ENERGY SECTOR TRANSFORMATION IN SOUTH AFRICA

A civil society view on sustainable and equitable transition to a low carbon and environmentally conscious energy future in South Africa

PROJECT 90
BY 2030

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Preface

This study deals with sustainable energy sector transformation in South Africa. In the context of climate change, environmental degradation, rising inequality, social injustice and energy access; the current status quo of our energy system must change. Energy issues at a national scale are both extremely complex and inextricably connected to other broad areas including food security, water systems, education, gender, economics and politics. Therefore, this short report is not meant to be exhaustive. It aims to give a high level overview of some of the key aspects that should allow our country to make progressive steps towards an improved energy sector that respects human rights and planetary boundaries.

To this end, the study first examines the status quo of our current energy system. This includes the key players and stakeholders along with effects on impoverished and marginalized communities. Chapters 2 and 3 provide negative and positive examples. These reveal areas for of the energy sector that must be improved and positive aspects to build on. Drawing from these first three chapters, key criteria for the transformation process itself are identified in Chapter 4. The main areas of change for energy sector transformation are discussed in Chapter 5 and the study concludes with policy recommendations to allow these changes to occur.

The study is structured so that the themes of energy production, supply and use run through the chapters, along with the framework components of governance and finance.

Civil society input

On the 27th and 28th February 2017, Project 90 by 2030 with support from Misereor, hosted a workshop that looked into components of a desirable energy future for South Africa and the transformation process required to achieve these. The workshop was held in Cape Town and attended by 35 people from 29 different South African organizations representing civil society and labour.

The first three chapters of this study provided the background information for the attendees to develop the criteria, scenarios and policy demands that formed the basis of Chapters 4, 5 and 6 respectively. Therefore the content of the last three chapters is reflective of a broader discussion on the key issues, which the authors of this study have grouped and prioritized as presented here.

The full workshop report is available at: http://90by2030.org.za/misereor-energy-project/

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Acronyms and abbreviations

ALRI	Acute lower respiratory infections
AMD	Acid mine drainage
bcf	Billion cubic feet
BIS	Biofuels Industrial Strategy
CEF	Central Energy Fund
CEO	Chief executive officer
CO_2	Carbon dioxide
CPI	Consumer Price Index
CSIR	Council for Scientific and Industrial Research
CSO	Civil society organisation
CSP	Concentrated solar power
CTL	Coal-to-liquid (conversion process)
DEA	Department of Environmental Affairs
DMR	Department of Mineral Resources
DNI	Direct normal irradiation
DoE	Department of Energy
DSM	Demand side management
EEDSM	Energy Efficiency Demand Side Management project (Eskom)
ELA	Earthlife Africa
ERC	Energy Research Centre
EV	Electric vehicle
FBAE	Free Basic Alternative Energy programme
FBE	Free Basic Electricity programme
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
GW	Gigawatt
GWh	Gigawatt-hour
Gt	Gigatonne
GTL	Gas-to-liquid (conversion process)
GUMP	Gas Utilisation Master Plan
hr	Hour
IEP	Integrated Energy Plan
INEP	Integrated National Electrification Programme
IPP	Independent power producer
IRP	Integrated Resource Plan
ISMO	Independent System and Market Operator
kg	Kilogram
kWh	Kilowatt-hour
LED	Local economic development
LSM	Living Standard Measure
LPG	Liquefied petroleum gas
MDGs	Millennium Development Goals
Mt	Megatonne
MW	Megawatt
MWh	Megawatt-hour
NCCRPWP	National Climate Change Response Policy White Paper
NDB	New Development Bank
NDP	National Development Plan
NECSA	Nuclear Energy Corporation of South Africa
NEDLAC	National Economic Development and Labour Council
NEES	National Energy Efficiency Strategy
NERSA	National Energy Regulator of South Africa
NNR	National Nuclear Regulator
NRWDI	National Radioactive Waste Disposal Institute
NUFCOR	Nuclear Fuels Corporation of South Africa
PBMR	Pebble Bed Modular Reactor
PCE	National Assembly Portfolio Committee on Energy
PJ	Petajoules
PPA	Power purchase agreement
PV	Photovoltaic
RE	Renewable energy
REI4P	Renewable Energy Independent Power Producer Procurement Programme
SA	South Africa
SALGA	South African Local Government Association
SANEDI	South African National Energy Development Institute
SAPP	Southern African Power Pool
SSEG	Small-scale embedded generation
SO_2	Sulphur dioxide
SOE	state-owned entity (now known as SOC – state-owned corporation)
t	Tonne
tcf	trillion cubic feet
UCT	University of Cape Town
USA	United States of America
USD	US Dollar
WASA	Wind Atlas for South Africa
WEF	World Economic Forum
WHO	World Health Organization
WWF	World Wide Fund for Nature
yr	Year
ZAR	South African Rand

1

The status quo of South Africa's energy system

1.1 Energy production

Primary energy resources

This section provides an overview of energy resources in South Africa (SA), with further details in the Appendices. SA has large reserves of coal. Lower quality stock is used locally and higher quality coal (about 30% of production) is exported. For national use, ~60% goes to power stations for electricity generation and ~25% is for coal-to-liquid (CTL) conversion processes [1]. Uranium has mainly been extracted as a by-product of gold and copper mining, with some dedicated trial mines in the 1970s [2]. While annual uranium output exceeds the need of SA's only nuclear power station (Koeberg), SA does not have a large-scale uranium enrichment facility, so the fuel rods for Koeberg are procured from world markets [3].

Offshore gas has provided feedstock for a gas-to-liquid (GTL) plant (Mossgas) for over 20 years, but this gas reserve is now almost depleted [4]. The majority of SA's natural gas requirements (~75%) are currently imported [1], but a new gas field [1] is coming online in 2017, and further offshore exploration licences have been issued. Preliminary studies indicated that there may be large reserves[2] of unconventional/ shale gas in the Karoo Basin [5], but these reserves have yet to be proven.

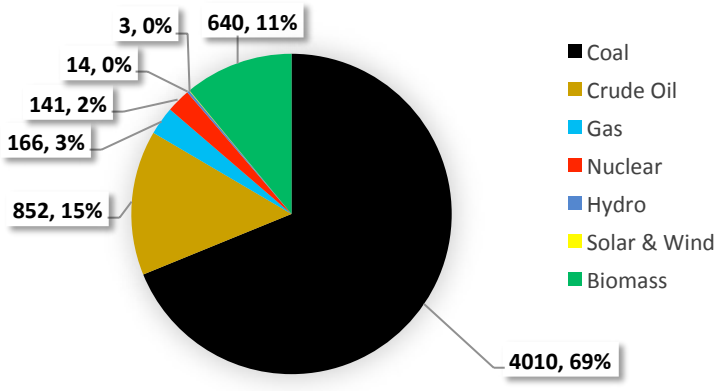
Oil reserves are limited to two small offshore fields (near end of life) which only supply a tiny fraction of SA's demand. The majority of crude oil is imported, but refinery output only covers about 60% of liquid fuel needs [6], and the balance is met from synthetic fuels produced via GTL and CTL plants and imports of refined products.[3] The distribution of energy resources and facilities is shown on the map is Appendix 1.

The main large-scale sources of biomass are commercial wood waste and bagasse, while small-scale use is predominantly fuelwood, charcoal and animal dung. The potential for large-scale hydropower in SA is limited due to geographical constraints and water availability, and small-scale hydro also has limited potential due to seasonal variations in river flow.

SA has world class wind and solar resources, which are only starting to be harnessed at a utility scale for electricity generation.

Figure 1 shows the split of primary energy supply, but since the latest energy balances[4] available from the Department of Energy (DoE), a number of large-scale solar and wind projects have come online as part of the Renewable Energy Independent Power Producer Procurement Programme (REI4P), discussed in Chapter 3. By the end of 2016, wind and solar contributed about 2% to primary energy supply, while the contributions from other energy sources remain similar to 2012. Fossil fuels still dominate, contributing at least 80% to primary energy supply in 2017.

Figure 1: Total primary energy supply in SA - 5826 PJ



Source: DoE Energy Balances (Aggregate), 2012.
Unit: PJ, integer rounded

1. Ibhubesi gas field (~540 bcf), to supply 30 bcf/year to open cycle gas turbines for peaking power [132].
2. Initial estimates of unproved but technically recoverable gas stood at 485 tcf in 2011, but these were reduced to 389 tcf in 2013.
3. 2015 net imports (million litres): Diesel – 4 830, petrol – 780 and liquified petroleum gas (LPG) – 30 [131].
4. The DoE data from 2012 was used because of significant problems with the biomass figures in the 2013 data.

Table 1: Primary energy reserves, production, trade and stakeholders

Primary source	Estimated reserves or potential reserves	Annual production or capacity (energy value) [a]	Annual imports (energy value) [a] [source]	Annual exports (energy value) [a] [destination]	Stakeholders
Coal	30 165 Gt [7] 3.4% of world total [8]	258 Mt (6 136 PJ)	0.1 Mt (3 PJ)	76 Mt (2 130 PJ) [>40 countries]	Mining companies, Sasol (CTL), Eskom
Uranium ore	338 100 t [b], 6% of world total [9]	476 t [9]	Negligible for ore (141 PJ)	Majority annual production	Gold/copper mines AngloGold Ashanti
Natural gas	Offshore: unknown Operational fields depleted	(45 PJ)	(121 PJ) [Mozambique]	Negligible	PetroSA (GTL) Sunbird Energy
Crude oil	Offshore: unknown Current fields depleted	0.05 Mt (45 PJ)	~ 19 Mt (807 PJ) [Middle East, rest of Africa]	Negligible	PetroSA, Transnet pipelines
Biomass	Large, but unevenly distributed [c]	640 PJ	Negligible	Negligible	Industries: paper, sugarcane, forestry
Hydro [d]	Minimal beyond current operational projects	600 MW [10] (~850 GWh = 3 PJ)	~9 000 GWh [11], [10] (~30 PJ) [Mozambique]	None	Eskom
Wind [e]	>35% capacity factor on ~70% suitable land area [12]	1 360 MW [13] (~13.4 PJ)	None	None	IPPs, Eskom
Solar [e]	Majority of country >2 000 kWh/m2/yr DNI PV capacity factor: 20% CSP capacity factor: 40%	PV: 1 350 MW [13] (~7.5 PJ) CSP: 200 MW [13] (~2.3 PJ)	None	None	IPPs, Eskom, residential

a) Coal, natural gas, crude oil and biomass energy values of indigenous production from DoE Energy Balances 2012. Nuclear value relates to energy produced at Koeberg from imported enriched uranium.
b) Identified recoverable resources (reasonably assured resources and inferred) <USD 130/kg.
c) Records of traditional biomass use are not available, but fuelwood use has been estimated at ~11.2 Mt/year, with 60% of supply from natural woodlands [14].
d) Hydro production and imports vary annually with rainfall and dam levels.
e) Solar and wind maps in Appendices 3 and 4. Energy value for capacity online in 2016 is estimated by: capacity x capacity factor x availability factor (90%) x 8 760 hr/yr, convert using 1 PJ = 277 GWh.

Stakeholders in energy production and trade

Major players in energy production are listed in Table 2. In terms of trade, coal exports (the 5th highest in the world) are handled by large coal mining operators such as Anglo American and BHP Billiton [15]. Uranium exports are mainly handled by NUFCOR[5]. Sasol Gas is the main player in the importation of gas from Mozambique, and the main importers of crude oil are corporations and state-owned entities (SOEs, also known as state-owned corporations)[6] linked to the four oil refineries in SA [16]. The Southern African Power Pool (SAPP) allows for the trade of electricity between 12 member countries[7] via shared grid infrastructure [17]. Transnational and multinational corporations feature across the sectors including mining, liquid fuels, natural gas, renewable energy (RE) and proposed hydraulic fracturing for shale gas.

Eskom is the national power utility, which supplies over 94% of SA's electricity [6]. Municipal power stations, and auto-generation by industry and the private sector make up the balance. Eskom owns and maintains the national grid and handles all imports and exports of electricity within the SAPP. Since Eskom only purchases ~8% of the electricity it distributes from local and independent power producers (IPPs) [10], it essentially has a monopoly over generation and transmission of electricity in SA, while distribution is shared with municipalities. The electricity Eskom produces is mainly from coal (91%), with smaller proportions from nuclear and diesel [8] [10].

5. Nuclear Fuels Corporation of South Africa which operates a small refinery in the southeast of the Gauteng province.
6. BP Southern Africa, Chevron SA, Engen Petroleum, PetroSA, Sasol Oil, Shell SA, Total SA.
7. Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, SA, Swaziland, Tanzania, Zambia and Zimbabwe.
8. Used in open cycle gas turbines for peaking power. Eskom also has 2 732 MW pumped storage capacity

Eskom is an SOE/ state-owned corporation which also functions as a company in the sense that it aims to make a profit. This has led to some conflicts of interest regarding the need to generate revenue on the one hand, versus the duty to provide a basic service to the entire population on the other. This is discussed in later chapters.

1.2 Energy supply

Access to energy supply and distribution grids

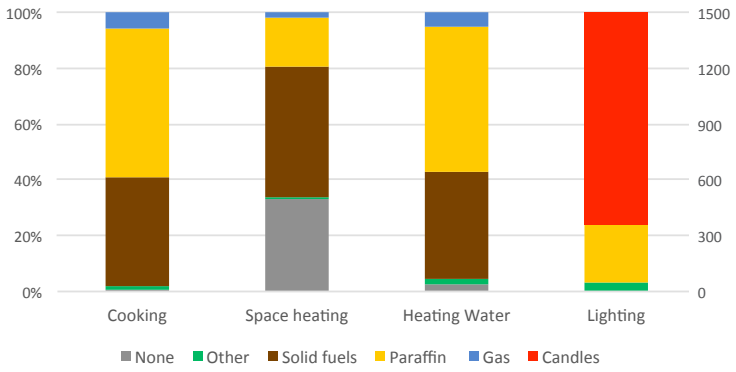
Petrol and diesel for transportation are sold to the public at over 4 600 service stations throughout SA [16], with easier access in urban areas (shorter distances between service stations). Solid fuels such as wood are sold in all parts of the country, but can also be gathered for free, particularly in rural areas. It goes without saying that there is easier access to biomass energy resources in the more vegetated areas of the country than the more arid areas. The harvesting of biomass resources for energy is not regulated or closely managed, so, in practice, a proportion of harvesting is unsustainable because the rate of harvesting exceeds the rate at which the resource is able to regenerate itself.

Approximately 91% of SA households had access to electricity in 2016 [18], and the backbone of the national grid is shown in Appendix 2. In 1994 this figure was about 50%, so the national electrification programme has significantly improved access to electricity [19]. However, in 2016, there were still ~1.5 million households (~4.75 million people) with no access to grid electricity [18]. While most households using electricity are connected directly to the grid, about 3.6% access electricity via alternative means. This is often by a connection to another source (such as a neighbour) who is then paid for the electricity, or an illegal connection (0.4% of households)[9] without payment [20]. A very small proportion of households produce their own electricity with solar systems. Diesel generators are used in some agricultural areas, and as backup supply (high-income households, industry and hospitals).

Grid connection rates now vary between 86% to 97% across the nine provinces of SA [18]. Larger differences are found when the race and age of the head of the household are compared, along with relative wealth of the household. However, the greatest variation in electricity access is based on dwelling type, with electrification rates in informal settlements as low as 53% [20]. Consumers purchase electricity directly from Eskom or via municipalities, depending on the distribution authority in the area, and the split between Eskom and the municipalities is almost exactly equal. Municipalities will often purchase electricity from Eskom and then add charges before selling it on to consumers. These additional charges are not standardised, although final electricity tariffs are subject to regulation by the National Energy Regulator of SA (NERSA). Regardless of end vendor, ~80% of electricity sales are made using a prepaid system [18]. Petrol and diesel prices are government-regulated, but prices at the coast are lower than inland areas because they are closer to fuel refineries.

Those who do not have affordable access to electricity use solid fuels (wood, animal dung, coal), paraffin, candles and gas to fulfil basic functions in the ratios shown in Figure 2.

Figure 2: Energy for basic needs where there is no access to electricity



Right scale bar: 1 000 households
Source data: Statistics SA, Household Energy Survey, 2012.

