State of

Renewable Energy

in South Africa

2017

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The State of Renewable Energy in South Africa Report was first published by the Department of Energy (DoE) in 2015. It was intended to share South Africa's remarkable journey in advancing RE in the country and to serve as an authoritative data resource regarding the progress made. The interest it received prompted the DoE to produce a more regular publication.

This second edition of the report is compiled two years after the first and tells the story of the most recent developments related to RE. It covers aspects associated with policy, markets, investments, economic development, energy access and innovation, among others.

The 2017 update of the State of Renewable Energy in South Africa Report was funded by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). This latest edition was released in November 2018 and is also available for download at www.energy.gov.za

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Foreword

by Mr Jeff Radebe - Minister of Energy

South Africa remains committed to its drive towards a low carbon and Green Economy trajectory, especially in ensuring that the proposed energy mix is at the forefront of energy security. This position has culminated in the review and update of the Integrated Resource Plan (IRP) 2010 and the Integrated Energy Plan (IEP). Most importantly to note, is that the two plans serve as policy instruments meant to provide policy certainty in the short, medium and long terms while intended to enable investments in the country. The Department of Energy (DoE) will continue its efforts to address any gaps within its regulatory environment to enable the deployment of all approved energy sources.

South Africa played a key role in the negotiations and processes that led to the development of the 2030 Agenda for Sustainable Development, including its 17 Sustainable Development Goals (SDG), and Agenda 2063. Aspects of these international negotiations, which culminated in the Paris Agreement, were informed by the priorities of the National Development Plan (NDP) as our overarching policy vision for 2030. The success of this ambitious blueprint will depend to a large degree on our momentum in deploying renewable energy (RE) for access to affordable, reliable, sustainable and modern energy for all.

Energy is universally recognised as an essential commodity that enables socio-economic development, preserving and creating jobs – and, most importantly, assists in addressing inequality. Our nation recognises this and has placed addressing our various energy constraints as a top priority on our country's nine-point plan, so as to enable Government to boost economic growth and create sustainable jobs. Accordingly, there is a need to ensure economic growth and development by opening new areas of the economy such as the Oceans Economy, Green Economy and shale gas fracking.

In the past few years, extensive technical and regulatory work has been done in these newly identified areas in an effort to grow the economy and create jobs. South Africa remains focused, and on course, to promote an affordable and sustainable energy mix in support of radical socio-economic transformation. As part of the energy mix policy, RE remains one of the key areas to be pursued by the DoE in tandem with our Constitutional mandate of ensuring that the economy and its citizens remain energy secure through sufficient, reliable and affordable access to energy at all times.

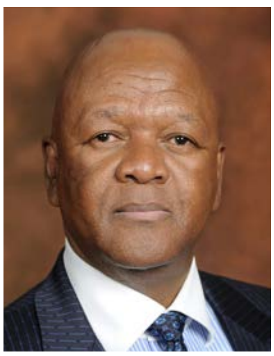
Also in 2015, we committed ourselves to periodically publish the 'State of Renewable Energy in South Africa report', which is meant to provide a consolidated and authoritative account of progress made by Government, private sector, academia, developmental organisations and any other stakeholder in advancing RE deployment. The DoE has committed to work closely with the Department of Public Enterprise (DPE) and Eskom in finding solutions on the delay encountered in concluding the Independent Power Producers (IPPs) contracts in bid rounds 3.5 and 4. The lessons we are taking from these solutions will certainly inform future decisions around the planning and implementation of the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP). In delivering on our promise, the DoE is excited to present this second edition of the State of Renewable Energy in South Africa report, which traditionally presents an overview of clean energy-related developments in the country.

This report provides various updates on policies, legislative framework, market penetration of RE technologies, innovations that enhance potential contributions of clean energy towards achieving universal access to modern energy services, as well as skills development initiatives. It underlines the contribution of research, development and innovation to this growing field. Coinciding with the release of the 2015 report were key international developments, i.e. the Paris Agreement and the adoption of SDG (replacing the Millennium Development Goals), wherein energy received prominence for the first time through SDG 7.

This report is anchored in these important international commitments and is aimed at keeping our conscience alive and focused on our collective accountability to these international developments. Recognising the crucial role of municipalities in a sustainable energy transition, the report also highlights the critical role of Local Government in delivering energy services. It raises the question of how this level of Government can participate and further enrich our energy planning processes.

As a department, we find ourselves at a critical juncture where energy is such a contested terrain that our best response, if we want to deliver successfully on our mandate, is to work together with many diverse stakeholders wearing multiple hats, e.g. municipalities and households that have become generators of energy. More than ever in the past, we embrace the challenge.

Mr. J. Radebe, MP
Minister of Energy



Statement of Commitment

by Ambassador Thembisile Majola - Deputy Minister of Energy

Expanding access to modern, reliable and affordable energy in South Africa remains our primary objective towards achieving sustainable development in all sectors of the economy. The South African economy is energy intensive, hence we need to diversify the country's energy mix in ensuring universal access. The reality of topography and sparsely settled households with respect to the extension of grid network to connect remote areas, has proven to be economically unviable. However, the South African government opted to introduce off-grid solutions in order to close the gap created by lack of access to electricity by areas that are unlikely to receive grid electricity over a defined planning period.

Energy is the backbone of service delivery and we therefore commit to work with all the all stakeholders charged with the responsibility of deploying all the energy sources. Eskom serves 48 percent of customers in the country and municipalities serve 52 percent. Our strong collaboration with municipalities and all relevant Government departments through established provincial energy fora is the way to go in moving away from fragmented and uncoordinated project planning and implementation.

This platform affords us an opportunity to address blockages that arise during project implementation as a collective and act as enablers for service delivery. We acknowledge the level of interdependencies in many projects and therefore value the role of municipalities at the coal face of service delivery matters. It is our view that the success of various projects is dependent on a strong relationship with all the stakeholders across the value chain; integrated planning informed by, but apart from, all the drivers and external factors.

We will continue to create an enabling environment through the regulatory framework as well as policy certainty. The National Development Plan (NDP) guides South Africa's drive to contribute towards universal access; SDG Goal 7 on modern access, reliable and affordable energy and Sustainable Energy for All (SE4All). The national commitment to RE is driven by South Africa's commitment towards a low carbon and Green Economy trajectory; it is reinforced by the country's ratification of international climate agreements and recent long-term energy planning iterations. We remain focused on ensuring that policy and regulatory developments add refinement to the existing framework, with progress made in respect to Small-Scale Embedded Generation (SSEG), industry self-regulation, tax incentives and enhanced integration between energy efficiency and RE.

Ambassador T. Majola, MP
Deputy Minister of Energy

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Abbreviations and acronyms

A	AC	Alternating current
	ADA	Austrian Development Agency
	AFD	French Development Agency
	AMEU	Association of Municipal Electricity Utilities
	ASSAf	Academy of Science of South Africa
B	B-BBEE	Broad-Based Black Economic Empowerment
	BEE	Black Economic Empowerment
	Bio-ERG	Bio-resources Engineering Research Group
C	CDM	Clean Development Mechanism
	CEF	CEF Group of Companies formerly known as Central Energy Fund
	CEM	Clean Energy Ministerial
	CER	Centre of Energy Research
	CESAR	Centre for Energy Systems Analysis and Research
	CGS	Council for Geosciences
	CHP	Combined-heat-and-power
	CO_2	Carbon Dioxide
	COC	Centres of Competence
	COD	Commercial Operation Date
	COE	Centre of Excellence
	COGTA	Cooperative Governance and Traditional Affairs
	CORDs	Centres of Research and Development
	CPI	Consumer Price Index
	CPUT	Cape Peninsula University of Technology
	CREW	Centre for Renewable Energy and Water
	CRSES	Centre for Renewable and Sustainable Energy Studies
	CSI	Corporate Social Investment
	CSIR	Council for Scientific and Industrial Research
	CSP	Concentrated Solar Power
	CSR	Corporate Social Responsibility
D	DANIDA	Danish International Development Agency
	DBREV	Douglas Banks Renewable Energy Vision
	DC	Direct current
	DEA	Department of Environmental Affairs
	DFI	Development Finance Institutes
	DHET	Department of Higher Education and Training
	DNA	Designated National Authority
	DoE	Department of Energy
	DoRA	Division of Revenue Act
	DoT	Department of Transport
	DRE	Distributed renewable energy
	DSM	Demand-side management
	DST	Department of Science and Technology
	DTI (**the dti**)	Department of Trade and Industry
	DUT	Durban University of Technology

E	EAC	Energy Autonomous Campus
	ECSA	Engineering Council of South Africa
	EDI	Electricity Distribution Industry
	EE	Energy Efficiency
	EEDSM	Energy efficiency demand-side management
	EETRC	Energy Efficient Training and Resource Centre
	EIUG	Energy Intensive User Group
	EMP	Energy Management Plan
	EPWP	Expanded Public Works Programme
	ERC	Energy Research Centre
	ESI	Electricity Supply Industry
	EU	European Union
	EV	Electric Vehicles
	EVIA	Electric Vehicle Industry Association
	EWSETA	Energy and Water Skills Education and Training Authority
F	FBE	Free Basic Energy
	FDI	Foreign Direct Investment
G	GAU	Grid Access Unit
	GCCA	Grid Connection Capacity Assessment
	GEF	Global Environment Facility
	GFSA	Government Framework Support Agreement
	GHG	Greenhouse Gas
	GIZ	German Agency for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit)
	GWh	Gigawatt hour
	GWhth	Gigawatt hour thermal
H	HEI	Higher education institutions
	HFO	Heavy Fuel Oil
	HVAC	Heating, ventilation and air conditioning
I	IA	Implementing Agreement
	ICLEI	International Council for Local Environmental Initiatives, aka Local Governments for Sustainability
	IDC	Industrial Development Corporation
	IEA	International Energy Agency
	IEP	Integrated Energy Plan
	IFC	International Finance Corporation
	INDC	Intended Nationally Determined Contribution
	INEP	Integrated National Electrification Programme
	INSETA	Insurance Skills Education and Training Authority
	IOPSA	Institute of Plumbing South Africa
	IP	Internet Protocol
	IPAP	Industrial Policy Action Plan
	IPP	Independent Power Producer
	IPPPP	Independent Power Producer Procurement Programme

	IRENA	International Renewable Energy Agency
	IRP	Integrated Resource Plan
	IT	Information Technology
K	kfW	Kreditanstalt für Wiederaufbau
	kW	Kilowatt
	kWe	Kilowatt electric
	kWp	Kilowatt peak
L	LA	Local Authority
	LCOE	Levelised Cost Of Electricity
	LM	Local Municipality
M	M&V	Monitoring and Verification
	MFMA	Municipal Finance Management Act
	MIG	Municipal Infrastructure Grant
	MoA	Memoranda of Agreement
	MoU	Memoranda of Understanding
	MSME	Micro, Small & Medium Enterprises
	MTEC	Medium-Term Expenditure Committee
	MTEF	Medium-Term Expenditure Framework
	MTSF	Medium-Term Strategic Framework
	MW	Megawatt
	MWp	Megawatt peak
	MYPD	Multi-Year Price Determination
N	NDA	National Development Agency
	NDP	National Devlopment Plan
	NEEA	National Energy Efficiency Agency
	NEEAP	National Energy Efficiency Action Plan
	NEES	National Energy Efficiency Strategy
	NERSA	National Energy Regulator of South Africa
	NGP	New Growth Path
	NMBM	Nelson Mandela Bay Municipality
	NMMU	Nelson Mandela Metropolitan University
	NREL	National Renewable Energy Laboratory
	NRF	National Research Foundation
	NT	National Treasury
	NWU	North-West University
O	OECD	Organisation for Economic Cooperation and Development
P	PDD	Project Design Document
	PDI	Previously Disadvantaged Individual
	PFMA	Public Finance Management Act
	PIRB	Plumbing Industry Registration Board
	PPA	Power Purchase Agreement
	PV	Photovoltaics

R	R&D	Research and Development
	RDI	Research Development and Innovation
	RE	Renewable Energy
	RECORD	Renewable Energy Centre for Research and Development
	REDZ	Renewable Energy Development Zones
	REEEP	Renewable Energy and Energy Efficiency Partnerships
	REFIT	Renewable energy feed-in-tariffs
	REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
	REN21	Renewable Energy Policy Network for the 21st Century
	RET	Renewable Energy Technology
	RFP	Request for proposals
	RISE	Regulatory Indicators for Sustainable Energy
S	SABIA	South African Biogas Industry Association
	SACN	South African Cities Network
	SADC	Southern African Development Community
	SAGEN	South African-German Energy Programme
	SAGEN	South Africa-German Energy Programme
	SALGA	South African Local Government Association
	SANEA	South African National Energy Association
	SANEDI	South African National Energy Development Institute
	SAPP	Southern African Power Pool
	SAPVIA	South African Photovoltaic Industry Association
	SAREBI	South African Renewable Energy Business Incubator
	SAREC	South African Renewable Energy Council
	SARETEC	South African Renewable Energy Technology Centre
	SARS	South African Revenue Service
	SAWEA	South African Wind Energy Association
	SAWEP	South African Wind Energy Programme
	SDBIP	Service Delivery and Budget Implementation Plan
	SDG	Sustainable Development Goals
	SE4All	Sustainable Energy for All
	SEA	Sustainable Energy Africa
	SEIA	Strategic Environmental Impact Assessment
	SETA	Sector Education and Training Authorities
	SHS	Solar Home Systems
	SIP	Strategic Infrastructure Project
	SMME / SME	Small, Medium and Micro Enterprises
	SOC	State Owned Company
	SOE	State Owned Entity
	SOLTRAIN	Southern African Solar Thermal Training and Demonstration Initiative
	SSEG	Small-Scale Embedded Generation
	SU	Stellenbosch University
	SWH	Solar water heaters/heating

T	TAI	Tax Allowance Incentive
	TAF	Technical Assistance Facility
	the dti (see also DTI)	Department of Trade and Industry
	TIA	Technology Innovation Agency
	TUT	Tshwane University of Technology
	TVET	Technical and Vocational Education and Training
U	UCT	University of Cape Town
	UFH	University of Fort Hare
	UFS	University of the Free State
	UJ	University of Johannesburg
	UKZN	University of KwaZulu-Natal
	UN	United Nations
	UNDP	United Nations Development Programme
	UNEP	United Nations Environment Programme
	UNIDO	United Nations Industrial Development Organisation
	UP	University of Pretoria
	USTDA	Unites States Trade and Development Agency
	UWC	University of the Western Cape
	UZ	University of Zululand
V	VRE	Variable Renewable Energy
	VUT	Vaal University of Technology
	VUT	Vaal University of Technology
W	WASA	Wind Atlas of South Africa
	WfE	Working for Energy Programme
	Wits	University of the Witwatersrand
	Wp	Watt peak
Y	YWP	Young Water Professionals

Executive Summary

Executive Summary

South Africa's ratification of the Paris Agreement and the recent long-term energy planning iterations has reinforced the country's commitment to renewable energy (RE). Policy and regulatory developments are adding refinement to the existing framework, with progress made in respect to Small-Scale Embedded Generation (SSEG), hydropower policy, carbon tax and the enhanced integration between energy efficiency (EE) and RE. Despite delays in the signing of Power Purchase Agreements (PPAs) with 37 preferred bidders from Bid Windows 3.5, 4 and 5 projects, temporarily stifling the growth of utility-scale RE during the preceding two years, many important building blocks have been established and some achievements attained since the publication of the 2015 edition.

In addition to policies and legislative framework, this 2017 report provides detailed updates on progress made regarding RE market innovations that enhance potential contributions of clean energy towards achieving universal access to modern energy services, skills development initiatives, as well as contributions to research and development in support of a thriving future RE sector. Since climate change is a serious environmental, security and socio-political challenge, its impact is visible at community level around the globe. Thus, this report recognises the important role of Local Government; it ends off by highlighting challenges and opportunities faced by Local Government, which is at the 'coal face' of service delivery, and further showcases innovative and proactive RE interventions being pursued at this third tier of Government.

Progressive policy-making has been found to have the greatest impact on a RE future. While the final Integrated Energy Plan (IEP) is awaited, it is clear that the approach to the draft IEP already reflects the international convergence of the electricity, transport and heating/cooling sectors. This suggests that the final document will be modern and aligned with cutting edge, international thinking.

The process of developing the post-2010 Integrated Resource Plan (IRP), received political and legal support when Cabinet approved the publication of the Draft IRP on 2 November 2016 for public comments. This revised draft will extend the long-term planning horizon from 2030 to 2050. This long-term planning takes cognisance of electricity demand projections, technology advances and South Africa's international commitments to SDG. Giving effect to national policy objectives while also building on the 2010 IRP, the draft plan maintains the commitment to a diversified electrical energy supply mix derived from coal, gas, nuclear and RE resources. As anticipated, all scenarios reflected in the draft plan show a dramatic ramp-up of South Africa's RE ambitions, surpassing even the audacious commitments made in the 2010 IRP.

Despite being a water-stressed country, South Africa has been advancing its policy on hydropower in order to enable the NDP, in the process addressing other important considerations such as climate change and ensuring a diverse mix of energy. In July 2016, the Draft Sustainable Hydropower Generation Policy was gazetted. It recognises the global shift towards RE. It further underlines that South African hydropower projects can be both environmentally and financially attractive due to existing, suitable infrastructure.

The Department of Transport is updating its White Paper on National Transport Policy with a Revised Draft dated May 2017 while also producing a Green Transport Strategy, 2016 to 2021. The stated goals in these documents include growing the economy and achieving social objectives in a manner that is environmentally sustainable and minimises negative impacts. In addition to the IRP's ambitious RE scenarios, the DoE's draft IEP includes an assumption of a 20 percent annual penetration of electric vehicles by 2050.

International work on our collective, international energy future has revealed profound and deep links between EE and RE. Both address climate change by lowering emissions – RE by leveraging emission-free energy generation sources and EE by dropping the energy intensity of the economy. In a recent paper by the International Renewable Energy Agency (IRENA), it appeared that a simultaneous and aggressive roll-out of both RE and EE (in the context of Sustainable Energy for All) would see the growth in total primary energy supply being reduced by up to 25 percent, compared to business as usual in 2030 in the countries studied.

EE measures would account for 50 to 75 percent of the total energy savings. Given this reality, it is encouraging that the South African policy framework for EE has been strengthened with the formulation of the National Energy Efficiency Strategy (NEES); the post-2015 version has been gazetted for public comment. As part of this framework, a National Energy Efficiency Action Plan (NEAAP) has also been developed to guide practical implementation.

The taxation regime in a country is usually a reflection of broad policy direction. In the case of technological change, the presence of tax incentives for a new technology can be seen as an indication that the Government is supportive of change. The climate resilience paradigm underpinning the Paris Agreement requires, among others, the lowest possible use of fossil fuels (EE and low carbon intensity). South African tax law already displays a familiarity with, and support for, this new reality. In the domain of EE, significant incentives exist, such as the 12I and 12L stimulus.

Once implemented, the pending carbon tax will also lead to the internalisation of the cost of greenhouse gas (GHG) emissions and will further benefit RE technologies. While the timeframes for implementation remain unclear, the Minister of Finance detailed the process in his Medium-Term Budget Speech (MTBS) of February 2017. It confirmed that Cabinet has approved and referred the carbon tax bill for parliament's consideration. Thus, it seems likely that some carbon off-setting will be allowed in the future.

In recent years, SSEG in the form of rooftop Solar PV has become dramatically cheaper, to the extent that its levelised cost is now usually well below the tariffs municipal consumers pay to their local authorities. It is especially attractive to consumers who use electricity all day during the day, such as shopping centres or wine farms. There has been a significant increase in installations and a need to develop the policy framework both at national and municipal level. On 2 December 2016, the Minister of Energy published the SSEG policy for public comment. The result of this is that SSEG below 1 MW would be able to proliferate in a reasonably free, legal, yet controlled manner. In time, the cap of 1 MW can be reassessed as may be required.

This national policy is being complemented by municipal by-laws to account for the fact that SSEG reflects lost sales for the local authority while most SSEG generators stay on-grid and practically use the grid as a storage facility. Metros such as Nelson Mandela Bay, the City of Cape Town and the City of Tshwane have developed by-laws providing a comprehensive set of definitions and rules on what is allowed, and under what circumstances.

The rapid development in embedded solar has created a need for a quality control mechanism that ensures newly created jobs falling to those who are well trained to carry them out. In a new development, voluntary industry self-regulation emerged as an initiative to assure quality, while supporting industry development and national objectives.

In 2015, the South African Photovoltaic Industry Association (SAPVIA) started work on what became the 'PV GreenCard', a certification system for embedded PV that can only be signed off by a properly trained technician who appears on the SAPVIA online database. The PV GreenCard was launched in May 2017 and is now operational.

Chapter 2 of this report therefore provides a detailed update on progress with respect to various policies and regulations meant to support RE deployment in the country.

While utility-scale RE development has slowed since 2015 in South Africa, the increased affordability of RE technology is giving rise to development in other areas. The rooftop Solar PV market has continued to grow rapidly, boosted by the fact that the levelised cost of electricity without battery storage has decreased to around R1,00/kWh or below for embedded rooftop Solar PV, while municipal electricity tariffs can be 80 percent or more above this figure.

The delay in signing of Power Purchase Agreements (PPA) has seen various projects with preferred bidder's rights in REIPPPP Bid Window 4 not reaching shovel stage.

The Department of Science and Technology (DST) commissioned the South African Environmental Observation Network (SAEON) to produce the BioEnergy Atlas for South Africa and design a portal for relevant data, reports and decision-support tools. The BioEnergy Atlas was developed and launched by the Minister of Science and Technology in March 2017. It is a freely available public resource aimed at supporting bioenergy development in South Africa.

IRENA's renewable energy capacity statistics show that among the BRICS countries, South Africa rank last on RE deployment, indicating significant unexplored potential for RE development when considering the wealth of the country's natural resources. In 2014, RE (including Hydro) represented just more than 5 percent of total installed power capacity for South Africa. The average for the world at the time was 27 percent and the comparative figures for BRICS ranged between 21 percent (Russia) and 80 percent (Brazil). South Africa's RE market growth since 2012 has, however, outpaced that of its BRICS counterparts, bringing the share of installed capacity in South Africa closer to 10 percent by September 2017.

Since the 2015 edition, electric vehicles have made some progress in South Africa. A total of three pure electric vehicle models (i.e. the BMW i3, BMW i8 and Nissan Leaf) are now sold in the country alongside a greater number of hybrid vehicles. Data obtained from the South African National Development Institute (SANEDI), showed the total number of electric vehicles (not including hybrids) sold between 2013 and 2016 is 274. Of these, 228 were sold during 2015 and 2016 calendar years, indicating an upward sales trend and penetration of green cars into the motor industry market. This upward curve should continue once electric charging networks become commonplace in cities.

Chapter 3 provides further details on the status of South Africa's market for utility- and small-scale RE.

Government's continuous commitment to off-grid electrification has seen an allocation of R171,809,000 towards the implementation of Solar Home Systems (SHS) for the financial year 2016/17. Service providers were appointed to install SHS for the 2016/17 financial year at various municipalities across five selected provinces, i.e. Eastern Cape, KwaZulu-Natal, Limpopo, Northern Cape and Western Cape. Between 2014/15 and 2016/17 financial years, 56,028 units were installed in municipalities throughout the above mentioned provinces.

The need for change in the delivery model used for off-grid electrification, coupled with a growing realisation of the contribution of the off-grid sector to universal access and an enriched and diversified energy environment, compelled the DoE to develop and publish the New Household Electrification Model; it was adopted by Parliament in June 2013. Looking ahead, the off-grid electrification programme is expected to implement the new delivery model.

Following the termination of the DoE-Eskom Memorandum of Agreement for the implementation of the Solar Water Heating (SWH) programme, Cabinet approved the Revised Contracting Model in 2015, paving the way for the amendment of the Appropriation Bill so that the funds can be allocated to the DoE as the implementer. The SWH programme has experienced delays since the publication of the previous report, with significant under spending at the end of the 2016/17 financial year primarily due to a protracted procurement process.

However, some progress has been made. The DoE has procured approximately 87, 206 SWH units for installation before the end of the 2016/17 financial year. The training of local communities for installation of SWH will soon commence once the municipalities have approved the Designated Installation Areas (DIAs) within their respective jurisdiction areas, with clear objectives set for skills and enterprise development, job creation and targeting designated groups such as youth, women and people with disabilities.

Another priority is to address defective installations from the initial SWH Rollout Programme to ensure continued operation of the installed systems and service delivery to the recipients. It is noteworthy to mention that in providing support to the Department of Energy, the IPP Office commissioned the Solar Water Heater Repair and Replace programme in just over 400 households in Sol Plaatjie Municipality with the primary objective to inform the future planning of the programme. Through this exercise, it was established that the repair value of over R6,000 per unit was uneconomical and as such the better option was to replace the defective systems with new ones.

The DoE, in collaboration with Eskom, initiated investigations into the development and operation of mini grids in South Africa. Eskom is developing several pilot projects that can inform decision-making and planning. In parallel, the DoE is focusing on creating the policy environment that will enable widespread deployment and is presently reviewing regulations for small-scale and mini grid renewable generation.

In the Northern Cape, the !Kheis Municipality implemented an off-grid solar, micro grid system for the Duineveld community. Duineveld is an informal community with approximately 300 families that did not previously have access to electricity.

Chapter 4 provides an update on programmes and initiatives underway in respect of clean energy contribution towards achieving universal access to modern energy services.

A transmission network study with horizon of up to 2040 was undertaken by the national utility, Eskom, in order to inform the identification of the best resource areas for development such as Renewable Energy Development Zones (REDZ) as well as identification of strategic transmission line routes to unlock network capacity to connect future Independent Power Producers (IPPs). The study considered the development requirements of the future transmission grid to accommodate the expected load demand needs and the potential impact of future generation scenarios, using the 2010 IRP as a baseline. This will be updated once the draft 2016 IRP is finalised. In addition, the study identified five main 'commonly occurring' power corridors that would need to be developed under all the potential generation scenarios, irrespective of whether these scenarios focus on any specific generation technology.

The Department of Environmental Affairs (DEA) introduced a Wind and Solar PV Strategic Environmental Assessment (SEA). The primary objective of the SEA is to streamline regulatory processes for new RE power plants in line with the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) and without compromising the environment. Subsequent to these processes, Cabinet approved the gazetting of eight Renewable Energy Development Zones and five Power Corridors in February 2016. These REDZ and Power Corridors are geographical areas where wind and solar photovoltaic technologies can be incentivised, where 'deep grid' expansion can be directed and where regulatory processes will be streamlined.

Due to delays and the costs of rolling out a grid expansion programme and costs of grid maintenance, smart grid technology is viewed as a key enabler for the South African electricity supply industry to achieve its proposed future energy mix and grid management requirements. Without smart grids, large-scale integration between different power supply options will be well highly impossible. The Department, together with SANEDI, also implemented a smart grid programme in ten municipalities (eThekwini, Nelson Mandela Bay, Govan Mbeki, City Power, Thabazimbi, Matatiele, Umsunduzi, Naledi, Nala, and Mogale City) through European Commission funding support. Accordingly, the implementation of this smart grid programme has resulted in general revenue collection ranging between 20 percent and 30 percent. Among the lessons learnt is that the successful implementation of a smart grid programme hinges on the thorough understanding and acknowledgement of the relevant dependencies; forging a close working relationship between the Engineering, Information Technology (IT) and Finance divisions of the municipalities is essential as the programme mainly involves all three.

