, with fewer and fewer secure manufacturing jobs able to provide the impetus for socio-economic development for significant numbers of people.

While international experience has shown that fewer women than men lost jobs in the recent recession, it has also been seen that most of new jobs created have gone to men. In the US, for instance, 80% of new jobs created since 2009 have gone to men[146]. The creation of new employment is therefore a key gender issue. In November 2011 the Million Climate jobs campaign[147], reviewed a range of job creation studies in RE and concluded, as have other authors in other countries, that per unit of electricity, RE creates more jobs than conventional utility-scale energy supply.

[146] Karimian, A. 2012. *80% of Jobs created since the Recession's End Have Gone to Men?* Economic Policy Institute. 18 July. Available at http://www.epi.org/blog/80-percent-jobs-created-recession-men [2013, April 11].

[147] Burton, J. 2011. *Renewable Energy jobs*. Report produced for the One Million Climate Jobs Campaign, November 2011. Available online at http://climatejobs.org.za

For this study, we have compared the number of jobs created for the IRP2010 policy-adjusted plan against our proposed Smart track electricity plan. We will also examine the possibilities of job creation in the energy conservation and efficiency sectors.

The Challenge

We can all agree that South African unemployment figures are a cause for concern. A 2010 Organisation for Economic & Cooperation development (OECD) report on South Africa showed that since 1997, the top 20% wage earners were the only ones to show growth, while the "real wages of the bottom 10% almost halved"[148]. According to Census 2011, 29-40% of South Africans of employable age are unemployed[149], with the majority under 35 years of age.

We have found that making the transition from an energy sector that is dependent on coal to one that capitalises on a diverse mix of renewable resources to meet its energy needs will have a positive impact on employment patterns in South Africa.

Whereas Coal-fired and Nuclear power plants are large, centrally located plants, RE power plants can be distributed all over the country, thereby providing a more distributed allocation of jobs. This means that **job creation in the RE industry is also likely to have broader impacts on migration patterns of job-seekers**.

Finally and most worryingly, the manner in which the current RE procurement programme has been run (through a tender process), while ostensibly forcing local content is unlikely to lead to a major RE industrial growth at this stage. This is because the current RE allocation in the IRP2010 is too low and local bidders are in fact often unable to compete with foreign bidders.

Government Policies such as the New Growth Path, Industrial Policy Action Plan and the National Development Plan have job creation as a key focus, as well as the stimulation of the economy through small businesses.

Several studies have highlighted that the manufacturing sector can produce the largest proportion of jobs when comparing across technologies. This knowledge, taken alongside our contention that RE projects can be beneficial for job creation in South Africa presents an opportunity to create an environment that more clearly favours RE manufacturing growth and which can then also lead to greater demand for RE.

Is local economic growth really supported by current RE policies?

The IRP2010 had in effect put a cap on RE uptake until 2017 – of 3 725 MW, not an environment that RE component manufacturers would be likely to invest in. It is therefore heartening to see that the Department of Energy has responded and the current South African renewables procurement programme is to be expanded by a further 3 200 MW up to 2020.

The benefits of localisation will only be felt if there is a sufficient demand for RE technologies.

According to SWH industry representatives, imported SWH components have been attracted into the market by the Eskom rebate programme and this has undermined growth of the local industry. One example is Solardome South Africa (a SWH company) established in 1969, which is now retrenching employees. The bids awarded have also not promoted gender equality.

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[148] Strauss, A., Doron Isaacs, D. 2012. Questioning the youth wage-subsidy logic. *Engineering News*. 22 June. Available at: http://www.engineeringnews.co.za/article/questioning-the-youth-wage-subsidy-logic-2012-06-22 [2013, April 11].

[149] Depending on whether one only takes into account those who are actively looking for work, or also include those who have given up on ever finding work.

In response to import impacts, manufacturers are asking for the rebate to only be offered to locally produced products[150]. An article in Engineering News of November 2012[151] reports that South Africa had lost out on $900 million in trade with sub-Saharan Africa because of increased Chinese SWH imports.

Part of the challenge of localising production and jobs is the tension between increasing local jobs which comes with higher prices, and the need to keep prices affordable. In response to this, the Department of Trade and Industry, together with WWF and SAPVIA (the Solar PV industry association) have commissioned a study to analyse the Solar PV industry in order to provide some recommendations on how to strengthen localisation of the industry. Preliminary findings indicate the importance of increasing the uptake rate in order to stimulate local manufacturing. **Even as little as 10% increase in demand would increase the number of jobs by 144 794**[152]**.**

The Department of Trade and Industry has also offered incentives for manufacturers who invest in RE component manufacturing. This is a great step in the right direction as it is can directly support development of a strong local industry. Such initiatives need to be scaled up to promote further local investment in manufacturing capacity.

Independent Power Producers who support localisation will try to source their materials from local manufacturers. However, it is possible that in the short term locally manufactured components may be more expensive than imported ones. If this is so, the IPP that commits to investing in RE generation that relies on local manufacturing plants or additional skills training for local employees, is unlikely to be able to produce electricity at a competitive rate (lower cost than those that bring in cheaper imported components), and therefore is less likely to be successful in the tender process; or will face financial losses later on.

We can therefore conclude that local economic growth is in fact not yet sufficiently supported by current RE policies. **However, if we were to include positive externalities in RE production, it would be seen that a decentralised multiple-scale energy system would do much to promote other social goals, such as entrepreneurship and the buffering of SMME's.** RE and energy efficiency offer many opportunities precisely because they are available at many scales, some which are more feasible for women and poor communities to access.

There are many international examples where this has been done successfully. Perhaps the most striking has been the Self-Employed Women's Association RE Project in rural Karnataka, Gujarat State, India, where women have financed one another through a micro-credit scheme to reach over 500 000 customers for RE[153].

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[150] Naidoo, B. 2011. Under pressure: SWHs taking strain. *Engineering News.* 25 November. Available at: http://www.engineeringnews.co.za/article/local-solar-water-heater-manufacturers-taking-strain-2011-11-11 [2013, April 11].

[151] Wait, M. 2012. Chinese imports not hurting SA, free market foundation asserts. *Engineering News*. 9 November. Available at: http://www.engineeringnews.co.za/article/china-imports-not-hurting-sa-free-market-foundation-asserts-2012-11-09 [2013, April 11].

[152] . South African Photovoltaic Industry Association, Department of Trade and Industry, World Wildlife Fund Localisation Strategy For PV Industry In SA:Preliminary Findings & Discussion Towards Proposed Strategy For Local Industry Development, 2013. Available at: http://www.sapvia.co.za/wp-content/uploads/2013/02/Localisation-strat-for-PV-in-SA.pdf

[153] SELCO-SEWA *Women As Partners*, Paper Presented at Energia conference *Bridging the Gender Gap For Development Effectiveness in the Energy Sector,* Amsterdam, 12-13 December, 2011. Available at http://www.energia.org/what-we-do/news/article/?txttnew%5Btt_news%5D=54&cHash=40a500f165122854c3bf5b4a3910f61e

How many jobs will Smart electricity planning create?

The IRP2010 contains a limited amount of RE and the inclusion of coal and nuclear could lead to some job creation. However, as we illustrate below, **many more jobs can be created with Smart electricity planning**.

In 2012, Burton produced a paper on climate jobs for South Africa and the potential of job creation if we addressed climate change using RE. In drawing up her report, she reviewed a number of employment studies[154] and this comprehensive employment review is not repeated here. Burton's climate jobs numbers are those used in this Smart energy planning jobs modelling exercise.

Job creation potential can be analysed in three ways[155]:

- Direct jobs - those jobs resulting directly from the RE project or installation, and include the entire production cycle from fuel production and component manufacture to waste management.
- Indirect jobs - those jobs that arise in addition to the direct jobs referred to above, and include services and inputs to the direct processes.
- Induced jobs - those jobs generated through the increased cash flow in the broader society that arises from the wages of those employed in direct and indirect jobs.

The employment estimates we put forward illustrate how many direct jobs[156] could be created with Smart electricity planning that includes more RE.

The details of the potential RE supply and electricity demand scenarios have been discussed in the Demand and Supply chapters of this report.

Energy efficiency and SWH jobs can be implemented relatively quickly and if we plan such interventions for the near future, then these jobs become spaces for learning and reskilling workers while also growing the RE manufacturing sector.

Measuring jobs potential

In 2003, Agama Energy produced a comprehensive study on the job potential for RE in South Africa. This is the most recent comprehensive local study available at this time, and in order to ensure that our RE implementation programme can unfold effectively, there is a clear need to undertake an independent study that can verify and update data related to jobs potential for RE and which can inform relevant economic development policy choices.

According to the International Labour Organisation (ILO) a decent job "involves opportunities for work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organise and participate in the decisions that affect their lives and equality of opportunity and treatment for all" (women and men)[157]. The jobs we have identified would fall into this definition.