While gas, mainly in the form of liquefied petroleum gas (LPG), is an attractive form of energy, SA has very few residential gas grids,[10] so LPG is largely consumed from gas bottles. For communities without access to affordable electricity, LPG would be a much safer and healthier form of energy than paraffin (kerosene), charcoal and fuelwood. However it is generally too expensive for low-income households.

9. This figure is likely to be an underestimate, since it relies on self-reporting in a large-scale community survey.
10. The largest provider is Egoli Gas, which supplies over 7 500 homes and businesses in Johannesburg.

Players in the energy sector

At a high level, the major players in energy supply sector (including policies and regulation) are summarised in Table 2. Linkages and other players are shown in Appendix 5.

Table 2: Major players in the energy sector - Governance, regulation, planning and supply

Name	Type of entity	Primary mandate or function
National Assembly Portfolio Committee on Energy (PCE)	Parliamentary committee	Make laws, review draft policies, exercise oversight of DoE operations and budgets and energy-related SOEs [6].
Department of Energy	National government	Optimise use of national resources related to energy supply [21].
Minister of Energy	Cabinet	Political head of the DoE, exercise oversight of energy regulators and energy-related SOEs, make energy policy and procurement determinations.
Eskom	SOE	Generation, transmission and distribution of electricity.
Central Energy Fund (CEF)	SOE	Contribute to the security of energy supply through commercial operations and developmental investments [22].
NERSA	Regulatory authority	Regulate the electricity, piped-gas and petroleum pipelines industries of SA [23], including tariff determination.
National Nuclear Regulator (NNR)	Regulatory authority	Protection of people, property and the environment against nuclear damage though safety and regulatory practices [24].
Nuclear Energy Corporation of SA (NECSA)	SOE	Research into nuclear energy, processing of source materials, operates Vaalputs low- and medium-level waste disposal facility [25].
SA National Energy Development Institute	SOE	Applied energy activities that promote the uptake of clean energy and energy efficiency in SA [26].
Sasol	Private international corporation	Produce synthetic liquid fuels from coal [27].
Transnet Pipelines	SOE	Provide liquid fuel and gas pipeline infrastructure [28].
Municipalities	Local government	Buy, sell and distribute electricity, manage cross-subsidies from national government at local level.
IPPs	Private sector	Sell electricity to Eskom via power purchase agreements.
PetroSA	National oil co.	Extract offshore gas and use it to produce liquid fuels.

Funding and subsidies

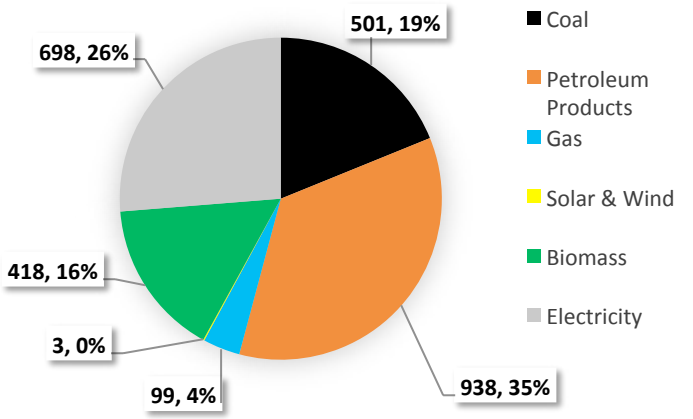
Mining, refining and some import/ export infrastructure are funded by the companies and corporations involved in these operations. IPPs fund their generation facilities, and in some cases, a portion of the grid connection infrastructure. Most of the large-scale energy supply infrastructure is state owned (via Eskom and municipalities for electricity, and Transnet for pipelines and freight rail for coal/ oil). Energy production subsidies, particularly for the fossil fuel and nuclear sectors, are addressed in Chapter 2.

1.3 Energy use

The national energy system is inefficient. Final energy use (2 657 PJ, Figure 3) is only 45% of total primary energy supply (5 826 PJ, Figure 1), indicating that over 50% is lost through transformation processes (electricity generation, GTL, GTL etc.) and via transmission/ distribution loss. [11]

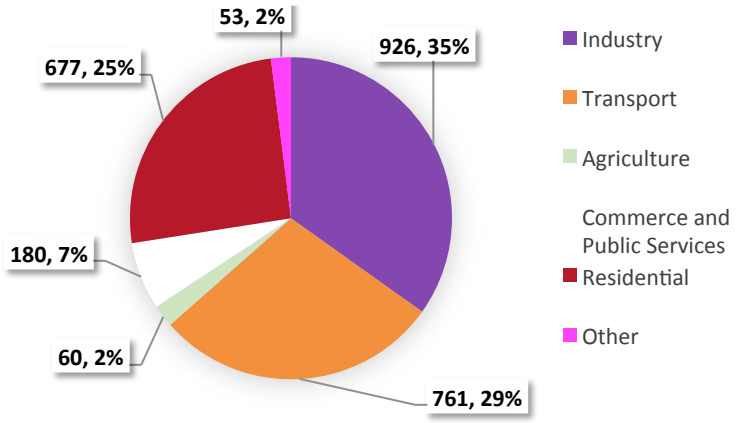
11. Statistical differences may be up to 10% of primary energy supply, so this proportion is a rough figure [1].

Figure 3: Final energy by source in SA - 2 567 PJ



Source: DoE Energy Balances (Aggregate), 2012.
Unit: PJ, integer rounded.

Figure 4: Final energy use by sector in SA - 2 657 PJ



Source: DoE Energy Balances (Aggregate), 2012.
Unit: PJ, integer rounded.

Since ~80% total electricity is generated from coal, Figure 3 reveals that ~75% of energy use is from fossil fuel-derived sources; leading to high emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs). From the sectoral breakdown (Figure 4), chief users of energy are industry, transport and residential. Within the industrial sector, iron, steel and mining, and quarrying each contribute about ~18% (of the industrial total), and road travel accounts for ~85% of the transport total.

For final electricity use, industry takes more than all other sectors combined, with 59% (Appendix 6). Transport only uses 2% of final electricity, but uses 79% of final petroleum product (Appendix 7).

Electric vehicles (EVs) must feature in medium-/ long-term transport planning, but the current coal-dominated electricity sector reduces the advantage of EVs from an environmental standpoint.[12] While steps are taken to decarbonise the electricity sector, and EVs are still expensive, SA should focus on improved and affordable public transport, increased fuel efficiency, and localisation to reduce transport fuel use without affecting productivity.

Regional use of energy (in terms of amount and source) varies enormously. At a settlement level, this is heavily influenced by major land-use functions. Compared to the national percentages (Figure 3), the eight metropolitan municipalities in SA along with small towns typically use much less coal but more petroleum products, while industrial cities use a much higher proportion of electricity and coal [29]. There are also marked differences between rural and urban areas, agricultural zones, and between the nine provinces [20]. So, although overall patterns of energy use will help inform key points of leverage for developing future energy scenarios at a national level, local planning must be tailored according to the main activities and functions, resource proximity, and financial means of people living in the area.

The energy use trends of impoverished and marginalised communities are different, and some additional figures are given in Appendix 8. Their mobility involves a higher proportion of walking, bicycle and public transport compared to higher-income groups. Despite the costs, low-income households in urban areas will use electricity where they are able to access it, and when they have the money, since cheap/ free alternatives such as wood are not as readily available as in rural areas. As a result, a quarter of this group spend more than 20% of their household income on electricity [20], but will sometimes just not be able to afford it, and will go without or use other sources of energy.

Over the last two decades, the proportion of population using any energy source for space heating has decreased significantly. This is partly due to the rising costs of all energy sources, which causes the least essential or most energy-intense functions to be abandoned first.

12. Even in coal-based electricity systems, EVs may reduce overall emissions due their efficiency, particular if a high proportion of the liquid fuel alternatives are produced by the polluting CTL process, but EVs have a much larger effect on emissions reduction when the electricity is based on renewable energy.

Consumer subsidies

Free Basic Electricity (FBE) is a government programme initiated in 2003 that aims to provide 50 kWh per household per month of free electricity, as a way to increase access to electricity for low-income households. Unfortunately the design of the programme fails to take into account larger family sizes, shared meters and on-selling of electricity in informal settlements. Surveys also indicate that only ~25% of electrified households actually receive FBE.[13] In addition, a number of projects have been undertaken in terms of the 2007 Free Basic Alternative Energy (FBAE) policy to assist those not connected to the grid to gain access to alternative energy sources with a value of at least ZAR 55/ household/ month (with increases indexed at the Consumer Price Index (CPI) plus 1.6% p.a.) [30]. The FBAE largely focused on providing access to cleaner fuels and appliances, but this has been difficult to implement, and there has been no assessment of its overall impact. As part of its Energy Efficiency Demand Side Management project, Eskom exchanged compact fluorescent lamps for incandescent light bulbs (because these use less energy), but the initiative was terminated after about six years [31] despite good results.[14] In 2009, the DoE launched a programme to install one million solar water heaters across the country [32], but there have been problems with quality of installations and delays in the implementation timeline. Consumer-targeted energy subsidies show a theme of progressive ideas let down by poor execution. In the future, the positive components should be implemented efficiently by appropriate, impartial agencies.

1.4 Framework and governance

Policies and development plans

The DoE acknowledges the criteria used by World Economic Forum (WEF) to measure energy system performance [33]. These are: i) economic growth and development; ii) environmental sustainability; and ii) energy access and security. National government realises that the development plans to deliver secure, affordable and sustainable energy should take into account how the system delivers against these three measurements. SA is currently ranked 76th out of 126 countries on this trilemma index, and has a low score on all three elements, particularly environmental sustainability [34].

Through policies and legislation, SA has recognised the lack of access to energy and addressed the electricity component via the Integrated National Electrification Programme (INEP). Government has also been working towards the improvement of energy governance by developing legislation to guide the government's decisions on electricity, nuclear, liquid fuels and gas. NERSA was established to regulate the energy sector, while SOEs were put in place to contribute toward energy security and enable development. The Energy White Paper of 1998 indicated that a heavy reliance on coal-based electricity required increased efforts to manage the negative environmental impacts of coal, and the need to secure supply through diversifying the energy mix. In 2003, the Renewable Energy White Paper was promulgated, which included a target for the expansion of renewable energies to 10 000 GWh by 2013 (i.e. over 10 years), which was seen as progressive, but not very ambitious.

The Integrated Energy Plan (IEP) is the strategic master plan for SA's entire energy system, but it functions only as a guideline and is not enforceable. The Integrated Resource Plan (IRP) is specific for electricity and articulates a planning framework for the management of electricity supply in SA, including infrastructure development. The IRP is key to shaping the country's electricity sector, as it dictates the electricity generation mix over time, and what type of new generation capacity will be built.

The current IRP was formalised in 2010, and an important component in this plan was the inclusion of 9.6 GW additional nuclear capacity by 2030 (forced in by model constraints). An update of the IRP was done in 2013, with a more critical view on nuclear, but was never promulgated. According to the National Energy Act, the IEP is to be updated annually (but this has not happened since 2005), while the IRP was to be revised at least every two years. The updated IRP and IEP were under review as of May 2017.

To manage the climate change impacts of energy use and generation in SA, the Department of Environmental Affairs (DEA) produced the National Climate Change Response Policy White Paper (NCCRPWP) in 2011. The policy provides for an effective climate change response, climate resilience, a lower-carbon economy, and it follows a defined emission trajectory to 2050 [35]. The National Development Plan (NDP) of 2011 strengthened the vision and objectives of

13. This varies widely by province (from 10% in Limpopo to 43% in Western Cape) and rural-urban location [20].
14. This is an inherent conflict of interest, since the national electricity provider was essentially trying to reduce consumption of its own product. Promoting energy efficiency runs against Eskom's profit-making obligations. It may have been motivated by a desire to reduce demand at a time when Eskom was unable to generate enough electricity.

the NCCRPWP and took a clear stance on the procurement of additional nuclear energy plants, saying that the timing and desirability of nuclear power needed to be reassessed. The NDP also underlined the need for an improved energy supply for marginalised communities through the provision of affordable electricity [36].

Regulations on new generation capacity under the Electricity Regulation Act enable the Minister of Energy, in consultation with NERSA, to make determinations on which new generation capacities will be procured, as long as they are in agreement with the IRP. These determinations can cover the whole IPP programme, including renewables, coal and co-generation [33]. By 2030 it is expected that 17 800 MW of the electricity will be provided by RE sources, with 7 000 MW already operational by 2020 [13].

Other planning documents are the National Energy Efficiency Strategy (NEES), which is currently under review (May 2017), and the Biofuels Industrial Strategy (BIS), which set a target of 2% biofuels in the national fuel mix. This strategy was followed by a biofuels mandatory blending regulation to require the blending of biofuels with petrol and diesel which had not been brought into effect by May 2017.

Due to limited public transport and growing mobility needs, it is estimated that the energy demand for transport will grow to approximately 44% of the total energy demand by 2050. These assumptions almost exclusively focus on the use of liquid fuels, despite growing global uptake of EVs [37]. Increased demand for liquid fuels will have implications for the GTL and CTL plants, as well as the amount of imported crude oil and refined fuels. Increased use of fossil fuels in the transport sector may also push carbon emissions beyond the emissions trajectory described in the NCCRPWP.

Funding

International and multilateral donors have provided technical and financial assistance for the development of a diversified energy sector. Governments of European countries have supported DoE with the setup of the RE and energy efficiency programmes. The Global Environment Facility (GEF) also provided a grant for advisory services under the Renewable Energy Market Transformation Project [33].

Eskom is in need of foreign and domestic support. The utility expects to borrow ZAR 327 billion between 1 April 2016 and 31 March 2021. Eskom's funding comes from equity investments (by the SA national government), funds from operations, and money borrowed on local and foreign debt markets. In the 2015/16 year, Eskom received financial support from development banks and bank credits from various financial institutions [38]. This was for grid extension and to support the operation and construction of the two new coal power stations (Medupi and Kusile), which Eskom has committed to complete by 2020 and 2022 respectively, but without a confirmed timeline. Substantial delays in building these two megaprojects have resulted in enormous cost overruns, estimated in July 2016 to already be ZAR 90.9 billion for the combined cost to completion of both projects, excluding interest during construction estimated at ~ZAR 100 billion, and rising [39].

Energy sector lock-ins

The electrical grid needs to be extended to connect new power generators to the grid, including mini-grids. Transport infrastructure upgrades and urban planning should encourage public and non-motorised transport, otherwise the result will be lock-ins for a transport system with a high proportion of private cars.

Eskom currently runs 13 coal power plants, all of which are scheduled to be closed down between 2024 and 2050 [40]. For liquid fuels, the four oil refineries are scheduled to run past 2050 (despite already being between 45 and 63 years old), and Sasol CTL until about 2040 [41], [42]. The GTL plant is meant to run until 2030, but is already constrained by limited gas feedstock supply. The lifespan of Medupi and Kusile are meant to be 50 and 60 years respectively from whenever they are completed [43], [44]. The new draft IEP still suggests the construction of new GTL and CTL plants beyond 2030, despite their inefficiency and high emissions [41]. These coal and liquid fuel infrastructure lock-ins will limit the rate of transformation of the energy system towards renewable resources. Furthermore, these new build projects risk becoming stranded assets if they are abandoned due to financial or climate change mitigation reasons.

The Koeberg nuclear plant was designed to run until 2025, but there are proposals to extend this to 2045 [45], and there are no published plans for undertaking and funding its decommissioning. If an additional 9.6 GW of nuclear were to be constructed as per the 2010 IRP, this would be a massive technology lock-in. The enormous cost will reduce available funds for other transformations in the energy sector.

2

Negative examples

An analysis of the social and environmental impacts of energy production, supply and use in SA should be sensitive to the overall energy landscape. The country is heavily reliant on coal (as described in Chapter 1), and for a period Eskom generated some of lowest cost electricity in the world. The industrial sector in particular has benefited from this history of cheap coal-based power, but the negative impacts on society (human health), the environment, and even the economy in the long term, have been substantial. The 1998 Energy White Paper 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".