While the national grid planning process is predominantly focused on the main 'formal' networks in the country, mini grids are also starting to be considered in order to provide access to clean energy for remote communities. Mini grids can be owned by the communities they serve, though they can also be financed by private sector operators or utility companies. Combinations of these financing mechanisms are also very common.

Chapter 5 outlines the latest on grid infrastructure developments in support of RE deployment in the country.

Since the previous version of this report in 2015, both positive and negative developments related to the REIPPPP have been noted. The design of the REIPPPP has continued to enable the simultaneous and successful pursuance of multiple sub-objectives, while the delay with the further roll-out of the programme and with financial close for successful bidders in rounds 3.5, 4 and beyond, has had some negative impact on Government's job creation and localisation efforts.

Through the REIPPPP, 6,422 MW of electricity has been procured from 112 Independent Power Producers (IPPs) in seven bid rounds. By 2017, the combined investment commitment (total project costs, including interest during construction) of projects under construction and projects in the process of closure, is R201.8 billion. Investment commitments have grown also with the addition of the small-scale procurement programme, adding approximately R10 billion to the very impressive totals reported in 2015. Of these commitments, those related to Bid Windows 1 to 3.5, approximately R145.5 billion have already been realised.

An analysis of the funding sources and shareholding, highlights the broad spectrum of participation and benefits that emanate from this investment. Of this total investment, R48.8 billion originates from foreign investment and financing. This represents more than double the foreign direct investment (FDI) attracted by South Africa during 2015 (R22.6 billion), as reported by the South African Reserve Bank.

Approximately 24 percent foreign equity and financing makes an important contribution towards the economy and national development objectives to grow FDI. Foreign financing and investments (equity and debt) recorded for the REIPPPP, originate from a variety of countries across the globe, but are dominated by Europe and the United States. It is significant to note that at least two countries from the African continent have also invested in the programme, providing financing and/or equity to IPPs.

Chapter 6 highlights the interrelation between energy, economic and sustainable development and the opportunities that arise through energy transformation to achieve broader and more substantive developmental aspirations.

The 2015 report identified remaining areas that required additional support to catalyse development and/or unlock the full spectrum of potential benefits. This report shows that South Africa, as with other developing countries, is still facing some urgent energy-related challenges.

Fortunately, South African research institutions, universities and universities of technology are in the process of tackling these challenges, pursuing some inspiring innovations as demonstrated in this chapter. To address skills gaps or needs, there is a growing offering of industry-related training and development opportunities across some of the key South African tertiary institutions. Universities and universities of technology in South Africa have introduced targeted programmes at tertiary level focused on RE research and innovation as a response to this growing field of study. Relevant programmes are implemented in close collaboration with industry partners to facilitate the integration of innovative developments with private sector interests.

Funding support from the National Research Foundation (NRF) is made available for Masters and Doctoral candidates who want to pursue research in RE-related fields. RE learning is also being incorporated in curriculums at all Technical Vocational Education and Training (TVET) Colleges throughout South Africa. Currently, 15 TVET colleges countrywide are offering a Renewable Energy Technologies (RET) elective as part of their three-year electrical engineering training programme. Through collaboration between the Departments of Higher Education and Training, Science and Technology and GIZ, formal practise-centred SWH installer training programmes are also being developed for TVET colleges.

SARETEC continues to offer specialised industry-related and accredited training for the entire RE industry, along with tailored short courses and workshops. Since 2013, 63 wind turbine technicians have been trained through this initiative. The 2016 group of trainees were the first technicians to receive training at the local SARETEC facility in Cape Town.

Also in the interest of developing and promoting training and implementation strategies for solar thermal technologies in Southern Africa, the SOLTRAIN project, which was initiated in 2009 and is now in its third phase, contributes by raising awareness around solar thermal energy, building competence in solar thermal technology, creating technology platforms and demonstrating working installations beyond South African borders. This project is financed by the Austrian Development Agency (ADA) and implemented by the Institute for Sustainable Technologies, Austria (AEE INTEC), in cooperation with project partners from South Africa (the South African Energy Development Institute (SANEDI), and Stellenbosch University), Namibia, Botswana, Zimbabwe, Mozambique and Lesotho. SANEDI's records show that 2,825 people received training and 216 SWH systems (of which 13 are demonstration systems) have been installed across the six partner countries, since inception.

In many rural areas, the responsibility for electricity services is shared between Eskom and the local municipality. Municipalities provide electricity services to the majority of households in the Free State (78,4%), Northern Cape (70,7%), Gauteng (60,5%) and Mpumalanga (58,7%), while Eskom is most active in Limpopo (79,7%), North West (67,3%) and Eastern Cape (63,75%). Overall, municipalities are often dependent on Eskom for the provision of electricity services in their areas of jurisdiction and have no direct control regarding timing for service delivery purposes. As an interim solution, the National Energy Regulator of South Africa (NERSA) has agreed, since July 2016, to approve municipal SSEG tariffs on a case-by-case basis, while waiting for relevant regulations[i] – on the understanding that the interim tariffs and processes will be adapted to the regulations once published.

Small-scale Solar PV installations and the associated services, are expected to offer significant employment opportunities. The economic opportunity extends to the supply chain, including manufacturing and assembly of PV panels and components.

Illustrating the growing interest in Solar PV solutions for public buildings, Gauteng Province, for example, announced in 2015 that it would be installing rooftop solar panels on the eight million square meters of rooftop space available across Provincial Government buildings. This is expected to provide between 300 MW and 500 MW generation capacity. The Gauteng Department of Infrastructure Development initiated the Rooftop Solar Photovoltaic Rollout Programme under their integrated demand management plan in 2015, and registered it as a potential Public-Private Partnership with National Treasury (NT).

In the 2017 State of the Province Address, the commitment to invest in green and sustainable energy infrastructure was reiterated. It was reported that the rooftop Solar PV Project is underway, currently seeking to roll out solar panels at 16 health facilities in the province.

In 2009, the DEA, in collaboration with the South African Local Government Association (SALGA) and the nine provinces, initiated a coordinated Local Government Support Programme designed to provide support to municipalities in performing their environmental functions, or to enhance municipal performance with respect to these functions. Support is packaged around thematic areas and can consist of financial and/or technical support (provision of human resource, development of tools, advisory services) and infrastructure.

Chapter 8 has, therefore, been introduced to highlight the critical role of Local Government in energy planning and in furthering energy service delivery to communities, i.e. the ultimate customers. It completes the report by highlighting challenges and opportunities faced by Local Government, showcases innovative and proactive RE interventions being pursued at this level as well as additional support that would enable Local Government to become active partners in the national sustainable energy solution.

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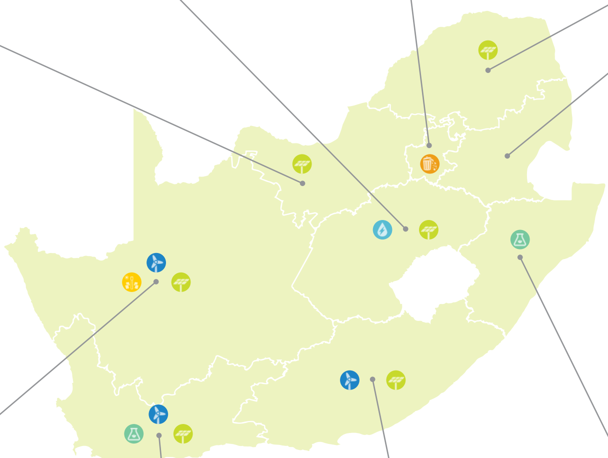
i Represents average percentage decrease of high and low end of LCOE range

Ranking of RE technology deployment in each province

AS AT END JUNE 2017



North West

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	0	0		0	0	
Landfill	0	0		0	0	
Hydro	0	0		0	0	
CSP	0	0		0	0	
Wind	0	0		0	0	
Solar PV	280	6	1	7	1	1
Total	280	6		7	1	

Free State

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	0	0		0	0	
Landfill	0	0		0	0	
Hydro	9	2	2	4	1	2
CSP	0	0		0	0	
Wind	0	0		0	0	
Solar PV	219	7	1	196	3	1
Total	228	9		200	4	

Gauteng

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	0	0		0	0	
Landfill	13	1	1	5	1	1
Hydro	0	0		0	0	
CSP	0	0		0	0	
Wind	0	0		0	0	
Solar PV	0	0		0	0	
Total	13	1		5	1	

Limpopo

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	0	0		0	0	
Landfill	0	0		0	0	
Hydro	0	0		0	0	
CSP	0	0		0	0	
Wind	0	0		0	0	
Solar PV	118	3	1	118	3	1
Total	118	3		118	3	

Mpumalanga

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	30	2	1	0	0	
Landfill	0	0		0	0	
Hydro	0	0		0	0	
CSP	0	0		0	0	
Wind	0	0		0	0	
Solar PV	0	0		0	0	
Total	30	2		0	0	

Nothern Cape

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	0	0		0	0	
Landfill	0	0		0	0	
Hydro	10	1	4	10	1	4
CSP	600	7	3	200	3	2
Wind	1,459	12	2	153	2	3
Solar PV	1,552	39	1	950	20	1
Total	3,621	59		1,313	26	

Western Cape

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	5	1	3	0	0	
Landfill	0	0		0	0	
Hydro	0	0		0	0	
CSP	0	0		0	0	
Wind	467	8	1	319	4	1
Solar PV	134	5	2	134	5	2
Total	606	14		452	9	

Eastern Cape

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	0	0		0	0	
Landfill	0	0		0	0	
Hydro	0	0		0	0	
CSP	0	0		0	0	
Wind	1,440	16	1	997	12	1
Solar PV	70	1	2	70	1	2
Total	1,509	17		1,066	13	

KwaZulu-Natal

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	17	1	1	0	0	
Landfill	0	0		0	0	
Hydro	0	0		0	0	
CSP	0	0		0	0	
Wind	0	0		0	0	
Solar PV	0	3		0	0	
Total	17	1		0	0	

Grand Total

Technology	Procured: Capacity in MWs	Projects	Rank	Operational: Actual capacity in MWs	Projects	Rank
Biomass	52	4	4	0	0	
Landfill	13	1	6	5	1	5
Hydro	19	3	5	14	2	4
CSP	600	7	3	200	3	3
Wind	3,366	36	1	1,468	18	2
Solar PV	2,372	61	2	1,474	33	1
Total	6,422	112		3,162	57	

Biomass Landfill Hydro CSP Wind Solar PV

123 Number of projects 123 Tech rank in province *Tech ranked by MWs procured

Ranking of the provinces by RE deployment

AS AT END JUNE 2017

Biomass

Procured	Capacity in MWs		
Eastern Cape	0	0	
Free State	0	0	
Gauteng	0	0	
KwaZulu-Natal	17	1	2
Limpopo	0	0	
Mpumalanga	30	2	1
North West	0	0	
Northern Cape	0	0	
Western Cape	5	1	3
Grand Total	**52**	**4**	

*Provinces ranked by MWs procured

Operational	Capacity in MWs		
Eastern Cape	0	0	
Free State	0	0	
Gauteng	0	0	
KwaZulu-Natal	0	0	
Limpopo	0	0	
Mpumalanga	0	0	
North West	0	0	
Northern Cape	0	0	
Western Cape	0	0	
Grand Total	**0**	**0**	

*Provinces ranked by MWs operational

Landfill

Procured	Capacity in MWs		
Eastern Cape	0	0	
Free State	0	0	
Gauteng	13	1	1
KwaZulu-Natal	0	0	
Limpopo	0	0	
Mpumalanga	0	0	
North West	0	0	
Northern Cape	0	0	
Western Cape	0	0	
Grand Total	**13**	**1**	

*Provinces ranked by MWs procured

Operational	Capacity in MWs		
Eastern Cape	0	0	
Free State	0	0	
Gauteng	5	1	1
KwaZulu-Natal	0	0	
Limpopo	0	0	
Mpumalanga	0	0	
North West	0	0	
Northern Cape	0	0	
Western Cape	0	0	
Grand Total	**5**	**1**	

*Provinces ranked by MWs operational

Hydro

Procured	Capacity in MWs		
Eastern Cape	0	0	
Free State	9	2	2
Gauteng	0	0	
KwaZulu-Natal	0	0	
Limpopo	0	0	
Mpumalanga	0	0	
North West	0	0	
Northern Cape	10	1	1
Western Cape	0	0	
Grand Total	**19**	**3**	

*Provinces ranked by MWs procured

Operational	Capacity in MWs		
Eastern Cape	0	0	
Free State	4	1	2
Gauteng	0	0	
KwaZulu-Natal	0	0	
Limpopo	0	0	
Mpumalanga	0	0	
North West	0	0	
Northern Cape	10	1	1
Western Cape	0	0	
Grand Total	**14**	**2**	

*Provinces ranked by MWs operational

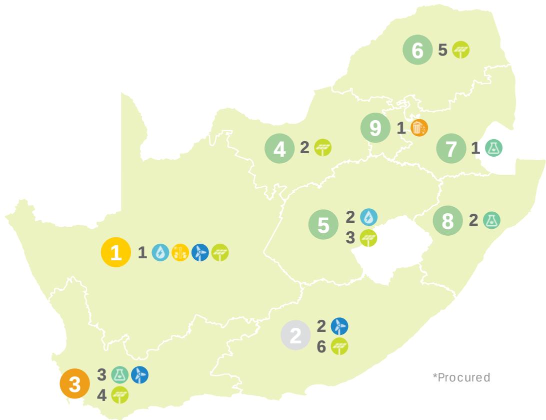
CSP

Procured	Capacity in MWs		
Eastern Cape	0	0	
Free State	0	0	
Gauteng	0	0	
KwaZulu-Natal	0	0	
Limpopo	0	0	
Mpumalanga	0	0	
North West	0	0	
Northern Cape	600	7	1
Western Cape	0	0	
Grand Total	**600**	**7**	

*Provinces ranked by MWs procured

Operational	Capacity in MWs		
Eastern Cape	0	0	
Free State	0	0	
Gauteng	0	0	
KwaZulu-Natal	0	0	
Limpopo	0	0	
Mpumalanga	0	0	
North West	0	0	
Northern Cape	200	3	1
Western Cape	0	0	
Grand Total	**200**	**3**	

*Provinces ranked by MWs operational



Wind

Procured	Capacity in MWs		
Eastern Cape	1440	16	2
Free State	0		
Gauteng	0		
KwaZulu-Natal	0		
Limpopo	0		
Mpumalanga	0		
North West	0		
Northern Cape	1459	12	1
Western Cape	467	8	3
Grand Total	**3366**	**36**	

*Provinces ranked by MWs procured

Operational	Capacity in MWs		
Eastern Cape	997	12	1
Free State	0	0	
Gauteng	0	0	
KwaZulu-Natal	0	0	
Limpopo	0	0	
Mpumalanga	0	0	
North West	0	0	
Northern Cape	153	2	3
Western Cape	319	4	2
Grand Total	**1468**	**18**	

*Provinces ranked by MWs operational

Solar PV

Procured	Capacity in MWs		
Eastern Cape	70	1	6
Free State	219	7	3
Gauteng	0	0	
KwaZulu-Natal	0	0	
Limpopo	118	3	5
Mpumalanga	0	0	
North West	280	6	2
Northern Cape	1552	39	1
Western Cape	134	5	4
Grand Total	**2372**	**61**	

*Provinces ranked by MWs procured

Operational	Capacity in MWs		
Eastern Cape	70	1	5
Free State	196	3	2
Gauteng	0	0	
KwaZulu-Natal	0	0	
Limpopo	118	3	4
Mpumalanga	0	0	
North West	7	1	6
Northern Cape	950	20	1
Western Cape	134	5	3
Grand Total	**1474**	**33**	

*Provinces ranked by MWs operational

Grand Total

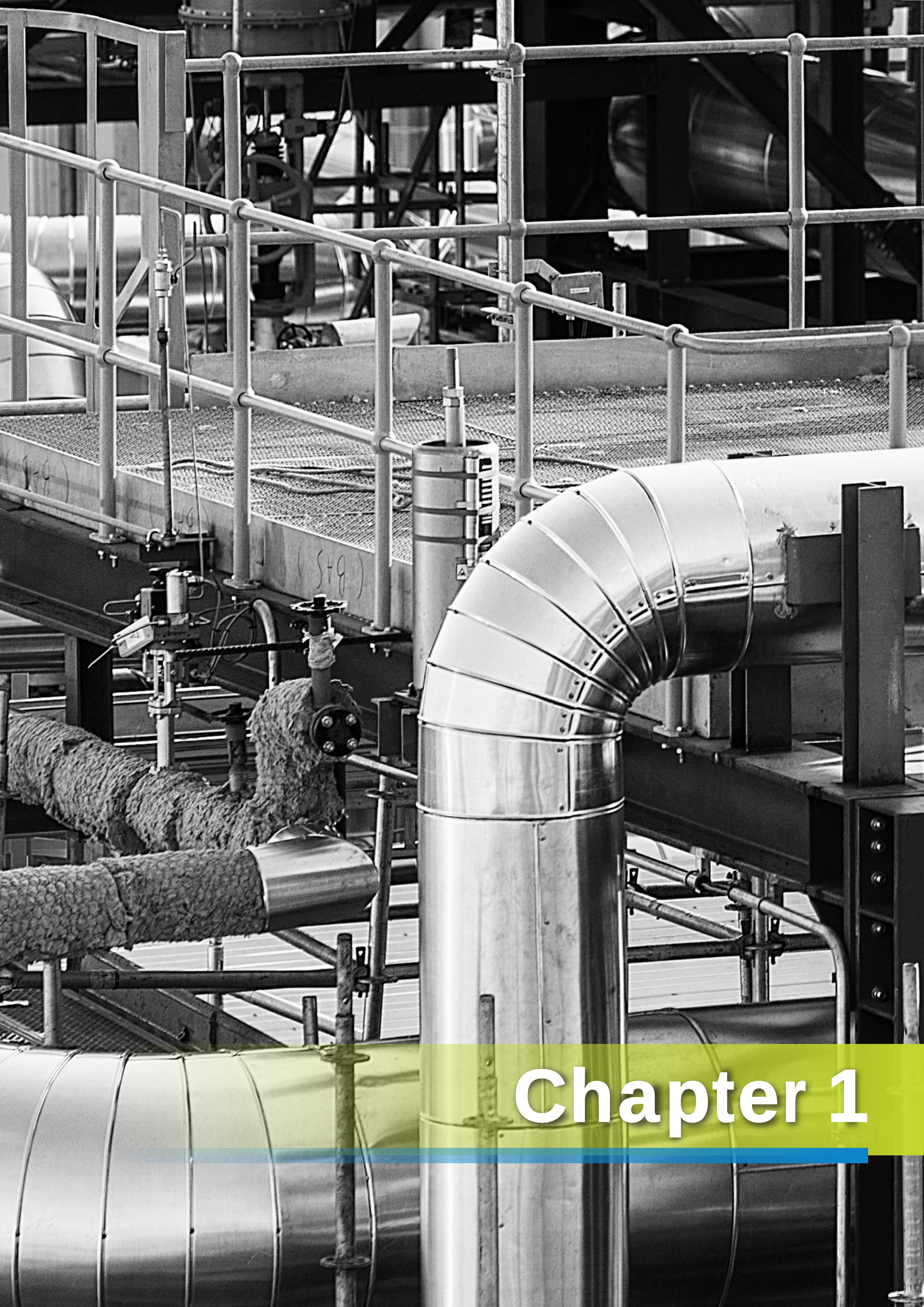
Procured	Capacity in MWs		
Eastern Cape	1509	17	2
Free State	228	9	5
Gauteng	13	1	9
KwaZulu-Natal	17	1	8
Limpopo	118	3	6
Mpumalanga	30	2	7
North West	280	6	4
Northern Cape	3621	59	1
Western Cape	606	14	3
Grand Total	**6422**	**112**	

*Provinces ranked by MWs procured

Operational	Capacity in MWs		
Eastern Cape	1066	13	2
Free State	200	4	4
Gauteng	5	1	6
KwaZulu-Natal		0	
Limpopo	118	3	
Mpumalanga		0	
North West	7	1	5
Northern Cape	1313	26	1
Western Cape	452	9	3
Grand Total	**3162**	**57**	

*Provinces ranked by MWs operational

- Biomass
- Landfill
- Hydro
- CSP
- Wind
- Solar PV
- 123 Number of projects
- 123 Province rank



Chapter 1

Chapter 1

Introduction

The Department of Energy (DoE), with support from the German government through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), developed and published the first State of Renewable Energy in South Africa Report in September 2015. This report provided a "consolidated and authoritative account of progress made in advancing renewable energy (RE) technologies to the economy and citizens at large".

The report detailed the extent of the national energy resources and took stock of progress made with implementing RE projects in SA at the time. Progress with the deployment of South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), launched in 2011, had led to the country becoming one of the leading RE investment destinations in the world. By end June 2015, 1,860 MW capacity had been added to the power system, growing the share of RE from 0 percent to 4 percent of the total installed capacity in the country within two-and-a-half years from commencement of construction.

The report acknowledged the contribution of a comprehensive and conducive regulatory environment, highlighting the main policy documents, legislative framework and role players driving the RE agenda. It also highlighted the integral role of research, development and human capital development, which are priorities for ensuring that South Africa keeps up with technological developments in the field. Other aspects covered include managing the development of the grid infrastructure to support RE deployment; and the potential role of clean energy in addressing energy poverty and energisation.

While celebrating the successes, the report also recognised the remaining areas requiring additional support to catalyse development and/or unlock the full spectrum of potential benefits.

During the two years that followed this first publication, the pace of RE development worldwide had accelerated far beyond what was anticipated at the time of compiling the 2015 report. Acceleration of the global energy transformation has been most evident in the power sector. A 2017 Bloomberg New Energy Finance (BNEF) and United Nations Environment Programme (UNEP)[1] trends analysis showed how RE is becoming the default choice for low-cost energy after dramatic cost reductions of the past few years, with prices continuing to fall. Despite the incredibly low costs already achieved, Lazard's latest Levelised Cost of Energy (LCOE) Analysis[2] – an annual study comparing the cost of generating energy from conventional and alternative technologies – showed the median LCOE from utility-scale PV technologies down approximately 11percent, rooftop residential Solar PV technology down approximately 26 percent and wind 7.5 percent lower during 2016[i].

i Represents average percentage decrease of high and low end of LCOE range

Figure 1: Technology price trends for wind and solar

(a) Represents average percentage decrease of high end and low end of LCOE range

(b) Low end represents crystalline utility-scale solar with single-axis tracking in high isolation jurisdictions (e.g. Southwest U.S.), while high end represents crystalline utility-scale solar with fixed-tilt design

(c) Lazards LCOE initiated reporting of rooftop Commercial and Industrial (C&I) solar in 2010

Source: Lazard estimates

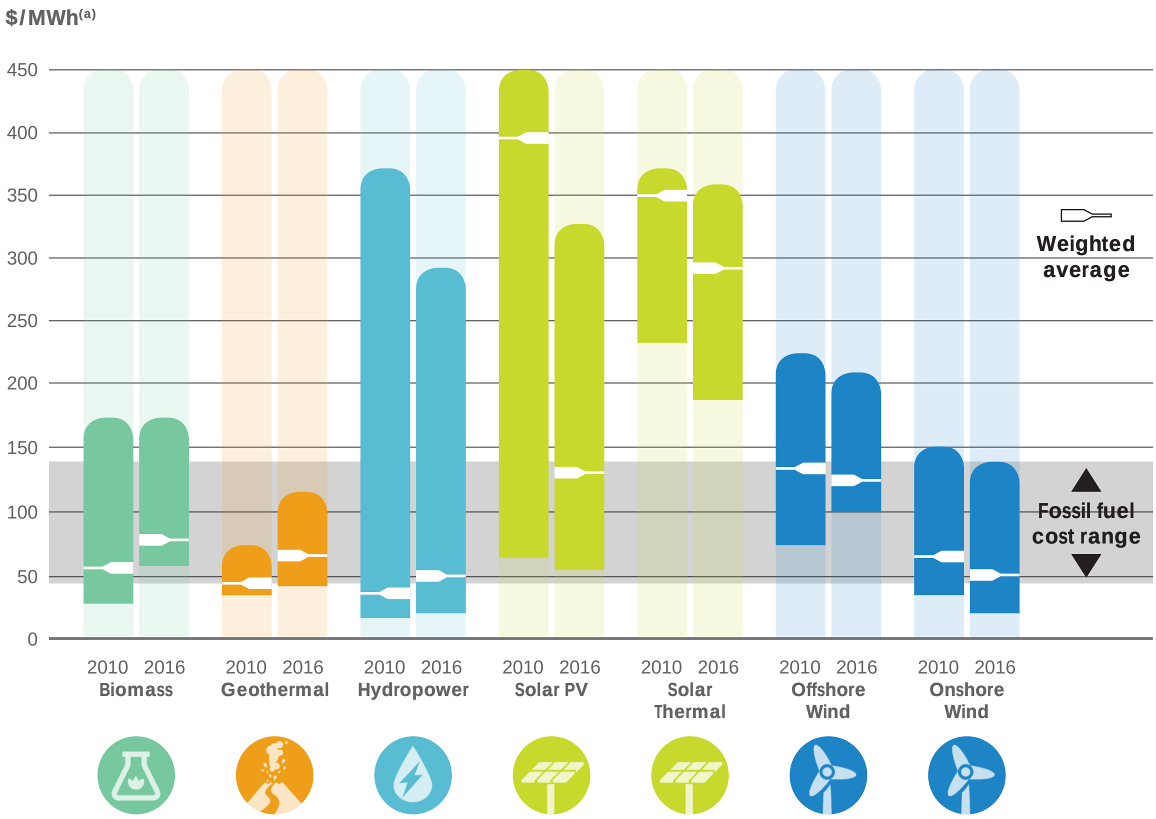


Figure 2: Levelised cost of electricity for utility-scale power (ranges and averages), 2010 and 2016

(a) MWh: megawatt hour
(b) All costs are in 2016 rate of $. Weighted Average Cost of Captial is 7.5% for OECD and China and 10% for Rest of World

A review[3] of global energy systems, published by International Renewable Energy Agency (IRENA) mid-2017, demonstrates the growing competitiveness of RE as presented by the LCOEs for various technologies in 2010 and 2016 compared with the current range for fossil fuel options[ii].

During 2016, a record number of installations of RE power capacity was achieved worldwide – ironically with the lowest investment in the sector since 2013, made possible because of the rapidly declining costs of RE technologies. Wind, Solar, Biomass and Waste-to-energy, Geothermal, Small Hydro and marine sources collectively added 138.5 GW, up from 127.5 GW the previous year. This gigawatt figure represents 55 percent of all the utility-scale generating capacity added globally, the highest share contributed by RE power in any year to date[4]. RE technology and cost developments are also enabling a convergence between traditionally distinct sub-sectors like electricity, transport and heating/cooling, further facilitating deployment levels of renewables.