In trying to determine the number of jobs that would be created with Smart energy planning, we decided to take a conservative approach, rather than appear to be putting forward unrealistic estimates.

[154] TIPS, Rutowitz, Agama Energy, 2006.
[155] Agama Energy. 2003. *Employment Potential of Renewable Energy in South Africa*. Earthlife & WWF. Available at: http://www.greentalent.co.za/wp-content/uploads/2011/04/Agama-Report_-EPRESA-Final-Nov-2003.pdf [2013, April 11].
[156] Our estimates are therefore conservative.
[157] http://www.fao-ilo.org/fileadmin/user_upload/fao_ilo/pdf/FAQs/Definitions__2_.pdf

Construction jobs are temporary, and cannot be regarded as sustainable jobs. See **Table 10** below for the difference between jobs estimates including and excluding construction. We have therefore excluded them from our detailed calculations. However, we have included an additional scenario including construction jobs for completeness. As in the short term, the benefits of such employment on locally unemployed communities would be significant for those communities.

Preferred Bidders
Job creation per Province

Description	Jobs during construction period	Jobs during operations period
	BW2	BW2
Eastern Cape Province	1 026	64
Free State Province	140	32
Limpopo Province	0	0
Northern Cape Province	4 709	151
North-West Province	0	0
Western Cape Province	1 184	81
TOTAL	**7 059**	**328**

25

Table 10: Short term construction jobs inflate job creation potential.

It is possible that construction jobs could be permanent jobs if we have a growing RE sector which is building a fixed amount of RE generation plants every year.

In that case we would have construction firms with permanent employees who would be reliably involved in the building trade. However this would be very different to what we have at present where **each building project appears to rely on a number of unskilled labourers drawn from the local community where the project is to be built**.

For example, because power pylons have been declared designated products, a certain level of localisation is now required and the plan to upgrade the power pylons for the transmission infrastructure would now create 1 500 jobs, including maintenance jobs. It was also claimed that power lines have a powerful multiplier effect where 1 000 direct jobs create 2 600 indirect full time decent jobs through supplies of materials, clothing, food etc.[158]. We have included indirect jobs figures for illustrative purposes only, see below.

Methodologies for measuring jobs potential

Different authors calculate the jobs per unit of energy differently. This difficulty in calculating actual numbers of jobs has been raised in several studies. One method is to use a unit of a job-year. Using this method, if a widget making factory employs 10 people for 1 year or 5 people for 2 years or 1 person for 10 years, the widget making industry would be regarded as having created 10 job years.

As we are aiming to create long term sustainable decent jobs, we have regarded a decent job as being a post that lasts for at least 10 years.

[158] SAISC. 2011. SAISC's Successful Efforts to have Power Pylons Designated will create more than1500 new Jobs. *Southern African Institute of Steel Construction.* Available at: http://saisc.co.za/saisc/news_events_newsDetail.php?25-34 [2013, April 11].

Agama Energy commented in their 2003 study that there are a number of different ways to identify and calculate jobs, some relying on an input/output macro-economic approach, some using a job per unit of energy and multiplying by the predicted amount of energy, and yet others focusing on the specific labour requirements for different installations. Agama used a combination of the second and third approach and for this study we have adopted a similar approach, given that this is a desktop modelling study, rather than based on gathering empirical evidence from the factory floor.

We quote Agama to illustrate this point: "*Direct employment figures have been presented in the literature in two different ways. Some studies refer to the number of job-years for a particular RE technology (RET), meaning that if a particular aspect of the technology requires four people for 1 year, then four job-years are required. Other studies simply refer to the number of employees, or jobs, for a particular RET.*

Whichever approach is taken, one is limited to the data that already exists as a basis from which to work. There is also uncertainty as to whether some studies, while referring to 'jobs', are not actually describing 'job-years', or whether the percentage breakdowns refers to the share of job-years rather than the share of jobs in a given year.

Since the majority of reviewed data expresses employment as the more simple 'jobs', this study shall thus also refer simply to jobs throughout, while explicitly implying a number of people employed in a given year."[159]

As has been stated, this study has relied on the findings of the Climate Jobs study (Burton 2011/2012), as she has covered much of the same ground.

Reducing Energy demand <u>and</u> creating jobs:

While seeking to create jobs, there are a number of potential demand-side interventions we could enable as well.

The installation of SWHs, ceilings and ceiling insulation, the replacement of energy-wasting light bulbs with more efficient ones, and major (but simple) industrial retrofitting exercises that will create jobs while saving energy are great examples of such interventions. Interventions such as these are good for the economy, because they save people money but result in a service of the same, or even better, quality. Again, such jobs, because of the level of scale, particularly lend themselves to the encouragement of SMME's.

For this study it was not possible to accurately determine the details of how many additional jobs would be created in implementing energy efficiency interventions, but for our Smart electricity planning projections**, using a figure of 0.5 jobs/GWh saved[160], over the 20 year period, we conservatively estimate** a further 25 000 job-years[161] or about 2 500 jobs for ten years each.

In our supply-side modelling, we have created the Smart track electricity plan that assumes a16% efficiency improvement over the next 20 years, and replaces all the projected nuclear and most of the new fossil generation post-Kusile.

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[159] Agama Energy 2003. *Op cit.*

[160] This is based on research carried out in developing countries by Jose Goldemberg, quoted in Wei et al (2010) "Putting renewables and energy efficiency to work: how many jobs can the clean energy industry generate in the US?" in *Energy Policy*, 38, pp919-931.

[161] Calculated from the 11 434 MW savings for each year in the Demand chapter and using SNAPP's system availability per year, to give us the GWhs saved per year (multiplied by 0.5 for job creation).

Solar Water Heaters

Although earlier estimates of SWH job creation were in the order of 20-22 jobs/MW[162], Du Toit (2010) showed that SWH job creation was much lower particularly when focused on systems for low income households.

Elsewhere in this report, as part of our Smart plan, we make the case for urgent provision of SWHs to two million households. The majority of households that need a SWH from an affordability perspective are low income. We have therefore opted to use the Du Toit figures to calculate job creation potential.

	Geyser manufacturing	**Panel manufacturing**	**Installation**	**Office support**	**Total**
Average number of jobs created	4.130	4.997	2.323	0.696	12.146
% Percent contribution	34	41.16	19.1	5.73	100

Table 11: Direct jobs created through a rollout of 1000 SWH systems (DuToit, 2010, page 167)[163]

If two million SWHs were installed, our modelling reveals that the number of job years would be 24 300. **If we accept a ten year period as constituting a permanent job, then we could create 2 430 jobs for ten years**. This would be based on 100% local production. **If the systems were all imported, then the number of jobs would be less than half of 2 430.**

If all the systems were to be produced in South Africa, these factories could also be distributed throughout the country. Once a factory was set up, we estimate that the job creation potential would amount to 12 jobs per 1 000 geysers per year. We have assumed that – with sufficient political will – 400 000 SWHs could be produced each year from 2014 to 2019. If production was slower in the earlier years, fewer jobs would be created initially but this could be increased as the production rate was increased.

According to the DoE, 370 000 SWHs have been installed due to the Eskom Demand-side Management programme to date.

If these geysers were to be replaced with high pressure SWHs (installation jobs are slightly higher than for low pressure systems) an additional 280 jobs with a lifespan of ten years could be created.

Energy Efficiency

One example put forward elsewhere in this report as a simple but Smart approach is to ensure that all houses are at least fitted with ceilings. The installation of ceilings insulates the house, keeping it warmer in winter and cooler in summer. This reduces the amount of energy needed to maintain a comfortable temperature for inhabitants. Such retrofitting programmes can also create jobs.

[162] Agama and Rutovitz, 2006.
[163] McDaid, E. 2011. *Developmental impacts of Cape Town's Energy and Climate Action Plan.* Sustainable Energy Africa/ City of Cape Town.

Jobs potential from various Renewable technologies

The available quantities and characteristics of the various categories of RE are detailed in the Supply chapter of this report. Here, we share some insights into the job creation potential of some of the different RE technologies that form part of the REIPPPP.

Solar PV

Over the last few years, the cost of Solar PV has dropped dramatically, making it a much more attractive technology for both rooftop and for large installations. The final IRP2010 contains 8 400 MW of Solar PV, with 631.53 MW having been included in the REIPPPP. This has begun to encourage local Solar PV investment e.g. one new large scale solar inverter factory has opened in Cape Town with the capacity to produce 200 MW of inverters a year[164].

Agama's numbers are relied upon for this study.

Comparison with Agama figures	Operation and maintenance Jobs/MW	Installation Jobs/MW	Manufacturing Jobs/MW
Agama	2.5	12.1	18.8

Table 12: Estimated number of new job per MW – Solar PV

Along the value chain, **manufacturing comprises 6% of the total value but creates 30% of the jobs**. A recent analysis by Mulcahey[165] suggests that there are approximately **30 jobs per MW** possible with a third of those to be found in manufacturing.