2.1 Energy production: Negative air quality, water quality and climate change impacts

A key issue related to its intensive coal use is SA's contribution to global greenhouse gases, the 13th highest total carbon emitter in the world [46]. In addition, the burning of coal produces large quantities of toxic coal-ash (1 tonne of coal-ash for every 4.8 tonnes of coal burned [47]) sulphur dioxide (SO_2), nitrogen oxides and particulate matter (around 185 000 tonnes per annum for all fuel-burning activities in the major urban centres [48]). This has been linked to a number of respiratory diseases such as black lung and is a major contributor to the bio-accumulation of neurotoxins such as mercury [48].

Coal mining is responsible for the degradation of natural water systems, particularly through acid mine drainage (AMD). This leads to undrinkable water, decreased agricultural productivity, the destruction of riverine ecosystems and damage to biodiversity [49]. Eskom is both the largest burner of coal, and the highest emitter of GHGs in the country. Sasol takes second place in terms of GHG emissions, with the Natref refinery in Sasolburg (Free State) and its CTL plant in Secunda (Mpumalanga) each producing high levels of toxic pollutants [50].

Both Durban and Cape Town are home to major oil refineries whose current emissions are based on SA standards that are far less stringent than those set by the World Health Organisation (WHO). These refineries are allowed to emit up to 22 000 kg of SO_2 per day, compared to European refineries with as little as 2 000 kg a day [50].

Converting fossil fuels into electricity requires large amounts of water for cooling and other processes. Eskom consumes 1.42 litres of water for every kWh sold to end users [51], making Eskom the single largest user of water in SA – about 2% of the country's available fresh water resources [52]. Even the new Kusile plant, which is dry-cooled (and will therefore use less water than other Eskom plants), will still use 173 times the amount of water per unit of energy than wind power [53].

The primary source of radioactive material being introduced into the environment is from coal mining, burning, and mine dumps [54]. There have been repeated breaches of maximum radioactivity emission level standards by SA's only radioactive waste disposal facility at Vaalputs in the Northern Cape [55] which only deals with low- and medium-level waste. Of serious concern is the lack of planning for the long-term storage of some 1 400 tonnes of high-level waste in pools at Koeberg, within 30 kilometres of Cape Town, a city of some 4 million people, and the fact that none of the nuclear facilities have any proper plan or budget for decommissioning [56].

All these energy production related impacts have a disproportionate impact on low-income households for two primary reasons. The first is that the poor tend to make use of more polluting indoor energy sources which results in concomitant relative increases in respiratory diseases for low-income households [57]. The second reason is that low-income households are invariably located nearest to mine-dumps, waste facilities and energy/fuel production facilities: such as those living near the oil refineries in the South Durban Basin. This trend has been recognised, and the DEA has released a 'Draft strategy to address air pollution in dense low-income settlements' [58].

2.2 Energy supply: Inefficient systems, high prices and outdated municipal revenue models

Another drawback of SA's coal-based power stations is the high transmission losses associated with delivering electricity generated in remote, coal-rich areas to distant centres of demand. According to the World Bank these losses account for up to 10% of SA's supply [59]. This point has been re-iterated on numerous occasions by RE proponents such as the World Wide Fund for Nature (WWF)[60], which argues that generation costs, transmission losses and supply security (in terms of loss of load probability) will all be reduced by a policy shift in favour of distributed RE.

Commenting on the draft IRP update (2016), Professor Anton Eberhard (a member of the Ministerial Advisory Council on Energy) stated in November 2016 that none of energy modelling done by any institution in SA, including the DoE and Eskom, would select nuclear energy over combinations of solar, wind and gas, unless the modellers force nuclear to be included, as appears to have been done in the IRP base-case currently under review [61]. Despite this, the SA government seems committed to a hasty procurement of 9.6 GW of nuclear power, prompting a widespread public outcry around the affordability and need for the project.

A further supply-side problem relates to the exorbitant price increases for electricity since 2008. While some of the revenue from these price increases has gone towards financing new generation capacity, there is still a significant capital shortfall, partly due to decreasing net demand since 2009 after the forced power outages (also called load-shedding) of 2008.

For the middle class and the wealthy, these increases are an irritation, one that has driven increased energy efficiency rather than caused a decline in the quality of life. This is not the case for low-income households whose options for energy efficiency are extremely limited. Since they lack the available capital to implement energy efficiency measures at home, they must very often simply go without. In 2013, the DoE estimated that 43% of South Africans are energy-poor as they spend more than 10% of their income on energy, with many households in the lowest Living Standard Measure (LSM) group spending over 25% [62]. This proportion is likely to increase as electricity prices continue to rise at higher than inflation as measured by the CPI (Appendix 10).

An added complication is that municipal sales of electricity continue to be a major income earner for municipalities with the 2014/15 national average being ~28% derived from electricity sales, second only to grants and subsidies at 31% [63]. This means that electricity sales subsidise a number of other services essential to low-income households and, as income from electricity sales accruing to municipalities decreases, the resources to provide subsidised services are becoming eroded. The situation for municipalities will be aggravated as the cost of rooftop solar photovoltaic (PV) technology drops and wealthier consumers start investing in their own generation facilities. A planned transition from this energy model is critical to ensure that municipal services are maintained. SA is not unique in this respect. Electricity utilities in the United States of America (USA) and the United Kingdom are also having to adapt to the threats and opportunities presented by distributed RE resources.

2.3 Energy use: Negative health and safety impacts on low income households

Biomass fuel in the form of fuelwood, coal, cow-dung and vegetable matter is widely used for cooking, water heating and space heating, especially among the 40% of the population in rural areas. Numerous respiratory problems are caused by the sustained indoor burning of biomass, primarily affecting women and children. It is estimated that around 20% of SA's households suffer from negative health impacts resulting from exposure to contaminated indoor air [64]. Exposure to contaminated air can result in a variety of respiratory diseases, including acute lower respiratory infections (ALRI), which is the world's leading cause of death of children under the age of five. ALRI is among the top four causes of death of SA children under five, causing approximately 1 400 deaths every year [64].

According to the DoE, the second most common means of heating in SA remains paraffin, with 68% of un-electrified homes and 22% of electrified homes using paraffin for this purpose [62]. While the utility of paraffin is not in question, there are significant drawbacks. For example, ~60% of paediatric poisonings in SA are attributable to children mistakenly drinking paraffin [65]. The risk to life and property from fires is also a major concern. The Paraffin Safety Association estimates that 53% of shack fires are attributable to paraffin stove accidents [66]. These risks are increasing because low-income electrified households resort to paraffin when they can no longer afford electricity.

Women and children are far more susceptible to these adverse health impacts, and low-income households are more likely to be living closer to sources of pollution and exposed to contaminated food, air and water.

2.4 Framework and governance: Subsidies that benefit the fossil fuel and nuclear industries

Although SA says it favours free-market principles, this is not the case when it comes to energy generation. Of particular concern are current fossil fuel subsidies as well as corruption, particularly in the coal and nuclear sectors.

The main issue is that much of the information around fossil fuel subsidies is not available to the public. Although the Overseas Development Institute calculated the value of direct fossil fuel subsidies to be at the relatively low average of ZAR 213 million per year in 2013 and 2014 [67], fossil fuel producers benefit from a range of other indirect financial mechanisms. These include exemptions from taxes, exemptions from environmental protection measures, income and price support, and benefiting from government-provided or government-purchased goods and services. Researchers at the University of Cape Town (UCT) Energy Research Centre (ERC) have calculated the value of direct transfers to have been between ZAR 5–23 billion per year (nominal), while foregone government revenues have been between ZAR 27 million and ZAR 3.7 billion per year (since 2007). When the price support[15] that Sasol receives through the regulated fuel price is factored in, an additional ZAR 13 – 32 billion per annum can be added to the total [67]. A further indirect subsidy is that of Eskom being permitted to avoid meeting its obligations to air-quality standards on the grounds that it cannot afford the ZAR 200 billion it will cost to comply with the standards (despite having stated that they will comply at the time of applying for construction finance). Eskom's failure to comply with air-quality standards has resulted in estimated health costs of over ZAR 230 billion over the non-compliance period and this non-compliance has been the indirect cause of over 2 200 deaths per year [68].

There is a great deal of concern around the fleet of nuclear power stations that was proposed in the 2010 IRP. Despite repeated evidence from all major energy modelling institutions in SA that no further nuclear energy is required, the state is still committed to the procurement of 9.6 GW of nuclear power at an estimated cost of ZAR 1 trillion. At present, state subsidies to the nuclear industry are low, with the largest portion being ZAR 599 million [69] for the year 2016/17 going to the Nuclear Energy Corporation of South Africa, but the nuclear industry has a history of heavy subsidisation by government.

For example, while Eskom's Koeberg power station never received a direct government subsidy, massive subsidies were directed at the Atomic Energy Corporation, the Council for Nuclear Safety and the former Nuclear Development Corporation, which received 70–80% of the Department of Minerals and Energy[16] budget during the 1980s [70]. More recently, the state mothballed the Pebble Bed Modular Reactor (PBMR) company after spending an estimated ZAR 12 billion on the technology [71].

What is really concerning about this sustained focus on new nuclear power is that it is happening in the face of rapidly falling RE costs and the oversupply of electricity due to low economic growth and partially due to the rapid success of the REI4P.

As the Council for Scientific and Industrial Research (CSIR) points out, new solar and wind are 40% cheaper than new coal (with none of the same externalities), yet the state is determined to present RE as a problem rather than a solution [72]. Under these circumstances, it is easy to suspect that corruption and vested interests are the real reason why the state continues to pursue more costly, more polluting and less job-intensive forms of energy production rather than RE. Unfortunately, high-level energy planning is SA seems to be directed more by patronage politics than logical and pragmatic solutions.

15. As a result of the basic fuel price regulations, Sasol still receives import parity prices for its domestically produced CTL synthetic fuels, even though the cost of production is now well below that of imported fuels. Initially, import parity pricing was meant to keep Sasol profitable when it had a very high cost base, but the situation has changed resulting in Sasol generating excessive profits. These pricing regulations have led to fuel prices that are higher than they would be without regulation, and has essentially extracted rent from the general public which has gone directly to Sasol, and as such, can be viewed as a subsidy.
16. Until 2011, the Department of Minerals and Energy was responsible for both portfolios, but there are now two separate departments.

Case example

High level corruption: Affecting our energy future

The last few years has seen numerous articles in the mainstream media linking a powerful business family (the Guptas) with both the coal and nuclear industries and key decision makers in government including current SA President, Jacob Zuma. While many allegations of corruption have yet been proved, there is strong evidence.

The Public Protector issued a report entitled 'State of Capture' in November 2016 [73]. The report includes details of how Eskom illegally advanced ZAR 600 million to the Gupta-owned company Tegeta Exploration and Resources, which was then used to purchase all the shares in the Optimum Coal mine and concludes that "... the conduct of Eskom was solely to the benefit of Tegeta". After being implicated in the State Capture report, the Eskom CEO Brian Molefe, stepped down in November 2016 in the interests of "good governance" [74] but subsequently made his way into the legislature as a member of Parliament [75]. It was then announced in early May 2017 that he would resume his post as the CEO of Eskom, amidst substantial public outcry and protest

The Denton Report (commissioned to investigate allegations of impropriety in Eskom) has implicated other high-ranking Eskom officials, including interim CEO Matshela Koko in making fuel tender choices (coal and diesel in particular) that were in their personal and family interests rather than those of Eskom [76].

There are also strong connections between the Gupta family (who also own the Shiva uranium mine), President Zuma and the Russian government in relation to the proposed nuclear expansion programme [77]. There is a widely held belief that two successive finance ministers have been removed by President Zuma because neither were willing to sign a nuclear deal [73], [78]. In April 2016, the High Court found that the ministerial determinations to procure 9.6 GW of nuclear power, and intergovernmental agreements with Russia (and other countries) regarding the planned procurement were "unlawful and "unconstitutional" and set these instruments aside [79].

The exact details regarding corruption at the highest levels of government may never come out, but it clear that corruption is having a self-serving effect in energy governance.

3

Positive examples

SA has undertaken a number of progressive initiatives which contribute to positive transformation of the energy sector. There have been significant improvements in access to electricity, a successful utility-scale RE programme, and steps to put better public transport in place. Research institutions have built up a good body of knowledge and civil society has an influential voice on energy issues. However there are issues that have the potential undermine this progress.

3.1 Energy production: The emergence of medium- and small-scale electricity generators

While the state and large multinationals control the majority of the energy sector at present, smaller scale operations are starting to play a role. Co-generation is when an energy carrier (often in the form of heat or waste biomass) that is produced during an existing process (and which would otherwise be lost), is harnessed to generate another form of energy. For example, Anglo Platinum's Waterval Smelter now uses waste heat to drive a turbine in a thermal harvesting plant. With a capacity of 5 MW, excess energy can also be fed back into the grid [81]. Collaborations are also emerging where industries are supplying energy (or energy carriers) to each other. For instance, BMW SA has an assembly facility that buys electricity from a biogas plant which in turn runs off organic waste supplied by nearby industries [82]. These type of medium-scale generators and partnerships contribute to making Eskom less of a monopoly while using lower carbon energy sources and enhancing overall system efficiency.

The rapid decline in rooftop solar PV prices and high Eskom tariffs has led to increased uptake of PV across the residential, commercial and industrial sectors in SA. This trend greatly strengthens the case for off-grid solar home systems and mini-grids in remote areas, and a growing number of municipal distributors are in the process of developing regulatory provisions for embedded generation [83]. However, the opportunity for affluent households and commercial consumers to opt out of the centralised electricity supply system will decrease municipal revenues (under the current system) and could reduce funds available for public infrastructure maintenance. This issue is addressed in Chapter 5.

3.2 Energy supply: Increased access to electricity and support for off-grid solutions

According to the DoE, between 1994 and 2016, over 6.7 million households were connected to the grid and, in the 2015/16 financial year, about 256 000 household grid connections were added [84]. This dramatic improvement in electrification was funded by National Treasury, co-ordinated by DoE and implemented by Eskom and municipalities. Work towards universal access[17] continues and importantly over 123 000 additional households were supplied with non-grid technology via solar home systems [84]. A recent study on decentralised energy systems published by the DEA [85] found that "From an economic perspective, it is clear that the off-grid programme is already a least-cost economic solution for the country...". The New Household Electrification Strategy, adopted in June 2013, focuses on more concerted work to provide access to electricity, including the installation of solar home systems by the state. While the support for off-grid solutions via INEP is a positive step, implementation of other off-grid projects is sometimes dependent on donor funding.

Widespread access to a reliable electricity supply can promote economic development in SA while reducing inequality and providing the health and safety benefits of modern energy sources. However, the key issue of affordability must be addressed in conjunction with increasing access. As described in Chapter 2, above-inflation increases in Eskom tariffs may actually reduce the use of grid-based electricity (or result in households being disconnected for non-payment) despite good programmes in place to increase access to electricity.