The economies of RE affirm its important and growing part in any future energy mix. Affordable RE power options further contribute diversification to a portfolio of resources, an important measure

ii It should be noted that the IRENA and Lazard LCOE analyses use different data sets and assumptions, resulting in slightly different cost ranges to ensure grid and system reliability at least cost. The Rocky Mountain Institute (RMI) beautifully describes this diversification of the power system as a symphony, integrating many energy resources, like instruments in an orchestra, at the right time, at the right volume[5].

Another remarkable milestone of the preceding two years has been the inclusion of energy under the United Nation's 2030 Agenda for Sustainable Development. On 25 September 2015, world leaders adopted 17 Sustainable Development Goals (SDG) to end poverty, protect the planet, and ensure prosperity for all as a blueprint for a sustainable future. These goals, which replaced the Millennium Development Goals, for the first time included energy[iii] targets. It states that "energy is central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential." As of 2015, energy stands at the centre of global efforts to induce a paradigm shift towards low-carbon energy systems, green economies, poverty eradication and ultimately sustainable development. South Africa's Presidency, as signatory to the SDG, will be monitoring progress and reporting on the wide range of social and environmental benefits.

Energy has been inextricably linked to climate impacts, to which developing countries are most vulnerable. Diversification of national energy portfolios to incorporate more RE and energy efficiency interventions, reduce energy and carbon intensities and decreases carbon and other harmful emissions.

The adoption of the Paris Agreement in December 2015 reinforced the global commitment to clean energy solutions and reducing greenhouse gas emissions. This agreement, signed by 194 countries and already ratified by more than 140, including South Africa, envisages *"complete decarbonisation after 2050"*. This ambition for decarbonisation and zero emissions of greenhouse gas entails a far-reaching commitment across economic sectors and activities. In the energy sector, it implies a switch to the highest possible penetration of RE as soon as possible.

RE development is, therefore, fast creating a converging opportunity for the needs of investors, people and the environment to meet, promising a shift to a better world for all.

With the timely and well-designed introduction of the REIPPPP, South Africa was one of the first countries to benefit from this evolution of the energy sector. The promise, however, extends further than utility-scale solutions. Energy technology developments in generation, grid intelligence and infrastructure and storage, combined with the success of the peer-to-peer economy, from Airbnb to Uber, paves the way for the democratisation and disintermediation of the energy market. RE provides opportunities for electricity to be produced and distributed in a way that benefits all role players.

In the energy sector, this market trend necessitates duly considered devolution of power, development of appropriate energy infrastructure and active involvement of municipalities in a way that will ensure the provision of affordable energy and the most economically viable energy solution for the country.

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iii Goal 7, Ensure access to affordable, reliable, sustainable and modern energy for all

Within this global context, this 2017 update of the State of Renewable Energy in South Africa, provides an overview of clean energy-related developments in the country since 2015. Despite delays with the signing of new Power Purchase Agreements (PPAs), which temporarily slowed the growth of utility-scale RE during the preceding two years, many important building blocks have been established over this period.

The national commitment to RE has been reinforced by South Africa's ratification of international climate agreements and recent long-term energy planning iterations. Policy and regulatory developments are adding refinement to the existing framework, with progress made with respect to small-scale embedded generation, industry self-regulation, tax incentives and enhanced integration between energy efficiency and RE (Chapter 2).

Chapters 3 and 4 provide an update on the continued growth in the market for RE, at both utility level and small scale. Chapter 4 also considers innovations that are enhancing the potential contribution of clean energy to achieving universal access to modern energy services.

Chapters 5 and 6 explore the creativity and innovation that is, or could potentially be, stimulated by a transition of the scale seen in the energy sector. Chapter 5 re-examines the skills development initiatives and contribution of research and development to stimulate a thriving future RE sector and Green Economy. Chapter 6 explores the interrelation between energy, economic and sustainable development and the opportunities that arise, through energy transformation, to achieve broader and more substantive developmental aspirations.

The existence of transmission infrastructure capable for RE integration, as well as clear rules on transmission access and connection, are critical enablers for diversification of the energy mix. Chapter 7 reviews the latest grid infrastructure developments in support of RE deployment in the country.

The 2015 Climate Summit for Local Leaders highlighted the crucial role of municipalities in a sustainable energy transition. Chapter 8 considers the challenges and opportunities faced by Local Government, showcases innovative and proactive RE interventions being pursued at Local Government level and highlights additional support that would enable Local Government to become legitimate partners in the national sustainable energy solution.

This 2017 State of Renewable Energy in South Africa report has the opportunity to witness RE shedding its label as 'alternative energy' and taking a convincing part in the power system of the future.

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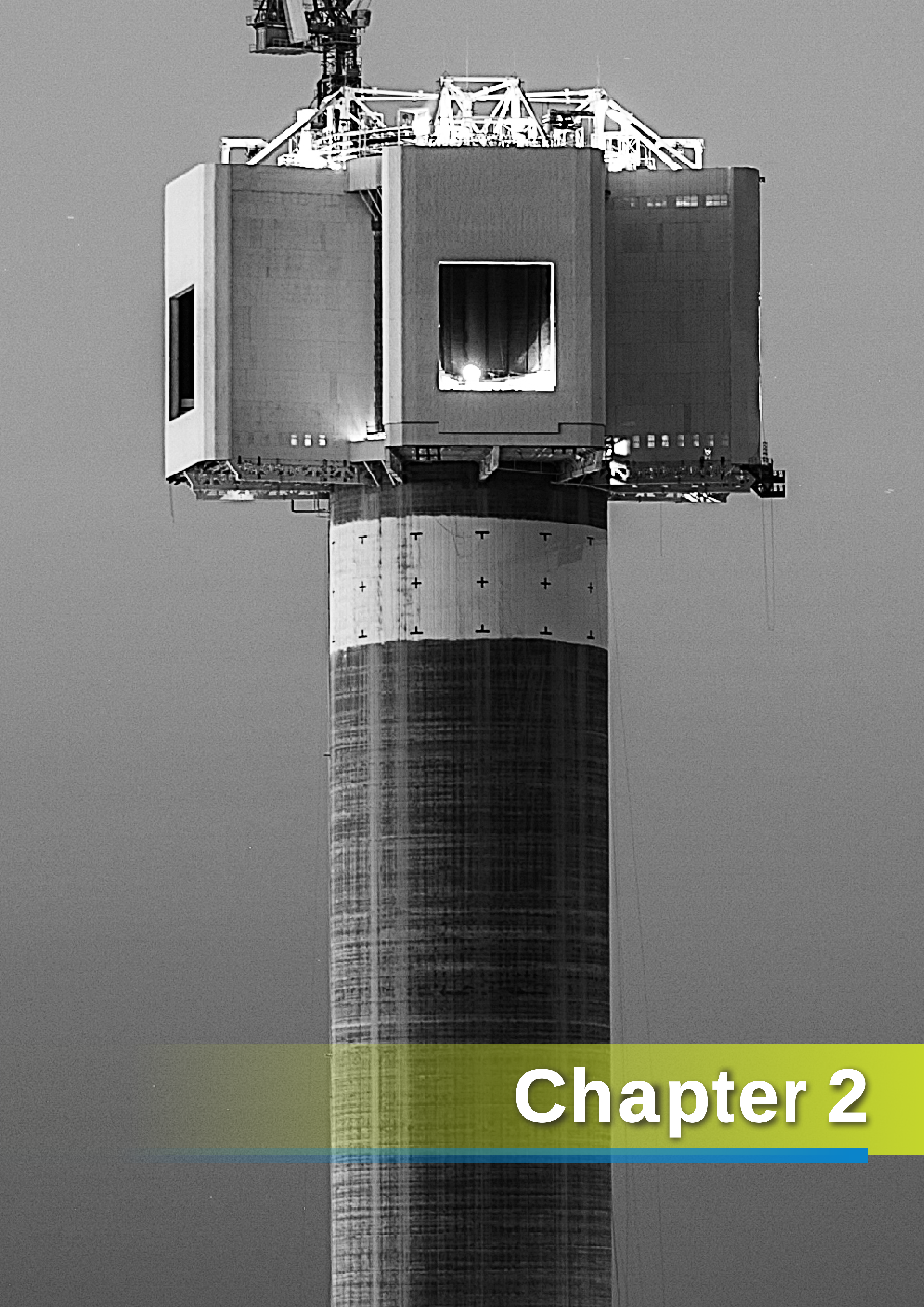
1 Frankfurt School-UNEP Centre/BNEF. 2017. Global Trends in Renewable Energy Investment 2017, http://www.fs-unep-centre.org (Frankfurt am Main)

2 Lazard. 2016. Lazard's levelised cost of energy analysis, version 10.0. December 2016

3 IRENA (2017), REthinking Energy 2017: Accelerating the global energy transformation. International Renewable Energy Agency, Abu Dhabi

4 Frankfurt School-UNEP Centre/BNEF. 2017. Global Trends in Renewable Energy Investment 2017, http://www.fs-unep-centre.org (Frankfurt am Main)

5 Dyson, M; Lovins, A. 2017. The Grid Needs a Symphony, Not a Shouting Match. 12 June 2017 Available at: https://www.rmi.org/news/grid-needs-symphony-not-shouting-match/ (Accessed: 18 June 2017)



Chapter 2

Chapter 2

The Regulatory and Policy Landscape

Since 1996, with the introduction of the Constitution, South Africa has methodically been creating the building blocks for economically and ecologically sustainable development and a sustainable energy future. The 2015 State of Renewable Energy Report provided a comprehensive overview of policies and instruments that had been established by various Government departments[i] and role players over the preceding two decades. For ease of reference, a list of the relevant policies and instruments are included as an appendix (Appendix A) to this report.

The experience over the 20-year period demonstrated that sound policies do not result in an effective and efficient development of RE in the absence of other critical policy tools. A combination of policy design, policy instruments and a fine-tuned regulatory regime is most effective to unlock market potential and achieve national clean energy objectives. The South African experience further demonstrated the importance of the following aspects to effect the development of RE and market sustainability:

- An appropriate and comprehensive policy framework that incorporates legal and regulatory preconditions, institutional and administrative capacity and efficiency across all areas of Government and especially across all regulatory approval bodies.
- The compatibility of coexisting policy instruments to advance the intended outcomes without compromising other policy objectives (as illustrated by the need to redesign the original Renewable energy feed-in-tariffs (REFIT) programme.
- Tailoring a unique solution for the country that did not replicate what was considered international 'best practice' at the time, but more appropriately responded to national objectives, policy environment, market structure, technology developments, demand and supply.

A 2011 World Bank analysis[1] of RE policy instruments performance in six developing countries[ii] echoed these findings, but also noted that policy and regulatory design is a dynamic process, requiring continual refinement to support different segments of the RE market at different times[2].

Bokpoort concentrated solar power plant near Groblershoop

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i Refer 2015 State of Renewable Energy in South Africa report, chapter 1 and 2, available at http://www.gov.za/sites/www.gov.za/files/State%20of%20Renewable%20Energy%20in%20South%20Africa_s.pdf

ii Brazil, India, Indonesia, Nicaragua, Sri Lanka, and Turkey

The success of the REIPPPP demonstrated that the established regulatory framework (refer Figure 1) is suitably robust and flexible to support utility-scale RE development in the country.

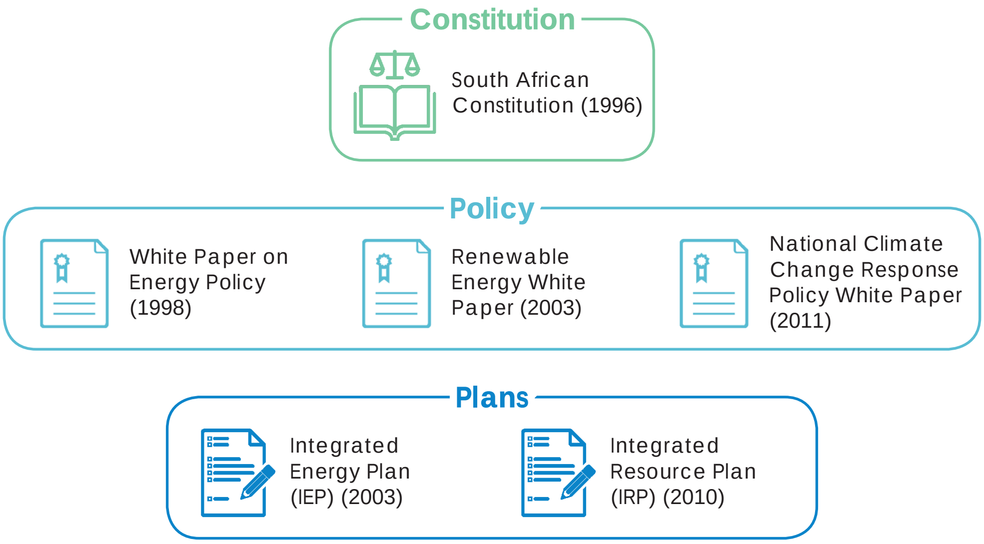

Figure 1: Policy context for energy in South Africa

The evolving policy and regulatory environment

During the preceding two years, work continued to respond to the changing energy landscape and the policy focus broadened to start address/resolve remaining or emerging areas of uncertainty.

As indicated earlier, 2015 concluded with the Paris Agreement (also known as the 21st Conference of the Parties, COP21) being adopted by the international community. South Africa ratified the agreement in November 2016 after being passed by both the National Assembly and the National Council of Provinces[3].

Leading up to COP 21, South Africa formulated its Intended Nationally Determined Contribution (INDC), indicating the planned actions to mitigate greenhouse gas emissions. The plan is based on a 'peak-plateau-decline' trajectory that also informed the National Climate Change Response White Paper Policy of 2011[4]. The INDC states an ambition for a decarbonised energy sector and "a complete transformation of the future energy mix", incorporating clean and high efficiency generation technology.

The INDC includes extensive modelling to quantify the estimated incremental cost to expand the REIPPPP, decarbonise electricity by 2050, carry out carbon capture and storage, move to electric vehicles, and introduce hybrid electric vehicles. South Africa's modelling developed a cost estimation of interventions, indicating the finance and investment requirements to realise the commitments. This modelling lays the basis for the country to apply for international funding to assist the transition.

BOX 1

Funding support emanating from South Africa's climate commitments

Achieving a transformation of the scale committed under the Paris Agreement will require significant investment. In recognition, this pledge was followed by global commitments for financial assistance to developing countries to accelerate progress towards a low carbon pathway. Developed countries have pledged to mobilise $100 billion per year by 2020, from a variety of sources, to facilitate transition to a low carbon economy.

South Africa is already benefiting from these international funding commitments. The Green Climate Fund (GCF) is set up as a dedicated facility to fund mitigation and adaptation initiatives and is already capitalised with more than $10 billion. The Fund is presently supporting 43 projects with a projected 128 million beneficiaries. A total of 20 of these projects are in Africa[5]. The Development Bank of Southern Africa is an accredited entity, as is the South African National Biodiversity Institute (SANBI).

A South African project has received $34 million in funding support to *"tap the expertise of South African-based developmental finance company SCF Capital Solutions to use supply chain financing to provide capital to green economy-focused MSMEs"*[6].

The INDC further clearly expresses South Africa's willingness to share in global responsibility for adaptation, and interest in international recognition of its domestic investments. Accordingly, the South African Green Fund was established with an allocated $0.11 billion in the 2011 to 2013 budgets to support catalytic and demonstration Green Economy initiatives. "Resources for the fund will have to be increased in future to enable and support the scaling up of viable and successful initiatives, including contributions from domestic, private sector and international sources".

South Africa's national response considers both development needs and climate change imperatives, reflecting our national priorities, as encapsulated in the National Development Plan (NDP) and incorporating the principle of a sustainable energy system, as represented by the energy triangle (refer Figure 1).

As a developing country, the INDC commitments are stated in the context of the country's development agenda with overriding priorities to eliminate poverty and eradicate inequality. Eliminating poverty and eradicating inequality requires addressing major challenges in creating decent employment, which in turn requires sustainable economic development, improving basic education, health and social welfare and many other basic needs such as access to food, shelter and modern energy services.

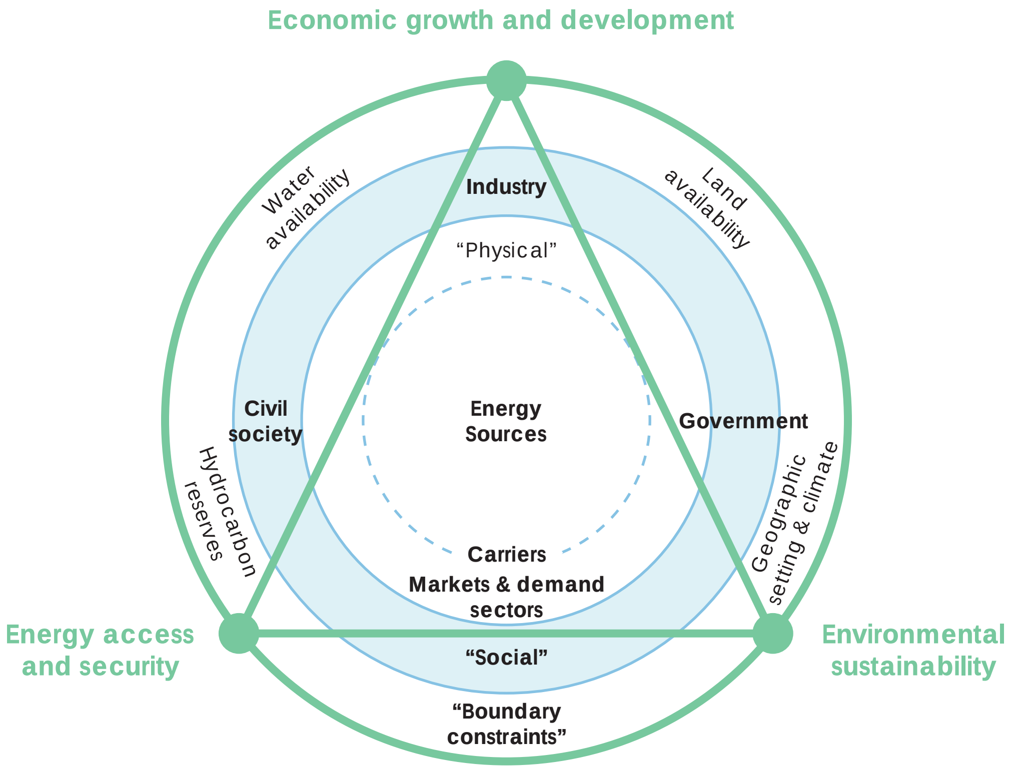

Figure 2: Energy Triangle *(World Economic Forum – Global Energy Architecture Performance Index Report, 2013)*

Setting the course for clean energy development

While the final Integrated Energy Plan (IEP) is awaited, it is clear that the approach to the IEP already reflects the international convergence of the electricity, transport and heating/cooling sectors, as referred to in the introduction and discussed in Chapter 3. This suggests that the final document will be modern and aligned with cutting edge, international thinking.

The Integrated Resource Plan (IRP) is the electricity sector plan that creates the context for supply side capacity development in the country. At the time of writing this report, the IRP 2010 remained the presiding plan, providing a planning horizon to 2030.

The process of reviewing and updating the next integrated resource plan was initiated in 2013 and advanced in November 2016. This updated plan will extend the planning horizon to 2050. Planning is taking cognisance of technology advances and South Africa's international SDGs climate commitments.

A draft IRP Base Case was released for public comment in November 2016. Giving effect to national policy objectives and building on the 2010 IRP, the draft plan embraces a diversified energy mix derived from coal, gas, nuclear and RE resources. As anticipated, all scenarios reflected in the draft plan see a dramatic ramp up in the RE ambitions of South Africa when compared to 2010. The base case limits RE deployment by displaying caution about the speed at which industry growth can physically and logistically occur, yet even so envisions a total installed capacity of more than 50 GW by 2050[7]. In other IRP modelling scenarios (Table 1), for instance the one done by the CSIR, even greater installed capacities of RE are required[8].

Table 1: Comparison of aspirations for 2030 between IRP 2010, draft IRP 2016 and IRP 2016 scenarios

IRP 2010 2030 - RE contribution (MW installed)	**17,800**[9]
Draft IRP 2016 2050 base case - RE contribution (MW installed)	**55, 250**[10]
Draft IRP 2016 2050 CSIR lowest cost scenario - RE contribution (MW installed)	**164,378**[11]
Draft IRP 2016 2050 CSIR decarbonised scenario - RE contribution (MW installed)	**200,782**[12]

Public meetings on the IRP were very well attended and extensive public comments were received. The DoE is presently processing the comments in order to come up with the next iteration of the IRP. The importance of the IRP in broader national planning processes is increasingly appreciated and demonstrated. A recent example hereof was Government's Inclusive Growth Action Plan, released on 18 July 2017, which targets February 2018 for the publication of a final lowest-cost IRP[iii] as part of key interventions to stimulate economic growth. At a broader level the NDP (although recognising that it will be amended to reflect the latest IRP, once finalised) sets a target of 20,000 MW of new-

De Aar Solar Power PV plant near De Aar

iii Minister of Finance, Gigaba, M. Government's Inclusive Growth Action Plan, 18 July 2017 build generation capacity from RE sources by 2030. The Green Energy Strategic Infrastructure Project aims to deliver a third of this (6.9 GW) through Independent Power Producers (IPPs) by 31 March 2019. These renewable technologies include on-shore Wind, Solar Photovoltaic (PV), Concentrated Solar Power (CSP), Biogas, Biomass, Landfill Gas and Hydropower. Even at municipal level, the City of Tshwane's 'Policy on Embedded Generation' refers to the IRP 2016 base case.

Clean energy spanning across national interests

Energy is by nature an intergovernmental issue, cutting across energy security, economic prosperity, employment and environment, among others. In recognition of the impacts and benefits with respect to these areas of national interest, clean energy is also being incorporated more comprehensively into the broader policy framework.

Hydropower Generation Policy and Pricing Strategy for Water Use Charges, Department of Water and Sanitation (DWS)

South Africa has been advancing its policy on hydropower in order to enable the NDP and address other important considerations like climate change. In July 2016, the Draft Sustainable Hydropower Generation Policy was gazetted. It recognises the global shift towards RE. It further underlines that South African hydropower projects (such as those which are retrofitted to existing dams) can be both environmentally and financially attractive due to existing, suitable infrastructure. There is a recognition of the inter-relation between water and energy.

The general approach seems to be that larger projects can be done at existing reservoirs while new dams will likely be approached with caution and run-of-river hydro will be supported. The REIPPPP has already seen successes in the latter regard, with 14 MW procured from small hydropower installations.

Leading up to the policy, a draft pricing strategy was gazetted by the Department of Water Affairs in November 2015. This strategy seeks to facilitate reform in the sector as well to provide transparency and predictability to water users on how water will be priced. It is intended to support the achievement of the goal, as articulated in the National Water Resources Strategy, that water is efficiently and effectively managed for equitable and sustainable growth and development.

The strategy redefined water use categories, recognising RE production from hydropower as a non-consumptive use. In addition, the strategy acknowledges the importance of supporting the viability of hydropower schemes as part of the diversification of the energy mix. It proposes a pricing approach that charges for water use and abstraction[iv], structured as a combination of a fixed charge on installed generation capacity and a variable charge based on power generated. Charges are further differentiated depending on the size of the plant, with all installations below 1 MW defined as micro hydropower and completely exempt from charges.

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iv No resource management or depreciation charges are levied for hydropower. Abstraction-related water resources management and infrastructure charges will be imposed under specified conditions

White Paper on Transport policy and Green Transport Strategy, Department of Transport (DoT)

The DoT has been updating its White Paper on National Transport Policy with a Revised Draft dated May 2017, while also producing a Green Transport Strategy 2016 – 2021.

The goals include broader economic and social objectives[13] and a link with RE is created by the inclusion of the aim to "...achieve the above objectives in a manner that is economically and environmentally sustainable, and minimises negative side effects". The transport sector produces 13 percent of South Africa's total Greenhouse Gas (GHG) emissions, predominantly from the combustion of liquid fossil fuels[14]. The Draft Integrated Energy Plan also includes an assumption of a 20 percent annual penetration by electric vehicles[15].

National Energy Efficiency Strategy (NEES), post-2015, Department of Energy (DoE)

International work on our collective, international energy future has revealed profound and deep links between energy efficiency (EE) and RE. Both address climate change by lowering emissions – RE by leveraging an emissions free generation source and EE by dropping the energy intensity of the economy. In a recent paper by IRENA, it appeared that a simultaneous and aggressive roll-out of both RE and EE (in the context of Sustainable Energy for All) would see the growth in total primary energy supply (TPES) being reduced by up to 25 percent compared to business as usual in 2030 in the countries studied. Energy efficiency measures would account for 50-75 percent of the total energy savings[16].

Given this reality, it is encouraging that the South African policy framework for EE has been strengthened with the formulation of NEES; the post-2015 version having been gazetted for comment[17]. The post-2015 NEES aims to stimulate a next tranche of EE improvements through a combination of fiscal and financial incentives, a robust legal and regulatory framework, and enabling measures; targeting an economy-wide reduction in final energy consumption of 29 percent relative to 2015. A comprehensive results framework was defined to describe targets and monitor progress.

Hopefield wind farm near Hopefield

Recognising that EE is a cross-cutting national concern, the strategy has been framed to complement the policies and strategies of the Department of Environmental Affairs (DEA), the Department of Public Works (DPW), the Department of Science and Technology (DST), Department of Trade and Industry (**the dti**), Department of Transport (DoT) and National Treasury. Under this framework, a National Energy Efficiency Action Plan (NEEAP) has also been developed to guide practical implementation.

Tax incentives, National Treasury (NT) in collaboration with partner Departments

The taxation regime in a country is usually a reflection of broad policy direction. In the case of technological change, the presence of tax incentives for a new technology can be seen as an indication that Government is supportive of change. As mentioned above, the climate resilience paradigm underpinning the Paris Agreement requires, among others, the lowest possible use of fossil fuels (EE and a low carbon intensity).

South African tax law already displays a familiarity with – and support for – this new reality. In the domain of EE, significant incentives exist.

In terms of Section 12L of the Income Tax Act, a deduction exists for EE savings. The saving is 95c/kWh (or kWh equivalent for non-electricity projects). The benefit until the first quarter of 2016 was 45c/kWh. The amendment displays an even higher level of support from Government. At the company tax rate of 28 percent the benefit would translate to about 26c/kWh. The regime extends to 2020 and creates a compelling reason for tax payers to deploy capital to effect EE by, for instance, improving the insulation in buildings so less heating and cooling would be required.[18] For example, an initiative to improve EE in brick making kilns used this tax benefit to deploy capital[19].

Section 12I isn't specific to energy but could potentially create benefits for energy projects should they be able to fit under the requirements pertaining to investment in manufacturing assets or the training of personnel[20]. The section 12I tax allowance and subsequent Regulation 639 of 23 July 2010, were introduced to support investment in manufacturing assets. The mechanism was intended to improve the productivity in the South African manufacturing sector, thereby accelerating economic growth and supporting economic policy objectives. A minimum of 10 percent energy improvement was introduced as one of the prerequisites for qualification.