Solar CSP

Large scale centralised Concentrated Solar Power generation plants have been proposed as a possible solution to the 'base load' challenge posed by electricity planners accustomed to large base load plants, because the technology has the capacity for storage. However, the levelised cost of energy (LCOE) for CSP plants is high compared to other RE technologies. Agama's jobs/MW numbers are relied upon for this study.

It is **likely that there will be more Solar PV jobs created in the next few years with solar CSP plants creating jobs in the longer term, once CSP technology comes into its own**.

	Operation and maintenance Jobs/MW	Installation Jobs/MW	Manufacturing Jobs/MW
Agama 2003	0.2	4	1.7

Table 13: Estimated number of job per MW – solar CSP

Wind

A study conducted for the South African Wind Energy Centre in the Western Cape looked at the overall number of new jobs created in the implementation of the 9 200 MW of wind in the IRP2010. These are projected to be 11 563[166].

[164] Engineering News. 2012. Utility scale solar inverter factory opens in Cape Town, *Engineering News*. 5 October. Available at: http://www.engineeringnews.co.za/article/sas-first-utility-scale-solar-inverter-factory-opens-2012-09-21 [2013, April 11].
[165] Mulcahey 2012, Masters' Thesis, University of Cape Town.
[166] SAWEC. 2011. Report includes O&M, R&D, construction, manufacturing, and consulting (assumed to be job years by 2030) pges 63/131. *Options for the Establishment of a*

While this is encouraging, in order to be consistent in job calculations, we have opted to rely on the Agama study here.

Operation and maintenance Jobs/MW	Installation Jobs/MW	Manufacturing Jobs/MW
1	0.5	3.2

Table 14: Estimated number of job-years per MW - wind[167]

Given all these estimates, the following (decent, long term) jobs potential per MW installed[168] were assumed for this study[169]:

Supply choice	Jobs per MW installed capacity
Coal	3
Existing coal Small	3
OCGT liquid fuels	1.2
PWR nuclear	0.5
Hydro	0.94
Landfill gas	6
Biomass	1
Supercritical coal	3
Wind (29% availability)	3.27
Solar CSP	5.9
Solar PV[170]	30
OCGT natural gas	1.2
CCGT	1.2
Fluidised Bed Combustion Coal	1.7
CCGT gas imported	1.2
IGCC	1.2
Pumped storage	0.94

Table 15: Jobs per MW for different supply technologies

The graph below – generated by SNAPP - provides an indication of the job creation potential of the policy adjusted IRP2010 compared to the Smart track Electricity Supply Plan.

South African Wind Energy Centre (SAWEC). GIZ. Available at: http://crses.sun.ac.za/files/research/publications/technical-reports/SAWEC-Report-final%20draft-06-2011.pdf [2013, April 11].

167 Agama 2003. *Op cit.*

168 These are total job ratios including manufacturing, installation, operations and maintenance but excluding construction.

169 Agama 2003 page 11. *Op cit.*

170 Mulcahey 2012, University of Cape Town.

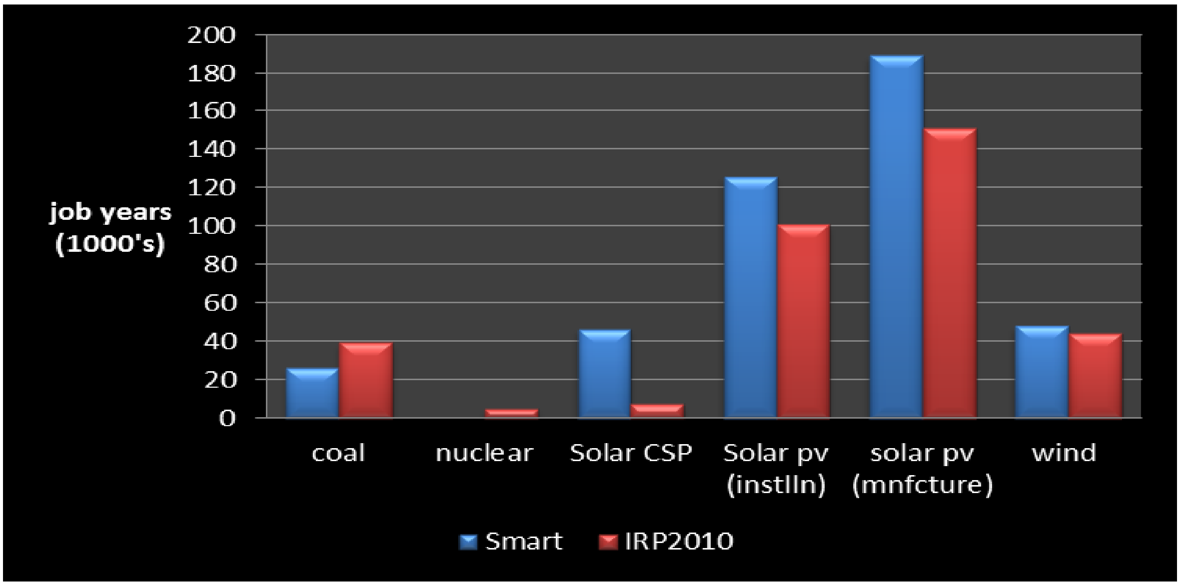

Figure 16: Comparison of the job years created through implementing the Smart track electricity plan compared to the IRP2010.

For many of these technologies, more jobs are created in manufacturing local components, compared to when parts are imported.

Figure 17 below shows **the jobs that can be created** if South Africa is able to maximise manufacturing jobs in the electricity sector.

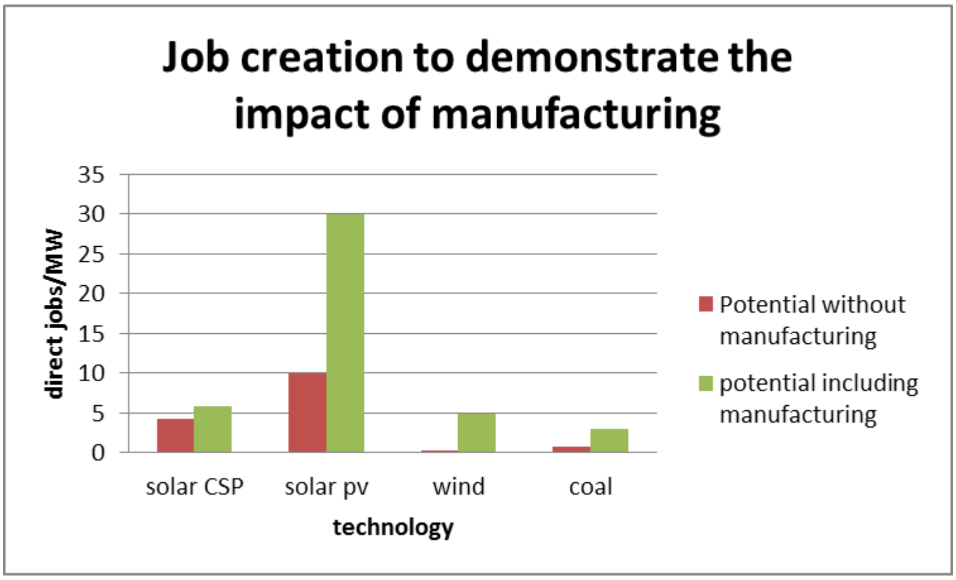

Figure 17: Manufacturing jobs potential (excluding construction).

Construction jobs have not been included above, but the graph below[171] illustrates the job creation potential with the REIPPPP initiated by DoE, and includes construction jobs.

[171] WWF Saliem Fakir presented at AIDC Energy seminar, 2012.

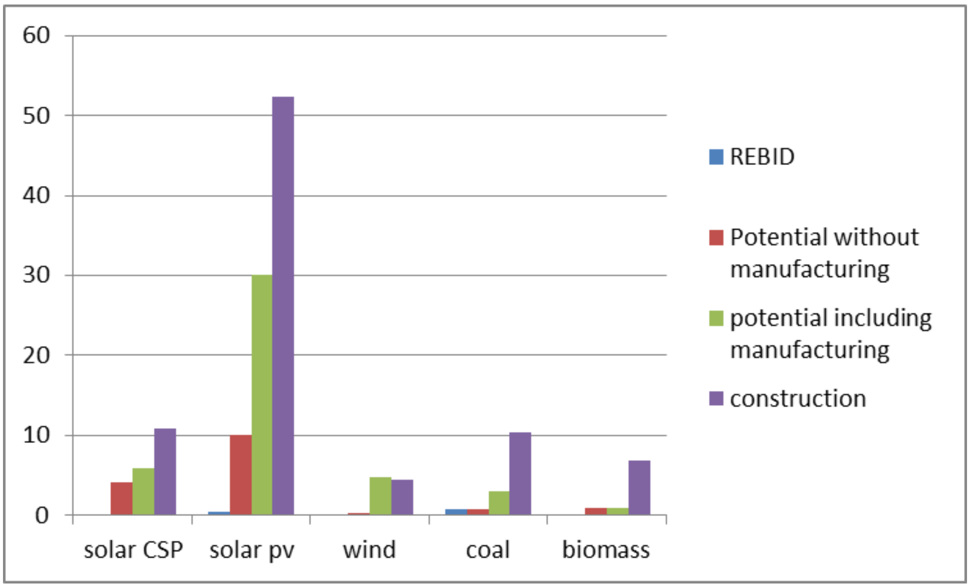

Figure 18: Manufacturing jobs potential (including construction).