17. The New Electrification Roadmap aims for 97% (90% grid, 7% non-grid) access by 2025 [134].

Case example

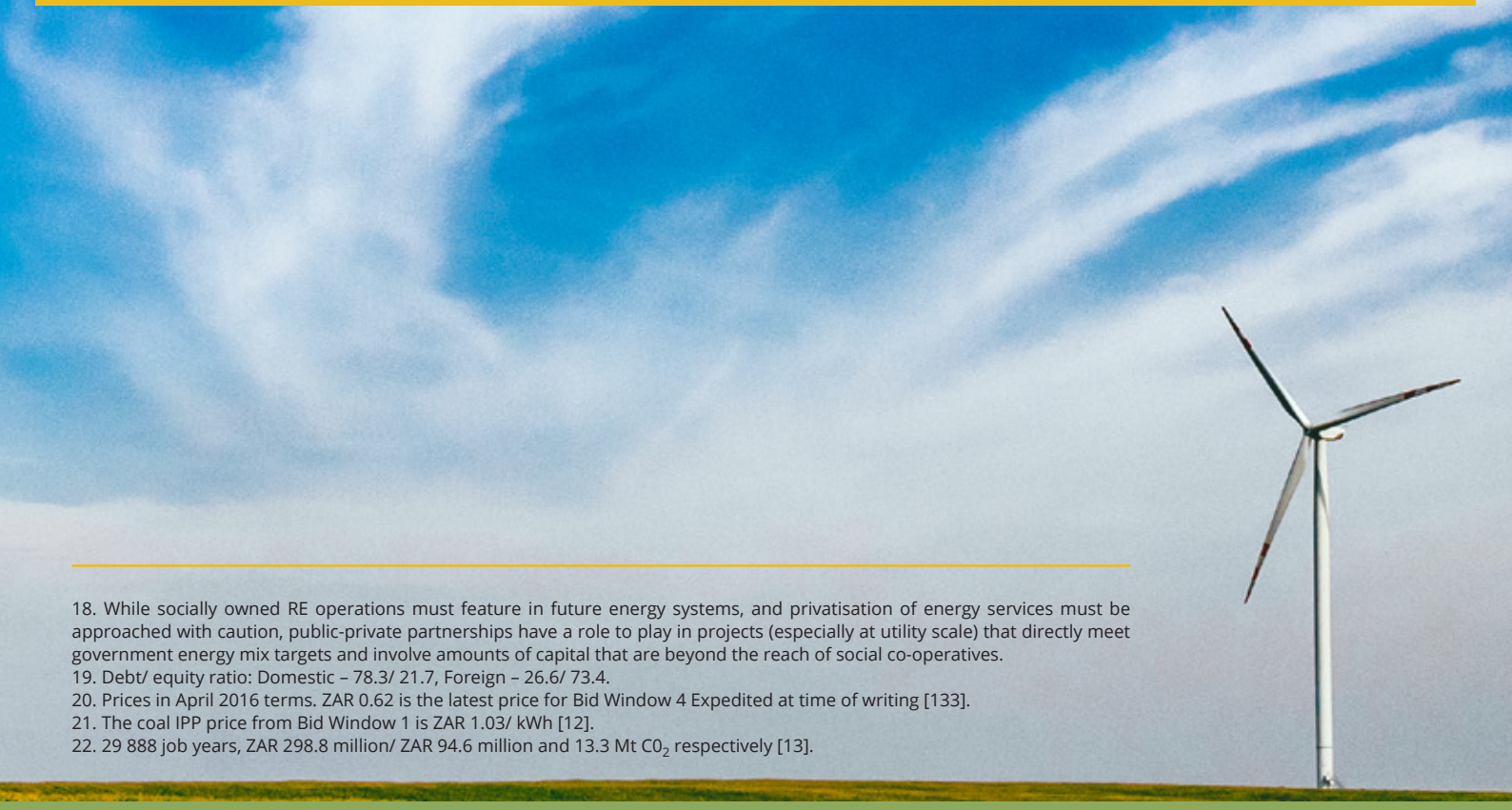
Renewable Energy Independent Power Producer Procurement Programme

The REI4P is an internationally recognised public-private partnership programme[18] that has facilitated rapid deployment of new RE generation capacity. Following a competitive bidding and selection process, IPPs then build the electricity generation infrastructure. Since there is independent project financing, any cost overruns are borne by the IPPs themselves, and not passed onto the public through increased tariffs. Power purchase agreements (PPAs) set a tariff (with provision for escalation with inflation) at which Eskom will purchase all electricity supplied for a 20-year period. The bidding IPPs also have to meet local economic development (LED) requirements. Since 2011, new RE capacity of 6 422 MW has been procured, of which 2 902 MW has been connected to the national grid. Total investment by September 2016 was ZAR 201.8 billion,[19] with 24% from foreign sources: Europe, the USA, Asia and other African countries [13].

A key outcome has been a dramatic drop in prices for large scale RE. Tariffs awarded for solar PV energy have fallen from ZAR 3.65 to ZAR 0.62 per kWh,[20] and wind energy from ZAR 1.51 to ZAR 0.62 per kWh, making RE the lowest cost new-build electricity generation option in SA.[21] The REI4P has essentially made large scale renewables economically competitive in SA, which is a major positive step for the energy sector.

The success of the programme can be attributed to having a stable policy and a bidding process that is both comprehensive and transparent. The IPP procurement office has been slightly distanced from the DoE and has functioned without the usual levels of political interference. Private investors and financiers like the process since it is well-designed, is sufficient profitable, and certain key risks are borne by government [80]. The REI4P has also provided positive outcomes in terms of job creation, socio-economic/ enterprise development and reduced carbon emissions.[22] The programme has been pivotal in successfully in kick-starting the utility-scale RE industry in SA, which could lead to the transformation of the energy sector.

Despite the overall success of the REI4P, there are some issues that need to be addressed. The incremental procurement approach (prioritising price reduction for grid supply) is not optimal for driving localisation of manufacturing, nor for facilitating social ownership in the energy services sector. There has also been limited success in turning project developers' LED commitments into lasting impacts on the ground. Trade unions whose members are employed in legacy energy systems have expressed opposition as they fear a net loss of jobs in the energy sector.



18. While socially owned RE operations must feature in future energy systems, and privatisation of energy services must be approached with caution, public-private partnerships have a role to play in projects (especially at utility scale) that directly meet government energy mix targets and involve amounts of capital that are beyond the reach of social co-operatives.
19. Debt/ equity ratio: Domestic – 78.3/ 21.7, Foreign – 26.6/ 73.4.
20. Prices in April 2016 terms. ZAR 0.62 is the latest price for Bid Window 4 Expedited at time of writing [133].
21. The coal IPP price from Bid Window 1 is ZAR 1.03/ kWh [12].
22. 29 888 job years, ZAR 298.8 million/ ZAR 94.6 million and 13.3 Mt $C0_2$ respectively [13].

3.3 Energy use: Improvements in the transport sector, particularly road transport

Since road transportation accounts for ~25% of total final energy use by sector (Chapter 1), it is critical that this component is transformed. Large-scale surveys show that ~70% of households already use minibus taxis [86]. Minibus taxis are preferable to private cars in terms of fuel use and emissions per capita, but buses and trains allow for even greater relative reductions in energy use and pollution. However, there has been a longstanding perception that public transport in SA is characterised by long waiting times, overcrowding, inaccessibility and reliability/ safety concerns, with only ~20% of households using buses and ~10% using trains[23] [86] in 2013.

To address these issues, substantial work has been undertaken in recent years to develop better public transport infrastructure, notably bus rapid transit (BRT) networks in several provinces and the Gautrain[24] in Johannesburg and Pretoria. These provide good quality service, and are a significant improvement compared to older bus and train services. This is pivotal to get more people to switch from private cars to public transport, which also reduces traffic congestion. These safe and efficient new public transport systems have been well supported, the routes are expanding, and there is a high level of public support.

The main issue is fares which are not easily unaffordable for low-income households, and which should be addressed, possibly via government subsidies of some sort. However, this investment in high-quality public transport is a positive first step toward a better, integrated transport system.

There are ongoing efforts to shift freight transport from road to rail, as this will reduce GHG emissions in the transport sector [87]. A tax on new vehicles has been introduced to penalise high CO_2 emissions [88]. Cleaner fuel standards have ended the addition of lead to petrol and have reduced the sulphur content of diesel, but these could be improved by implementing more stringent standards. Enforcing fuel efficiency standards for new vehicles, promoting eco-driving[25], and the development of bicycle lanes [89] are further positive steps toward improving road transport.

3.4 Framework and governance: The positive contribution of civil society organisations

Civil society plays an important role in promoting public accountability and process transparency while seeking to ensure that human and environmental rights are taken into account during planning. In SA, civil society has been active in the available public consultation processes, with efforts to expand provisions for participation, and has complemented this by direct lobbying and legal action such as use of the Public Access to Information Act and submitting complaints to the Public Protector. Earthlife Africa Johannesburg (ELA) and the Southern African Faith Communities' Environment Institute are two environmental justice organisations that took successful legal action against the government's plan to develop a new nuclear industry (Chapter 2) which ended in certain agreements and a ministerial determination being set aside. The first climate change court case in SA, against the proposed Thabametsi coal fired power station, was also initiated (and won) by ELA, represented by the Centre for Environmental rights (also a non-profit organisation).

23. These are 12-15 seater vehicles that are ubiquitous in most South African towns and cities and generally provide easily available and affordable transport to the general public.
24. 2014/15 financial year operation levels: 98% for punctuality, 99% system availability [135].
25. This has been incorporated into driving school curricula to improve driver awareness of fuel consumption.

3.5 Availability of good quality resources and research

Good-quality data is a prerequisite to sound decision-making. Even though official DoE energy statistics are several years old, SA now has some great resources that have emerged from government agencies and independent academic institutions [90]. For example, the Strategic Environmental Assessment for wind and solar PV (an interdepartmental process led by the DEA) has prioritised eight RE development zones targeting high-poverty areas and provided foundations for improved grid planning and expedited environmental assessments for RE projects. The Wind Atlas for South Africa (WASA) [91] provides long-term, high fidelity wind data that can be used in energy modelling. The public availability of data like this allows a variety of groups to conduct analysis and develop alternative energy plans for SA.

In 2016 the CSIR published a study, based on three years of meteorological data and comprehensive analysis of country-wide resource availability, showing that variable RE resources could meet at least 75% of total electricity demand with the current system load profile, with the balance provided by flexible generation options such as open-cycle gas turbines and storage [92]. In 2017, the CSIR provided cost optimisation results (using the same model as the DoE), which illustrate how renewables and gas can supply SA's electricity needs at a lower cost than any new coal or nuclear power generation plants [93].

These alternative scenarios are being used to challenge draft national plans (the IRP and IEP) which seem to favour vested interests in coal and nuclear (Chapter 2), and Eskom's attempts to maintain a monopoly on the electricity sector. This is an important and positive part of the process to push government and SOEs to facilitate a just energy transformation.

4

Key process-level criteria for energy system transformation to respect human rights and planetary boundaries

Chapters 2 and 3 of this report have discussed both the positive and negative elements of the current energy system, with Chapter 2 pointing out the disproportionately negative impacts on the poor, particularly through pricing and health impacts. This trend is also recognised by the South African Human Rights Commission: "Cheap energy from the burning of coal may provide short term benefits but it is not sustainable in the longer term. South Africa's contribution to global climate change will have significant local impacts and is a threat to sustainability and to the progressive realisation of the Millennium Development Goals (MDGs), environmental rights and other human rights" [94]. This position can only be reinforced by the fact that renewables are now 40% cheaper than new coal, and since the MDGs have evolved to include sustainability criteria under the Sustainable Development Goals.

Not only does the nature of our energy system affect human rights, but it also has direct causal implications for key planetary boundaries [95] (Figure 5). Humanity must meet the justifiable needs of the social foundation, but remain within the ecological ceiling, as shown by the green doughnut.

Defining a new energy trajectory that promotes the attainment of equitable human development in the context of a sustainable planet requires reformulation of energy policy in SA.

Figure 5: The sustainability doughnut

It should be:
Open, transparent, participatory, recognises our dependence upon our biophysical environment, and affirms that electricity generation and access is a public good.

This chapter deals with high-level criteria (in the context of the transformation process itself), that will lead to future energy systems that respect human rights and planetary boundaries. These are briefly discussed in the contemporary SA context.

1. Promote a pro-poor, just transition

The concept of a just transition hinges on the notion that "the preservation of the ecosystem and resources, and employment are inextricably linked" [96]. In the South African context this has come to represent an industry level shift which must be planned to ensure that jobs lost in environmentally damaging industries can be absorbed by the "green" economy.

In addition, the transition should be in the interests of the majority of South Africans, who remain poor. Developing mechanisms such as an expanded low-income household energy policy that increases the allocation and distribution of FBE, ramps up access to non-electrical energy sources and promotes awareness of household energy efficiency options is crucial in delivering equitable access to energy. Recognising that energy usage has different impacts on different sectors of society, particularly with regard to issues such as the gendered impacts of indoor air quality, environmental impacts on places close to centres of energy generation, and the educational disadvantage for youth of energy poverty should be factored into such a policy.

These concerns are particularly relevant given Section 24 of the 1996 Constitution [97] which provides the right "to have the environment protected, for the benefit of present and future generations".

2. Promote an energy transition that also promotes economic development

The choices made about how energy services are generated and distributed have implications for SA's economic development. Choosing energy generation options that rely on foreign service providers will reduce the potential for local economic activity and job creation. This is especially true of mega-projects based on a centralised generation model, because the economic multipliers associated with decentralised grid suppliers will be lost. In addition, state-owned mega-projects carry significant debt-servicing implications. As has been seen in the IPP programme, the state may carry part of the risk for the project, but the debt is carried by the IPP.

Developing effective frameworks for domestic RE feed-in tariffs would provide a mechanism to keep middle- and high-income households connected to the grid, and it has the potential to generate numerous jobs in the solar PV rooftop industry. There are also significant economic development opportunities in energy efficiency initiatives, including new and more efficient modes of transport, as well as improving domestic, commercial and industrial energy efficiency.

3. Promote transparent decision making and good governance

As per Chapter 2, there are a large number of irregular decisions being taken around energy planning that are not the least-cost options for SA's energy supply from a financial, social or environmental perspective. Details about energy subsidies are obscure, which means that the public remains in the dark about how vested interests may affect decision making.

Opening up processes such as the IRP and IEP for meaningful and broad-based consultation is critical for effective governance so that the best possible choices to secure a just energy future are made, unencumbered by vested interests and the potential for corruption.

4. Promote public participation in a distributed energy system

Meaningful public participation must go beyond consulting social groups on the nature of energy planning. It should also strive to include broad sections of society, especially those on the economic periphery, in the actual implementation of the plan on the ground. This means developing mechanisms for socially owned energy generation infrastructure, which must in its very nature be spatially distributed in order to promote transmission efficiency as well as social equity goals. This should be supported by focusing on energy choices that can promote the growth of local industry for the support of this energy infrastructure.

5. Prioritise low-carbon and least environmentally damaging options

SA's international obligations to combat climate change include honouring its commitment to cut carbon emissions by 34% by 2020 and 42% by 2025 [98]. Beyond this, energy planning must select options that have the lowest impact on land and soil systems, freshwater sources, ocean health and biodiversity, and the least pollution.

By 2017, a national energy plan based on RE was shown to be the cheapest, to have the lowest carbon emissions, the lowest water use, and the lowest overall environmental and social externalities [99]. Future low-cost options can now also be low-carbon options, which are both the most appropriate for SA, and will enable the country to meet its international climate change obligations most quickly.

5

Scenarios: Planning for transformation of the energy sector

Energy sector transformation is key to a broader societal transformation with environmental and social justice at its core. Universal access to energy is an underlying premise for a transformed energy system, with the desired sources of energy guiding what changes are needed to achieve this vision. By 2017, we have reached a point where large-scale energy systems based on RE are technically possible. This is now beneficial not only in terms of environmental and health benefits, but can also be cheaper without subsidies. As a result, the discussion of how to achieve this transformation now centres on politics and governance. In SA, we are faced with a situation where the transparency around decision making has reduced, while vested interests and patronage politics are shaping our energy future. National energy planning is evidently influenced by certain powerful individuals who stand to benefit from specific fuel and infrastructure tenders, while side-lining progressive alternatives.

This chapter is not intended be exhaustive. It aims to highlight critical points of change from the status quo of the energy system (diagram in Appendix 11), to identify some current policy/ planning options, and to a give brief overview of funding mechanisms.

5.1 Fundamental components of energy transformation in SA

- Making a fundamental shift in the energy mix to low-carbon sources at least cost.
- Adapting infrastructure to allow renewable energy to be the major contributor to energy supply.
- Expanding the energy supply system (particularly off-grid solutions) to achieve universal access.
- Developing pricing models that allow for the equitable use of energy.
- Moving from centralised, monopoly/ oligopoly ownership of energy generators to decentralised, community-owned models.
- Avoiding complicated mega-projects with a small number of direct beneficiaries.
- Maximise overall energy system efficiency by reducing the conversion of non-renewable resources and minimising wastage of all energy carriers through the value chain.
- In the long term, moving towards electricity as the primary energy carrier.

5.2 Overarching political and governance issues that must be addressed to achieve change

- Finding ways to combat political bias and the dominance of vested interests in energy governance.
- Reversing patronage, corruption and state capture, particularly in relation to mineral resources and the provision of basic services such as access to energy.
- Recognising the importance of relationships between affordable energy services, poverty alleviation, gender equality, food security, and water supply.

SA requires a development model that serves the public interest and positively affects all stakeholders in the long term. A transition to RE can be a catalyst for development that seeks synergies between business interests and social/ environmental imperatives. To this end, government and business decisions should be directed to achieving the most resource-efficient systems and sustainable practices, while recognising the need to mitigate short-term social and detrimental economic effects where necessary. Environmental fiscal reform, including a real carbon tax on emissions, could contribute significantly to a just energy transition.