"The new tax incentive, contained in section 12I, aims to assist the transformation of production processes and methods by supporting investment in manufacturing assets that will improve the productivity of the South African manufacturing sector... The Minister of Finance has made R5.6 billion available over five years for incentives in aid of industrial policy objectives which translates into R20 billion of additional tax deductions. This incentive will be fully available for new projects as well as expansions or upgrades of existing projects"[21].

An example might be an EE intervention that allows production at lower cost.

RE, like EE, is specifically promoted by the tax regime. Section 12B of the Income Tax Act allows accelerated depreciation on RE assets. At present a 50/30/20 write-off is allowed in respect of any machinery, plant, implement, utensil or article (referred to as a qualifying asset) owned by the taxpayer. The qualifying technologies are Wind, Solar, Hydro below 30 MW and Biomass[22]. In the case of Solar PV below 1 MW, the depreciation period has since 1 January 2016 been shortened and strengthened to one year, providing strong support for embedded PV[23].

Carbon tax, National Treasury (NT)

The strongly mooted carbon tax, once implemented, will lead to the internalisation of the cost of GHG emissions and will further benefit RE. While the timeframes for implementation are uncertain, the process was detailed in the budget speech by the Minister of Finance in February 2017[24]. The Carbon Tax Bill was recently approved by Cabinet and referred for Parliament's consultation and consideration as confirmed in the Minister of Finance's Medium-Term Budget Process in October 2017. The Bill is expected to be released soon for public consultation. It seems likely that some carbon off-setting will be allowed.

South Africa's policy work to facilitate the discharge of its international obligations is also evident from the Draft National Greenhouse Gas Emission Reporting Regulations ("the Draft GHG Regulations") to be made in terms of the National Environmental Management: Air Quality Act 39 of 2004. These were Gazetted in April 2017 and state in section 2 that the purpose is to:

> *"...introduce a single national reporting system for the transparent reporting of greenhouse gas emissions, which will be used (a) to update and maintain a National Greenhouse Gas Inventory; (b) for the Republic of South Africa to meet its reporting obligations under the United Framework Convention on Climate Change (UNFCCC) and instrument treaties to which it is bound; and (c) to inform the formulation and implementation of legislation and policy"*[25].

Small-Scale Embedded Generation (SSEG), Department of Energy (DoE)

Changed economic and technological circumstances have required policy development in the domain of Small-Scale Embedded Generation. For some decades, Solar PV and other embedded generation options like small-scale Wind and small-scale Hydro have been available but mostly used by sustainable energy enthusiasts and people without access to the national grid. The possibilities of cogeneration, trigeneration and waste heat recovery were nascent, though not very prevalent either.

Khi Solar 1 concentrated solar power plant near Upington

The policy framework reflected this former status quo in that the Electricity Regulation Act 4 of 2006 ("ERA") in section 7 provides that no person may, without a license issued by the National Energy Regulator (NERSA), operate any generation facility, save in regard to the exceptions listed in Schedule 2 of the ERA, namely:

- any generation plant constructed and operated for demonstration purposes only and not connected to an inter-connected power supply;
- any generation plant constructed and operated for own use; and
- non-grid connected supply of electricity except for commercial use.

In recent years, SSEG in the form of Rooftop PV has become dramatically cheaper to the extent that its levelised cost is now usually well below the cost municipal consumers pay to their local authorities. SSEG owners also acquire an additional degree of energy security. It is especially attractive to consumers who use electricity all day during the day, such as shopping centres, hotels or wine farms, among others. There has been a significant increase in installations and a concomitant need to develop the policy framework both at national and municipal level.

v Embedded generation is included as an important area in the Integrated Resource Plan (IRP) and is recognised as an important demand-side measure for Government and particularly the Department of Energy (DoE), but there was previously no policy to promote it

On 2 December 2016, the Minister of Energy published for public comment such updated policy in GN R 1482 Government Gazette 40464. This was followed by the publication of the Licensing Exemption and Regulation Notice for SSEG On 10 November 2017.

The Licensing Exemption and Regulation Notice amends Schedule 2 of the ERA and exempts various categories of generation facilities and electricity resellers from the requirement to hold a license under the ERA, merely requiring that these activities be registered with NERSA.

The following activities are mooted to be exempt:[26]

Below 1 MW and providing the Minister has not published a notice in the Government Gazette stating that the amount of megawatts allocated in the IRP for embedded generation of this nature has been reached:

- embedded generation where no wheeling takes place;
- facilities that wheel through the grid;

Below 1 MW without further conditions:

- off-grid generation;

Without further conditions:

- facilities used for demonstration purposes; and
- back-up or standby generation.

The result of this is that SSEG below 1 MW would be able to proliferate in a reasonably free, legal yet controlled manner, with the installations known so that technicians working on the grid can do so safe in the knowledge of where live, embedded generation assets are situated. In time, the cap of 1 MW can be reassessed as may be required, and potentially moved up.

At municipal level, the growth in SSEG likewise requires policy development to account for the fact that SSEG reflects lost sales for the local authority while most SSEG generators stay on-grid and practically use the grid as a storage facility, potentially starting to draw load at any moment in time. It is anticipated then that national policy in this regard will be complemented by municipal bylaws and tariff structures. The likely outcome is that the tariff structures for municipal users will be amended to consist of a combination of an energy charge and a capacity/availability charge, in order to better compensate the local authority for the service it is providing to municipal customers. Some work has already been done in this regard by both Nelson Mandela Bay and the City of Cape Town. Chapter 8 provides an update on the work being developed and implemented at municipal level to accommodate this market development.

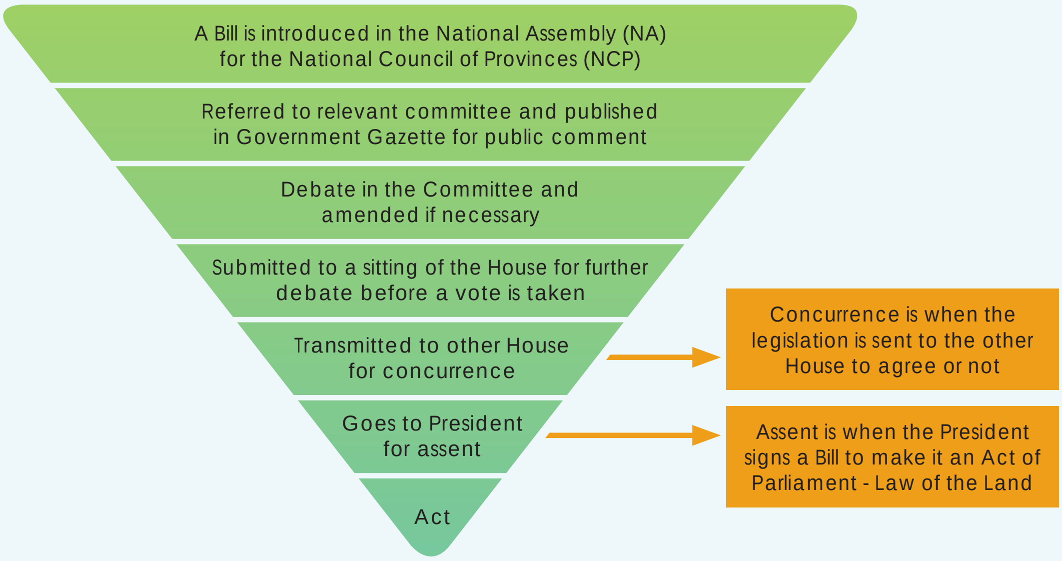
The growth in SSEG is likely to continue and, as the enabling environment is clarified and streamlined, this trend may further accelerate as technology prices continue to come down.

BOX 2

Process for getting an act or regulation promulgated

In South Africa, the Constitution guides the robust process that ultimately leads to the making of a law. Public participation is required for all legislation, inclusive of regulations made in terms of the legislation. The form and scope of public participation is usually contained in the Act itself, but some general principles exist[27].

Public participation is implicit in the process described like this: "It may start with a discussion document called a Green Paper that is drafted in the Ministry or department dealing with a specific issue. This discussion document gives an idea of the general thinking that informs a particular policy. It is then published for comment, suggestions or ideas. This leads to the development of a more refined discussion document, a White Paper, which is a broad statement of Government policy. It is drafted by the relevant department or task team and the relevant parliamentary committees may propose amendments or other proposals. After this, it is sent back to the Ministry for further discussion, input and final decisions"[28].



While the status of the Integrated Resource Plan (IRP) is somewhat uncertain, as to whether it is policy or legislation , it remains a policy implementation tool similar to other plans, strategies and standards. Consequently, there is an established practice for comprehensive public participation to take place. The same is generally true for other guiding documents and strategies even if they should arguably fall in the policy domain, like the National Energy Efficiency Strategy (NEES).

A framework for regulating implementation

We also see that the direction given at national level is effectively finding its way into practical application at industry and municipal level.

South African Photovoltaic Industry Association (SAPVIA) Green card, an industry led initiative

The rapid development in embedded solar has created a need for a quality control mechanism ensuring that newly created jobs fall to those who are well trained to carry them out. In a new development, voluntary industry self-regulation emerged as an initiative to assure quality while supporting industry development and national objectives.

In 2015, SAPVIA, in partnership with GIZ, BSW Solar, GreenCape, the South African Renewable Energy Technology Centre (SARETEC) and DGS Berlin, started work on what became known as the 'PV GreenCard'. The PV GreenCard Programme is a safety certification and training programme for PV installers, designed to protect the integrity of the rooftop PV industry, and to empower the end consumer (SAPVIA, 2017).

This programme concentrates on education, skills development and training to build installer capacity as well as improve standards development and compliance in line with international best practice. The programme was also developed to promote safe and high-quality Solar PV installations. It requires embedded PV installations to be signed off by a properly trained technician that appears on the online SAPVIA database. As such, it leads to peace of mind for clients that all necessary safety and quality standards are being met and can be used as proof of compliance for insurance, finance, and regulatory purposes[29]. In short, the PV GreenCard is an industry-led quality label that is inclusive in nature and is the key to ensure a high standard of quality for small-scale solar PV installations.

The PV GreenCard was launched in May 2017 and is now operational[30].

SAPVIA and SARETEC have further developed an assessment process to test Solar PV technicians in the field for competence; it retrains those who do not pass the initial assessment. In this manner quality standards of installations are continuously improved while providing further training for those already in the field, who may need it.

Municipal bylaws

South African cities are now actively accommodating RE. For example, the City of Tshwane has developed, through its Energy and Electricity Department, a policy on embedded generation. The policy states in the paragraph on background: "The City of Tshwane has been inundated with applications from residential, commercial or industrial customers to develop, install and commission embedded generation (EG). It is thus essential that the City of Tshwane regulates this process." It goes on to say: "RE technologies are viewed not only as tools for improving energy security and mitigating and adapting to climate change, but are also increasingly recognised as investments that can provide direct and indirect economic advantages."

It further provides a comprehensive set of definitions and rules on what is allowed, and under what circumstances, together with a comprehensive explanation of the role divisions and responsibilities. In addition, the applicants are required to register their respective EG facilities.

Similar efforts are under way in Cape Town and Nelson Mandela Bay, evidencing a maturing of the policy framework in the country.

Conclusion

A thriving RE eco-system was created within only a few years, with the public and private sector collaborating to strive for sustainable development through RE projects. The robust policy and regulatory framework created the foundation for this success.

The policy environment supporting RE in South Africa has been strengthened by the developments during the preceding two years. At a long term level the ratification of the Paris Agreement has aligned South Africa with the collaborative, international focus on a high-penetration RE future. This has been augmented from the ground up by long-term energy modelling for the IRP that shows that this high penetration future makes complete economic sense. The confluence between the electricity, transport and heating/cooling sectors already manifests in the basic approach to South Africa's Integrated Energy Plan.

Perhaps most pleasing is the way in which the policy framework has bedded down from national to municipal level, across different Government departments and across the quantitative silos of utility-scale generation and embedded generation (large and small). The presently feasible generation technologies have been advanced and EE has been further incentivised.

The policy framework ideally needs integration from the highest and most abstract level (the Constitution) to the lowest and most practical (municipal bylaws). When this occurs for RE, as it is now, it is an indication that the regulatory framework has adjusted to what is a new chapter in our energy history.

1 Azuela, G.E., Barrosa, L.A. 2011. Design and performance of Policy instruments to promote the development of RE: Emerging experience in selected developing countries. World Bank, Energy and mining sector board discussion paper, Paper no. 22, April 2011

2 Azuela, G.E., Barrosa, L.A. 2011. Design and performance of Policy instruments to promote the development of RE: Emerging experience in selected developing countries. World Bank, Energy and mining sector board discussion paper, Paper no. 22, April 2011

3 See http://www.justice.gov.za/legislation/constitution/SAConstitution-web-eng-14.pdf, retrieved 11 April 2017

4 See http://www.climateresponse.co.za/home/gp/4, accessed 13 April 2017

5 See http://www.greenclimate.fund/projects/portfolio, retrieved 5 May 2017

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7 See http://www.energy.gov.za/IRP/irp-presentaions/IRP-Update-Presentation-22-Nov-2016.pdf p 18, retrieved 14 April 2017

8 See "IRP Analyses" at https://www.csir.co.za/csir-energy-centre, retrieved on 13 April 2017

9 See http://www.energy.gov.za/IRP/irp-presentaions/IRP-Update-Presentation-22-Nov-2016.pdf p 18, retrieved 14 April 2017

10 See "IRP Analyses" at https://www.csir.co.za/csir-energy-centre, retrieved on 13 April 2017

11 See http://www.energy.gov.za/IRP/irp-presentaions/IRP-Update-Presentation-22-Nov-2016.pdf p 18, retrieved 14 April 2017

12 See "IRP Analyses" at https://www.csir.co.za/csir-energy-centre, retrieved on 13 April 2017

13 "To support the goals of the prevailing National Development Plan 2030, National Infrastructure Plan and Government's Programme of Action To enable customers requiring transport for people or goods to access the transport system in ways that best satisfy their chosen criteria; To improve the safety, security, reliability, quality, and speed of transporting goods and people; To improve South Africa's competitiveness and that of its transport infrastructure and operations by reducing the cost of doing business; To invest in infrastructure or transport systems in ways that satisfy social, economic or strategic investment criteria."

14 Green Transport Strategy 2016 – 2021, Executive Summary, p 5

15 See http://www.energy.gov.za/files/IEP/presentations/Integrated-Energy-Plan-22-Nov-2016.pdf, page 14, retrieved 22 August 2017

16 See http://www.irena.org/DocumentDownloads/Publications/IRENA_C2E2_Synergies_RE_EE_paper_2015.pdf, retrieved 20 August 2017

17 See http://www.gov.za/sites/www.gov.za/files/40515_gen948.pdf, retrieved 5 May 201718 For a discussion, see "Energy efficiency tax incentive Section 12L of the Income Tax Act comes into effect" http://www.urbanearth.co.za/articles/energy-efficiency-tax-incentive-section-12l-income-tax-act-comes-effect

19 See http://www.sanedi.org.za/img/Case%20Study%20-%2012%20L%20Tax%20Rebate%20for%20RVSBKs.pdf, retrieved on 20 August 2017

20 The minimum investment in Qualifying Assets required is R50 million for a greenfield project and an additional investment of R30 million for a brownfield project

21 See https://www.ensafrica.com/newsletter/briefs/taxapr09govern.html, retrieved 20 August 2017

22 See http://www.thesait.org.za/news/269950/Powering-up-A-look-at-section-12B-allowance-for-renewable-energy-machinery.htm, retrieved on 20 August 2017

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24 See http://www.engineeringnews.co.za/article/2017-budget-speech-carbon-tax-to-be-considered-by-parliament-2017-03-28, retrieved on 20 August 2017

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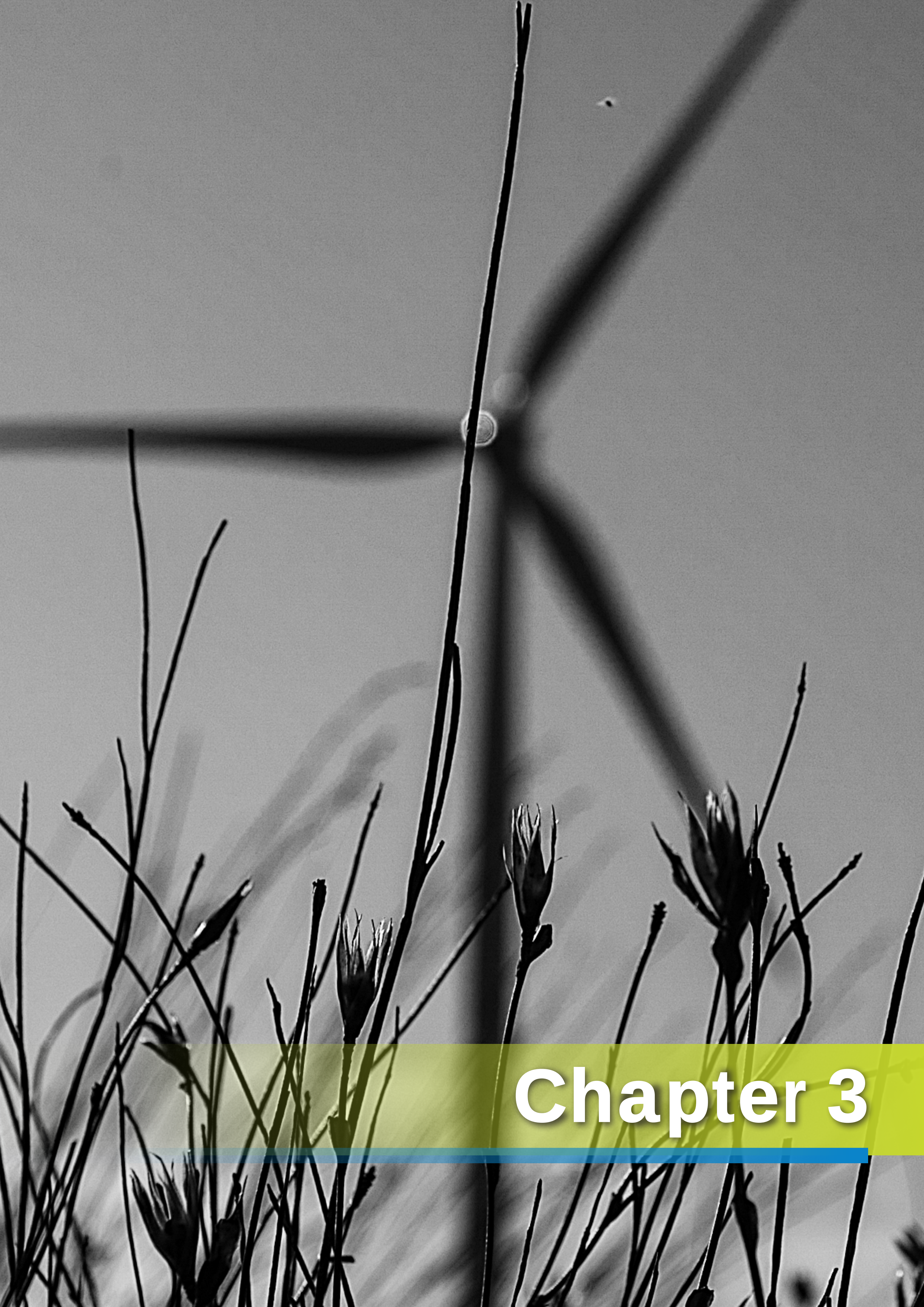
26 See http://www.webberwentzel.com/wwb/content/en/ww-in-the-news?oid=56997&sn=Detail-2011&pid=32711, retrieved 22 August 2017

27 See http://www.sals.gov.za/docs/pubs/ppf.pdf, retrieved 18 September 2017

28 See https://www.parliament.gov.za/how-law-made, retrieved on 18 September 2017

29 PV GreenCard. (2017). The PV GreenCard. Retrieved from https://www.pvgreencard.co.za/

30 South African Photovoltaic Industry Association (SAPVIA). 2017. PV GreenCard launch event. Retrieved from http://www.sapvia.co.za/pv-greencard-launch-event/



Chapter 3

Market Penetration

The evolutionary path of the energy technology supporting our global civilisation shows that distinct paths were taken by heating and cooling, transport and the electricity sector. Most recent developments further show innovations from yesteryear making a comeback, albeit in refined modernised forms. Electricity remains the epitome of modern energy advances. Subsequent attention has therefore been on finding alternative sources of energy to generate electricity.

Internationally, heating of living and working spaces was initially achieved in most domains by the combustion of either biomass or fossil fuels such as coal or oil. With the exception of sustainable biomass, this inevitably led to the emission of greenhouse gases (GHGs) into the atmosphere. Refrigeration was originally accomplished through the evaporation of highly volatile liquids, such as alcohol and ether, and later by vapour compression and gas absorption[1]. Electric refrigeration became popular as electrification rates increased. Air-conditioning became to be driven predominantly by electricity in modern domains[i].

In the world of transport, the automobile started to replace the horse a little over a century ago. The first cars invented from 1808 used a variety of energy sources: hydrogen, gasoline, diesel, the fuel cell, steam and, indeed, electricity[2]. During the 20th century, gasoline and diesel-fueled cars became dominant commercially, with the result that a large global network of distributed refueling stations was developed. Cars came to operate distinctly from the sectors of heating/cooling and electricity, while emitting significant amounts of GHG.

Air transport shows a similar adoption of carbon intensive fuels while rail transport mostly migrated away from steam towards electricity as an energy source; its impact in a modern economy would depend on the fuel sources of the national grid. Electricity generation came to be dominated by fossil fuels during the 20th century. While delivering countless benefits that access to energy offers, such an energy sector also uses finite natural resources, consumes precious water and produces harmful emissions, including GHGs, with significant health implications for impacted communities. In South Africa, every Kilowatt hour (kWh) produced would come at the cost of almost a kilogram of GHG emissions[3] and 1.4 litres of water[4] – the latter a significant figure for a water-stressed country such as ours.

The impacts associated with energy use led to various alternative forms of energy being explored but, until recently, the financial costs of cleaner alternative energy sources limited the extent to which clean energy was adopted. Consequently, the greatest emphasis in response to pollution impacts has been on energy efficiency (EE)[5]. In the electricity sector this typically manifested in the form of energy efficient appliances and lights. In transport, efficiency solutions included more fuel-efficient vehicles and policies to promote mass transportation. In water heating, solar water heaters (SWH) have received significant support and constituted an example of an electric application being replaced by a thermal application. Fuel switching has been targeted in cooking, especially in developing countries where non-sustainable biomass use is prevalent.

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i An additional impact of cooling in this manner has been the emission of hydrofluorocarbons (HFCs), which is a group of very impactful GHGs, exacerbating a negative impact on climate. Several Clean Development Mechanism (CDM) projects have targeted these gases. Because of such interventions, the link between electric cooling using fossil fuels and the emissions of HFCs is no longer implicit. The GHG impact of CO2 emissions associated with cooling, however, still remain if the fuel source is a fossil fuel


Bokpoort concentrated solar power plant near Groblershoop

All the above was implicitly premised on the fact that fossil fuel-derived electricity was cheaper than the available alternatives, including renewables.

Recent advances in RE technology and rapid decline in costs now allow for accelerated adoption of RE and greater diversification of energy sources.

Diversification of supply contributes to greater resilience of energy systems, as was recognised in South Africa as early as the Energy White Paper Policy of 1998[6,ii]. Not only is risk mitigated and energy security improved, but more sustainable forms of energy are able to bring the impacts of modern living into balance with the ability of the natural environment to absorb such impacts.

RE also makes it possible to 'share' or 'couple' energy across sectors. The Renewable Energy Policy Network for the 21st Century (REN21) Global Status Report for 2017 contains a special report on this issue and says in summary:

> *"Coupling of the electricity, thermal (heating and cooling) and transport sectors can improve flexibility in the power system by adding dynamic demand and storage for electricity. For example, charging of electric vehicles can be timed to coincide with peak variable generation, and heating systems can incorporate thermal storage for added flexibility[7]."*

A recent study by the Stanford School of Earth, Energy and Environmental Sciences[8] projected that by converting energy end uses that are currently burning fuel, to electricity generated from renewables, would reduce overall primary energy use in 2050 by more than 40 percent. Such a shift would consume less natural resources, reduce global energy budgets[iii], reduce emissions

ii *"Significant international shifts have occurred in post-oil crisis energy policies. South Africa can learn from abroad. Perhaps the most significant shift is that energy security is now being achieved through greater diversification and flexibility of supply." – White Paper on Energy, 1998*

iii *Lower energy use from energy-intensive activities such as mining, transporting, and fuel refining would reduce costs* and reportedly also increase employment opportunities. This would suggest a significantly greater deployment of RE is possible than anticipated before, with benefits more broadly distributed throughout the economy.

International market growth – electricity pulling ahead

Given the increasing importance of the RE electricity sector, international market growth will initially be analysed from the perspective of all energy forms combined, then from a renewable electricity perspective and, finally, relating to specific developments in renewable heating/cooling and transport[iv].

When considering RE's share of final energy consumption, international data produced by REN21 and IRENA shows a steady increase of RE. The REN21 Global Status Report shows that, as of 2015, RE provided an estimated 19.3 percent of global **final energy consumption**[9]. Of this total share, traditional biomass, used primarily for cooking and heating in remote and rural areas of developing countries, accounted for approximately 9.1 percent, and modern renewables (not including traditional biomass) increased their share relative to 2014 to approximately 10.2 percent, broken down into: Hydropower 3.6 percent; renewable power from Wind, Solar, Biomass and Geothermal 1.6 percent; renewable heat 4.2 percent; and transport Biofuels 0.8 percent (Figure 1).