As has been discussed earlier in this chapter, there are a variety of ways in which to measure the number of jobs and standardisation appears to be lacking.

According to Burton, a multiplier of 3 could be used to provide an estimation of the associated indirect jobs that could be created[172]. If we apply this to the Smart track Electricity Plan, the total number of job years would increase to approximately 1 320 000 job-years[173].

Powering up to take advantage of global trends

With the increasing use of Solar PV in the renewable sector, we are likely to see an increasing need for Solar PV manufacturing in South Africa.

The number of job-years created in the IRP2010 is potentially 360 000 until 2030. However, our Smart track electricity plan which includes efficiency jobs and the installation of SWHs is calculated to create about 530 000 job-years.

Some of our coal-fired power stations would reach the end of their useful lives after 2025, and workers would need to be deployed elsewhere. An additional consideration would be the need for workers to retain their jobs to decommission the coal power station but this has not been included in any of our modelling at this time, as a comprehensive transition plan would be needed for each power station.

Figure 21 below provides a comparison between the potential direct total job years that could be created using the Smart track plan of RE and energy efficiency, as against the IRP2010.

[172] This multiplier is based on the research in Agama (2003). The Department of Trade & Industry's Industrial Policy Action Plan includes sectoral multipliers for various manufacturing industries (but not renewable energy), and comparatively, a multiplier of three is considered conservative.
[173] 1 320 000 job years is equivalent to 132 000 people having a permanent job for ten years.

Figure 21: Job creation potential of Smart track plan compared to IRP2010.

Training and skills development

South Africa's skills shortage challenge is starkly highlighted in the job creation potential statistics provided in the first RE project implementation plan. Approximately 13 000 Construction jobs are to be created and 10 000 Operations jobs. Of the 13 000 Construction jobs, 10 000 will be earmarked for South Africans. Of the 10 000 Operations jobs that will be created only **463** are earmarked for South Africans[174].

Back in 2003, the Agama energy study emphasised the need for significant skills development to meet the future employment needs of a RE implementation plan. RE generation plants are now being built, and although there are a number of training initiatives underway, much more is needed. According to Engineering News (April 2012), the welding skills at Eskom's current power plants are not up to standard and Eskom has to import foreign welders to address this shortcoming[175].

South African Wind Energy Centre SAWEC[176] highlights the lack of skills in the engineering sector. For example, a 2010 study found that South Africa is short 17 000 engineers and technicians. The Engineering Council of South Africa said that in Germany there is one engineer for every 200 people, while in Japan, the ratio is 1:310. **In South Africa we only have one engineer for every 3 100 people**[177].

Although Eskom's Academy of Learning currently takes in 6 400 learners each year, it plans to train an additional 5 000 learners per annum through its 24 training centres and 244 on-the-job training sites[178].

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174 Dept of Energy, Facts sheet Window one REIPP Economic Development benefit, 05 November 2012.
175 Engineering news April 6 to 12th, 2012 – skills partnership – new energy training centre opens at Vaal University.
176 SAWEC. 2011. Options for the establishment of a wind energy centre. *South African Wind Energy Centre SAWEC. Op cit.*
177 ECSA quoted in Education, training not meeting demand. Moodley, S. 2012. *Engineering News* 27 July 27. Available at: http://www.engineeringnews.co.za/article/education-training-initiatives-not-meeting-engineering-demand-2012-07-27 [2013, April 11].
178 Odendaal, N. 2012. New Eskom school aims to train over 700 welders in seven years. *Engineering News.* 13 April. Available at: http://www.engineeringnews.co.za/article/eskom-launches-welding-school-as-gigaba-commits-soes-to-training-2012-04-13 [2013, April 11].

One forward-thinking step is Eskom's establishment of a welding school that aims to train up 700 welders. Eskom has established this school, the Welding school of excellence, as part of preparing for the new-build programme. In addition, the French government, the Vaal University of Technology and the private sector partner Schneider Electric South Africa, have established a centre to train artisans, technicians in fields of energy, electricity and the maintenance of automated systems[179].

At a community level, we have several examples of where the recipients of SWH home systems have also received training in maintenance.

Incentives to encourage skilling up apprentices

In the Western Cape, for the SWH industry, it has been suggested that, in the short term, scaling up can take place through employment of extra staff and increasing the running time of the factories through shift work[180].

A formal telephone interview with Robin Thomson (SESSA) revealed that there is a shortage of plumbers for large scale roll-out and that a training system that enables plumber assistants to qualify as plumbers would be one way of increasing the pool of plumbers that would have experience. However, there is no incentive for existing plumbers to skill up their assistants – higher qualifications mean the need to pay higher wages and assistants then become potential competitors – additional qualified plumbers competing for work[181].

However, such problems can be overcome through the creation of the appropriate policy environment. A great benefit of decentralised RE is that it offers work much closer to the existing skills base than do both coal and nuclear. An example would be the Rwandan biogas programme, where women are trained to be entrepreneurs supplying biogas digesters within a matter of a year[182].

> "We must confront our challenges boldly, and with hope."
>
> – Pravin Gordhan, SA Minister of Finance, 2013 Budget speech

Conclusion

Unemployment levels in South Africa are extremely high and our energy sector is coal-dependent. While the coal industry traditionally employed large numbers of people, it is common knowledge that this number has declined significantly over time.[183]

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[179] Wait, M. 2012.. 2012. New energy training centre opens at Vaal University of Technology. *Engineering News*. 6 April. Available at: http://www.engineeringnews.co.za/article/vaal-university-of-technology-launches-new-training-centre-2012-04-06 [2013, April 11].

[180] Du Toit, J. 2010. *A value chain analysis of the solar water heater industry in the Western Cape: Investigating opportunities for local economic development, poverty alleviation and energy conservation* (MSc thesis Dec 2010, Univ. Stellenbosch).

[181] McDaid, E. 2011. Developmental Impacts of Cape Town's Energy and Climate Change Plan, prepared for Sustainable Energy Africa & City of Cape Town.

[182] SNV *Domestic Biogas Newsletter,* No 6, March 2012, pp.4, available at http://www.snvworld.org/sites/www.snvworld.org/files/publications/snv_domestic_biogas_newsletter_-_issue_6_-_march_2012.pdf [2013, April, 11].

[183] World Watch Institute. n.d. World Watch Institute Coal Industry Hands Out Pink Slips While Green Collar Jobs Take Off. World Watch Institute. Available at http://www.worldwatch.org/node/5824 [2013, April 11].

We have found that making the transition from an energy sector that is dependent on coal to one that optimally draws on a diverse mix of renewable sources to meet its energy needs can and will have a positive impact on employment patterns in South Africa.

The manufacturing sector can produce the largest proportion of jobs when comparing across technologies; providing an opportunity to create jobs through the stimulation of a RE manufacturing industry. The current RE allocation in the IRP2010 and the procurement processes are too low to drive such stimulation.

Currently, local manufacturing has been (and will continue to be) undercut by foreign imports. Since most job creation potential lies in manufacturing, incentives need to be focused on the development of local industry through standards, financial incentives, fiscal incentives such as tax breaks, and bylaws.

The number of job-years created in the IRP2010 is potentially 360 000 until 2030. However, our Smart track electricity plan which includes efficiency jobs and the installation of SWHs is calculated to create about 530 000 job years. An energy services plan based on RE and energy efficiency can create not only significantly more jobs than a fossil fuel-based system, but will likely create jobs in marginalised and diverse geographic regions, contributing to rural economies and livelihoods.

Employment tenure contributes significantly to a personal sense of decent work and dignity. The SMART track electricity scenario could potentially create 1 320 000 job years – the equivalent to 132 000 people having a permanent job for ten years.

South Africa has a shortage of 17 000 engineers – having only 1 engineer for every 3100 people. For South Africa to be able to fully reap the rewards of a RE growth sector, significant investment in skills development and training is needed. We also need to encourage the technologies which are most appropriate to the levels of skill existing amongst women and poor communities, since the positive externalities will far outweigh potential cost differentials.

The Institutional framework for Smart electricity planning

Authors: Liz McDaid and Dr Yvette Abrahams

Contributors: Robert Fischer, Jesse Burton

"Accountability is the hallmark of modern democratic governance. Democracy remains clichéd if those in power cannot be held accountable in public for their acts or omissions, for their decisions, their expenditure or policies" [184]

There are many challenges to good governance in the Energy sector

All over the world, governments and their citizens are faced with the challenges of providing access to clean reliable and affordable electricity, and dealing with major environmental challenges. Governments everywhere face a common significant challenge in managing public good while dealing with powerful interest groups.