For a just transition to take place, the interests of specific interest groups (e.g. owners of the fossil fuel industries and their employees) in maintaining the status quo cannot be allowed to trump the broader interests of SA society as a whole. While it is true that workers in the fossil fuel industry would bear the initial brunt of the transition disruption, this should be managed with dedicated support including reskilling and localisation of alternative industries.

5.3 What change is required and how are stakeholders affected?

Energy transformation in SA has different requirements at different levels of the energy system over various timeframes. Effects on various stakeholders and opportunities for a just transition are discussed in this chapter and the specific policy recommendations relating to these changes are presented in Chapter 6.

Energy production

While a future energy mix that focuses on a range of RE and a transition from fossil fuel will provide widespread, long-term social and environmental benefits, critical barriers such as existing energy subsidies and taxes and a shift in investment models must be addressed.

Subsidies and taxes: Transparency is required for informed decision-making

Subsidies are a complex issue. There are arguments for subsidising energy sources that have positive climate change, health and social benefits, while there is a case for having a more level playing field (i.e. minimal subsidies across the board). In order to make decisions as to what path of funding support to take, all the information on current subsidies must be made available. At present, much of this information is not in the public domain [100]. Proper financial comparisons of energy source costs can only be done with access to all the relevant information. Once the appropriate information on existing market instruments and energy costs including all externalities (environmental and social impacts) has been collected and made available to interested and affected parties, then more meaningful discussions on subsidies and taxes can take place and decisions made. Furthermore, the numerous exemptions in the proposed carbon tax should be reduced to ensure that there is sufficient incentive to reduce emissions.

Investment choices should avoid the risk of overcapitalising on large-scale inflexible generation options

A paradigm shift is required in investment thinking which recognises the long-term benefits of transformed energy systems. In a future where large, centralised energy generations such as coal and nuclear power plants will become stranded assets, substantial amounts of sunk capital will fail to generate a return. Making this change in long-term thinking will have a direct effect on current investment decisions.

Moving away from coal will require significant political will

Primary energy supply in SA is heavily reliant on its own coal for electricity generation and synthetic fuel production. Since burning coal and converting it to liquid fuels contribute to climate change, environmental degradation, air and water pollution, and a host of health impacts, its use as an energy source must decline. While this will provide opportunities in alternative energy sectors, the prevailing resistance from players in the coal sector is sure to continue. In addition, Eskom and Sasol are tied to coal in their current business models. Both entities are major and influential players in the national energy system. Furthermore, there are strong individual interests in coal (at the level of political decision makers[26]) beyond its contribution to the economy as an export product. Coal has been entrenched in both the energy and economic system for such a long time that a shift will also require fundamental changes at a governance level and an understanding that not all available mineral resources should be exploited. Mitigating the risk of opposition from organised labour will require putting in place programmes for reskilling and employment opportunities, and this poses a significant potential challenge.

Substantially increase the proportion of large- and medium-scale renewables in the energy mix

RE has a key role to play in covering future increases in national energy demand, and to replace capacity currently provided by fossil fuels. Over and above the environmental pollution, public health and climate change benefits, these technologies are now economically competitive, and provide more jobs per unit of energy than fossil fuels [101]. In the long term, they will reduce the relative cost of grid-based electricity. All of these benefits apply to society at large and to investors and players in the RE industry. A distributed and decentralised RE based generation system that allows and enables social ownership of the generators will benefit communities at a local level and will receive support from labour unions. However, these changes are at odds with Eskom's model of centralised control of generation and the current political and vested interests in both the coal and nuclear industries. Not surprisingly, these stakeholders are opposing RE at a number of levels.

26. A significant number of influential people in government have direct or family business ties to the coal mining sector. This includes the current President, Deputy President and Minister in the Presidency (as at April 2017).

Promote the cost-effective use of small-scale embedded generation (SSEG) and co-generation

To achieve a transformed energy sector, SSEG and co-generation will play a major future role at the residential, commercial, industrial and municipal levels. The combined economic trends in SA of falling technology costs (especially rooftop solar PV) and increasing costs of grid-based electricity are financial drivers for the uptake of SSEG and co-generation. However, the lack of regulation is a serious concern as increasing affordability of RE technology enables private off-grid systems which do not support a co-generation model and therefore cannot contribute to making grid-based electricity more affordable for people in need. Some cities have started making provision for this, but this must be supported at the national level [102]. These changes are directly linked to, and will have effects on, the supply changes of pricing, technical grid adaptations and the role of municipalities (discussed in the next section).

Make infrastructural provision for the expanded use of gas, particularly biogas

Gas only contributes about 3% to current primary energy supply, but it is a useful fuel for flexible power generation. Gas-powered generators can be designed for variable gas sources, which could be used for natural gas from imports in the short term and, in the long term, be used in conjunction with local biogas projects. These changes should provide job opportunities, particularly for workers from the coal and oil industries, as they already have some of the necessary skills. The use of shale gas through hydraulic fracturing is a contested issue, and evidence from the USA is that there is a definite risk of ground water contamination [103]. This is a serious concern, especially in a water-stressed country like SA.

Energy supply

Eskom: Structural reform or unbundling

The vertically integrated nature of the SA electricity industry, with Eskom having a virtual monopoly over the sector, has resulted in financial mismanagement, ineffective planning, operational inefficiency and corruption in the utility for many years [76]. Furthermore, despite being state-owned, Eskom has effectively been undermining the government-backed REI4P by refusing to sign PPAs with IPPs since July 2016, which appears to be a move to protect its own financial viability and its interests in coal and nuclear [104]. There is widespread support for the restructuring of Eskom among members of the general public, academics, commerce, and industry. However, the details of what change is required is subject to debate, with contrasting views on which components of the electricity system should be public rather privately run, and how to this relates to basic service provision. The options that appear to have the most support are variations on a theme in which Eskom maintains and manages the grid (transmission) and shares the distribution infrastructure with municipalities, while electricity generation is provided by Eskom, the municipalities, IPPs, businesses and individuals in an open market. This approach would empower an independent body to manage supply and demand in the system. An Independent System and Market Operator (ISMO) Bill was first introduced in Parliament in 2011 [105], but the Bill was rejected, and a revised Bill is still under consideration.

The national grid should accommodate new generation technologies and energy flow patterns

An energy system with a higher proportion of distributed small and large scale RE generators will require changes to the national grid. Energy storage options will need to be built and linkage systems between mini-grids and larger grid modules will need to be designed. Provision will need to be made for both smart and net metering, with increased feed-in of electricity from residential and industrial sectors. Consequently, the nature and scope of electricity system operators will change, and will be better suited to a situation where electricity system management is a public service, rather than a profit-orientated business.

Municipalities should play a greater role in energy management

In a future system of greater distributed and decentralised energy generation, municipalities should have an increased role in the generation of energy, as well as in management tailored to local needs. As seen in Chapter 1, energy use in different towns and cities varies enormously, and municipalities are best placed to manage the energy system and do transformational planning at local level.

The electricity pricing structure should adapt to future energy systems

A shift from fossil fuels to renewables will necessitate changes in the electricity pricing structure. The first issue is a possible reduction in net consumer demand for grid electricity (due to off-grid electricity options and co-generation coupled with increased energy efficiency) until EVs are more affordable (which will increase electricity demand). As a result, the price of grid electricity will need to be carefully structured. It needs to remain competitive while covering its costs, but not impact negatively on low-income households which have least access to energy alternatives. The second issue is the

need for time-of-use tariffs to shift consumption to align with generation. Tariffs are a complex issue, beyond the scope of this study, but the key message is that significant work will be required on electricity pricing (including feed-in tariffs), and that current pricing structures are not suited to the needs of future energy systems. This will also have a direct effect on the role of NERSA, and on municipalities, which currently use revenue from electricity sales to cross subsidise the provision of other services [106].

Increase access and affordability of electricity: The role of consumer subsidies and off-grid solutions

In addition to providing access to electricity to the ~10% of households that currently have any, government should take steps to reduce the costs of grid electricity. Many households cannot afford to buy sufficient electricity for the month and only use grid electricity for lighting in their homes. Access to affordable electricity helps mitigate the harmful health effects of alternatives such as paraffin and fuelwood (Chapter 2). While it will be necessary to improve the implementation and structure of FBE/ FBAE subsidies, an expanded programme to provide off-grid solutions, such as subsidised rooftop solar PV, can help address both access and cost issues simultaneously, and can be linked to social enterprise development.

Energy use

Prioritise energy efficiency

A critical change regarding energy use is simply to use less energy without reducing productivity. This will benefit all consumers by reducing costs and resource utilisation. Energy efficiency applies across the spectrum of scale and energy carrier. In an energy system of low optimisation (such as SA), it is cheaper and quicker to reduce energy costs through efficiency improvements than to increase generation capacity. There is enormous opportunity for interventions[27] to be made by individuals, organisations, corporations and municipalities to make their use of electricity, gas and liquid fuels within the current system more efficient. Moving forward, new objects (from appliances to buildings) must be built with energy efficiency as a chief design parameter. Generally, gross economic loss from energy provision stakeholders will be balanced by economic gains from opportunities in industries promoting energy efficiency (e.g. retrofitting) and reduced energy costs for end consumers.

Transport sector: Reduce liquid fuel use and facilitate a long-term move to electric vehicles

Petroleum products form the highest proportion of final energy use (35%, Figure 3), and the majority of this is allocated to transport. As mentioned in Chapter 1, EVs should take the role of reducing liquid fuel use in the long term while, in the short term, SA must focus on integrated public transport as part of effective city planning along with vehicle fuel efficiency. The question then remains about which is the best source of petroleum products in the short term. Sasol's CTL plants and SA's ageing oil refineries are all highly polluting, worse than international standards. Since the majority of oil is imported anyway, there is an argument that SA should just import refined products in the short to medium term. This move would meet opposition from stakeholders in the oil industry, and have impacts on energy security, but be welcomed by those living near conversion and refining facilities. These difficult trade-offs reinforce both the need to electrify transport and decarbonise electricity generation as soon as possible. There are also alternative methods of producing synthetic liquid fuels (from electricity, water and CO_2) that can be commercialised for functions such as aviation, which are unlikely to be electrified in the near future.

Biomass: Promote efficient use and support for biogas opportunities

For at least the medium term, biomass and paraffin will continue to be an important energy source for low-income and rural households. Until universal access to affordable electricity is achieved, the most practical changes around biomass relate to using fuel-efficient stoves and thermal cooking bags to reduce fuelwood consumption and indoor air pollution. Educational programmes around the safer use of paraffin can reduce fires and poisoning accidents. A transition from wood to organic waste can be facilitated by biogas technologies, but this will require technical and financial support in most of the applicable areas. The Eastern Cape and KwaZulu-Natal are well suited to this due to large number of farms (agricultural waste) and sugar cane plantations (bagasse).

Industry should be the sector that leads energy transformation

Since industry is the largest energy user by sector (Figure 4), it can potentially have the greatest impact in leading energy transformation. Furthermore, industrial players are quite likely to have the necessary capital to initiate significant energy efficiency programmes and install their own renewable and co-generation facilities.

27. E.g. Lighting: increased use of natural lighting in buildings during the day, reducing electricity by using compact fluorescent lamp bulbs, motion sensors/ timer switches so lights are off when not needed.

Framework and governance

Having progressive policies is not sufficient, they must be effectively implemented

SA has a number of good policies and pieces of legislation, but there has been a noticeable shortfall in implementation, processes for strategic prioritisation, and participatory decision-making. Implementation has been delayed in the past by lengthy parliamentary procedures that can take years to complete. There are democratic institutional arrangements for deliberation of these issues, such as the National Economic Development and Labour Council (NEDLAC), but these are not being effectively or transparently utilised. This provides conditions conducive to patronage, corruption and manipulation by vested interests.

Policy alignment should be improved and climate change ambitions increased

Regulations regarding water, air and land protection along with GHG emission reductions are managed by the DEA. These and other climate change and human rights issues are directly linked to energy, but are often handled by different government departments, resulting in a disjuncture in policies. Furthermore, in areas such as RE expansion and emission reductions, the targets are too low to have the necessary climate change mitigation effect, even if they were implemented [107].

Public participation should be improved and have tangible impact on policies

The current energy planning process has fairly limited participation in decision making. There is often no proper record of how public concerns are incorporated into final policy development, and consultation regularly appears to function as a tick-box exercise without much meaningful impact. There should be systemic transparent planning that treats all energy resources equitably, acknowledges all externalities and meaningfully includes all voices in such decisions.

Lock-ins: Avoid further infrastructure development in coal and nuclear

Despite international obligations to reduce emissions, there is still talk about building yet another large coal-fired power station: 'Coal 3'. The construction of a nuclear fleet of 9.6 GW (or more) is still under consideration. Any further utility-scale coal or nuclear plants will potentially set the renewables programme back or result in stranded assets. Neither coal nor nuclear new builds are progressive steps in energy transformation at least cost, since renewables are now the cheapest new-build options. While nuclear has low operational emissions, the financing costs of construction (medium term) and decommissioning/ waste management (long term) are economic lock-ins that will limit funding available for other areas of energy system transformation.

5.4 What future energy options and policies can be considered?

SA has ample renewable and non-renewable energy resources (with the exception of oil and natural gas). There are more opportunities for energy development than is required for sustainable development, even if SA greatly increases energy exports. Therefore, key constraints on options are existing infrastructure (and projects under construction), vested interests, and inaccurate perceptions (such as statements from Eskom) that alternatives to the existing energy system are not really viable.

For proponents of a just transition to sustainable energy, the pivotal question regarding available options has shifted from how much can be done with renewable energy and how quickly, to how the use of fossil fuels can most responsibly be scaled back and how fast. The answers to the first question are increasingly well-established in the public domain (though still contested), while the information required to answer the second, such as the condition of existing infrastructure and the extent to which public investment is linked to fossil fuel use, is not available in the public domain, even when it is available to the state.

A key challenge facing energy stakeholders in SA is a lack of any process or coherent propositions for determining the primary energy supply mix, especially the role of coal, in the short-, medium- or long-term future. This inhibits strategic decision-making regarding the most desirable energy carriers, and the optimal use of state capacity for financial risk-management for infrastructure development. A failure to make a choice between alternatives is effectively a decision to perpetuate the status quo.

Policy options from government

As discussed in Chapter 1, the SA government has addressed universal access through the INEP. The DEA has promulgated the NCCRPWP as a climate change response, and the biofuels policy aims to assist in decarbonising the liquid fuel sector. The NDP contains low carbon and energy chapters and a transport masterplan. While these options exist on paper, with the exception of INEP, SA is yet to see meaningful results. Furthermore, a number of Acts and policies are more than 10 years old (see Appendix 9), and are based on outdated energy figures. The REI4P, on the other hand, has been successful in adding RE capacity to the national grid and attracting investment, but is now under threat due to political moves from Eskom [104], the coal sector [108] and the National Union of Mineworkers [109].

The most direct plans from government regarding the energy future of SA are the IEP and IRP, which are both under review (as at May 2017). The IEP is essential toothless, as it is a guideline and is not enforceable (which leaves a lack of proper direction, particularly for the liquid fuel sector). The draft IEP 2016 supports developing all available energy opportunities, but gives no coherent plan or investment priorities to put this into practice. Furthermore, there has been no consideration of significant or deliberate shifts in the proportional share of energy carriers in the supply mix, though the NDP does suggest that such change is desirable. In fact, the proposed IRP base case actually restricts RE availability, resulting in a sub-optimal solution, even before any policy adjustments. This leaves the 2010 IRP, which despite being six years out of date, as the official mandate on electricity infrastructure planning until the current review is complete. On balance, government planning and policy statements reflect a resistance to anything more than incremental change in the energy sector, with the apparent exception of an insistence upon the acquisition of a new nuclear industry.

Policy options from credible research institutes

Two leading SA energy research institutes are the Energy Research Centre at UCT and the CSIR. The ERC has modelled energy options for the future that meet key socio-economic parameters, but remain within a 14 Gt CO_2 equivalent cumulative energy sector constraint [110]. ERC studies on decarbonisation [111] reiterated that lack of transparency and power struggles within policy sphere are main barriers to transformation in the sector, while an analysis of the proposed nuclear build programme [112] concluded "... that there is no economic case to be made for a firm commitment to commissioning a full fleet of 9.6 GW of nuclear power by 2030".