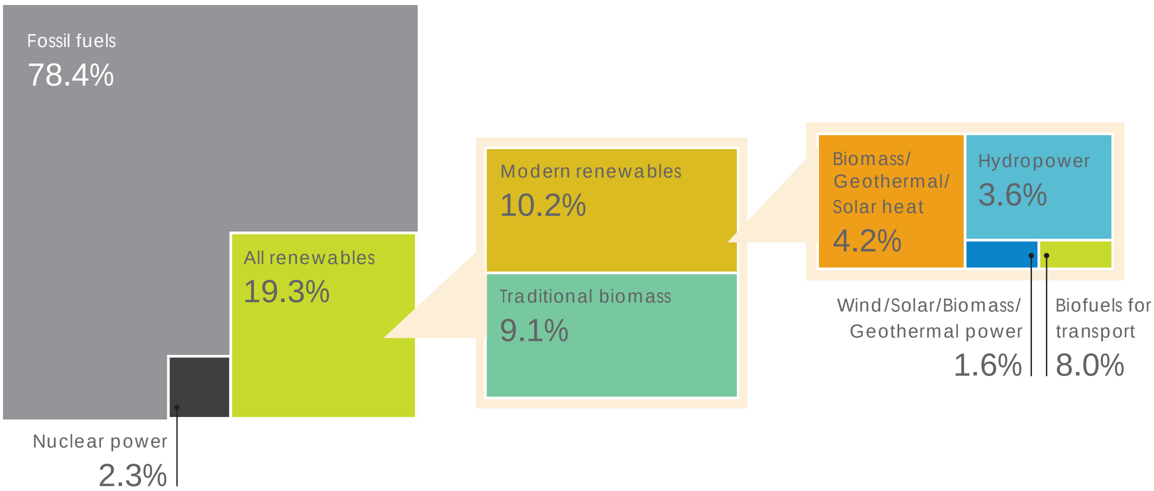


Figure 1: Estimated RE share of total final energy consumption, 2015

As modern electricity or energy becomes more readily available, the share from traditional biomass is expected to shrink.

iv The growth of RE can be measured in several ways. The most conservative is to measure the renewable share of final energy consumption. Such a metric shows a steady increase in the penetration of RE and is the one that in the long run has to be met by the international community as it migrates to sustainability. A second metric for the electricity sector is the proportion of total installed capacity that is renewable. This is less conservative given that the variability of RE typically means that this comparison will look more favourable to renewables than the share of final electricity consumption mentioned above. A third metric, particularly important in the electricity sector, is the rate of change – or, put differently, to measure the rate at which renewables are growing and/or what proportion of new energy recently constructed was renewable in relation to non-renewable. This is also referred to as marginal change and is a very important indicator of trends in the sector and how investors and financiers are looking at the future of the system. By way of example, even if RE only claimed 10 percent of final electricity consumption in a given year, if 100 percent of new plants constructed were renewable, it would tend to indicate a future increasingly dominated by renewables. Likewise, a very high annual growth in renewables would lead to excitement even if the base is low

Global RE electricity generation capacity increased by 161 Gigawatts (GW) in 2016, making it the strongest year ever for new capacity additions, according to statistics released by IRENA. *RE Capacity Statistics 2017*[10] estimates that, by the end of 2016, the world's renewable generation capacity had reached 2,006 GW with a growth rate of 8.7 percent. New solar energy contributed a record 71 GW, leading the global capacity additions — the first time since 2013 that solar energy outpaced wind energy capacity additions. It was still a strong year for Wind, with 51 GW of new capacity, followed by Hydropower with 30 GW, and bio-energy with 9 GW. A breakdown of growth rates across the respective RE technologies is provided in Figure 4.

De Aar Solar Power PV plant near De Aar

A similar picture emerges from REN21's Global Status Reports for 2016 and 2017[v]. Already in the 2016 report, it was clear that the world now adds more renewable power capacity annually than it adds (net) capacity from all fossil fuels combined. In 2015, renewables accounted for approximately 60 percent of net additions to global power generating capacity, and for far higher shares of capacity added in several countries around the world. The growth was achieved despite low oil prices that in earlier times might have been expected to depress progress[11].

If the last decade is examined to gain the perspective of a longer time span, world RE capacity has doubled impressively since 2007, when it was only 989 GW, growing to 2,006 GW in 2016 (refer Table 1). The IRENA 2017 RE Statistics report details the overall figures for each RE technology, as well as from each continent and country. Asia accounted for 58 percent of all new RE capacity additions in 2016, increasing its cumulative capacity to 812 GW, or approximately 41 percent of the world's total capacity. Asia was also the fastest growing region, with a 13.1 percent increase in RE capacity.

Africa (including South Africa) doubled its 2015 installation figures, installing 4.1 GW, bringing it up to a total of 38 GW (refer Table 1). Despite this growth, installed capacity across all of Africa is lower than any one of the BRIC[vi] countries (Table 1).

v Renewable power generating capacity saw its largest annual increase ever in 2015, with an estimated 147 GW of renewable capacity added. Total global capacity was up almost 9 percent compared to 2014, to an estimated 1,849 GW at year's end. Wind and Solar PV both saw record additions for the second consecutive year, together making up about 77 percent of all renewable power capacity added in 2015. Hydropower capacity rose by 2.7 percent to an estimated 1,064 GW, accounting for approximately 19 percent of additions. In 2016, similar trends persisted

vi Brazil, Russian Federation, India and China

Table 1: Installed, RE capacity (MW, cumulative) from 2007 to 2016 (IRENA)

Capacity (MW)	World	Africa	Brazil	Russian Federation	India	China	South Africa
2007	**989,213**	23,050	81,219	46,952	41,867	148,446	822
2008	**1,058,208**	23,690	82,940	47,194	45,279	178,015	838
2009	**1,133,347**	25,190	84,933	47,419	47,894	205,193	848
2010	**1,223,089**	26,778	89,558	47,504	51,560	236,257	853
2011	**1,326,016**	27,197	92,917	47,552	57,141	270,992	897
2012	**1,444,143**	28,531	96,726	49,518	61,552	304,696	903
2013	**1,563,539**	30,107	101,081	50,177	65,254	360,765	1,358
2014	**1,690,177**	32,445	107,513	51,095	70,560	413,012	2,424
2015	**1,845,180**	34,080	114,121	51,691	77,663	481,084	3,110
2016	**2,006,202**	38,192	122,951	51,747	90,748	545,206	4,064

The rapid growth in renewable electricity has been quicker than the growth in RE across all energy carriers. REN21's estimations for power generated at the end of 2016 show the following:

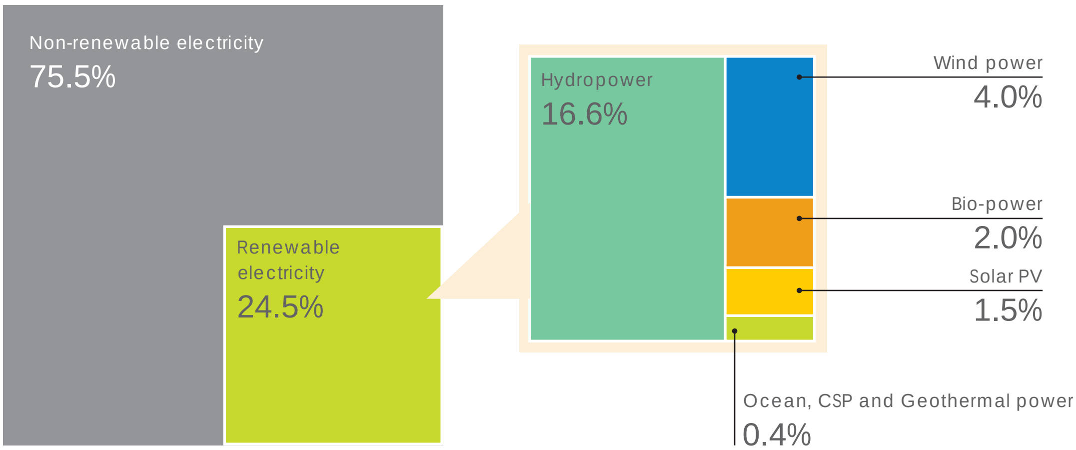


Figure 2: Estimated RE share of **global electricity production**, year-end 2016

It should be noted that in the electricity sector the renewables penetration is approximately 25 percent, as opposed to 20 percent across all energy carriers. Both Wind and Solar PV have become very large industries in absolute terms, with total global installed capacity at 433 GW and 227 GW, respectively, at the end of 2015. Data[12] shows that Denmark, for instance, now gets more than 40 percent of all its electricity from wind power.

Nevertheless, measuring progress in this manner fails to fully articulate how well renewables are positioned to contribute to international energy development in the future. It is when the marginal change is considered that a different and far-reaching picture emerges (what percentage of new energy came from renewables). This is a way of trying to gauge how the world is changing. In 2015, solar and wind energy sources supplied only 2 percent of total energy, yet 33 percent of marginal energy supply (refer Figure 3)[13].

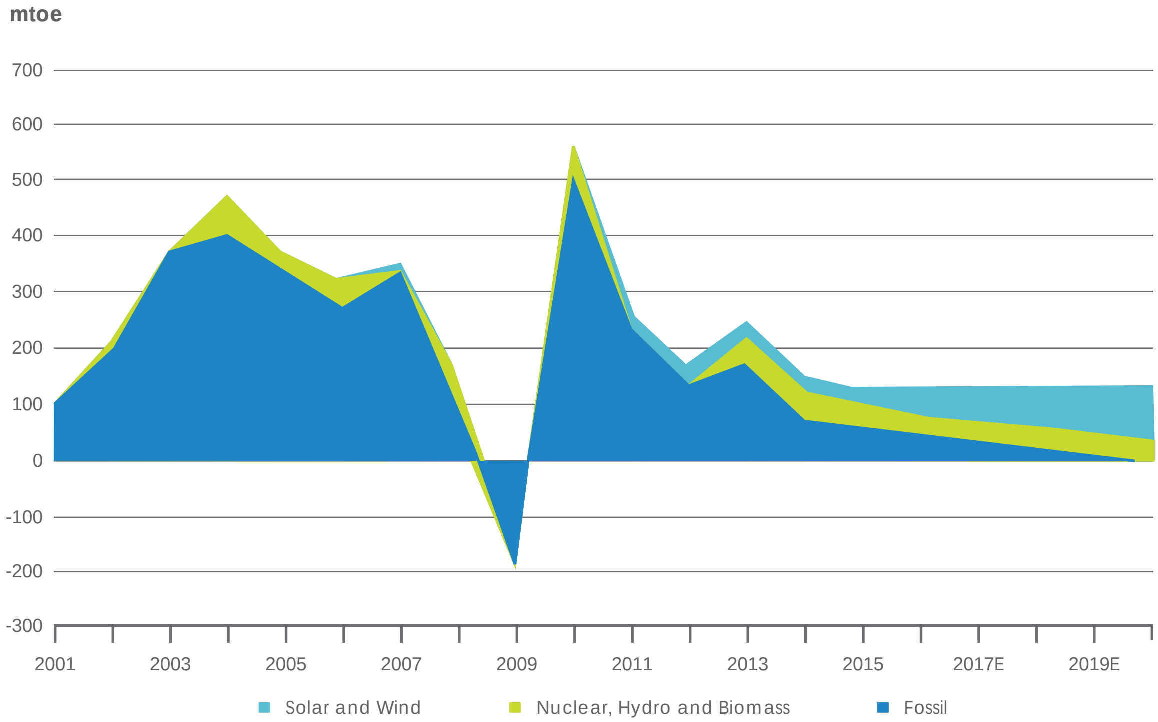


Figure 3: Marginal supply of energy *(mtoe)*, actual to 2015 and projected to 2019

Investors are likely to be favourably disposed towards renewables when such a graph of marginal change reveals the full extent to which RE is poised to dominate the market for new installed capacity. This will again create a feedback loop that may well further accelerate RE growth.

International market growth in heating/cooling and transport

REN21 reports that energy use for heat accounted for approximately half of total world final energy consumption in 2015. Thus, it is clear that climate targets imply the need for significant progress in using RE for heating. Renewable heat capacity increased by approximately 38 Gigawatt hours thermal (GWh_{th}).

RE is used to meet heating and cooling demands by means of solar, geothermal, aerothermal or hydrothermal, or biomass resources in solid, liquid and gaseous forms. Renewable technologies also can supply electricity that can be converted to heat. In 2015, RE's share of final energy use in the heat sector was 25 percent; of this share, more than two-thirds was traditional biomass, predominantly in the developing world.

The pleasing aspect from the REN21 report is to note that EE may be starting to pay off and the global growth in heating demand is now below 1 percent per annum.

In summary, renewables are gaining a proportionally larger share of the heat market, with the market size likely to be stable.

In the global transport sector, attention was focused mainly on the increased production and use of biofuels.

Figure 4, below, compares the relative growth rate of renewables across different energy carriers.

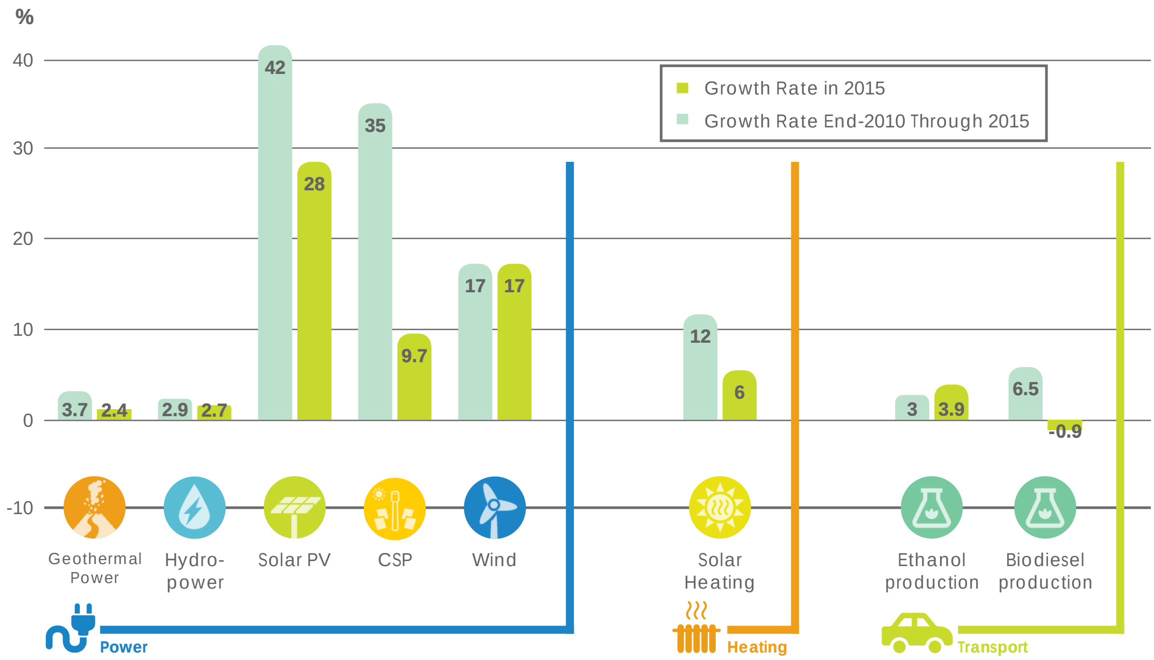


Figure 4: Average annual growth rates of RE capacity and biofuel production, end-2010 to end-2015

REN21 reported that, in 2015, electric vehicles did not get significant policy support. Despite this, electric vehicles gained much traction in certain domains, with the three largest manufacturers, Renault-Nissan, Tesla and Build Your Dreams (BYD) selling a historical aggregate of nearly 700,000 electric vehicles by the end of 2016.

RE market penetration in South Africa

Internationally, the strong RE market growth is stimulated by a combination of low costs and an international regulatory regime that intends to promote clean energy.

The same factors affect developments in South Africa – but another, country-specific aspect, enables current developments to be extrapolated and contextualised with some accuracy far into the future. This is South Africa's strong framework for integrated energy planning and the transparent publication of our long-term blueprints in the form of the Integrated Energy Plan (IEP; all energy carriers), and Integrated Resource Plan (IRP; electricity specific). .

Once policy-adjusted and published, the IEP and IRP will give a clear direction of future growth and development. Even the current draft IRP 2016 provides a very good indication that, over the planning horizon, renewable ambitions are, if anything, likely to increase. This expectation is supported by RE's inclusion within various policy documents as described in Chapter 2.

In the electricity sector, aspirations for greater diversification and a larger share of RE is demonstrated by the IRP 2010, the National Development Plan and Medium-Term Strategic Framework (MTSF), and reiterated by the draft IRP 2016 (base case) with projections up to 2050 (refer Figure 5).

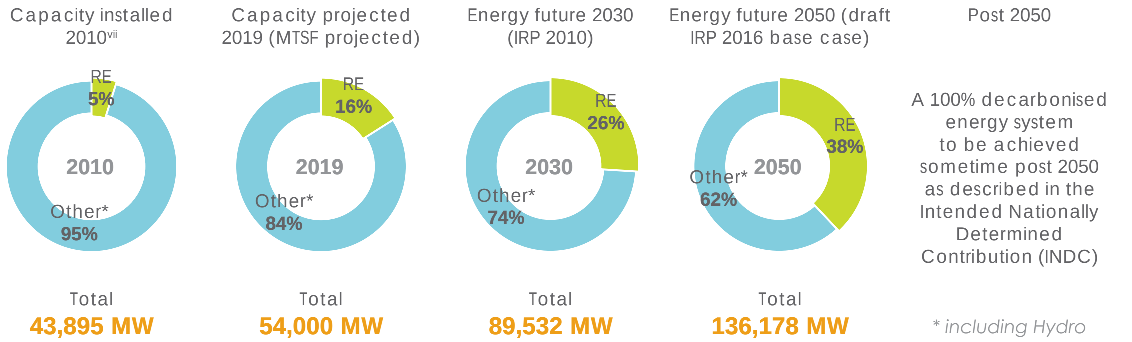


Figure 5: Energy development in the context of long-term aspirations *(including Hydro, but excluding pumped storage)*

The impressive price path of renewables internationally has been reflected in South Africa in the REIPPPP – the Government-led procurement programme.

Because of considerable investor interest and the competitive bidding approach, South Africa benefitted significantly from downward technology price trends. The REIPPPP procured energy at increasingly cost competitive rates, with significant price drops between every bid round (refer Figure 6)[14].

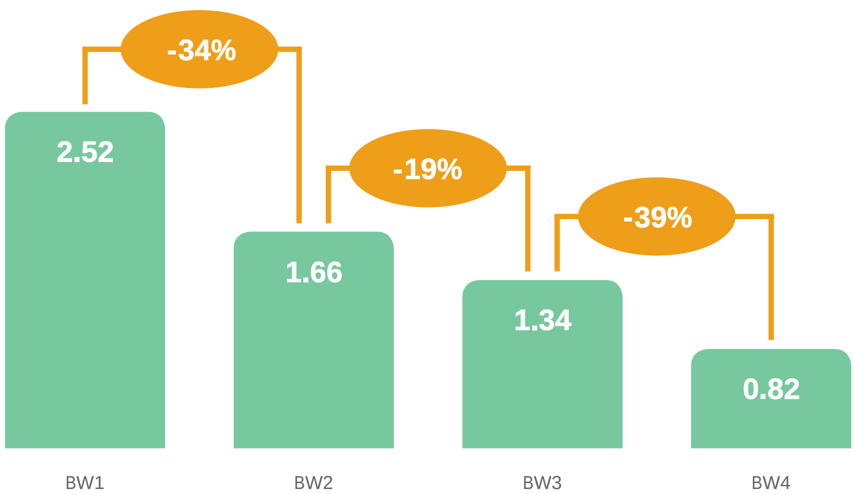


Figure 6: REIPPPP portfolio price trend *(R/kWh)*[viii], April 2016 prices

vii As per IRP 2010

viii Prices stated in April 2016 terms. Energy weighted average (R/kWh) considering average technology Request For Proposals (RFP) submission price (published) per Bid Window (BW) and projected, annual energy contribution per technology type

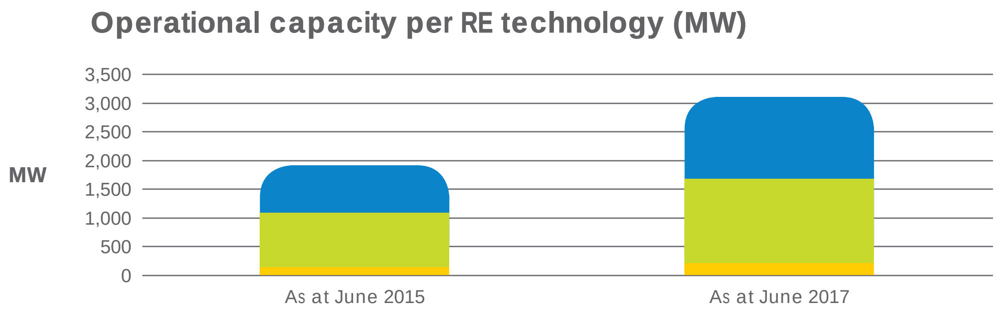
The portfolio price trends reflect an energy-weighted average (R/kWh) per Bid Window that considers average technology prices and projected, annual energy production. Pricing and trends vary across the respective technologies, but have shown a similar downward trend for all technologies (refer Figure 7).

Figure 7: REIPPPP technology price trend *(R/kWh)*[ix], April 2016 prices

Given the trends of lower prices, international regulatory certainty and long-term domestic visibility of a multi-decade transition to a diversified, renewables-rich future, the country has already seen significant market growth in RE since 2010. The biggest contribution has been from utility-scale RE, driven mainly by the REIPPPP.

Between 2015 and June 2017, 1,141 MW had been added to the installed capacity, bringing the total operational capacity under the REIPPPP to 3,162 MW. As would be expected, considering South Africa's abundant solar and wind resources, 99 percent of this capacity has been contributed from Solar PV and Wind. This reflects the international trend towards fast growth in these two technologies, which looks set to become the bedrock of RE expansion in the future.

ix Prices stated in April 2016 terms. Energy weighted average (R/kWh) considering average technology RFP submission price (published) per Bid Window, and projected, annual energy contribution per technology type



Per technology (MW)	As at June 2015	As at June 2017
Wind	790	1,468
Solar PV	960	1,474
Concentrated Solar Power	100	200
Biomass	0	0
Small Hydro	10	14
Landfill Gas	0	5

Figure 8: Operational RE capacity in South Africa, 2015 and 2017

During the 2017 financial year, these operational REIPPPP power plants supplied 6,948 GWh to the national grid[15]. At this juncture, however, it remains a modest share of the total 214,121 GWh of electricity sales reported by Eskom during the financial year ending 2017.

RE capacity has been established across all provinces (refer to page 9). While some, such as the Northern Cape, have good wind and solar resources, all provinces have at least one of the two at an endowment level that will make meaningful development possible (refer to page 10).

Eight additional IPP projects (839 MW) are still under construction and projected to start commercial operation by the end of 2018, bringing the total operational capacity to just more than 4,000 MW[x] by the end of next year.

South Africa has entered a phase of electricity over-capacity and is experiencing a slowdown in the growth of utility-scale RE. Only 95 MW from small-scale REIPPs have been announced as preferred bidders since October 2015 and no further REIPPs have reached financial close. The next procurement round (Bid Window 4) was concluded and preferred bidders, offering 2,205 MW of additional capacity, were announced in April 2015. At this juncture, Eskom declined to enter into further agreements (refer Box 1). Consequently, the process stalled for more than two years until 1 September 2017, when an announcement was made indicating that the bulk of these agreements would be signed in the last week of October 2017. The date for signature was later postponed to early 2018.

Two further bid rounds, that would add an estimated 3,366 MW of additional capacity, have been identified[xi] and are on hold until the completion of the review and update of the IRP. In these bid rounds, both Wind and Solar PV were bid at an average price of 62c/kWh.

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x Cumulative capacity procured across bid rounds 1, 2, 3 and 3.5

xi Cumulative capacity targeted under the expedited bid round (4b) and Bid Window 5 (identified to align with planned capacity development as per IRP 2010)

BOX 1

Eskom and the procurement of REIPPs

The REIPPPP is designed in a manner that tasks the Department of Energy with procuring electricity (Figure 9) while Eskom, the national power utility, is designated as the contractual buyer and claws back costs through the Multi-Year Price Determination (MYPD) process as administered by NERSA.

Contractual Arrangement

- Bidders are issued standardised agreements [Implementation Agreements (IA) and Power Purchase Agreements (PPAs)] as part of the RFP. These agreements are signed at financial close. Note: PPAs are technology dependent.
- Agreements are established between four parties:

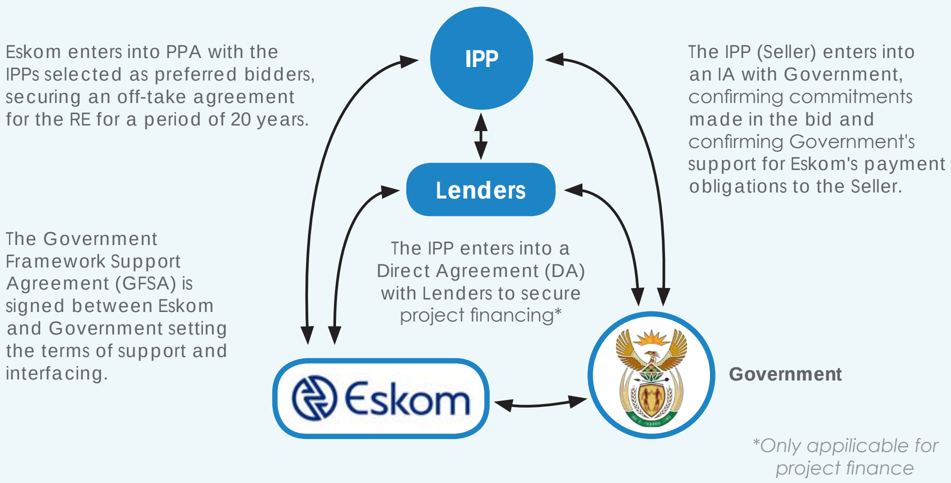


Figure 9: Contractual arrangement / configuration under the REIPPPP

Eskom's role manifests at the end of the procurement process when the Power Purchase Agreements (PPAs) are signed. Eskom has not signed any PPAs since 2015, even though additional preferred bidders have been announced by the Department of Energy.

After a protracted period of supply constraints and occasional load shedding, the national utility's operations stabilised during 2015 and reached a state of surplus capacity during 2016/17. This is ascribed to slowing electricity demand, the addition of new build capacity and a significant improvement in the utility's operational performance. Consequently, Eskom indicated that the addition of further large-scale RE capacity might lead to significant overcapacity on the system and declined to sign PPAs.

This led to an impasse in the REIPPPP, with the construction of new projects not commencing. Round 4 of the REIPPPP was awaiting signature only while the so-called round 4(b) – also called the 'Expedited bid round' for the reason that it was additionally procured to ease supply constraints – had reached the stage of the selection of preferred bidders, but without an announcement being made.

After Government intervention, the uncertainty was eventually resolved on 1 September 2017 with a media release by the Minister of Energy indicating that:

- Round 4 will be signed by the end of October 2017 (this date was later postponed to early 2018), provided bidders can meet a price cap of 77c/kWh;

- Round 4(b) will await the finalisation of the updated IRP before its status is decided.

Even before this resolution, Eskom, from its position of operational stability and surplus capacity, stated its support for the REIPPPP and commitment to connect IPPs up to Bid Window 4.5, provided the bid prices are at a level that translates to below their average selling price of electricity. The utility placed emphasis on the importance of procuring IPPs within a holistic assessment framework of security of supply, electricity price, environmental benefits and socio-economic factors, to ensure that new generation capacity is rolled out at a cost and pace that is optimal for both South Africa and the national utility. The future procurement plan – cost and pace – will be informed by the updated IRP that is currently being finalised by the Department of Energy.

Eskom's comments show the need to update the IRP and IEP often, as they are designed to be done.

The utility's 2016/17 annual report and associated media statements reiterated the need for South Africa to invest in lower or zero-emitting technologies, as the current coal-fired electricity generation fleet reaches the end of its life. It identified technologies such as nuclear, cleaner coal technologies, renewables, gas and large hydro imports as essential for meeting international climate change commitments, while acknowledging that the quantum and timing are to be informed by the updated Integrated Resource Plan 2016, once it is finalised by DoE.

Eskom has also successfully invested in its own RE capacity with the 100 MW Sere Wind Farm, a flagship wind power plant, delivered on time and within budget. Internationally, we have seen utilities diversifying into renewables and even ring-fencing fossil fuel assets to be 'sweated'[xiii] until the end of life while concentrating new business development on renewables[16]. Given Eskom's acknowledgement and stated acceptance of the emerging energy paradigm, similar opportunities for diversification of the traditional business model would be available to them.

xii A colloquial phrase meaning to extract more value from an asset beyond its original intended value-exchange. That is, extract more use/output from it than it was designed for

Comparisons between Africa and the BRICS countries

To plot South Africa's progress, it might be meaningful to assess it in comparison to African countries and to BRIC countries other than China. The picture that emerges is of South Africa being well placed among its peers in Africa for total RE capacity installed, while significantly lagging behind the BRIC countries in total capacity installed and percentage of RE installed relative to total generation capacity.