In South Africa, while we have many outstanding policies in place, a very active civil society sector and parliamentary processes which are increasingly illustrating a commitment to public participation, there are still a number of shortcomings in both the policy and regulatory aspects of Energy planning.

These shortcomings include[185]:

- There is limited opportunity for the public to make meaningful inputs into policy-making, despite professed commitment to such requirements. There is also some doubt whether these opportunities are used meaningfully within the ambit of the law. For instance, since energy concerns every one of South Africa's people, it is doubtful whether the 479 submissions received under the Integrated Resource Plan 2010 process would be considered 'sufficient' public participation[186]. Recently the Supreme Court of Appeal found that Promotion Of Administrative Justice Act 6(2)(e)(iii) required that the name change of Louis Trichardt to Makhado be reviewed and set aside, on the grounds that an insufficient proportion of interested and affected parties had been consulted. In this case, less than 1.5% of the town's population had participated in the consultation process. This gives some perspective on what the law would consider sufficient public consultation[187].
- There is evidence of an historical adversarial and non-cooperative relationship between elements of the executive and other government agencies. An example of this would again be the IRP2010 process, where a large number of the comments received from civil society were not taken into account. Similarly, the grounds on which the National Electricity Regulator makes decisions are often opaque and unclear to the general public.

[184] Extract from: "oversight and Accountability model – asserting parliament's oversight role in enhancing democracy" Page 16, published by Parliament of SA – undated.
[185] EGI-SA. 2010. *The governance of power – shedding a light on the electricity sector in South Africa*, Cape Town: IDASA. Available at: http://electricitygovernance.wri.org/publications/governance-power-shedding-light-electricity-sector-south-africa [2013, April, 11].
[186] Department of Energy. 2010. *Integrated Resource Plan for Electricity 2010-2030 Revision 2, final Report.* Pretoria: Department of Energy. p. 10. Available at: http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf [2013, April 11].
[187] The Chairperson's Association v Minister of Arts and Culture (2007) SCA 44 (RSA).

There is a lack of clarity and organisational certainty that has weakened government capacity and functioning, rendering policy processes vulnerable to external influences of powerful groups outside government.

An excellent example is the recent Multi-Year Price Determination (MYPD3) process, where Eskom has argued that:

> "Eskom supports the need for integration at a policy level. Eskom's application is made in line with policy in the electricity sector. A decision cannot be delayed until all the policy matters are resolved. Interventions required to protect specific sectors is the responsibility of government."[188]

Eskom then went on to list six policy issues on which it required urgent clarity. If our national utility monopoly is dissatisfied with the level of policy cohesion, how much more unhappy must the community of electricity users be?

Systems of governance depend fundamentally on their conceptual understandings of democracy and empowerment. **We cannot solve that which we cannot see.** If our conceptual framework fails to grasp reality adequately, we can develop no useful program of action. Therefore it is important that the reality of the poor, women, and the other disadvantaged groups who form the majority of the population is given full play in the development of a conceptual framework through statutory means of consultation. Our national utility is formally owned by the South African people and therefore should serve the interests of the South African people. These interests cannot be defined by a small part of the population. A useful approach to developing such a conceptual framework is through an analysis of elite capture.

'Elite capture' has been defined as follows:

> "Elite capture is a phenomenon where resources transferred for the benefit of the masses are usurped by a few, usually politically and /or economically powerful groups, at the expense of the less economically and/or politically influential groups. "[189]

As will be seen in the section below, this approach is a good description of the situation with respect to electricity production and consumption in South Africa. The following examples have been offered as signals that elite capture is present in a political process:

- **Controlling ideology** – the way we see the world is shaped by ideological messages. When ideology strays away from basic democratic and human rights values it can become a powerful tool for suppression and domination.
- **Shaping the political agenda** – powerful people can define which rights or issues are priorities for public debate and policy decision-making, and which are not. They can also control the production of and access to information to give credibility to some issues and not others.
- **Determining whose voice is heard in decision making arenas** – deciding who is able to participate, influence, shape and implement public policies by privileging certain groups and excluding others.
- **Framing formal decision-making and implementation processes** – powerful

[188] Eskom. 2013. *NERSA Public Hearing: Concluding Remarks, MYPD3*. Gauteng, January 2013, pp. 10. Available at http://www.eskom.co.za/content/MYPDclosingremarks1Feb0800.pdf [2013, April 11].
[189] Dutta, D. 2009. Elite Capture and Corruption: Concepts and Definitions. *National Council Of Applied Economic Research*, India. p.3. Available at http://www.ruralgov-ncaer.org/images/product/doc/3_1345011280_EliteCaptureandCorruption1.pdf

people can organise governance structures and mechanisms that regulate policy implementation so that they benefit some members of society and not others[190].

As such, the proposition that electricity governance processes need to observe statutory provisions is not a minor issue, since in their absence ideology can become divorced from economic necessities. For instance, the idea that electricity supply must primarily serve large industrial energy-intensive users, with typically low job-creation capacity and minor knock-on effects in the local economy, is an ideological concept which does not necessarily serve the interests of South Africa's people.

It is the nature of the process which has given this idea such currency, rather than empirical data regarding economic development. That the political agenda with respect to political planning is over-determined by interests related to coal is not a secret. Thus Eskom awarded a R40 billion contract for boilers at the Medupi and Kusile power stations to Hitachi Power Africa, in which Chancellor House (the business arm of the ANC) has a 25% shareholding.

Similarly, Eskom awarded a R2 billion contract for materials-handling at the new Kusile power station to engineering company Bateman Africa in which Chancellor House has a 10% stake[191]. This is clearly a conflict of interest, since Eskom reports to the Department of Public Enterprises which is managed by the ANC. It demonstrates the extent to which a political elite has managed to capture decision-making processes around electricity supply.

The recent public consultation processes (IRP2010 and MYPD 2 and 3), though much improved, still leave a lot to be desired in terms of opening up the process to the broader community, who in a technical sense are the owners of Eskom.

Technical documents and calls for submissions need to go beyond the small proportion of South Africans who are English speaking and have access to the internet. They should be published in the indigenous languages as guaranteed in the 1996 Constitution.

Information workshops should also be held to accommodate the 12% of adults who are illiterate, but whose right to shape the conceptual underpinnings of electricity policy making are undoubted[192]. It should be noted that female literacy rates are consistently lower than male, while adult females have the lowest literacy rates of the entire population, so inertia in this respect discrimination on the grounds of both gender and age.

The process of decision making, when constructed in such a way that it simultaneously determines whose voice is heard and whose is not, is a classic case of elite capture.

Similarly, public participation should not be limited to simply being consulted on specific issues. Such an approach assumes that people have the capacity to participate, in the sense that they have access to documents, the ability to formulate submissions, and the resources to attend public hearings.

However, to the extent that communities have been able to participate in recent processes it is because NGO's have assisted them to participate, and as such we have an excellent grip on the kind of resources needed to bring people into the process.

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[190] Action Aid International Governance Team Power 2012. Elite Capture and Hidden Influence. *Action Aid.* p. 8. Available at: http://www.actionaidusa.org/sites/files/actionaid/final_power_double_page_spread_march_2012.pdf [2013, April 11].

[191] Vicki Robinson, V., Brǘmmer, S. 2006. *SA Democracy Incorporated: Corporate Fronts and Political Party Funding.* Cape Town: Institute For Security Studies. Available at: http://mercury.ethz.ch/serviceengine/Files/ISN/98914/ipublicationdocument_singledocument/b9b5374a-d409-47fa-93f9-d72a905f22de/en/PAPER129.pdf [2013, April 11].

[192] Figures for 2007 available at http://www.indexmundi.com/facts/south-africa/literacy-rate

Yet, public participation also means that people should be able to determine the overall aims and objectives of policy, as well as the mechanisms through which we analyse and measure those objectives. Questions need to be raised about how electricity planning and supply can be used to empower people in this respect. Until this is done, the powerful – in government and civil society – are going to have a disproportionate influence on the process.
In 2010, EGI-SA published a governance analysis of the electricity sector in South Africa[193] which revealed a number of shortcomings in both the policy and regulatory aspects, some of which continue to plague the sector today. These are summarised below.

Policy recommendations

Policy design and implementation can be greatly improved by increasing public participation and transparency, as these are the cornerstones of good governance.

There is an urgent need to open up processes for:

- Clarifying energy policy for electricity provision and associated planning roles and responsibilities, through an inclusive national discussion in order to agree on a common vision. The Integrated Energy Plan (IEP) is the mechanism through which this should happen. It is important that the IEP be developed in full cognisance of the danger of elite capture, and with measures designed to address this. The current uncertainty around future energy planning increases risk and discourages investors, which in the long run will negatively affect economic development.
- The internal design, resourcing and staffing of the Department of Energy (DOE) and the Department of Public Enterprises (DPE) to reflect this vision. The Performance Management Appraisals of the Ministers and Heads of Departments should be made publicly available. All vacant posts in the DOE should be filled. In order to ensure that priority focus areas, such as RE, receive adequate attention, it is vital that the head of the RE sub-department is appointed. For example: The filling of the nuclear department head before the appointment of the RE department head[194] raises the perception that government places a higher priority on nuclear energy than renewables.