The CSIR has used the same modelling software as the DoE used for the IRP, but with updated cost assumptions and without limiting any specific technology. Researchers there have developed a least cost option to 2050 [99] based primarily on wind, solar and flexible generators (natural gas, CSP, hydro, biogas). By comparison to the draft IRP base cases from the DoE (Figure 6) the CSIR option uses less water, emits less CO_2 and is significantly cheaper, both in predicted yearly system costs and consumer tariffs.

Policy options from NGOs and civil society

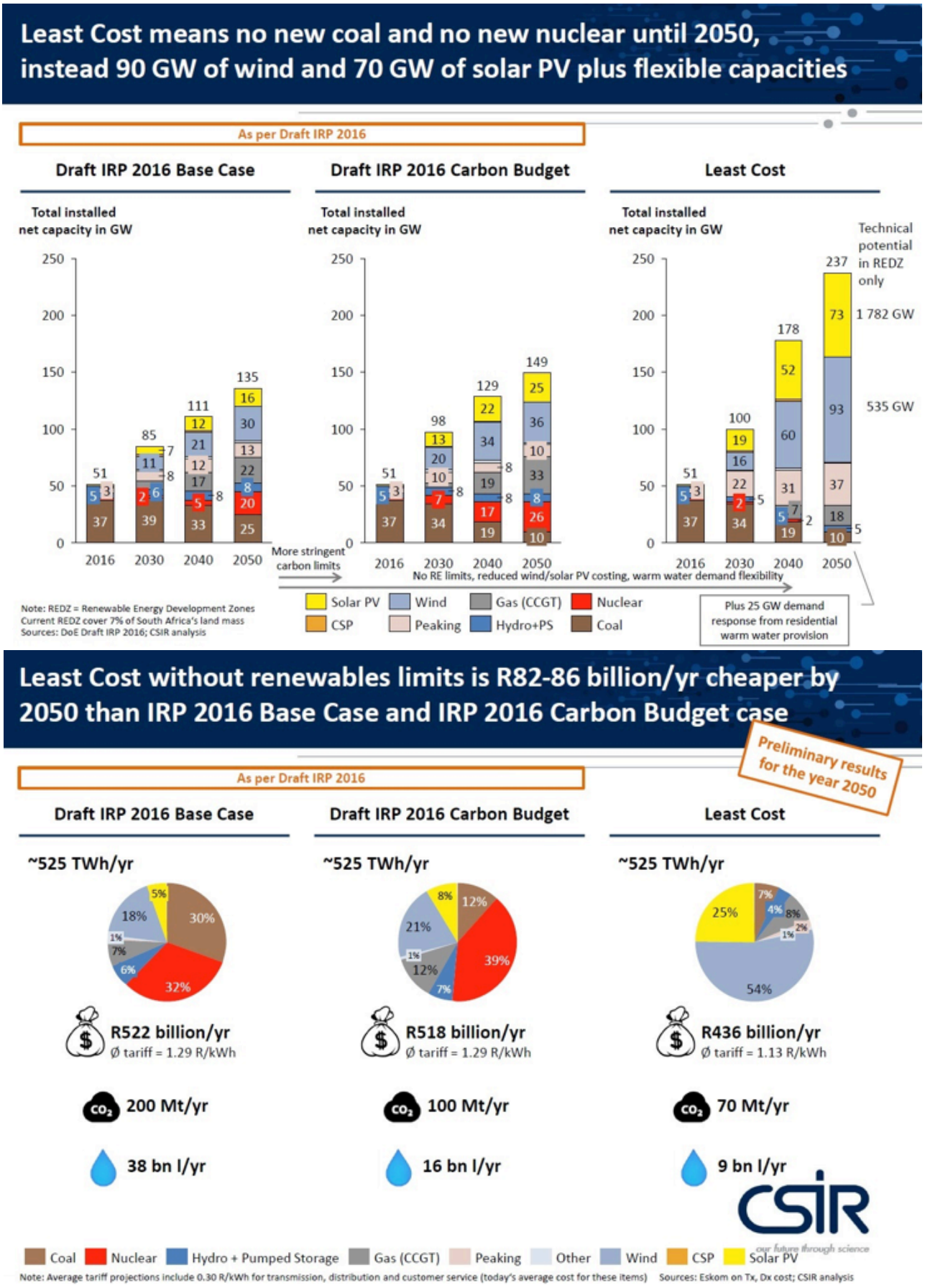
A number of established NGOs have produced future energy recommendations for SA. Some examples include: "Depending on Renewable Energy: South Africa's Best Development Path" by 350.org [113] in 2015, "Renewable Energy Vision 2030 – South Africa" by WWF [114] in 2014 and "Powering the Future, Renewable Energy Roll-out in South Africa" by Greenpeace [115] in 2013. The Energy Governance Initiative of SA (a network of CSOs) produced "Smart Electricity Planning" [116] in 2013. Key themes in all these reports include a transition from fossil fuel to renewables as the major primary energy source, no new nuclear capacity, improved energy governance, and the promotion of energy efficiency.

5.5 Which energy planning options and policies have public support?

Both the IRP and IEP drafts of 2016 were heavily criticised at the public hearings, and there is not much support for either in their current form outside of Eskom and the fossil fuel/ nuclear fuel industries. Conversely, the "alternative IRP" scenario presented by the CSIR has been widely commended in the media and appears to have support from business, industry and civil society. The nuclear lobby and representatives of the fossil fuel industry are opposed to it, but presumably on grounds that their preferred energy sources do not feature significantly in the future. The pattern is clearly one of organisations and corporations supporting the option that favours their vested interests, with the general public favouring the options that cost the least or take the environmental and health aspects into account. Scenarios from environmental groups get support from CSOs and community-based organisations, but less from the wider public as they are often seen as admirable but unrealistic.

The fundamental change in the last few years has been that the least-cost options (in the long term) are now also the ones that have lower environmental and health impacts due to steadily declining RE costs. This key point is likely to cause a further shift in support from business/ industry away from fossil fuel and nuclear-based options, unless there is government intervention to keep energy prices from coal and nuclear artificially low by subsidisation (funded by the taxpayer).

Figure 6: The CSIR 'Least Cost' plan compared to the DoE draft IRP 2016 'Base Case' and 'Carbon Budget'



Source: CSIR, Electricity Scenarios for South Africa. Presentation to the Portfolio Committee on Energy, 2017.

5.6 What funding is available for energy sector transformation?

This question is viewed in relation to the components of energy system transformation cited above. The short answer is that there is comparatively little funding[28] for energy system transformation at present, given the overall size of the energy sector. This does not necessarily reflect the potential amount of funding that may be available, it is because that there are relatively few large-scale transformation projects in SA for which funds are currently being sought.[29] An exception to this is the REI4P, which was discussed along with financing in Chapter 3. The main funding source categories, and examples of contributions to energy sector transformation, are summarised below, but many projects will receive funding from a combination of sources. Future funding could be increased by implementing the policy recommendations in Chapter 6.

National government – funding from the national budget

Electrification is largely funded from the national fiscus. Beyond residential grid extension, a number of the RE IPPs have been connected to the national grid, and there is an off-grid residential programme.[30] Analysis of the expected national expenditure by DoE for the next three years [117] shows a limited allocation of only 9.3% of the total budget to the Clean Energy Programme, which covers energy efficiency, demand side management (DSM) and RE. In principle, the mandate of the South African National Energy Development Institute (SANEDI)[31] covers energy system transformation, and it has been allocated a budget of ZAR 237.1 million for 2017/18. Some funds allocated to the Climate Change and Air Quality programme under the DEA budget (ZAR 294.9 million for 2017/18) could be used in energy-related work, but this will require a high level of co-operation between the DEA and the DoE.

Local grants and loans – limited availability at present

Prior to 2014, the SA government invested ~USD 3.48 billion in grants and ~USD 139.1 million in loans for climate change-related programmes, but only ~USD 376 million of the combined total was directly for energy system transformation-related projects [118]. There have been a few other sources of local grant funding over recent years, but the current status of available resources is not clear, as it appears that a number of committed funding streams, such as the Green Fund,[32] have been fully allocated [119]. Provincial and local governments are promoting low-carbon pathways, mainly via energy efficiency, SSEG, and solar water heater initiatives, but sustainable financing models (in relation to municipal revenues) are still being developed.

International grants – future may depend on historical performance

Between 2000 and 2014, SA received ~USD 269.8 million in grants from bilateral and multilateral donors for climate change-related programmes, of which ~USD 195 million was directly for energy system transformation activities [118]. The Wind Atlas for South Africa was pivotal in launching the wind industry as part of the REI4P, and received funding from the GEF and the Danish International Development Agency. The success of WASA could be used as evidence to apply for more funding from these organisations for additional wind projects. GIZ[33] has sponsored and funded a number of initiatives including the Solar Energy Technology Roadmap, the formation of the South African Renewable Energy Council, a national biogas strategy, and extensive solar cooker research [120], and it is likely that this kind of co-operation with GIZ will continue. The Development Bank of Southern Africa is accredited with Green Climate Fund [121], which enables the bank to process applications for funding for climate change adaptation and mitigation projects from a global pool of funds, which aims to reach USD 100 billion per year by 2020 [122].

International loans – become increasing problematic with credit rating downgrades of Eskom and SA

Between 2000 and 2014, SA received USD 2.27 billion in grants from bilateral and multilateral donors for climate change-related programmes and ~98% was directly for energy system transformation activities [118]. In 2010, Eskom secured a USD 3.75 billion loan from the World Bank. While the majority covers aspects of the Medupi coal-fired power station, it also contributes to the construction of a 100 MW wind farm and a 100 MW CSP plant [123]. To build transmission lines to connect RE IPPs to the national grid, Eskom secured a USD 339 million loan in April 2015 from Germany's kfW development bank [124], and another loan from the New Development Bank (NDB) was approved in April 2016 for USD 180 million [125]. However, Eskom is yet to build the CSP plant that formed part of the 2010 World Bank loan agreement, and it has not signed the NDB loan or utilised all of the kfW loan [126]. SA has also had concessional loans through the Clean Technology Fund [127], but prospects for further funding are unknown based on Eskom's poor implementation record and an incremental national approach.

SA's credit rating was downgraded to junk status by S&P [128] and Fitch [129] in April 2017. This will have a major impact on the availability and cost of new finance, as well as increasing the burden of existing loans, which will all contribute to difficulties in accessing international funding for transformation in the energy sector.

28. Difficult to quantify: no single repository of information, and funding data in terms of subsidies often unavailable.
29. Although energy sector transformation does feature in SA's current energy policies, implementation, apart from the REI4P, has been slow and sporadic. Eskom's resistance to the REI4P and government's seeming prioritisation of coal and nuclear capacity expansion has left limited funding for wider transformation.
30. Only covers 7.5% of planned connections over medium term (3 years), budget for 2016/17 is ZAR 171.8 million [117].
31. See Table 1, Chapter 1.
32. Covers energy efficiency, RE, off-grid and mini-grid solutions in promoting low carbon development pathways.
33. GIZ = Deutsche Gesellschaft für Internationale Zusammenarbeit.

Private finance

Private capital used to develop entities such as energy services companies (which implement energy efficiency technologies aimed at reducing the energy bills of their customers), solar water heater installers and service providers for small scale generation (primarily rooftop solar PV) has increased in the last ten years. Since the REI4P programme, much larger private investors have entered the RE market in SA, including, in some cases, private commercial banks [130].

6
Policy and planning recommendations

In addition to the main policy recommendations listed below, there are a few fundamental changes in overall governance in SA that are needed to maximise the positive outcomes of policy and legislative reform, particularly those focusing on an improved energy future:

1. Corruption, vested interests, and political interference should minimised if policies are to be effective. The role of the NERSA could be expanded to evaluate policy implementation, along with an independent body to manage infrastructure tenders to reduce patronage and nepotism.
2. A dedicated institutional facility or platform should be established to co-ordinate a just energy transition. This could be housed within the National Planning Commission.
3. The Department of Planning, Monitoring and Evaluation should have the necessary resources to enforce policies so that they are actually converted into meaningful action.
4. All information on national energy planning (including subsidies) should made publicly available.

6.1 Two immediate priorities: IRP, IEP and positive energy sector transformation policy

a) The IRP and IEP should be developed in an open, logical and unbiased manner

- The IRP assumptions should be corrected (particularly around costs and build limitations) and then a new base case should be generated before further engagement with the public takes place.
- The DoE should partner with leading research institutes in its modelling work, so that the best available science is the basis for all energy scenario planning.
- The IRP design should be flexible enough to allow for the required regular revision.
- The IEP should be developed into a coherent plan that aligns with the IRP.
- The IEP should include state-driven electrification of transport and decarbonisation of power supply at its core. The non-electricity section should be enforceable rather than just be a guideline.
- The current nuclear procurement process should be stopped until the current revision of the IRP has been finalised.

b) Develop a dedicated policy for energy sector transformation

- A clear plan should be developed for the shift in energy production from fossil fuels to renewables with clear annual targets. The plan should include plans for advancing to a decentralised, distributed generation and supply system.
- A realistic model should be developed for a "just transition". This concept has been discussed for years in civil society but now urgently requires policy-level development.[34] The transition plan should include skills transfer, retraining, and localisation of new industries.

34. A 'just transition' includes a focus on protecting the ability of workers to earn a living, so the support of trade unions is critical. Socially owned RE components should be a core feature, but the plan can extend beyond the energy sector. This plan should be developed with academics and industry players as soon as possible.

6.2 Energy production: Large-, medium- and small-scale shifts to low-carbon production

- The SA Coal Road Map should be revised for a total phase-out of coal use within a maximum of 50 years, with annual, measurable targets along the way. All coal plants that will continue to operate should be required to install best practice anti-pollution and water-saving technology.
- The targets for utility-scale RE to expedite the movement away from fossil fuels should be made much more ambitious, with clear annual, measurable targets. This should be coupled with a framework to guide public-private partnerships and local content. Within the REI4P, the design and implementation of LED activities should be improved.
- The Nuclear Energy Act should be revised to focus on the safe operation, waste management (particularly high-level waste) and decommissioning plans for existing installed nuclear capacity.
- The Gas Act should be updated to include the bridging role of gas for flexible power generation with the long-term aim for gas-powered generation facilities to be running off biogas. The Gas Utilisation Master Plan (GUMP) should incorporate more new utility-scale biogas projects.
- The Clean Fuels 2 programme (which was published in 2012) should be implemented immediately.
- No more CTL plants should be included in energy planning, but research into alternative mechanisms of synthetic liquid fuels production should be made a priority, particularly for aviation.
- The Electricity Regulation Act should be amended to make legal provision for the role and regulation of SSEG and co-generation in SA's energy mix. National policy and regulations should be in place for SSEG and co-generation, and these should be implemented at the municipal level for net- and smart-metering.
- Residential SSEG should be highlighted in the New Household Electrification Strategy, and a dedicated off-grid management authority should be established.
- National Desired Emission Reduction Outcomes for 2030 and 2050 should be put in place that are actually in line with the global goal of limiting warming to 2 degrees, backed up by a clear national carbon budget allocation for energy.
- Environmental standards (air and water quality, land impact rehabilitation etc.) should be enforced at all mining and energy generation facilities, with severe penalties for transgressions.
- Rehabilitation and compliance requirements should be applied across the mining sector and governed by the DEA, not the Department of Mineral Resources.

6.3 Energy supply: Focus on electricity: Alternative access, pricing reform and Eskom restructuring

- INEP should promote the best use of off-grid electrification solutions to expand access to energy including an "off-grid" unit within DoE.
- Electricity infrastructure planning should explain in detail how changes to the national grid will be undertaken and funded. This includes energy storage, integration with micro/ mini grids and load management, and elevate the role of municipalities in energy management.
- The electricity pricing policy should be updated to give comprehensive guidance on feed-in tariffs and to make planning provision for a long-term restructuring of grid electricity pricing to best suit a changing energy system. This should be done in conjunction with restructuring municipal revenues and be designed to shield low-income households from the effects of price increases. Price increases should be below inflation.
- The design of the FBE and FBAE policies should be improved to account for different numbers of people included in a "household", e.g., for FBE, each meter should be set in line with the number of people in that household, and for FBAE the monthly grant should allow for different-sized households. Implementation of the FBE and FBAE policies should be monitored and enforced and education should be provided about how to get access to these policies.
- The ISMO Bill, or a variation of it, should be passed as an initial step in restructuring Eskom.
- As regulatory bodies, NERSA and NNR, should operate completely independently from government, and should be guaranteed sufficient funding to function optimally.