Within Africa, South Africa ranked second after Ethiopia and just ahead of Egypt for installed RE capacity[17].

Among the BRICS countries (Figure 10), South Africa ranked last, showing significant unexplored potential for RE development when considering the wealth of the country's natural resources.

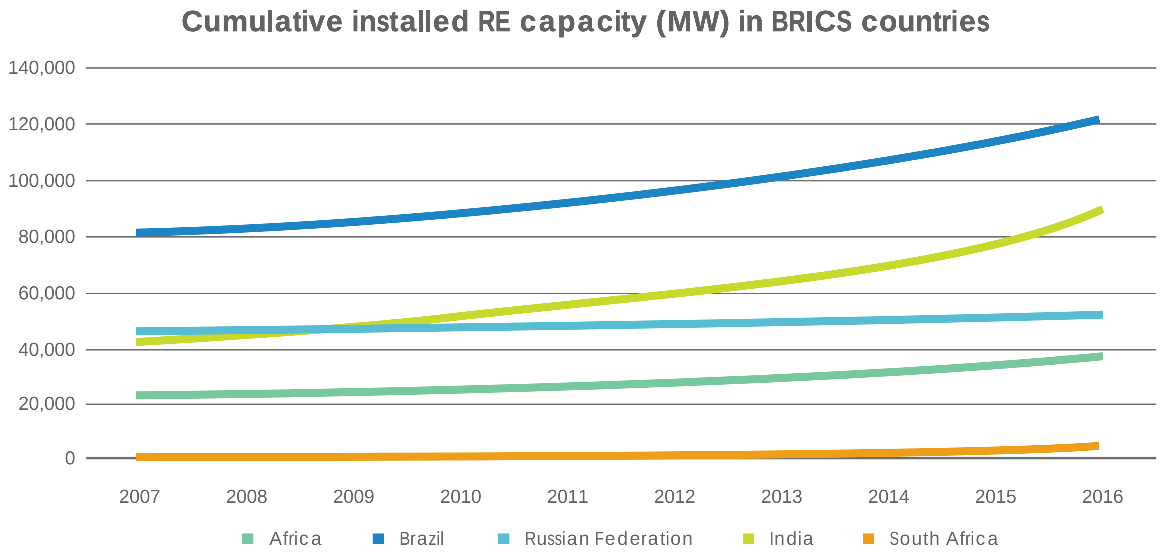


Figure 10: Installed capacity (MW) in BRIC countries and Africa between 2007 to 2016

In 2014, RE (including Hydro) represented just more than 5 percent of total installed power capacity for South Africa. The average for the world at the time was 27 percent and the comparative figures for BRIC countries ranged between 21 percent (Russia) and 80 percent (Brazil).

South Africa's RE market growth since 2012 has, however, outpaced that of its BRICS counterparts (Figure 11), bringing the share of installed capacity in South Africa closer to 10 percent by September 2017.

South Africa's high growth rate corresponds closely to global trends seen between 2010 and 2015 (refer earlier Figure 4).

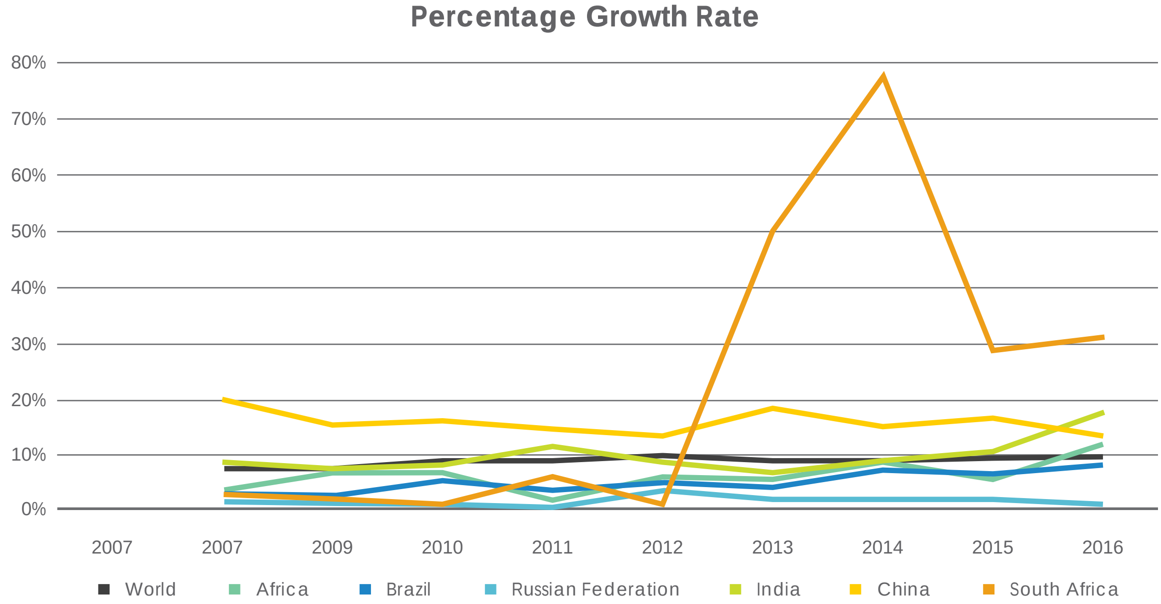


Figure 11: RE growth rates 2007 to 2016 *(IRENA)*

The current and future shape of renewable electricity in South Africa

The factors shaping renewable electricity in South Africa to 2020 and beyond are both international and national.

The cost of renewable electricity will impact on the share of the total, future electricity sector that the updated IRP and subsequent iterations allocate to renewables. The lower the prices go internationally, the greater the renewables allocation in the IRP is likely to be.

Hopefield wind farm near Hopefield

Since the bid announcement for Bid Window 4 in April 2015, technology costs and bid prices across the globe continued to fall sharply. For wind power, some of the lowest prices were recorded in North Africa, where Egypt announced a winning bid price of $41/MWh in 2015. Soon after (in 2016), Morocco announced the lowest winning bid price at $28/MWh. The average bid price across all wind farms in 2016 was $30/MWh.

By 2016, Solar PV bids in the most competitive countries came in below $60/MWh (refer Figure 12).

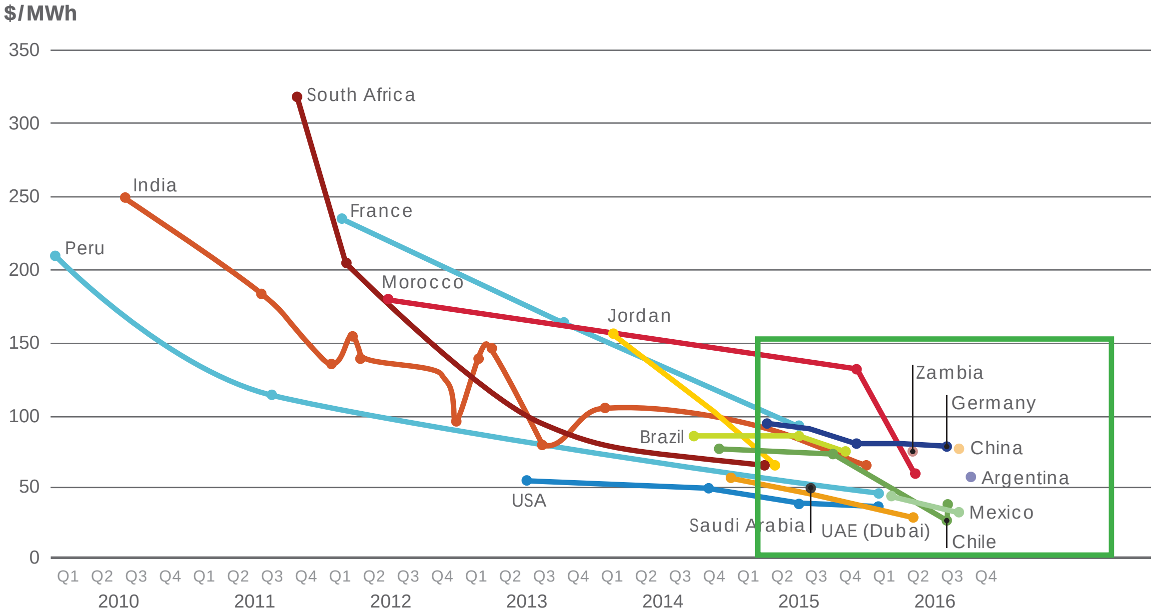


Figure 12: Evolution of utility-scale Solar PV auction prices around the world *Source: IRENA, 2017a*

Bokpoort concentrated solar power plant near Groblershoop

The price trend internationally is sharply down in many countries around the globe:

Canada (Ontario)

299.5 MW **Wind** at 66 $/MWh
140 MW **Solar** at 120 $/MWh
15.5 MW **Hydro** at 135 $/MWh

USA

26 MW **Solar** at 26.7 $/MWh

Mexico

First Auction

620 MW **Wind** at 54.3 $/MWh
1,100 MW **Solar** at 44 $/MWh

Second Auction

1,038 MW **Wind** at 36.2 $/MWh
1,853 MW **Solar** at 32.8 $/MWh

Denmark

600 MW **Offshore Wind** at 53.9 $/MWh

Kingdom of the Netherlands

700 MW **Offshore Wind** at 80.4 $/MWh

Germany

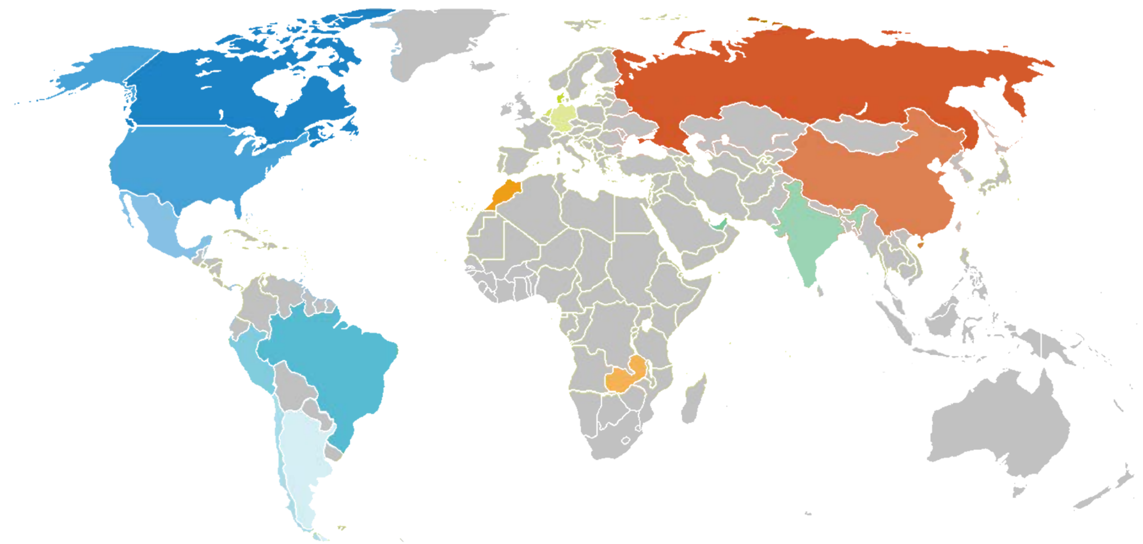
128 MW **Solar** at 84 $/MWh (4th tender)
130 MW **Solar** at 81 $/MWh (5th tender)

Russian Federation

600 MW **Wind**

China

1,000 MW **Solar** at 78 $/MWh



Brazil

500 MW **Hydro** at 57.5 $/MWh
198 MW **Biomass** at 60.2 $/MWh

Peru

162 MW **Wind** at 37 $/MWh
184.5 MW **Solar** at 48 $/MWh
80 MW **Hydro** at 46 $/MWh

Chile

4,400 GWh*/year **Wind** at 45.2 $/MWh
580 GWh*/year **Solar** at 29.1 $/MWh

Argentina

First Auction

700 MW **Wind** at 59.5 $/MWh
400 MW **Solar** at 60 $/MWh
1,2 MW **Biomass** at 118 $/MWh

Second Auction

1,038 MW **Wind** at 53 $/MWh
1,853 MW **Solar** at 55 $/MWh

Morocco

850 MW **Wind** at 30 $/MWh

Zambia

73 MW **Solar** at 67 $/MWh

UAE

800 MW **Solar** at 29.9 $/MWh (Dubai Auction)
350 MW **Solar** at 24.2 $/MWh (Abu Dhabi Auction)

India

6,500 MW **Solar** at 73 $/MWh

Figure 13: Global RE procurement and prices achieved during 2016

Droogfontein solar power PV plant near Kimberley

The majority of Solar PV bid prices following South Africa's Bid Window 4 (highlighted by the green block in Figure 12) demonstrate the growing competitiveness of Solar PV. The analysis also reveals that prices are converging across a number of countries, many of which are developing economies. There remains a relatively wide range between the highest and lowest prices, most evident perhaps between bids in Germany and Chile (Q3, 2016 calendar year). Price differences are ascribed to resource potential, financing costs and enabling country-specific conditions.

For all of the above, what is quite clear is that RE is becoming more attractive, all the time.

Within South Africa, the path to 2020 and beyond is shaped by the regulatory and policy framework. Generally, the NDP and current MTSF targets 5,000 MW of RE to be operational by 2019[18] and at least 7,000 MW by 2020[19].

It appears these national targets can be reached easily through the REIPPPP. For the current portfolio of operational IPP projects, the average delivery lead time from financial close to commercial operation has been 1.8 years, i.e. just less than two years. When considering the distribution of lead times (refer Figure 14 below), 80 percent of the operational capacity was delivered between 16 and 27 months[20].

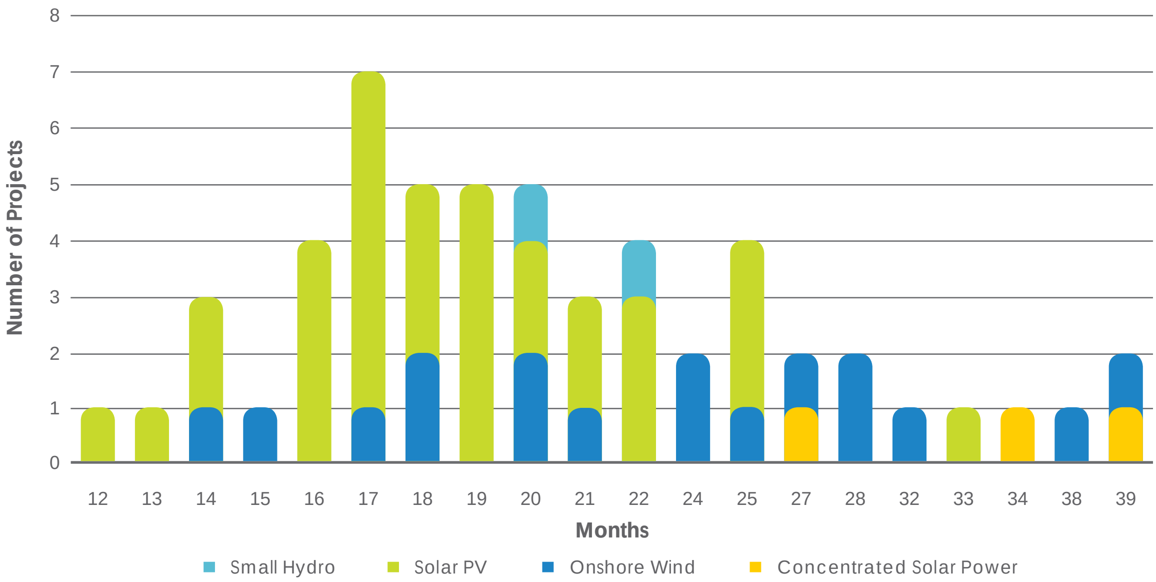


Figure 14: Distribution of construction lead times *(in months)* for REIPPs

The lead time between financial close and commercial operation is illustrated on an annual aggregate level in the table and graph below.

Table 2: Comparison of generation capacity reaching financial close and commercial operation per year[21].

Capacity (MW)	2012	2013	2014	2015	2016	2017	Total
Capacity reaching financial close (MW)	1,425	961	439	1,075	100	0	**4,001**
Capacity starting commercial operation (MW)	-	7[xiii]	1,047	967	717	260[xiv]	**3,162**

While the REIPPPP demonstrated that new RE capacity can be brought online quickly, this still represents a lead time that should inform planning and development timelines. With these construction timelines in mind, meeting the stated NDP and MTSF targets for 2019 and 2020, respectively, would require the next tranche of REIPPs, contributing at least 3,000 MW of additional capacity, to reach financial close before December 2017. The recent announcement that the Round 4 financial close will occur in October 2017 will ensure that the country gets very close to the NDP and MTSF targets, with rapid growth in rooftop Solar PV likely to fill any incremental gap (see below).

Additionally, the revised IRP will set the pace of further RE roll-out. The small-scale projects have generally been more expensive, but constitute a tiny fraction of the whole programme, and will therefore have no significant impact on average prices in a holistic sense[xv].

In this context, it is worth noting that the price differential between RE and new coal (based on a pure R/kWh basis without considering firmness of capacity and potential grid integration costs at higher RE penetrations) is already very significant, even if the considerable externalities of coal are ignored. These have been estimated by the University of Pretoria to be between 31 and 56c/kWh for Kusile[22]. A CSIR study[23] confirmed RE's relative cost competitiveness using prices from the last bid round that closed in 2015 (Figure 15).

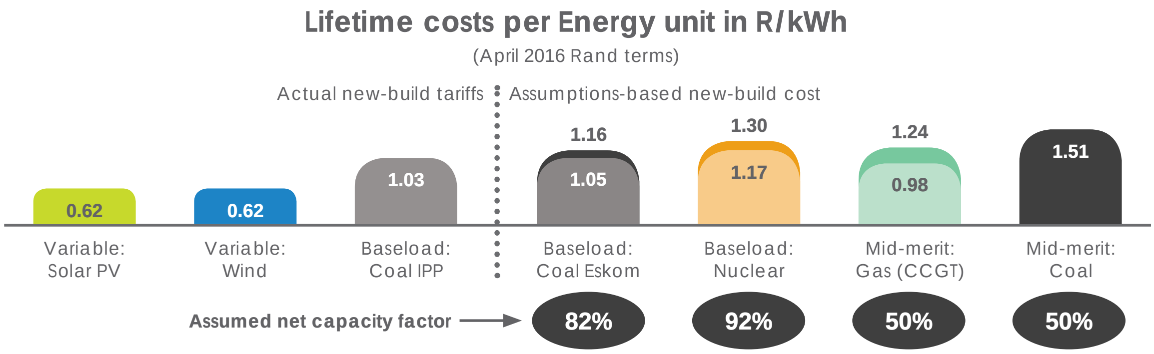


Figure 15: Comparative cost (LCOE) of new build generation options in South Africa

xiii The first RE IPP reached commercial operation in November 2013. This 7 MW Solar PV plant is located in North West Province.

xiv As at 31 March 2017

xv The rates achieved in the first small projects procurement round, as announced in October 2015, are comparable to the corresponding large-scale rates achieved in Bid Window 3 (bid announcements for this phase was made in October 2013, two years prior). More recently, the second small-scale renewable Bid Window has been procured at an average price of R1.01/kWh for Solar PV projects. As anticipated, this is significantly lower than the first small Bid Window – a similar downward price trend, as with the large projects, was realised. With wind projects the benefits of scale are steeper and the price differential is expected to remain larger

Hence, it is evident that the migration to RE has moved in only a few years from being a financial sacrifice made for the sake of sustainability to being a financial reward for moving to sustainability. From this new approach of 'base cost' RE technologies as opposed to 'base load' fossil fuel technologies, financial benefits are created that should more than offset the cost of adapting to change.

When using issued environmental approvals as a proxy, it appears that a large number of projects remain ready to be implemented quickly, if so required[xvi]. This impression was reinforced by the significant number of RE IPP projects that participated in the expedited Bid Window 4, when invited to bid within shortened timeframes during 2015. This suggests that a large portfolio of 'shovel ready projects' are poised to go into construction at short notice and to complete construction within timeframes that are comparatively short compared to mega-projects in conventional technologies.

Rooftop Solar PV in South Africa

While utility-scale development has slowed, the increased affordability of RE technology is giving rise to development in other areas.

The rooftop Solar PV market has continued to grow rapidly, boosted by the fact that LCOE without battery storage has decreased to around R1/kWh or below for embedded, rooftop Solar PV while municipal electricity tariffs can be 80 percent or more above that figure[xvii].

Records of rooftop Solar PV installed in the Nelson Mandela Bay Municipality (NMBM) and City of Cape Town (COCT) reveal this trend wherein the numbers of solar systems have increased as follows[24]:

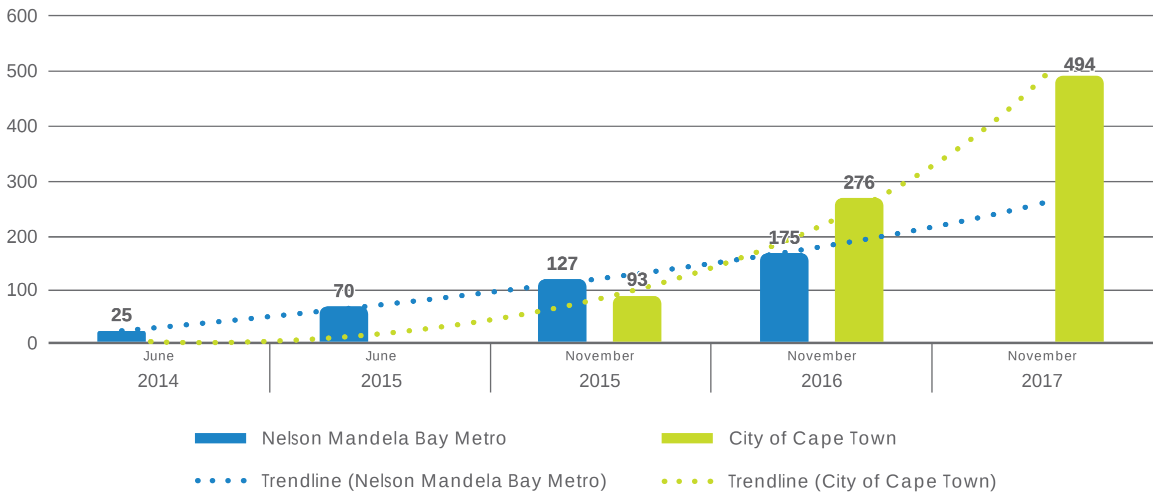


Figure 16: Number of rooftop Solar PV systems registered in NMBM and Cape Town respectively(cumulative)

xvi The Environmental Impact Assessment (EIA) is both a long-lead item and considerable expense in RE project development, and developers will usually run other regulatory approval processes in parallel. An approval tends to indicate project readiness in the broader sense

xvii As an example, the Cape Town 'Block 2 Domestic Tariff' is R2,06 plus VAT = R2,34 while in the City of Johannesburg , the top post-paid tariff is R1,50 plus monthly administration costs of R114,57 and a network charge of R337,52

While available data does not support a growth analysis in other cities or towns, installed capacities have reached significant levels in a number of them. City of Johannesburg has 32 commissioned installations on their database[24]; In Western Cape towns, Drakenstein and George, each has more than 100 installations while Langeberg, Mossel Bay and Cederberg each has more than 50[24]. Data is also being gathered for Swartland, Stellenbosch, Beaufort West, Overstrand, Theewaterskloof, Breede Valley and Oudtshoorn. Growth rates should become available once another year's data has been aggregated.

A report published by PQRS[25], a privately held database of non-utility Solar PV installations in Africa, reflected 120 MW_p[xviii] installed capacity in South Africa at the time of reporting in November 2016 (Figure 17). It was highlighted that the data point for 2016 was preliminary, pending completion of the data collection process.

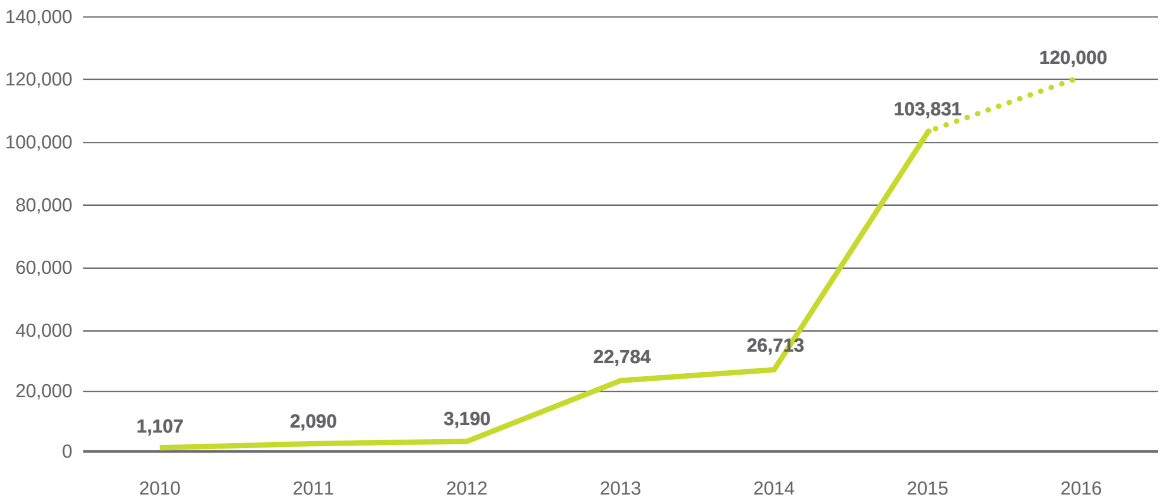


Figure 17: Installed capacity of rooftop Solar PV in South Africa (Cumulative, kW_p)

Installation data is reported voluntarily to this database, but data is subjected to a verification process to confirm existence, location, installation data and to ensure no double counting. Considering their data collection and verification process and methodology, the average lag experienced with data reporting and capturing into the database combined with Solar PV sales figures for 2016, PQRS estimated the total installed capacity by the end of 2016 to be around 280 MW_p. This estimation was confirmed by industry sources[26], placing the country-wide installed capacity at approximately 300 MW_p by August 2017, an almost seven-fold increase from May 2015.