On the regulatory side, the following findings were made:

- There is uncertainty regarding the role of the regulator, NERSA, and shifting responsibilities, opaque appointment procedures and no apparent system of performance management of regulators only make matters worse.
- Limited capacity has undermined NERSA's authority and its capacity particularly in the areas of social and environmental mandate, the inclusion of weaker groups in decision-making, and monitoring and enforcement of license conditions.
- In its interpretation of the Public Access to Information Act (PAIA), NERSA does not seem to have met its responsibility to capture data and make it available in digestible format according to the law. For example, it uncritically allowed Eskom to assert confidentiality exceptions on the basis of 'commercial confidentiality'.
- NERSA decision-making processes are generally transparent, although limited capacity prevents it extending to use multiple modes of dissemination. Thus, though NERSA's processes maybe visible to the specialist, the public is still in the dark as to how key decisions get made.
- NERSA's capacity to impose challenging and creative licence conditions is severely constrained.

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[193] EGI-SA. 2010. *The governance of power – shedding a light on the electricity sector in South Africa*, Cape Town: IDASA. Available at: http://electricitygovernance.wri.org/publications/governance-power-shedding-light-electricity-sector-south-africa [2013, April, 11].
[194] DOE (pers comm) Energy Caucus in Gauteng 30th, 31st October, 2012

Policy design and implementation: the cornerstones of good governance

In 2011-2012, after the finalisation of the EGI-SA report mentioned above, EGI-SA participated in the public engagement around the formulation of the IRP2010. Shortly thereafter EGI-SA also undertook a detailed analysis of the RE procurement process using an analytical framework tool developed by EGI partners internationally, and found that many of these same weaknesses remained. One of the findings of the report included the finding that the REIPPPP process was opaque. No information was forthcoming from the Department of Energy on the extent to which laws, policy and Treasury regulations regarding procurement were followed. The development of the REIPPPP showed once again a lack of transparency on the part of the DoE, and as the REIPPPP was carried out while NERSA was in process of reviewing its REFIT programme. This indicated, at the very least, a lack of intra-government cooperation, or perhaps a lack of power on the part of NERSA.

Moreover, REIPPPP violated the most basic tenets of governance. **The abandonment of REFIT and the introduction of REIPPPP took place without any public consultation, access to information or transparent decision-making.** There was no consultation with civil society regarding the decision to use a tendering process, nor on how the price would be determined, or on any of the criteria used to select successful bidders. The Department of Energy was reluctant to release any details of the tender documents, and in the end did so only under a Promotion of Access to Information Act (PAIA) request, and upon payment of a hefty fee[195]. Reflecting on the findings of the EGI-SA energy governance analysis from 2009/2010, on the policy side, unfortunately, many of the conclusions remain true for the Department of Energy.

The initiation of the Integrated Energy Plan review and the review of the IRP both planned for 2012 and now delayed into 2013 provide an opportunity for critical public engagement. However, DOE's approach toward public engagement for the IEP (one public workshop held in March 2012 and thereafter no further engagement) has failed to build public trust.

The engagement process was limited to inviting stakeholders to Pretoria – at their own cost. These actions ignore the lack of capacity of the poor and marginalised to participate in these debates and ultimately undermine the building of trust in the process.

From the regulatory point of view, the proposed legislative amendments to NERSA appear to weaken the authority of the regulator, and do little to address the confusing roles and responsibilities. NERSA's application of its environmental mandate remains unclear.

However, there have been some changes:

- In processing the REIPPPP license applications, NERSA held public hearings in each of the provinces within which IPPs were to be located, thereby making it possible for a greater range of stakeholders to attend, and become informed about the process. It also provided recorded proceedings of those hearings on request.
- In its reporting to parliament, NERSA has indicated that it has initiated a process of investigating electricity trading and reselling, as well as having commissioned a study on the impact of Inclining block tariffs on the poor, thereby indicating it is taking its social responsibilities seriously.
- This year, Parliament's portfolio committee on energy has used its oversight role and held a number of stakeholder meetings which it presides over but which allow different stakeholders to engage each other on energy-related issues; particularly those of the challenges facing RE.
- Parliament's role in monitoring the Executive's progress in achieving its goal was illustrated through the Budgetary Review and Recommendation (BRR) process which

[195] EGI-SA report on Policy Assessment Framework: Entry of Renewable Energy Generators into the National Grid, EGI-SA, 2012.

takes place during October. In the 2012 BRR process, state institutions reported progress on their specific objectives/outcomes within a broader mandate of national goals. This was linked with the performance agreement of Minister Dipuo Peters, which is linked to her contribution towards the achievement of 12 national outcomes.

Both DOE and NERSA's strategic objectives are linked to the following national outcomes:

- a long and healthy life for all South Africans
- decent employment through inclusive economic growth
- an efficient, competitive and responsive economic infrastructure network
- sustainable human settlements and improved quality of household life
- environmental assets and natural resources that are well protected and continually enhanced
- an efficient, effective and development orientated public service and an empowered, fair and inclusive citizenship.

In NERSA's report[196], it appears to have performed well, completing its role in the REIPPPP of approving licenses competently and ahead of schedule; "all 28 licenses were granted in April 2012 within 90 days after receipt of applications (thirty days less than statutory deadlines)". It also received an unqualified audit report from the Auditor General.

For the Department of Energy, although the Auditor General found that the financial statements were generally acceptable, it is of some concern that the Auditor General also states "The department in conjunction with the Special Investigation unit are in the process of investigating allegations that state employees are involved in the procurement processes"[197].

Governance for a smarter energy future

The Oversight and Accountability model handbook of the South African parliament provides detailed guidelines of how oversight should work in theory at the different spheres of government and how they relate.

It proposes mechanisms to broaden debate through the use of traditional spaces for discussion such as lekgotlas, develops sanctions for Ministers that fail to account to parliament and recommends training and advisory services to support MPs in holding the Executive accountable. Public Participation is also acknowledged as important and Parliament has recently called for submissions on ways in which to broaden participation. However, bearing in mind the resource constraints which govern the larger section of civil society, it is important that mechanisms be put in place to strengthen civil society's ability to participate.

In our view, there are a number of steps that need to be introduced in order to improve good governance and that can promote a transition from a business as usual approach towards a Smart approach to electricity governance.

Regulatory recommendations from the EGI-SA's 2010 report can be summarised as follows:

a) The process of appointment of regulator senior staff should be reviewed to increase transparency, thereby affirming the independence and authority of the regulator.
b) NERSA should be resourced to enable it to fully implement its social responsibilities and environmental mandate.

[196] PMG. 2012. National Energy Regulator of South Africa Annual Report 2011/12. A presentation to Parliamentary Portfolio Committee on Energy, 16th October 2012. Available at: http://www.pmg.org.za/report/20121016-presentation-annual-report-nersa-201112-financial-year [2013, April 11].
[197] Auditor General report to parliament on vote 29, Department of Energy Annual report 2012.

c) NERSA should exercise greater creativity in the use of its authority to facilitate sustained and meaningful communication and engagement between licensees and consumers, including the use of standing forums to provide it with information on licence compliance. It should expand its public education activities, including wider dissemination of its decisions, which may be facilitated through translations.
d) NERSA should urgently review its interpretation and practice to make more information more easily available. Transparency is essential to democratic accountability and access to information is vital to meaningful enjoyment of a range of socio-economic rights.

Recommendations to address challenges to current effective electricity governance:

- In order to strengthen an independent regulator, NERSA should be transformed into a Chapter 9 Institution[198]. As long as NERSA must report to DOE only, it cannot properly fulfil its function.
- All policy processes must be designed in a participative manner with active steps to include marginalised and vulnerable groups.
- Solutions must be found to ensure that public participation processes do not automatically exclude the poor. These should include overcoming such issues as language, presentation of technical information in accessible formats, the lack of access to the internet and the lack of mobility.
- Advisory panels dedicated to Departments must encompass the full range of expertise and as a matter of course be visibly representative of diverse sectoral interests.
- The fees charged to view tender documents should advance a transparent and accountable government. Initial documents must be open to public scrutiny without cost. To avoid frivolous applications, those developers that actually submit tender bids should be asked to pay an application fee on submission.
- Policy and planning decision-making processes should be transparent and reasons for decisions must be given in sufficient detail as to comply with the Promotion of Administrative Justice Act (PAJA).
- Policy processes must ensure that negative environmental externalities such as water provision, carbon emissions, mining implications (Rare Earth Minerals, coal, gas, uranium) as well as positive ones such as job creation and rural development, are central to decision-making processes.
- There should be a clear, transparent mechanism for processing public comments and responding meaningfully within a given timeframe. This should apply not only to legislation, but also to regulations.
- The ISMO bill is supposed to ensure an independent systems operator which will ensure fairness in access to the grid. This bill should be prioritised in 2013 and in order to address the challenges outlined above, the transmission assets should be transferred to the systems operator. Any transmission refurbishment contracts to be finalised in the period before the ISMO takes over should be subject to external review to avoid the possible conflict of interest as outlined above.