6.4 Energy use: Efficiency and fuel-switching

- The National Transport Master Plan should be revised to develop a stronger integrated public transport component. Also a long-term strategy should be put in place to minimise dependence on internal combustion engines and fossil fuel inputs (primarily via long-term electrification of the transport fleet and analysis of transport sector lock-ins that favour private vehicles. Links to urban planning should be strengthened.
- The National Energy Efficiency Strategy should be made more ambitious and enforceable. Stringent new building standards should be applied, and retrofitting should be given financial incentives.
- Education and technology programmes should be established to promote the efficient use of biomass in rural areas and implementation of biogas projects in suitable regions to reduce fuelwood consumption.
- Programmes should be established to raise public understanding about energy efficiency, safer biomass and paraffin use, and time-of-use tariffs for electricity to better align consumption with production.

6.5 Framework and governance: Public participation, policy updates, and policy alignment

- Several policies are out of date and need general revision (e.g. the Energy White Paper).
- Scheduled policy updates should be done as required by applicable instruments.
- Public participation should feature in policy making a meaningful way (i.e. adequate time, widespread consultations and records made available of how concerns were incorporated into policy).
- Risk analysis should be done on all policies to avoid technological lock-in and stranded assets.
- Megaprojects should be avoided as they are the most susceptible to cost overruns, delays and corruption.
- Steps should be taken to ensure policy alignment, not just between DoE policies, but also to align relevant DEA and DMR policies.

6.6 Economics: Progressive steps to attract financing for energy sector transformation

- Externality costing should be included in all energy plans.
- The carbon tax should be implemented, as broadly proposed by Treasury, but with fewer exclusions. Funds generated should be ring-fenced for energy sector transformation projects.
- A national bank should be established to provide low-cost financing for RE projects.
- Financial assessments should go beyond assessments of GDP and the "triple bottom line".
- State investment decision makers such as the Public Investment Corporation should undertake carbon risk assessments and avoid carbon-intensive investments.
- There should be transparency around existing energy subsidies, followed by a re-design of the entire subsidy structure. If there are subsidies in future, they should promote the best options in terms of carbon intensity, job creation, cost of supply, water use, and environmental damage.
- There should be policy-level support for fossil fuel divestment and incentives for making sound re-investment decisions.
- Innovative financing models should be established specifically for RE (as high capital costs but low running costs) and for bottom-up community-owned power plants.

7

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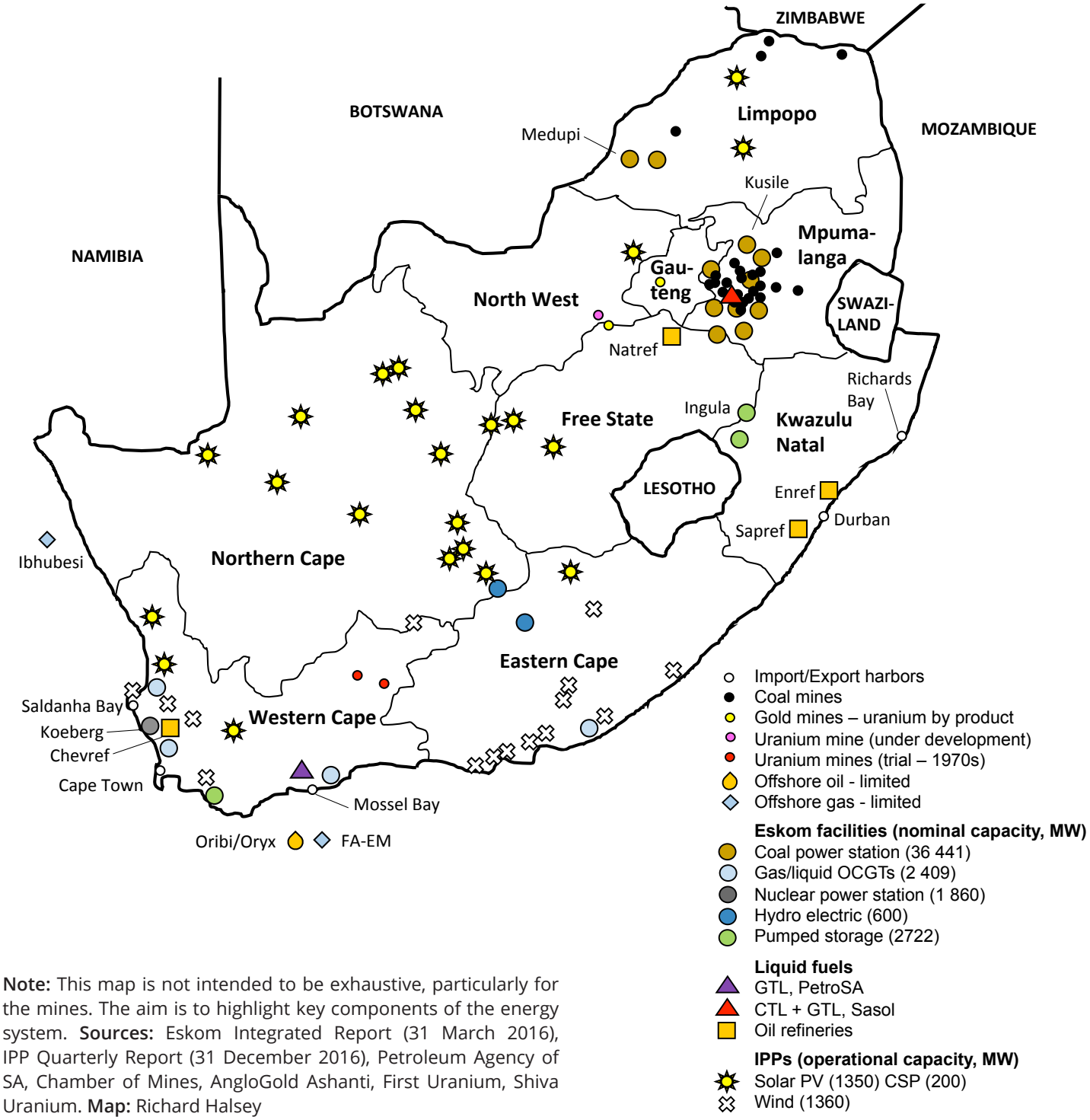
8

Appendices

Appendix 1:

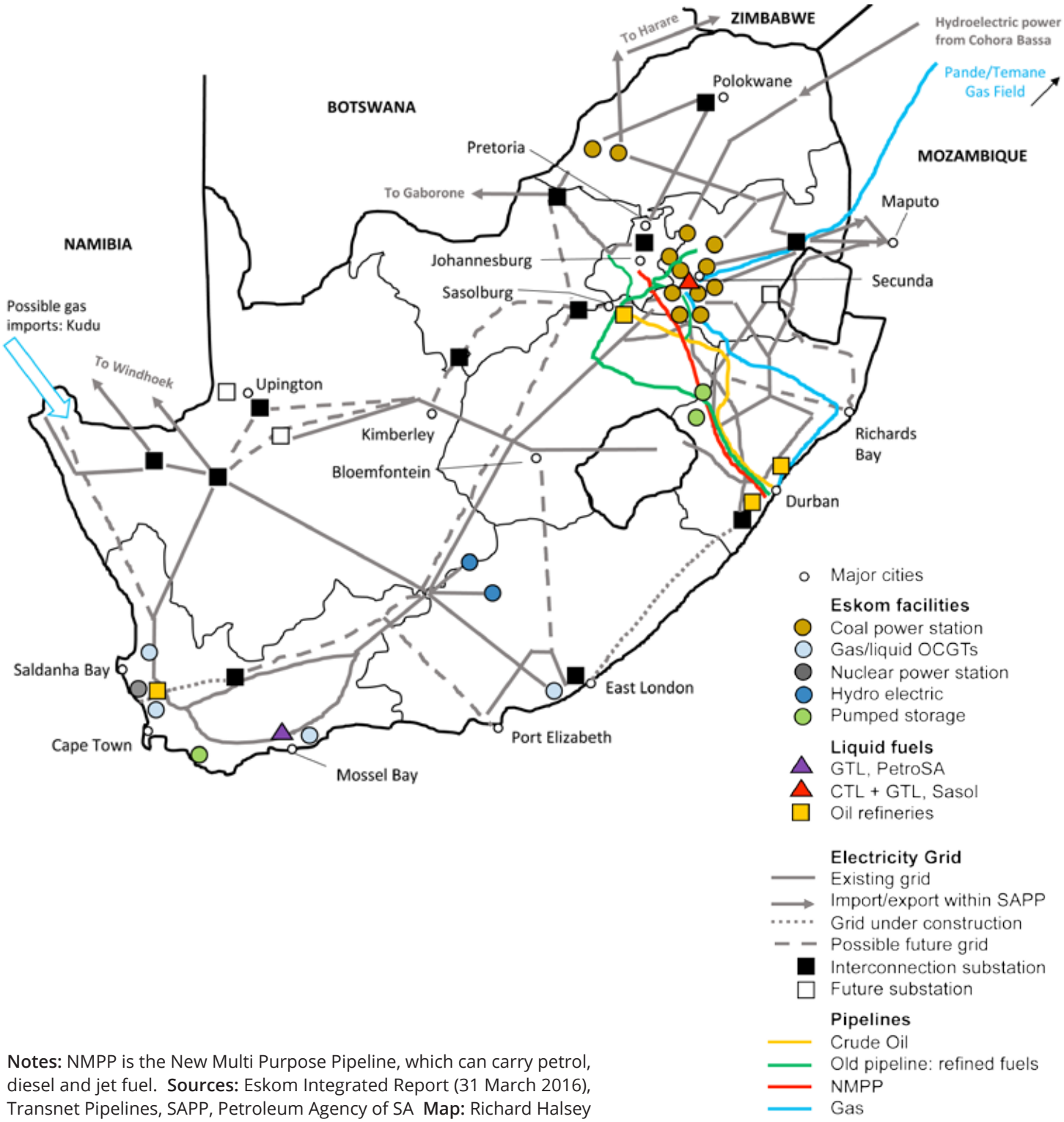
Map showing major energy resources and facilities in SA



Note: This map is not intended to be exhaustive, particularly for the mines. The aim is to highlight key components of the energy system. **Sources:** Eskom Integrated Report (31 March 2016), IPP Quarterly Report (31 December 2016), Petroleum Agency of SA, Chamber of Mines, AngloGold Ashanti, First Uranium, Shiva Uranium. **Map:** Richard Halsey

Appendix 2:

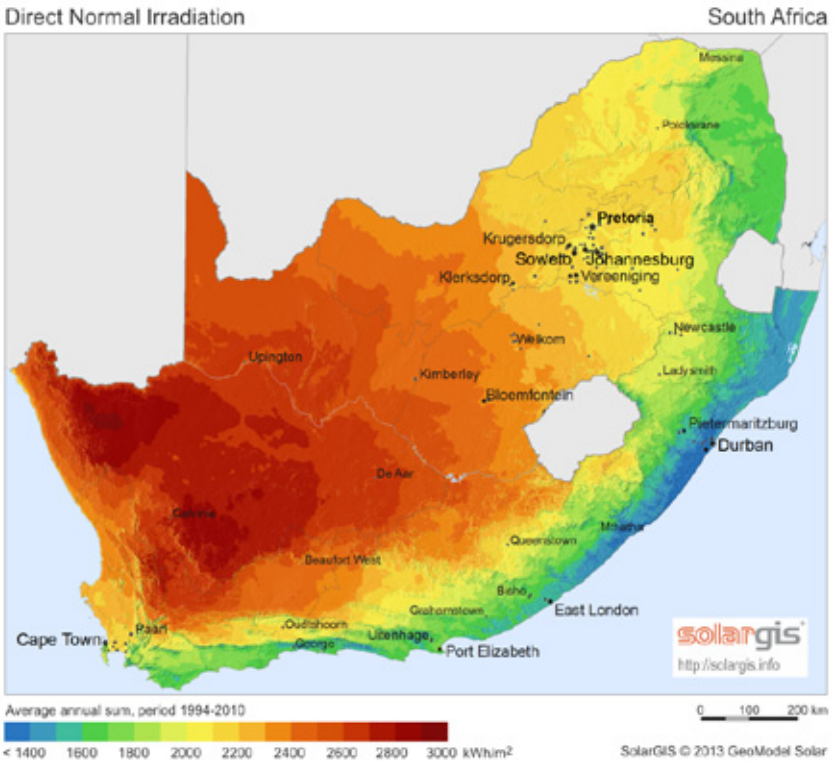
Map showing major components of SA electricity grid and pipelines



Notes: NMPP is the New Multi Purpose Pipeline, which can carry petrol, diesel and jet fuel. **Sources:** Eskom Integrated Report (31 March 2016), Transnet Pipelines, SAPP, Petroleum Agency of SA **Map:** Richard Halsey

Appendix 3:

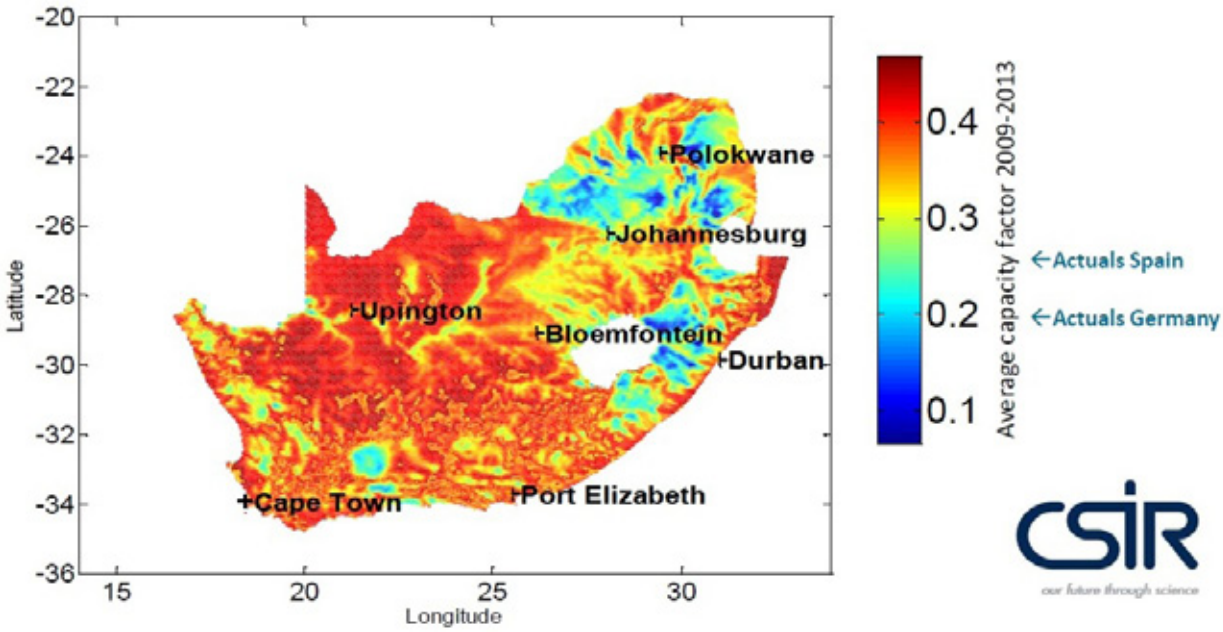
Map showing solar radiation potential



Source: Solargis

Appendix 4:

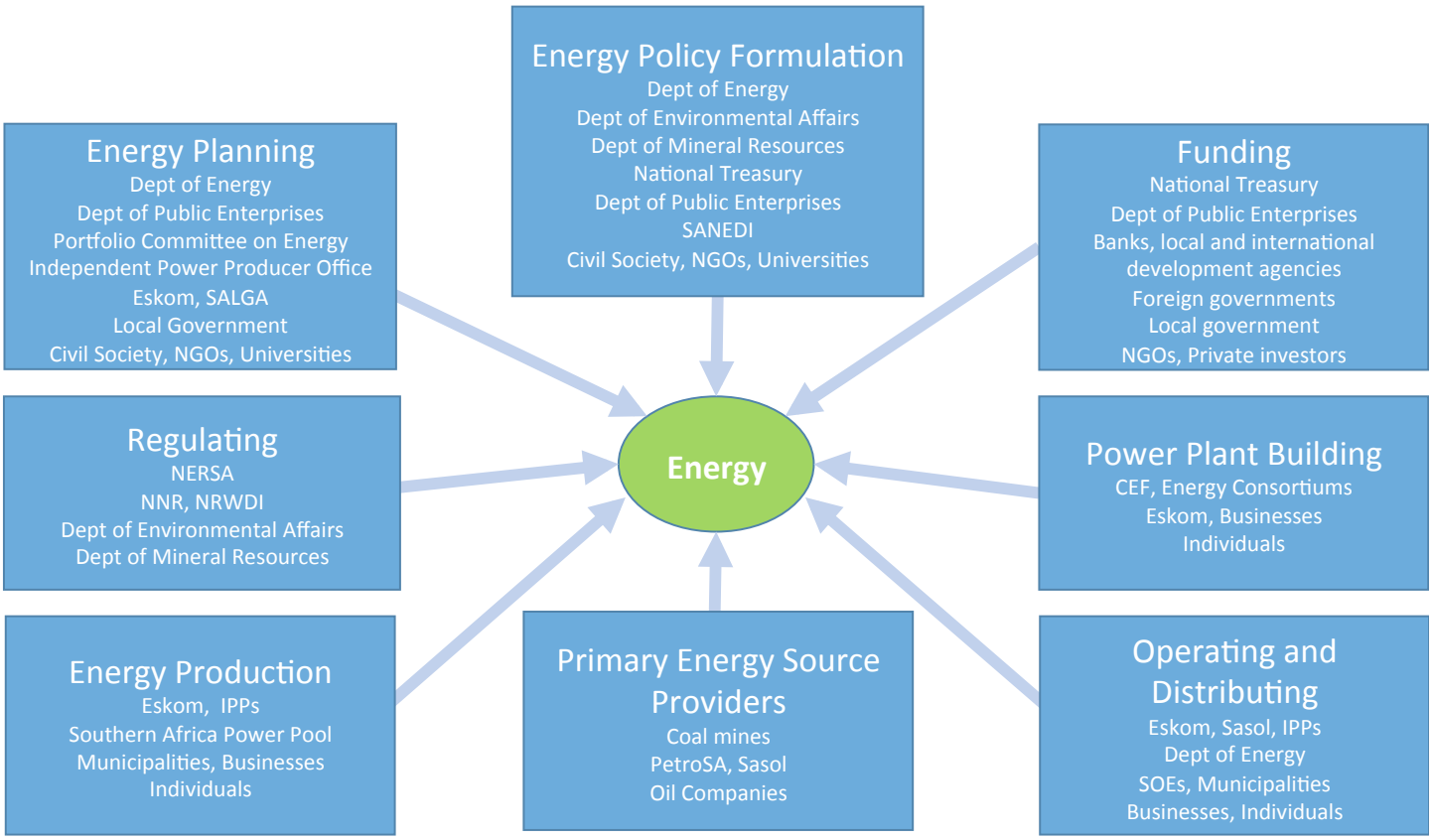
Map showing achievable wind capacity factor across all turbine types



Source: CSIR, high fidelity data to enable high-renewable planning, 2016

Appendix 5:

Linkage diagram between energy players

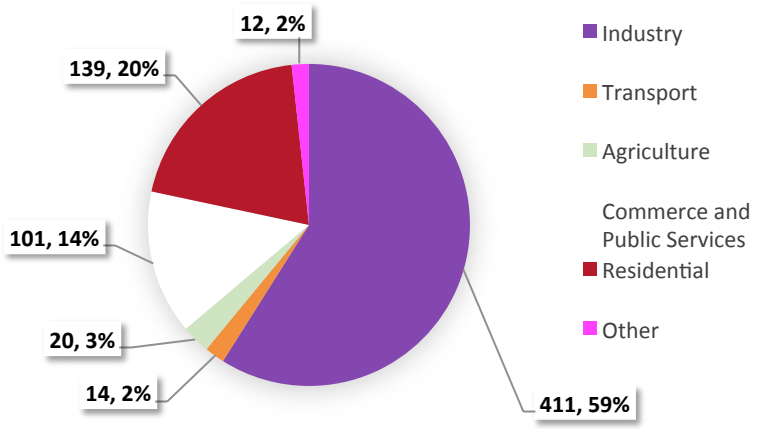


Glossary

CEF	Central Energy Fund
Eskom	Electricity Supply Commission (SOE)
IPP	Independent Power Producer
NECSA	South African Nuclear Energy Corporation (SOE)
NERSA	National Energy Regulator of South Africa
NNR	National Nuclear Regulator
NRWDI	National Radioactive Waste Disposal Institute (SOE)
PetroSA	South African National Oil Company (SOE)
SALGA	South African Local Government Organisation
SANEDI	South African National Energy Development Institute (SOE)
SOE	State Owned Entity (Eskom, Sasol, Transnet, NECSA, etc)

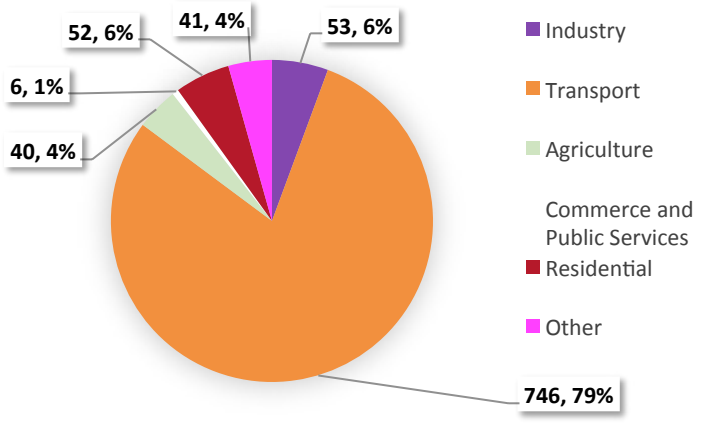
Diagram by Peter Atkins.

Appendix 6:
Final electricity use by sector



Source: DoE Energy Balances (Aggregate), 2012.
Unit: PJ, integer rounded

Appendix 7:
Final petroleum product use by sector



Source: DoE Energy Balances (Aggregate), 2012.
Unit: PJ, integer rounded

Appendix 8:

Additional energy use patterns for low-income, marginalised communities

If there is electricity access

⇨ then regardless of income and urban vs rural location, over **97%** of households will use it for **lighting**.

⇨ Electricity use by **low income households** is significantly effected by geographical location

⇩

Rate of use is **25-35% lower** in low income **rural** households compared to low income urban households for other basic functions (cooking, water heating and space heating). This energy requirement is replaced almost exclusively by wood, which is often freely available in rural areas

Low LSM[1] households

⇨ only have a 60% rate of electrification (30% less than national average)

⇨ lowest overall rate of electricity use at <45% for all basic energy functions

Informal settlements

⇨ ~14% of household distribution

⇨ higher use of paraffin for cooking and water heating than other dwelling types.

⇨ highest rate of illegal electricity connections

1. Living standard measures 1 to 4.
Source: Analysis of figures in the Energy Household Survey, StatsSA, 2012

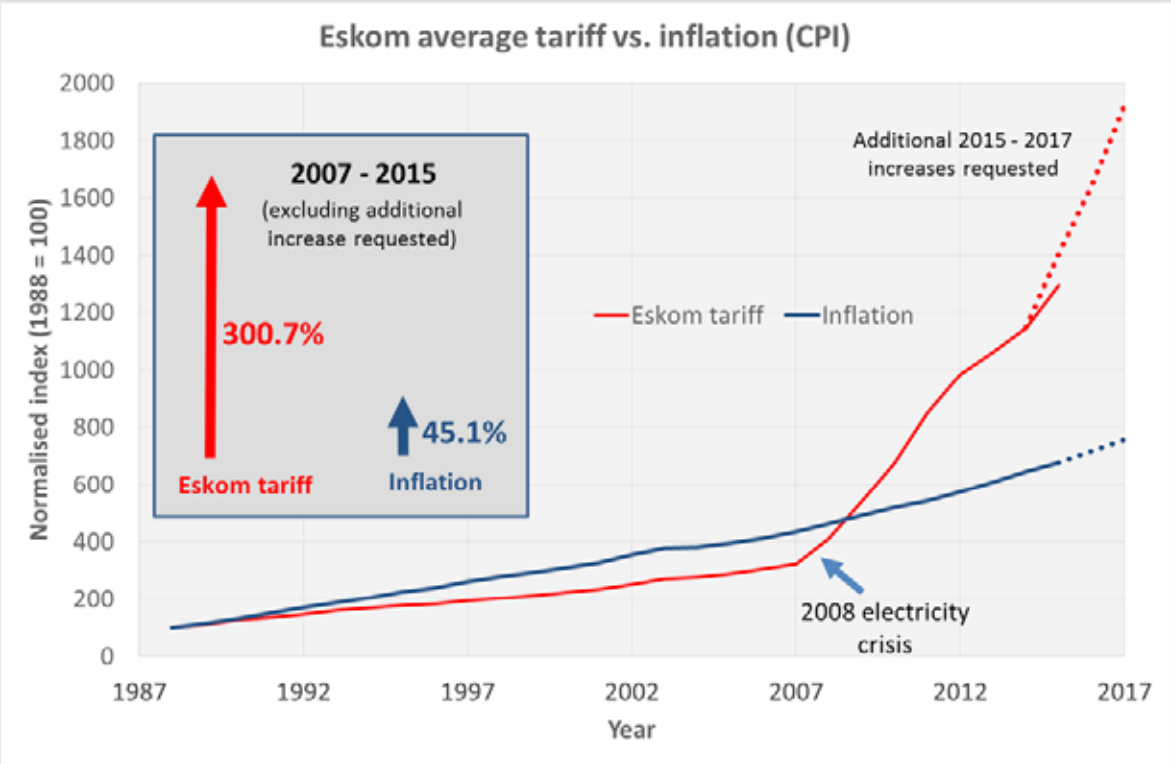
Appendix 9:

Table of energy legislation and policies

Name	Objectives
Petroleum Products Act, 1997	Provide measures for the efficient and effective distribution of petroleum products and price control.
Nuclear Energy Act, 1999	Provide a governance framework for the industry. Increase the role of nuclear energy as part of the process of diversifying South Africa's primary energy sources.
Gas Act, 2002	Promote the development of a piped gas industry in South Africa and the establishment of a gas regulator.
National Energy Regulator Act, 2004	Establish a single regulator to regulate the electricity, piped-gas and petroleum pipeline industries.
Electricity Regulation Act, 2006	National regulatory framework for the electricity supply industry: - to make the National Energy Regulator the custodian and enforcer of the national electricity regulatory framework; - to provide for licences and registration as the manner in which generation, transmission, distribution, trading and the import and export of electricity are regulated.
National Energy Act 2008	Strengthen energy planning to ensure that diverse energy resources are available, in sustainable quantities and at affordable prices.
Energy White Paper, 1998	Increase access to affordable energy services. Improve energy governance Stimulate economic development Manage energy-related environmental and health effects Secure supply through diversity
White Paper on Renewable Energy, 2003	Promote and implement renewable energy Expand renewable energies to 10 000 GWh by 2013
Integrated National Electrification Programme, 2002	Achieve higher electrification rates in South Africa and policies on subsidies for marginalised households and pricing of electricity
National Energy Efficiency Strategy, 2005, second draft, 2012 not finalised	Ensure affordable energy for all Develop and implement energy efficiency practices in South Africa
Biofuels Industrial Strategy, 2007	Short-term focus (5 years) to achieve a 2% penetration level of biofuels in the national liquid fuel supply, or 400 million litres p.a.
Electricity Pricing Policy, 2008	Regulate electricity pricing, Focus on national strategies and priorities while NERSA develops the rules, regulations, plans, standards, programmes and plans in finer detail to ensure the policy's implementation.
National Climate Change Response White Paper, 2011	Vision for an effective climate change response and the long-term, just transition to a climate-resilient and lower-carbon economy and society.
Integrated Energy Plan, 2003, 2005 update, 2016 update out for consultation	Energy planning framework that creates the context for supply-side capacity development and to be able to get a power generation licence issued for any new power plant, there needs to be an alignment with the plan or an extraordinary approval from the Ministe
Integrated Resource Plan 2010-2030 (2011), update (2016) out for consultation	Determines the demand profile for electricity over the next 20 years and details how this demand can be most effectively met from different sources
Biofuels Mandatory Blending Regulation, 2012, still not in force	Blending of biofuels with petrol and diesel Provides for all licensed petroleum manufacturers to purchase locally produced biofuels from licensed biofuels manufacturers
National Transport Master Plan (NATMAP) 2050 (2016)	Framework for the implementation of transport and the provision of infrastructure and services

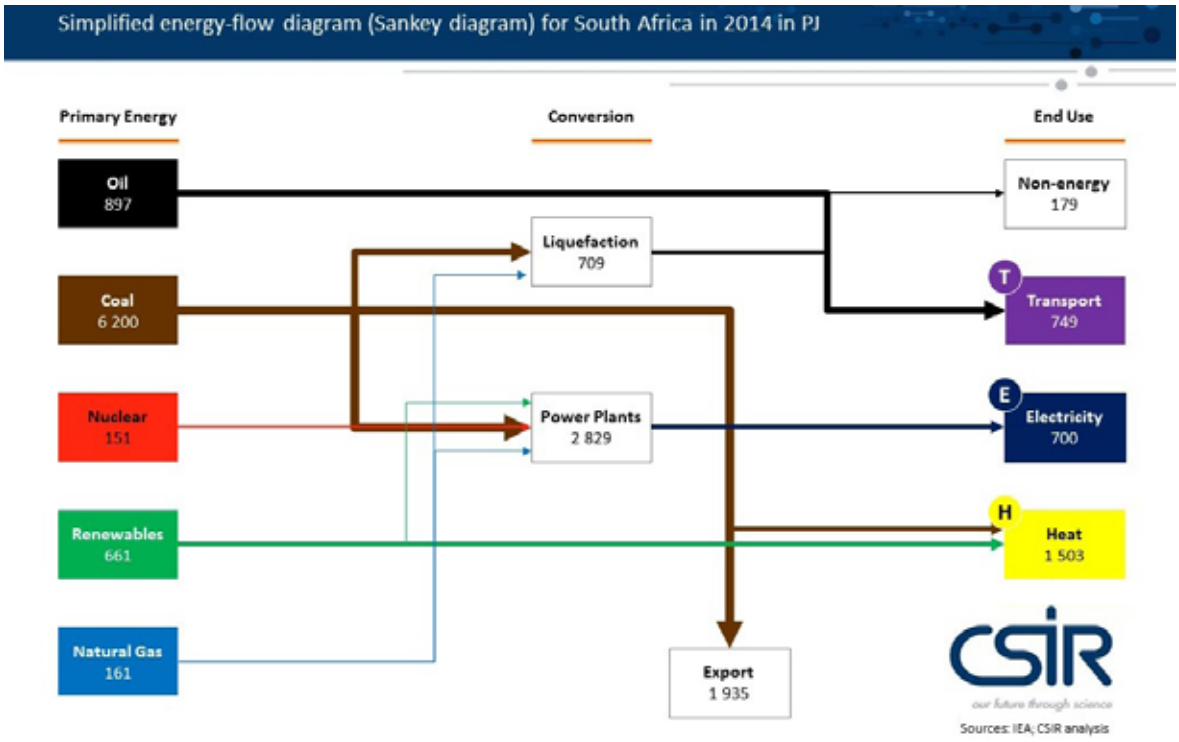
Source: Cape Town State of Energy 2015, City of Cape Town and analysis by Tina Schubert

Appendix 10:
Electricity price increases, 2007–2015



Source: http://www.poweroptimal.com/infographic-eskom-tariff-increases-vs-inflation-since-1988/

Appendix 11:
Energy flow diagram for South Africa (2014)



Source: CSIR, "What could South Africa's energy future look like?" Presentation at workshop hosted by Project 90 by 2030.