In August 2017, the PQRS dataset had recorded 183 MW of rooftop PV installations that had been allocated to specific provinces[xix]. Growth in Gauteng appears to have outpaced the rest of the country, with 44 percent of registered rooftop Solar PV installations in this province. The Western Cape, Northern Cape and Eastern Cape provinces contribute a further 32 percent of the recorded installations.

xviii Where MW_p or kW_p refer to the peak or maximum capacity of installed solar systems, recognising that system output may vary dependent on available solar radiation

xix A number of installations were logged as national or unallocated

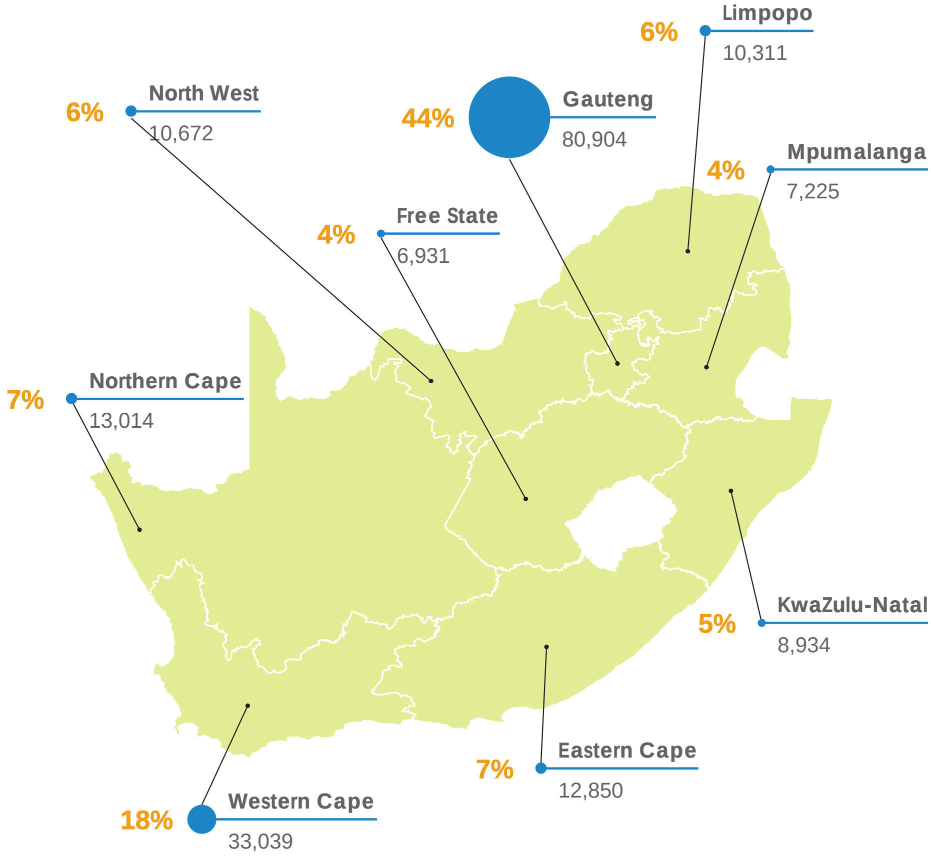


Figure 18: Provincial share of recorded small-scale *(rooftop)* Solar PV installations

Lower prices are making rooftop Solar PV increasingly attractive to electricity consumers as part of their supply solution. Market uptake may further accelerate as technology prices continue to drop and with the resolution of the regulatory environment. The total rooftop space available in the country for Solar PV has been estimated at 73 GW[27], presenting an enormous remaining opportunity for market uptake in this area. If coordinated into a national initiative, this market potential could be developed with optimal economic benefit to South Africa.

Renewable transport in South Africa (electric vehicles)

Electric vehicles are of increasing importance to RE internationally because of two reasons. The first is the trend of convergence of different energy carriers where more and more end uses are electrified, as described early on in this chapter. The second and related reason is that very high penetrations of RE imply installing a greater capacity than the country's peak demand to cater for the variability of RE. In such a scenario, there will be times when more electricity is produced than can be used and charging electric vehicles would allow an economic use to be made of this excess power rather than to merely curtail production. Indeed, electric vehicles might act as distributed storage devices

xix A number of installations were logged as national or unallocated that balance the grid and sell part of their charge back to the grid operator in time of need.

Since the first edition of this report in 2015, electric vehicles have made significant progress in South Africa. A total of three pure electric vehicle models (i.e. the BMW i series and Nissan Leaf) are now sold in the country alongside a greater number of hybrid vehicles. The total number of electric vehicles (not including hybrids) sold between 2013 and 2016 is 274[28]. Of these, 228 were sold during 2015 and 2016, indicating an upward sales trend.

Table 3: Electric vehicle sales (number) in South Africa[28]

Year	2013	2014	2015	2016
EV sales	34	14	126	102

Renewable heat in South Africa

Process heat in South African industrial applications is used extensively. For order of magnitude, by one estimate South African industry uses approximately 120 TWh annually in process heating[29]. At this time data does not exist to investigate the degree to which RE has been used to provide process heat, but there is no evidence to suggest it has been happening at a meaningful scale. The potential is there for CSP to provide process heat and has been investigated for parts of the United States by the National Renewable Energy Laboratory (NREL)[30].

The status of solar water heating in South Africa is detailed in Chapter 4.

Trends and developments of the South African small-scale Hydro

South Africa is an arid country, which means that our excellent solar and wind resources tend to overshadow the limited potential of Hydro and Biomass. That said, superb Hydro opportunities exist across our borders –South Africa already imports approximately 2 GW of electricity from Cahora Bassa in Mozambique. Imports of hydro power may increase over time as additional opportunities might arise in the implementation of other country-to-country MoUs. Existing examples include the one signed between the Government of South Africa and the Government of Lesotho on the Lesotho Highlands Project and the approved Treaty on Inga 3 with the Democratic Republic of Congo (DRC). There is over 2 GW estimated from the Inga 3 project once it is completed. Technical teams from both countries have been collaborating on the planning of the project and work is still in progress. It is not yet clear when the actual project will progress to the next phase of project implementation.

Domestic hydro is limited. In existence are some larger plants built decades ago and operated by Eskom, some defunct Eskom plants that are small, and some private plants[31]. Since 2015 a total of 14,5 MW has been added to a baseline of 665 MW, of which two old projects make up 600 MW, and of which another approximately 50 MW are defunct.
The pumped storage schemes in South Africa cannot be categorised as hydro as the water is

merely a storage medium (refer storage discussion below) and the bulk of the electricity being so stored is generated from coal. These schemes will 'green' with the grid over time, as the renewables penetration increases.

Bio-energy sector (Biomass, Biogas) developments

Cost–effective biomass opportunities are likewise limited. Historically, some embedded generation has existed at sugar mills and pulp and paper plants, with some electricity being fed back to the grid. The totals amount to 414 MW installed in pulp, paper and sawmilling and 191 MW in 13 sugar mills (total 606 MW). Exportable power from these plants is 50 MW and 6 MW (total 56 MW), respectively, with the remainder being generated for own use[xx].

While a 25 MW biomass project at Ngodwana is a preferred bidder in REIPPPP Round 4, no significant change has occurred since 2015. In long-term planning, biomass never contributes more than approximately 1 GW in any modelling scenario other than in the decarbonised scenario, in which case biomass adds nearly 10 GW of capacity – though only after 2040[32].

Given the scarcity of this resource, optimisation is important. To this end, the BioEnergy Atlas for South Africa, funded by the Department of Science and Technology (DST), was developed and launched in March 2017[33]. It is a public resource aimed at supporting bioenergy development in South Africa. The DST commissioned The South African Environmental Observation Network (SAEON) to produce the BioEnergy Atlas and design a portal for relevant data, reports and decision-support tools.
Biogas, like Biomass, has the advantage that it is not a variable renewable resource, provided

Figure 19: The Minister of Science and Technology, Naledi Pandor, unveils the hardcopy version of South Africa's BioEnergy Atlas[34]

Figure 20: The core team responsible for the Atlas project. From left: Wim Hugo (SAEON), Dr Rebecca Maserumule (Chief Director for Hydrogen and Energy at the Department of Science and Technology) and Somila Xosa (DST)[34]

xx See the report 'South African Cogeneration Review Study' prepared for DFIC/GIZ by IES Energy in February 2015. Pulp, paper and sawmilling capacity includes some condensing power. The total is 399 MW, to which was added an estimated 15 MW in the sawmilling sector owned by York Timbers at Sabie and Boskor – information from Dave Long at IES Energy. See Sections 6.1 and 6.3 of the report. As regards 'export' numbers, higher numbers have been sold historically to Eskom but this was an accounting difference meant to incentivise higher generation even if the power would be used onsite and did not mean that physical export capability was higher adequate volumes and quality of feedstock is available to sustain supply. Again, the cost-effective potential seems limited, with all but one IRP scenario estimating the entire Biogas contribution by 2050, to be below 400 MW. Only in the decarbonised scenario does Biogas contribute an additional 5 GW of capacity, and only after 2040[35]. As with Biomass, the strictly commercial potential seems limited for the medium term.

South African energy storage potential to unlock further RE potential

Energy storage technologies, particularly batteries, are advancing rapidly. In countries with deep penetrations of RE, storage is becoming an increasingly important tool for integrating a rising share of variable RE, including Solar PV, into existing power systems. Some countries also have a small but growing market for energy storage solutions with residential and commercial Solar PV systems. In the future, storage will probably play a major role in providing energy for island systems and for access in remote areas of the developing world, particularly when combined with Solar PV.

More detail appears in Chapters 5 and 7 below. For purposes of this chapter, it is sufficient to note that technical studies suggest[36,37] that South Africa has unique endowments and characteristics that significantly lower the need for electricity storage and allows a penetration of approximately 65 percent of final energy delivered to come from variable renewable resources without significant excess energy that would require storage or curtailment. This result assumed that RE is distributed widely across the country's large surface to achieve a more stable supply as opposed to concentrating RE plants where the resource is at its very best.

The implication of this result is that, if good planning is done in the dispersion of RE and in the balance of Wind/Solar PV, the country can practically build out its RE sector as fast as it is able to for a decade or more without considering storage or curtailment.

Conclusion

The rapid growth of RE internationally is still gathering pace and it's clear that RE is set for a central role in future energy systems. Similarly, RE will play a very significant long-term role in South Africa's future.

In the years since 2011, the short term has always looked very promising, with the RE industry growing explosively and market penetration increasing rapidly. While there has been a slowdown, the Round 4 projects will soon start construction and will mark another short-term success for RE. Rooftop Solar PV marks a notable area of growth outside of the REIPPPP.

The unresolved time frame is the medium term. If the final revised IRP manages – in the context of low demand – to maintain regular procurement of RE at levels high enough to sustain investment, job creation, the expansion of research capacity and the drive to higher levels of local content and industrialisation, the medium-term challenges will have been resolved.

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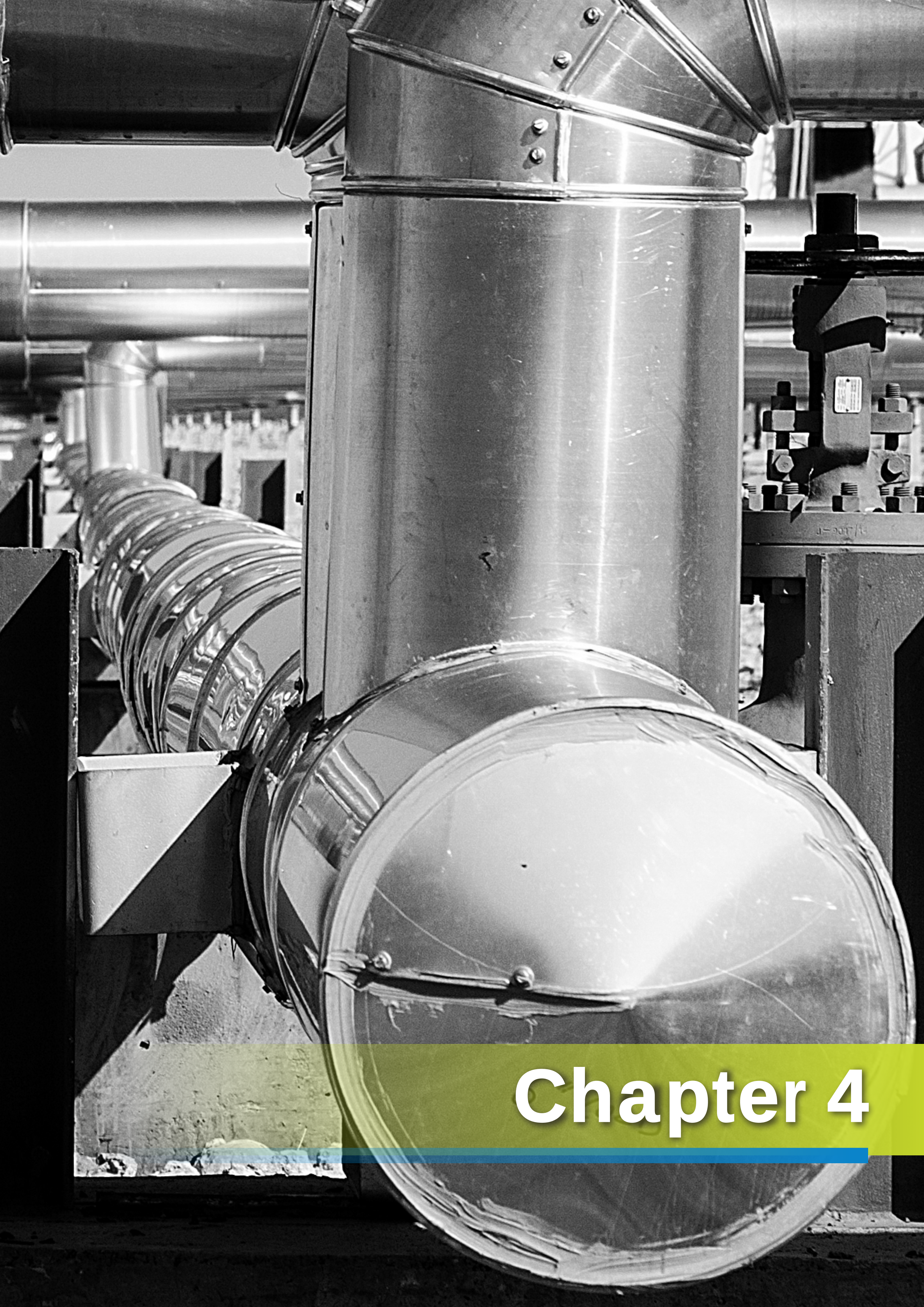

Chapter 4

Chapter 4

Modern energy services for every household

The Regulatory Indicators for Sustainable Energy (RISE) report, published by the World Bank[1], analyses sustainable energy policies in more than 100 countries. This global energy policy scorecard identifies South Africa, among other developing countries, as an emerging leader in sustainable energy, with robust policies to support energy access, renewables and EE. RISE, however, acknowledges that there remains a lot of work to be done towards achieving SDG 7 – access to clean, affordable energy – by 2030.

This chapter seeks to highlight current, RE-related programmes that aim to contribute to the goal of universal access to modern energy services, as envisaged under the SDG 7 and Sustainable Energy for All (SE4All). These include the off-grid electrification and SWH implementation programmes and mini grids[i] pilot initiatives, led by the DoE and Eskom. The chapter also considers the localised solutions that are increasingly possible as result of technological advances.

The previous chapters have underlined the prevailing context supporting the advancement of RE options where the landmark adoption of the Sustainable Development Goals (SDGs), including SDG 7 and the Paris Agreement on climate change, have reaffirmed that the transition to sustainable energy supply and use is pivotal to meeting the development and climate objectives of all nations. To be meaningful and effective, the Paris Agreement requires implementation by all the signatories to keep it alive; put simply, it means it needs to be embedded in national policies and actions – and that implementation needs to be monitored. SDG 7 recognises the importance of affordable, reliable, sustainable and modern energy for all, which was previously encapsulated by the SE4All initiative launched by the former United Nations Secretary-General, Ban Ki-moon, in 2012. In addition, energy is acknowledged as central to the achievement of all other SDGs, such as eradicating extreme poverty, eliminating avoidable child deaths, achieving universal access to secondary education, more inclusive growth, gender equality and sustainable land use.

Enkanini Settlement, Stellenbosch, Western Cape

i The Energypedia defines a mini grid, also sometimes referred to as a 'micro grid or isolated grid', as a set of electricity generators and possibly energy storage systems interconnected to a distribution network that supplies electricity to a localised group of customers

South Africa's National Development Plan (NDP) has similarly recognised the need to decarbonise power sources, increase private participation and investment in the energy field, ensure reliable distribution and equitable pricing and widening access to affordable electricity services for the poor.

As stated in the 2015 State of Renewable Energy in South Africa report, RE technologies are flexible enough to be deployed on a large scale through grid-connected utility-scale projects and also on a smaller, stand-alone scale where these can directly benefit households, farmers, communities and businesses, thereby contributing towards the goal of universal access to modern energy services. The energy deficit that affects the continent, including many communities in South Africa, has the unfortunate consequence of reinforcing poverty, especially for people in designated groups such as women, youth and people living with disabilities, in addition to people living in rural areas and informal settlements. It is therefore important that no effort is spared to widen access to modern energy services to all South Africans. The DoE accordingly identified the need to set up an off-grid management authority within the Department as part of the objectives of the Integrated National Electrification Programme, that will focus on this priority delivery area[ii].

Grid extension was traditionally the only method of electrification. However, the advent of decentralised energy solutions and the plummeting prices of RE solutions are challenging this traditional mindset. Within the new framework of decentralised access to electricity, new options including SWH, Solar Home Systems (SHS) and mini grids, are increasingly driving the growth of this sector. Technology developments and emerging, decentralised solutions are empowering local beneficiaries to contribute to the expansion.

Off-grid electrification programme

Grid electrification rates are generally high nationally (refer Chapter 8 for details), which results in expectations for grid connections remaining very high from a social equality perspective. The reality of topography (i.e. sparsely settled households in geographically remote areas) with respect to the extension of the grid network has proven to be economically unviable. Caught between the financial costs of expanding the national grid to the rural areas (approximately 12.4 percent of households[2]) and providing alternative off-grid solutions in the form of stand-alone solar home systems and mini grid/hybrid systems, the South African government opted to introduce the latter to a targeted number of households that have been clearly identified through the planning process as unlikely to receive grid electricity over a defined planning period.

The SHS off-grid programme was launched by Government in the early 2000s as part of its ambitions to achieve universal access to electricity by 2012. The off-grid electrification programme was therefore meant to complement the grid electrification expansion programme. A 10 percent target was set for off-grid electrification and 90 percent for grid electrification via the NDP, for achievement by 2030. From inception, the programme targeted three provinces, namely the Eastern Cape, KwaZulu-Natal and Limpopo. These were the provinces with the highest numbers of unelectrified remote rural households. From the 2013/14 financial year, the Northern Cape was included in this programme,

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ii The off-grid management authority has been designed to maximise off-grid opportunities, reform the existing SHS programme, increase technology diversification and private sector investment as well as accelerating universal access to electricity in the country. This design work was funded by the EU and concluded in September 2016 which resulted in the province installing approximately 1,307 units. The expansion continued with the Western Cape now having approximately 1,600 units installed between the 2015/16 and 2016/17 financial years.

Actual progress regarding implementation of this programme benefits from participation of private sector companies through a Government-sponsored programme, with some contribution from international donors and agencies. For example, there is also a German Kreditanstalt für Wiederaufbau (KfW), donor-funded non-grid project implemented in the Eastern Cape. For the financial year 2016/17, the DoE allocated R171,809,000 towards the implementation of the SHS programme. Of this amount, R137,730,637 was spent. Approximately 12 service providers were appointed from an established panel of service providers to install SHS for the 2016/17 financial year at various municipalities across the five provinces (refer to Figure 1 below for the type of installed units).

Adapting non-grid delivery models to open up opportunities for more private sector participants

Over the years the delivery models for this programme have evolved. At first, Government supported a few companies to roll out the off-grid electrification programme using a concessionaire model. These concessionaires were selected and appointed through a competitive tender process and were given exclusive rights[iii] to the Government subsidy, which enabled the installation of SHS in specific rural villages in the Eastern Cape, Limpopo and KwaZulu-Natal provinces. This also meant they had privileged access to Government's SHS subsidy within their allocated geographic areas. To make the businesses viable, these companies were allocated a substantial number of systems, collectively adding up to 80,000 installations. The model was designed in a way that the appointed companies were expected to install and maintain the systems over a period of 20 years.

Figure 1: SHS installation, Ladysmith, KwaZulu-Natal

iii The concessions had exclusive access to the Government subsidy within the concession, though it did not exclude other role-players / installers to install systems (without a subsidy) within the same geographic area

A number of events conspired to motivate the DoE to rethink the SHS concession programme and the country's off-grid prospects more generally, adapting non-grid delivery models to open up opportunities for more private sector participants.

Firstly, the high costs of rural grid connections placed increasing strain on the DoE's resources and its ability to clear up the backlog within the 2012 target period, in line with the original commitment to achieve universal access to electricity at the time. Second, the notion of a 'concession' with guaranteed rights to public funds in the form of a subsidy was being questioned as contrary to the competitive requirements of the Public Finance Management Act (PFMA) (Act 1 of 1999, as amended by Act 29 of 1999). Thirdly, long-term service level agreements were more easily accommodated under the Municipal Finance Management Act (MFMA) which, based on constitutional provisions, placed municipalities at the centre of service delivery (refer to Chapter 8, Box 2).

In summary, the need for change in the delivery model used for off-grid electrification, coupled with a growing realisation of the contribution of the off-grid sector to universal access and an enriched and diversified energy environment, compelled the DoE to act. This led to the publication of the New Household Electrification strategy, which was adopted by Parliament in June 2013. The DoE sought technical advice and support from the European Union, through the SE4All Technical Assistance Facility (TAF), to ensure a more responsive and compliant SHS programme as well as a more capacitated and dedicated institutional environment to support the off-grid sector in broad terms.

At operational level nationally, there were a range of other issues that continue to have an influence on the performance of the off-grid sector. These include stabilising access to the Free Basic Energy (FBE) subsidy, which is an important operational subsidy designed to mitigate risks that often confront service providers operating within the low income/rural household sector. The administration of this subsidy presented two hurdles; on the one hand is the fact that the subsidy is provided on an annual basis, which places an administrative burden of renewal – often leading to a temporary suspension of the subsidy in certain cases, which can last up to six months. This situation impacted on the cash flow of the private sector service providers. On the other hand, many SHS customer households did not appear on the municipality's indigent list and are therefore not eligible for FBE, even though some of them may have qualified for this benefit.

Figure 2: Solar Home systems in Matatiele, Eastern Cape

Figure 3: Solar Home System installation, Matatiele, Eastern Cape

Here, as elsewhere in the southern hemisphere, authorities are grappling with the challenge of providing basic services to far more people than limited resources readily allow. RE, storage and network technologies are, however, rapidly maturing into viable solutions to support South Africa meeting its own universal access target, as well as meeting electricity demand growth fueled by population- and economic growth. Besides addressing energy challenges, these emerging energy solutions also hold the potential for local economic development.

The current delivery model

Due to the above challenges and a reduction in fiscal resources, the DoE has replaced the concession model, which offered long-term contracts to a few private sector companies, with open competition – allowing more private sector players to participate. As such, the number of participants has grown from three to 12 during the past 16 years. In addition, municipalities are now actively involved and responsible for identifying installation areas. Procurement, however, is still handled at national level by the DoE. Working together with other departments, it is considered important to ensure consistency in the flow of FBE funds; keeping track of the number of unelectrified households; and ensuring that opportunities for learnerships and mentoring are offered to unemployed youth within the targeted areas. The aim is to provide exposure and build capacity so as to not undermine the longer-term sustainability of the SHS programme and compromise delivery of one of the key flagship programmes within the off-grid sector in South Africa. There are various stakeholders in the SHS value chain, from policy makers and administrators to installers, operational and maintenance companies as well as the participating communities who need to buy in to the opportunities that a well-managed off-grid SHS programme presents.

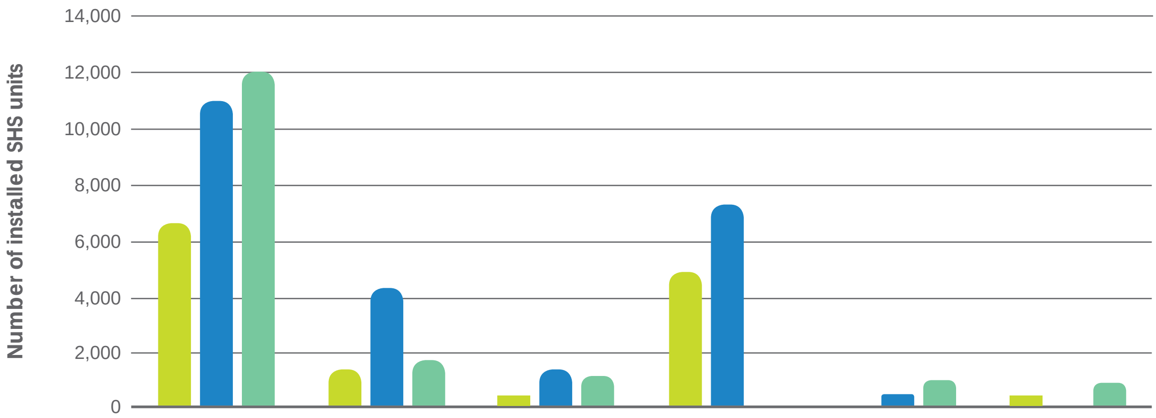
While the concession-based electrification programme had been abandoned, ostensibly to ensure policy alignment, the emergent non-concession programme revealed similar policy conflicts. Central to the conflict is the national procurement of SHS, as opposed to this procurement taking place at the Local Authority (LA) level (as is the case in grid electrification), which shifts the legal framework to a more accommodating Municipal Finance Management Act (MFMA) as opposed to the Public Finance Management Act (PFMA).

The former is centred on the constitutional 'service delivery' role of the LA and enables longer-term service delivery contracts while the latter requires, in this regard, more short-term, competitive contracts. The emphasis is on enhancing the role of LAs, which are not only constitutionally compelled but are far more familiar with the service delivery requirements within their constituencies. Moreover, devolving procurement down to the LAs would compel them to incorporate these assets, acquired through their own supply chain processes, onto the municipal asset register.

Acknowledged ownership of assets should compel municipalities to maintain them, which should translate into improved access to FBE, i.e. an operational subsidy. It is acknowledged that such an allocation of responsibility would add a burden on municipalities, necessitating additional capacity, including human resources, to be made available to the municipalities to absorb the (extra) load. An appropriate institutional arrangement is yet to be found, but there are proposals in place and some consensus that the grid electrification model will not be suitable.