Taking up these recommendations would inspire confidence that the playing fields are indeed levelling out and that the policy context required for Smart electricity planning is taking shape.

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[198] Chapter nine institutions refer to a group of organisations established in terms of Chapter 9 of the South African Constitution to guard democracy. The institutions are: the Public Protector, South African Human Rights Commission (SAHRC), Commission for the Promotion and Protection of the Rights of Cultural, Religious and Linguistic Communities (CRL Rights Commission), Commission for Gender Equality (CGE), Auditor-General, Independent Electoral Commission (IEC), Independent Authority to Regulate Broadcasting.

Moving forward

Author: Brenda Martin

Contributor: Louise Tait

In 2010, partners of the Electricity Governance Initiative of South Africa (EGI-SA) pooled resources to provide research-based input to the IRP2010. The EGI-SA presentations at various public hearings around the country were widely acknowledged as breaking new ground. This Smart electricity planning report was initiated in 2012 when we updated our 2010 electricity supply and demand research findings.

With this report we have aimed to simply describe the features of Smart electricity planning, the wide ranging and interrelated considerations that can inform such planning and that can accelerate our transition to a modern, forward-thinking, strong, pro-poor, electricity supply in South Africa. It has been prepared as a contribution to forthcoming public participation in the IRP2010 review process.

Energy access to support critical human and economic development should be a cornerstone of national energy and electricity planning. Planning in a country where levels of inequality are extreme and the majority of people live in conditions of poverty must consider a range of social and environmental objectives so that investment choices do not end up posing a threat to human health and safety, are affordable, reliable and environmentally sustainable.

In South Africa access to modern energy services is also bound up in broader solutions to social problems such as: intergenerational poverty, unemployment, inequality, housing, health and social ills. To this end it is not feasible to expect that energy policy can, in isolation, effectively address many of the key issues around energy poverty. **An approach that is integrated in broader social policy is essential.**

Smart electricity planning calls for a radical rethink on how to provide modern electricity and energy services to all citizens in South Africa. **From the outset it must be remembered that delivering access to modern energy services is not a debate about technical solutions.** Rather it involves looking for ways to effectively integrate new, less environmentally damaging technologies in the context of complex social issues which have multiple and contested causes and often have no clear solutions.

Smart electricity planning recognises that, before we sign up for expensive, restrictive, dirty and outdated centralised power solutions, it would be wise to consider energy conservation and efficiency, effective demand management initiatives and job creating renewable technologies options first.

These options are readily available to us and make financial, social and environmental sense. Solutions that do not lock us into long term debt, improve wellbeing of people and slow the pace of environmental degradation are the key building blocks for an energy secure future in South Africa.

The realisation of a justice-oriented and environmentally attuned electricity future is contingent on astute political leadership making forward-thinking planning choices, supported by commitment from industry and every single person living in South Africa.

The choices we make today, will directly determine the future that emerges for our country.

Further reading

Here you will find further detail on topics touched on within the body of the report.

Coal-fired power stations currently being built:

1. Medupi

The Medupi Power Station is a new, dry-cooled, coal-fired power station being built by Eskom near Lephalale in Limpopo province. When completed, the power station will have six boilers each powering an 800 MW turbine, producing 4 800 MW of power. It is expected to become the largest dry-cooled coal-fired power station in the world.

Contracts have been placed with Hitachi to supply the boilers and Alstom to provide the steam turbines for this plant. At R33.6 billion, these are the biggest contracts ever placed by Eskom. Super-critical boilers will be used to improve the efficiency of the power plant.

Medupi will be supplied by coal from Exxaro's Grootegeluk coal mine, located north of the site. Eskom has placed a contract with Exxaro to supply 14.6 MT of coal per year for 40 years. The first 800 MW unit was initially expected to be commissioned by the end of 2012 (Eskom recently announced that a second delay has shifted the likely commissioning to the end of 2013), with the next units following at nine-month intervals. The power station is currently expected to cost R125 billion, this includes interest during construction of R 35 billion, but excluding the flue gas desulphurisation (FGD), which has to be built and running by 2021 in terms of ther World Bank loan[199]. Construction has been suspended a number of times and costs have escalated accordingly.

The African Development Bank lent $500 million for the project in 2008. In 2010, the World Bank agreed to lend South Africa $3.75 billion to assist with several energy projects, with $3.05 billion allocated for completion of the Medupi power station.

2. Kusile

The Kusile power station is being built in eMalahleni, Mpumalanga. The station will consist of six units, each rated at approximately 800 MW installed capacity, giving a total of 4 800 MW. It is expected to deliver its first power to the grid by the end of 2014. It is the second ‘advanced’ power project at Eskom, along with Medupi and cost estimates are higher at R 142 billion (including interest during construction costs and the FGD plant, see the footnote reference below).

Eskom has insufficient funds to complete the project. It is, therefore, planning to sell some of its stake in Kusile in order to meet the funding gap.

The land on which the plant is being constructed is on the farms, Hartbeesfontein and Klipfontein, and was earlier used for agriculture and cattle grazing.

Eskom has predicted that it will take 8 years to complete. Kusile’s first unit is scheduled to start commercial operation in 2014. It is also experiencing construction delays.

[199] Yelland, C. 2013. *Further cost increases on the cards for Eskom's Medupi and Kusile power stations.* EE Publishers 25 March. Available at: http://www.eepublishers.co.za/article/further-cost-increases-on-the-cards-for-eskoms-medupi-and-kusile-power-stations.html [2013, April 11].

Financing recommendations for Smart energy services

Where could we easily access the money needed to pay for simple, quickly implementable, household-level energy supply investments?

1. **The Environmental levy:**

Presently, the National Energy Regulator of South Africa (NERSA) has stipulated that Eskom's electricity sales include an additional tax in the form of an environmental levy of 2c/kWh. Since 2010 approximately R12 billion has been collected by Eskom through this levy[200]. If this levy were to be utilised to roll out energy services to the marginalised, this could result in hundreds of thousands more energy-secure households.

2. **Social Investment projects from new generation:**

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) forces Independent Power Producers (IPPs) to use a proportion of their profits on local economic development. The effective use of such funds can complement government roll-out programmes.

Community benefit requirements as formulated in the REIPPPP have also been indicated in other sectors such as mining, land reform, fisheries etc. Implementation of these requirements have had mixed outcomes and can provide important guidance for the REIPPPP.

It is essential that clear and reliable indicators for compliance are identified so that these can be monitored for effectiveness and assessed to ensure that earmarked funds are provided and utilised as intended.

Demand: Energy conservation & efficiency case studies

Please note that evaluation of the presented information in such case studies is difficult, since South Africa has failed so far to implement a mandatory standardised reporting system on energy use and energy efficiency. Results are often presented in absolute figures of cost reduction or peak demand changes or energy savings, also without exactly specifying whether savings have been achieved in electricity use only or energy use in general.[201]

Mining Energy efficiency measures taken to reduce Demand

Case Study 1 – Anglo Gold Ashanti:

Optimised process scheduling (by modelling the mines' water system in a software tool) has reduced the total average evening peak demand by 108 MW (26%). This project resulted in significant cost savings, because pump operations are scheduled now during standard and off-peak tariff periods. Another pumping project at its Moab Khotsong mine at Vaal River will improve the turbine's pump efficiency from 70% to 98% efficiency. Energy efficient lighting was installed at all mines, both above ground and underground. Optimisation of air compressors and optimisation of ventilation fans are other ongoing projects at Anglo Gold Ashanti.

Besides investing in energy efficient solutions at the mine sites, AngloGold uses CFL lighting, movement sensors and improved air conditioning in its new corporate offices in Newton, Johannesburg.

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[200] R3.3 billion (2010) + R4.3 billion (2011) + R4.3 billion (2012) http://financialresults.co.za/2011/eskom_ar2011/cd_fin_perform.php and http://financialresults.co.za/2012/eskom_ar2012/divisional-report/finance.php.

[201] All information in this section extracted from the National Business Initiative Assessment Study of the Energy Efficiency Accord, 2008; available at http://www.nbi.org.za/SiteCollectionDocuments/ee_accord_assessment_report.pdf

Pumping in mining and especially in gold mining contributes a significant share of the total electrical energy requirement. Both the reduction of peak demand and the improved efficiency to reduce energy consumption for pumping are highly important efficiency measures in the mining sectors.

Case Study 2 – Harmony Gold Mining:

Harmony's total electricity consumption in 2010 was 3 659 GWh. The annual electricity consumption increased by 6% from 2010, whilst the mined rock increased by 18%, showing an significant improvement in energy efficiency. Harmony is currently involved in a number of energy efficiency projects. It attributes significant electricity savings to the scheduling of pumping and installation of variable-speed pump motors. Additional savings were made through refrigeration optimisation, SWHs, installation of water turbines, other water and air optimisation projects and a further seven projects which are in the pipeline, including the improvement of a compressed air system. Harmony's report states energy and demand savings for some of the projects but unfortunately does not put the savings in relation to a baseline consumption or demand. The given reduction figures in energy add up to roughly 400 GWh per year, reflecting a 10% energy savings comparing to the given annual consumption.

Case Study 3 – Anglo Platinum: RE and energy efficiency projects:

SWHs at change-houses, hostels and homes have been implemented. A feasibility study into a 50 MW concentrated solar power (CSP) plant is ongoing. Another study analyses the feasibility of using parabolic trough solar collectors to power absorption chillers. Energy efficiency projects addressing the saving potential of compressed air, ventilation, lighting, refrigeration and pumping are at various stages of planning and execution at all the operations. Projects which aim to increase pumping and ventilation-fan efficiency are in underway. All these activities are undertaken in line with the Group's commitment to reducing energy consumption per unit produced by 15% by 2014.

Case Study 4 – Lonmin Plc: Sustainable Development Report (2011):

Lonmin's Sustainable Development – Report 2011 lists various activities to reduce its energy intensity. Lonmin reports a reduction of energy use per unit of production by 11.1% from the 2007 baseline. The following projects have been implemented: Re-design and replacement of compressed air systems. Air networks have been optimised. Industrial change houses and hostels now use heat pumps for water heating. All motors in the concentrators have been replaced by high-efficiency motors. Replacement of perimeter lights by solar lights. It improved efficiency of the electro-winning process, the furnace and the smelters.

Case Study 5 – Kumba Iron Ore: Reducing electricity consumption in auxiliary operations (2011):

Kumba Iron Ore has installed solar water heaters at its mine hostels, houses and change-houses. Smaller motors have been installed as part of a dust suppression system, replacing a dust extraction system.

Reflecting on the chosen areas of investment into energy saving and comparing to the stated areas of priority by Eskom (Eskom, 2010) it becomes clear that material handling and processing – which are the biggest consumers of electricity are hardly addressed by the ongoing initiatives. Pumping, ventilation, lighting, cooling, compressed air and water heating seem to be the low-hanging fruits where, with comparably little investment, remarkable savings can be achieved. Mining companies seem to be still hesitant to embark on improvement projects in material handling and processing, since this would require higher capital investment. If new incentives from Eskom and the Government were put in place to finance such investments, this might support future decisions in order not to risk the closure of mines due to further increasing electricity tariffs.

Another area of intervention is to replace the use of grid-electricity by own on-site co-generation. Considering the entire supply chain from coal-mining to electricity generation, transmission and distribution, on-site co-generation could materially reduce losses along this supply chain and additionally allow use of the waste-heat of power generation for heating and cooling purposes on-site. Such developments would need to be regulated, controlled and monitored through an adapted legal framework to minimise water and air pollution through on-site generation. Some initiatives in this direction have been kicked off recently[202].

Municipal Energy efficiency measures to reduce Demand

Case Study: The Optimum Energy Future for Cape Town (CoCT, 2011)

In order to support and extend the City of Cape Town's Energy and Climate Action Plan (ECAP, adopted by Council in May 2010) the project on Energy Scenarios was undertaken by SEA and ERC/UCT. Cape Town established an Energy and Climate Change Strategy in 2006 as well as the implementation of institutional reforms to support this initiative.[203] The ECAP with the overarching goal of energy security covers 11 key objectives and implements projects in a range of programme areas extending over a three year period. The Energy Scenarios cover the period up to 2050 and provide an in depth energy sector analysis and projections based on an extended and up-to-date set of energy consumption data, supply mix options, costing and trends.

The Energy Scenarios proposes the Optimum Energy Future (OEF) scenario as compared to a business as usual (BAU) scenario and to the National Long-Term Mitigation Scenarios (LTMS).[204]

The OEF for Cape Town in line with the ECAP Energy Vision promotes the following:

- Significant employment creation.
- A vibrant, efficient economy, robust in a carbon-constrained future.
- Lower overall cost of energy for the city, with no compromise in energy services provided.
- A carbon profile for the city in line with national and international obligations.
- A 'green' city.

The following objectives of the ECAP are most relevant for electricity demand projections of the CoCT:

- City-wide, including council operations: 10% reduction in electricity consumption on business as usual growth by 2012.
- 10% Renewable and cleaner energy supply by 2020; all growth in electricity demand to be met by cleaner / renewable supply.
- Local economic development in energy sector.

In comparison with the targets of the National Energy Efficiency Strategy[205] - 12% energy intensity reduction by 2015, 15% final energy demand reduction for industry by 2015 the

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202 http://www.howwemadeitinafrica.com/south-african-mines-might-start-generating-their-own-power/14794/
203 City of Cape Town. 2006. *Energy and Climate Change Strategy.* Available at: www.capetown.gov.za/en/EnvironmentalResourceManagement/projects/Documents/Environmental/Energy__Climate_Change_Strategy_2_-_10_2007_301020079335_465.pdf
204 City Of Cape Town. 2011. *Energy scenarios for Cape Town*. Available at: http://www.capetown.gov.za/en/EnvironmentalResourceManagement/publications/Documents/Energy_Scenarios_for_CT_to_2050_2011-08.pdf [2013, April 11].

above objectives do not seem to be totally in line with the national targets. However it is understood from repeated reports from City officials[206] that the electricity demand has remained stable since 2007, which reflects a 13.8% drop in demand down from a business as usual scenario. This clearly shows the shortcoming of business as usual projections as a planning basis. A future detailed analysis will need to unveil how energy efficiency interventions, increased tariffs and slower economic growth have all contributed to the lower electricity demand growth.

Electricity in Cape Town is supplied by the City of Cape Town (75%) and by Eskom (25%). The Energy Scenarios for Cape Town project did not have access to recent detailed data for the areas supplied by Eskom and hence rely on Eskom projections from 2003 for these areas. Electricity consumption in Cape Town is split amongst the residential sector (43%), the commercial sector (40%) and the industrial sector (13%), transport and Council use (2% each).

Case Study – European building regulations – The Net-Zero-Energy Building:

The European Union (EU) has recently amended the 2002 Energy Performance of Buildings Directive with the mandatory requirement that buildings in all EU Member States have to produce as much energy as they consume on-site by 31st December 2018[207].

The EU Industry Committee also wants Member States to set intermediate national targets for existing buildings, i.e. to fix minimum percentages of buildings that should be zero energy by 2015 and by 2020 respectively.

The newly released South African National Standard SANS 10400-XA: Energy Usage in Buildings can be seen as an important first step in this direction, where other countries have been taking the lead. Research for Zero- or Net-Zero Energy buildings is already taking place in South Africa – CSIR is implementing a zero-energy pilot in Port Elizabeth[208]. International developments and outcomes from local research like this will inform future building regulations for South Africa.

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[205] DOE 2012. *Draft Second National Energy Efficiency Strategy Review*. Pretoria, Department of Energy. Available at: http://www.info.gov.za/view/DownloadFileAction?id=179403 [2013, April 11].
[206] Sarah Ward, City of Cape Town: At WWF - Renewable Energy Workshop, Johannesburg, 21st November 2012.
[207] http://europa.eu/
[208] http://www.csir.co.za/Built_environment/index.html

Abbreviations

AMD	Acid Mine Drainage
BAU	Business as usual
CoCT	City of Cape Town
CSP	Concentrated Solar Power
CO_2e	Carbon dioxide equivalent emissions
DSM	Demand-side Management
EE	Energy efficiency
EEDSM	Energy efficiency and demand side management
EGI	Electricity Governance Initiative
ERC	Energy Research Centre at UCT
EWP	1998 White Paper on Energy Policy of South Africa
IEP	Integrated Energy Plan
IPP	Independent Power Producers
IRP2010	Integrated Resource Plan for Electricity 2010 – 2030
ISEP	Integrated Strategic Electricity Plan as implemented by Eskom
LTMS	National Long-Term Mitigation Scenarios
Mt	Millions of metric tonnes
NBI	The National Business Initiative
NIRP	National Integrated Energy Plan (predecessor of IRP)
PV	Photovoltaic
PWR	Pressurised Water Reactor
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Producers' Procurement Programme
SEA	Sustainable Energy Africa
SNAPP	Sustainable National Accessible Power Planning
SO	System operator, a department of Eskom
SO-low	Low demand forecast prepared for IRP2010 but not used
SO-Mod	Moderate demand forecast used to inform the promulgated IRP2010
SWH	Solar water heating
UCT	University of Cape Town
WEC	World Energy Council
WRI	World Resources Institute

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