Quantitative progress between 2014/15 and 2016/17 financial years

The figure below provides a break-down of SHS units installed between 2014/15 and 2016/17:

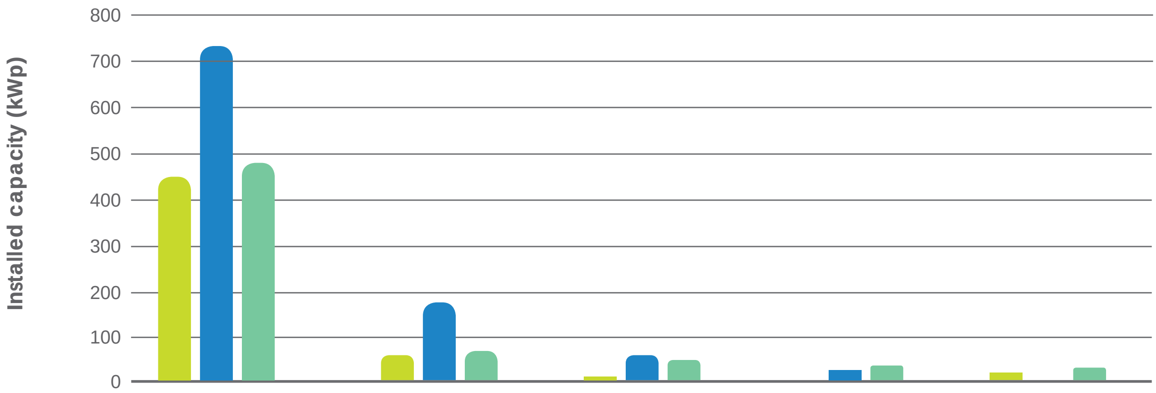


	Eastern Cape	KwaZulu-Natal	Limpopo	KfW (Donor, Eastern Cape)	Western Cape	Northern Cape
2014/15 (Feb)	6,547	1,663	286	5,027	0	507
2015/16	10,973	4,571	1,500	7,372	660	0
2016/17	12,020	1,829	1,273	0	1,000	800

Figure 4: Number of SHS installations per province per annum (zero figures indicate no installations during that particular financial year)

The collective power produced via SHS is estimated at approximately 2.85 Gigawatt hours per year. This figure is based on a 0.04 kWp panel size[iv] with an 80 percent assumed efficiency[v]. Systems are capable of operating at full capacity for 4.8 hours when the battery is fully charged, meaning that the system can produce power at capacity for 1,752 hours per annum (4.8 X 365 days). The system allows for use of black-and-white television, indoor and outdoor lighting, cell phone charging and audio-visual appliances for more than four hours.

Installed capacity and associated power supply were distributed geographically between 2014 and 2017 as follows:



	Eastern Cape	KwaZulu-Natal	Limpopo	Western Cape	Northern Cape
2014/15	463	67	11	0	20
2015/16	734	183	60	26	0
2016/17	481	73	51	40	32

Figure 5: SHS installed capacity (kWp) per financial year per province

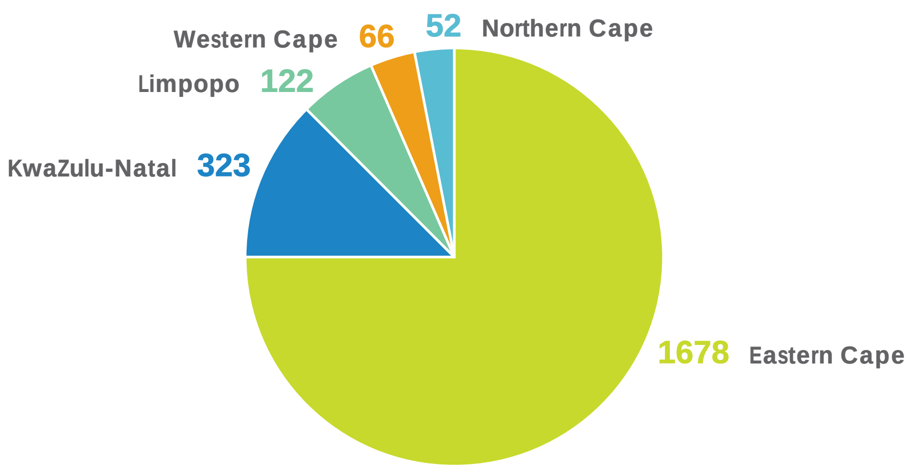
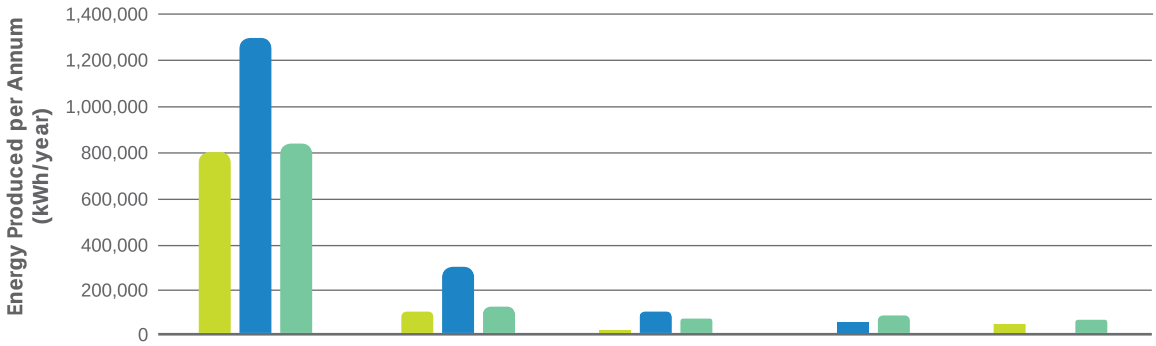


Figure 6: Total SHS installed capacity (kWp), 2014/15 to 2016/17

iv kW_p refers to the peak capacity, noting that output of solar systems can vary during the day

v The original estimates and calculations were based on 40 Wp (i.e. 50 Wp at 100 percent efficiency). Because of downward price trends, module sizes were increased to 100 Wp (0.1k Wp or 0.08 kWp at 80 percent efficiency). Many of the installations done on the programmes were upgraded accordingly. It is estimated that the average size of the modules installed is therefore around 75 Wp or 0.075 (or 0.06 kWp considering 80 percent efficiency) if it is assumed that at least 50 percent of the installations were upgraded to 100 Wp

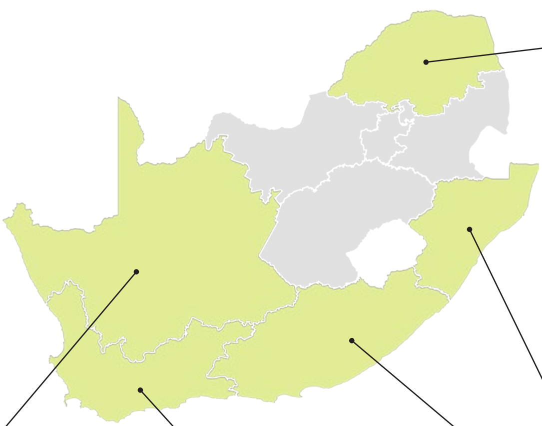
The annual energy production from the SHS installations have grown significantly since 2014 (Figure 7).



	Eastern Cape	KwaZulu-Natal	Limpopo	Western Cape	Northern Cape
2014/15	811,106	116,543	20,043	0	35,531
2015/16	1,285,618	320,336	105,120	46,253	0
2016/17	842,362	128,176	89,212	70,080	56,064

Figure 7: Annual energy production (kWh/annum), 2014/15 to 2016/17

These annual installations have delivered 9,482 kW_p cumulative capacity and are expected to produce 16,6 GW/h of energy during 2017. The figure below shows the distribution across provinces.



TOTAL

Installed capacity (kWp)

2014/15	5,000
2015/16	5,564
2016/17	6,968
TOTAL	17,532

Energy produced per annum (kWh/year)

2014/15	8,760,841
2015/16	10,774,659
2016/17	12,209,057
TOTAL	31,744,557

Limpopo

Installed capacity (kWp)

2014/15	471
2015/16	531
2016/17	582
TOTAL	1,584

Energy produced per annum (kWh/year)

2014/15	825,402
2015/16	930,522
2016/17	1,019,734
TOTAL	2,775,658

Northern Cape

Installed capacity (kWp)

2014/15	500
2015/16	0
2016/17	709
TOTAL	1,209

Energy produced per annum (kWh/year)

2014/15	875,650
2015/16	1,027,022
2016/17	1,242,378
TOTAL	3,145,050

Western Cape

Installed capacity (kWp)

2014/15	471
2015/16	558
2016/17	648
TOTAL	1,677

Energy produced per annum (kWh/year)

2014/15	825,402
2015/16	976,775
2016/17	1,136,067
TOTAL	2,938,244

Eastern Cape

Installed capacity (kWp)

2014/15	1,429
2015/16	2,163
2016/17	2,644
TOTAL	6,236

Energy produced per annum (kWh/year)

2014/15	2,504,099
2015/16	3,789,716
2016/17	4,632,078
TOTAL	10,925,893

KwaZulu-Natal

Installed capacity (kWp)

2014/15	2,129
2015/16	2,312
2016/17	2,385
TOTAL	6,826

Energy produced per annum (kWh/year)

2014/15	3,730,288
2015/16	4,050,624
2016/17	4,178,800
TOTAL	11,959,712

Figure 8: Cumulative installed capacity (kWp) per province

Figure 9: Low pressure SWH system

National Solar Water Heater (SWH) programme

Following the termination of the DoE-Eskom Memorandum of Agreement for the implementation of the SWH programme, Cabinet approved the Revised Contracting Model in 2015, paving the way for the amendment of the Appropriation Bill so that the funds can be allocated to the DoE as the implementer. The SWH programme has experienced delays since the publication of the previous report, to the extent that in 2016/17 there was underspending of R112.52 million at the end of the financial year.

It is necessary to underline that this programme has three legs and many developmental objectives, hence it received significant budget allocation from the fiscus.

- The first leg is that of a social focus, where the intention is to extend access to hot water services to under-served low income communities, but where there is at least access to reticulated water to a house rather than a communal tap; typically, in low income urban areas. Contextually, this is driven by the need for redress.

- Second, there is the load reduction programme which is aimed at shifting demand for heated water, which has been traditionally driven by electric geysers, to solar geysers, particularly in middle- to upper-income households. Ultimately, the aim of this programme, which originated in the time when electricity demand was too high, was to reduce pressure on the national grid.

- The third and final leg of the programme focuses on repair and replacement of faulty geysers from the initial SWH Rollout Programme.

Underpinning the entire programme approach, is a desire to create new industries through increasing local manufacturing capacity. Anticipated spin-offs are job creation and skills development.

Medium- to long-term SWH installation targets have been set as a reflection of national commitment in realising Government's objectives. In this regard, the fifth administration has set a cumulative target of 1,75 million SWH installations by 2019. This target might not be achieved due to the technical bearings that needed to be refined to ensure conformity to quality and standards prescribed by the programme. However, by mitigating these challenges now, the long-term target through the NDP (a cumulative target of 5 million SWHs by 2030) can more realistically be secured.

The budget for the SWH programme allows for the installation of approximately 50,000 systems annually. Between 2015/16 and 2017/18 financial years, the procurement of 87,206 locally manufactured baseline SWH systems was completed. The DoE entered into a Memorandum of Agreement (MoA) with the South African Bureau of Standards (SABS), as designated by **the dti**, to verify and confirm that the locally procured baselines systems comply with the 70 percent local content requirement. This requirement corresponds with the National Treasury practice notice published in 2014 in an effort to support the creation of a local industrial base and jobs in the manufacturing sector. Accordingly, baseline systems were exclusively procured from local manufacturing companies located across the country (Figure 10), from 12 suppliers with at least a Level 4 BBBEE contribution status.

All the procured baseline systems would be allocated to the selected municipalities for installation as per the signed Framework Agreements that are supported by Municipal Council Resolutions.

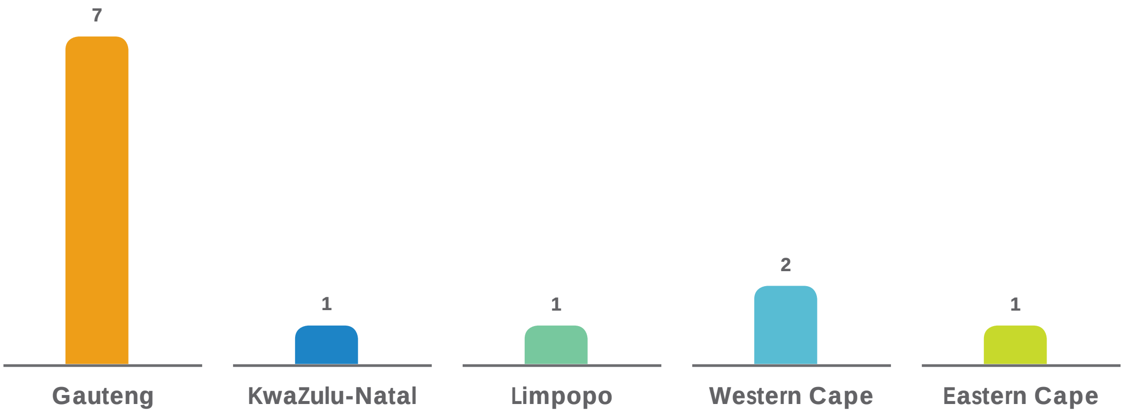


Figure 10: Distribution of SWH suppliers (number of) per province

An electronic monitoring system has been developed that will create a secure database of all SWH systems that are installed. Each SWH system will be uniquely identified with a barcode with tracking capability, making it possible to map the geospatial distribution of each system at the manufacturer's factory, and track the movement of the systems from the factory to the storage hub to the rooftop where it is installed.

Social facilitation service providers have also been appointed to support the implementation programme and service providers will be assigned to each participating municipality.

The DoE committed to commence with the training of local communities in the installation of solar water heating systems to ensure the programme contributes towards local economic development with clear objectives set for skills and enterprise development, job creation and the targeted designated groups such as youth, women, people with disabilities and any other identified groups. Another priority is to address defective installations from the initial SWH Rollout Programme to ensure continued operation of the installed systems and service delivery to the recipients. This should address the challenges and dysfunction that the previous phase of this programme was beset with. The current baseline systems are procured from suppliers with a five-year warranty commencing from the date the baseline system is installed. The warranty, among others, provides for claims to be made within three months of detection of the defect and to be attended to within 72 working hours, provided the baseline in question is easily available for inspection by the supplier or its representative.

This corrective SWH Programme has been identified to serve as an incubator to develop suitably skilled and experienced SWH installers and installation businesses. The platform will provide technical training at different skills levels and create an opportunity for work-based experience with regard to all aspects of SWH installation, including the identification of installation and system defects; repairs; and new and replacement installations. This initiative is an ideal prospect for youth development and the establishment of an industry that can support the delivery of the larger national SWH target.

Mini- or micro grids, facilitating the provision of modern energy

Historically, the electrification focus had been on grid expansion. The off-grid electrification programme, described earlier, introduced solar standalone systems to remote communities. RE and network innovations are now presenting new solutions with the potential to contribute meaningfully towards universal energy access. Combining various forms of RE with micro- or mini grids, is emerging[3] as a practical, and increasingly cost effective, option for providing grid-quality power to rural communities[vi,4].

The sharp decline in Solar PV costs, improvements in battery costs, which are are expected to continue to decline as adoption rates increase globally, combined with advances in energy management systems, make it possible to balance generation and load across the micro grid and provide a reliable and sustainable service.

The DoE, in collaboration with Eskom, initiated investigations in the development and operation of mini grids in South Africa. Eskom is developing several pilot projects (refer Box 1 for a case study on RE and micro grid technology for electrification) that can inform decision making and planning. In parallel, the DoE is focused on creating the policy environment that will enable widespread deployment and is presently reviewing regulations for small-scale and mini grid renewable generation[5].

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vi East Africa has pioneered the implementation of micro / mini grid and the establishment of mini grid distributed energy services companies. Successes in Tanzania has been reviewed and documented as 'benchmarks by the International Finance Corporation (IFC) to serve as input guide to similar developments elsewhere

BOX 1

Case Study: RE and micro grid technology for electrification[6,7]

The Eskom Research, Testing and Development (RT&D) unit has developed a micro grid demonstration plant in a rural, unelectrified village, near Ficksburg, in the Free State. The project is being rolled out in collaboration with the Department of Agriculture, Forestry and Fisheries, the community of Wilhelmina farm and Eskom RT&D's Smart Grid Centre of Excellence.

The micro grid system incorporates Solar PV generation, battery storage and intelligent energy management. These technologies have been integrated into a standard low-voltage reticulation network, where electricity is delivered to consumers through conductor wires in a local distribution network. Residual electricity is stored in three sets of lithium-ion batteries, which have a combined capacity of 90 kWh. This stored energy supplies the inverters during cloud-outs and when the sun sets. Based on the anticipated battery life, the system is expected to be operational for 22 years. The modular pilot system has been tailored to the demand needs of 14 households, but could be augmented should there be any increase in demand.

The micro grid was operational at the start of September, after being launched in May 2017, delivering power to the community in only a few months. And, it has already served as a sharp learning curve. Providing power to the 14 households, at a cost of R4.2 million. Design optimisation from a cost perspective, as informed by the pilot project, means that a similar sized micro grid could now cost in the region of R1.75 million to deploy – and additional cost optimisation may be possible through partnerships with equipment suppliers.

During the pilot testing phase, the operations of the micro grid will be monitored on an ongoing basis from a control room at Eskom Research, Testing and Development's Rosherville campus, in Johannesburg. Monitoring data and findings will be used to inform further design refinements and potential future roll out.

Experiences and lessons from the mini grid pilot initiatives will inform multiple dimensions such as coverage and trend, technical designs, institutional arrangements, financial mechanism, tariffs, and operation and maintenance aspects.

If South Africa can successfully refine the mini grid technology and business case, it can serve as a solution to local energy challenges and support regional electrification, where grid penetration is lower and electricity access remains a serious challenge to economic development.

Despite immediately remaining cost challenges, there is little question that micro grids are an increasingly compelling proposition for geographically challenging areas that are either difficult to access, or require extensive capital investment to reach. However, the mini grid may be designed to interconnect with the central grid, creating the flexibility to move between autonomous operation and interconnection. As such, it can also be deployed to support congested networks[8], network optimisation and resilience and address non-technical losses.

In itself, connection to grid-quality electricity means the power to access economic opportunity. Electrification will enable the most remote rural communities to be economically active and/or access opportunities for education and other needed services. The potential size of the local and regional market also suggests an opportunity for the formation of local industries, contributing to the development of the Green Economy and creation of 'green jobs'.

Municipal and community-based solutions

These technological developments now also allow consumers to participate in the energy system like never before, opening doors to prospective and existing electricity users as well as municipalities to explore localised solutions. In South Africa, this has given rise to numerous innovations, testing and demonstrating the social, economic and sustainability benefits of reliable, unlimited, uninterrupted, and low-cost electricity that can be realised by localised solutions. A few of these initial, innovative pilot projects are highlighted here to illustrate the scope of solutions that are becoming possible.

Solar Power Internet Schools

Poor rural communities in South Africa are benefiting from a new initiative using solar power and the internet to provide education[9]. These mobile schools, pioneered by Samsung[10], are made up of shipping containers kitted out as health centres and schools, all running on solar power.

The first village module consists of a 'smart school; that provides students with a computer and internet access[11]. The school is built in a 12m renovated shipping container that can accommodate up to 24 pupils, and fitted with solar panels that power the equipment. It is equipped with a large-format display screen, a teacher's laptop, Samsung notebooks, a printer, and fans to cool the container. The classroom's computer server is loaded with educational content that covers the entire basic education syllabus, allowing facilitators to teach any subject or grade. Energy efficient LED lighting and an Internet Protocol (IP) camera, which is designed to use 3G connectivity, allows for remote classroom monitoring.

Containers can easily be moved hundreds of kilometres to remote locations and additional containers can be added to expand the village services. Schools could be expanded into 'smart villages' to include medical centres[vii], police offices and postal services in a similar solar-powered, containerised format, all of which have been developed to different degrees.

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vii "The medical centre, which also runs on solar power, provides eye, ear and dental care as well as state-of-the-art blood-analysis facilities. Registered nurses are being trained to use the digital village technology, which enables doctors to assist patients with diagnosis from anywhere in the world through video conferencing" – Euronews, 21 November 2011

SolarTurtle and PowerTurtle[12,13]

The SolarTurtle is a proudly South African innovation[viii] that offers a community solar power plant and energy spaza shop suitable for unelectrified, rural communities. The portable micro-utility is built into a standard 6m shipping container, with solar panels that are unfolded in the morning and again locked away in the hard shell of the container once it gets dark. This fold-away Solar PV system can provide basic electricity to 300 households and local schools and businesses. No on-site infrastructure or skills are required to set up and operate the system and it requires very little maintenance.

These community-owned solar kiosks sell electricity 'by the bottle'. This means that a recycled plastic bottle is halved and a battery inserted; the lid is then converted to a 12V cigarette lighter socket, allowing communities to build and maintain their own battery packs. The small power plant also serves as a shop where customers can buy EE devices such as lights, TV, radios and stoves. For customers needing more electricity, SolarTurtle sells home Solar PV kits. Micro grid connections are offered additionally to power local schools and businesses.

A dedicated, solar power container, called the PowerTurtle, has also been developed, providing an ultra-secure solar electricity solution in a box. PowerTurtle is deployed to provide safe and reliable, clean energy to offices, shops, clinics or utilities in remote locations.

Figure 11: SolarTurtle container with partially unfolded PV panels (photo sourced from SolarTurtle Twitter feed)

viii Developed as a research project, the SolarTurtle prototype was supported and funded by SANEDI, Technology Innovation Agency (TIA) and DST and deployed at a school in the Eastern Cape

Figure 12: SolarTurtle container doubling as a trading spot at a school in Transkei (photo sourced from SolarTurtle Twitter feed)

iShack Project

The iShack Project, implemented in the Enkanini informal settlement in Stellenbosch, evolved from a research project of the Sustainability Institute into a successful off-grid, solar electricity utility. Early research identified electricity supply to be the most urgent need among residents of Enkanini. The municipality was, however, unable to immediately provide grid electricity and therefore decided to support the iShack Project in providing a temporary energy service using solar technology[14].

The iShack Project has been established as a large-scale energy utility that provides a subsidized electricity service to 1,600 households in Enkanini[15]. The off-grid utility provides household electricity to power lights, television, cell-phone charging and other small media appliances. Some of the residents from the community have been trained as 'iShack Agents' to market, install and maintain the utility.

The initial research project did benefit from donor support as well as a significant start-up grant from the Green Fund, but the business model is designed to ensure the energy service is financially sustainable. A 'Free Basic Electricity' (FBE) subsidy is provided by the municipality for each household which ensures that the main operations costs are covered, and residents only have to pay for maintenance if and when needed. The South African National Energy Association (SANEA) awarded the Stellenbosch Municipality a Highly-Commended Award[16] in recognition of the municipality's innovative use of the FBE subsidy that demonstrates how green technologies can be used to address South Africa's service-delivery needs – in this case, providing a modest but impactful off-grid electricity service while communities wait for grid connectivity, and at the same time providing jobs and building local enterprise capacity and resilience within the community.

Figure 13: iShack installations, Enkanini informal settlement, Stellenbosch (photo source: www.ishackproject.co.za)

Nelson Mandela Bay Metro Municipality, SHS pilot

Other municipalities are similarly investigating solar home systems for off-grid electrification in urban informal settlements. Late in 2014, Nelson Mandela Bay Metro Municipality initiated a pilot project, installing 12 volt SHS on 3,000 informal houses. The basic solar PV system consists of one PV panel, a battery, charge controller, four LED lights with switches and a 12V car cigarette lighter socket mobile for use as a phone charger. R22 million was made available by the Integrated National Electrification Programme (INEP) for the pilot project that is being implemented and monitored over a period of three years.

The Nelson Mandela Metropolitan University (NMMU) was contracted by the metro to conduct two surveys at sites selected for non-grid SHS in informal settlements. The surveys are intended to gauge the knowledge and understanding of the Solar PV system before and after installation, as well as the impact that the system has on residents. This information will serve to refine further phases.

!Kheis Municipality, micro grid pilot

In the Northern Cape, the !Kheis[ix] Municipality implemented an off-grid solar, micro grid system for the Duineveld community. Duineveld is an informal community with approximately 300 families that did not previously have access to electricity.

Using solar power, dwellings[x] have been electrified with sufficient power to operate lights, a radio, a TV and a refrigerator and a separate cellphone charging station. All appliances operate on direct current (DC), rather than the more traditional alternating current (AC), and connects into a DC micro grid system that is remotely managed by a web-based management platform suitable for large-scale, distributed solar energy supply. This micro grid solution provides the !Kheis Municipality[17] an online Off-Grid Energy Management Utility with remote switching, payment facilitation, vendor management, solar system and end-user management services.

Innovative RE solutions such as these offer new opportunities for electrification, while opening wider economic prospects. The micro grid system has been developed by a South African company, Specialized Solar Systems, who will continue to provide product support to the Municipality; local community members were trained to do the installation and maintenance for the systems.

The Duineveld project was made possible with the contribution and support of a locally based REIPP, as part of their socio-economic development commitment. In this case, it assisted the municipality with financing of the micro grid solution, technology considerations, development of a business case and the associated contractual structures. Recognising that municipalities are required to navigate this unfamiliar territory, the CSIR and Carbon Trust[xi] developed a mini grid toolkit to provide support to interested municipalities (refer to Box 2, below on the Carbon Trust Toolkit for Mini Grids).

BOX 2

Carbon Trust Toolkit for Mini Grids

The Carbon Trust and the Council of Scientific and Industrial Research (CSIR) developed and published a mini grid toolkit, mid-2017, with the financial support of the United Kingdom's Foreign Commonwealth Office. This toolkit's principal aim is to be a key reference document for the development of sustainable business models and operational off-grid projects in South Africa. It has been structured as a comprehensive guidebook, to support Local Government planners and decision makers with assessing the viability and structuring of mini grid solutions.

The Carbon Trust will be working with SALGA to adapt this document into an 'easy-to-use' reference manual for local authorities in South Africa, providing assistance with defining the required service levels and relevant technical requirements, evaluating costs and identifying the preferred business models that will enable the development of fundable, sustainable and scalable mini grid systems. The reference manual should serve to strengthen the capacity of municipalities to fulfil their constitutional mandate to deliver services.

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ix *!Kheis is a Khoi name meaning "a place where you live, or a home". The municipality is named in recognition of the Khoi people who were the first permanent dwellers of the area*

x *A total of 1,500 homes were targeted, but current installed numbers were not confirmed.*

xi *The Carbon Trust is an independent, expert organisation, committed to a more sustainable future through carbon reduction, resource efficiency strategies and commercialising low carbon technologies*

Woodlands Diary, biomass boiler

Beyond lighting and domestic applications, RE is also being used to power pumping, processing, cooling/heating and boilers, among numerous other industrialised uses. As an example, in the Eastern Cape, biomass, in the form of sustainable wood chips from a local sawmill, is powering a green, biomass-fuelled boiler system. The steam boiler supplies the majority of the steam requirements of the Woodlands Dairy in Humansdorp, where large quantities of steam are used in the dairy processing to pasteurise and sterilise milk. The solution enables economic activity with substantially reduced electricity usage, reduced energy costs and reduced usage of Heavy Fuel Oil (HFO) and carbon emissions.

Conclusion

South Africa is actively exploring the new opportunities and acting to integrate appropriate solutions in national energy frameworks and initiatives as part of improving its delivery models to assist the country to reach its set universal access targets. It also acknowledges the localised nature of emerging solutions, recognising that a comprehensive and sustainable solution to universal access will likely depend on a collaborative spirit, incorporating all spheres of Government and local stakeholders.

Expanding access to modern, reliable and affordable energy in South Africa remains our primary objective towards achieving sustainable development in all sectors of the economy. The South African economy is energy intensive, hence we need to diversify the country's energy mix in ensuring universal access. The reality on topography and sparsely settled households with respect to the extension of grid network to connect remote areas has proven to be economically unviable. However, the South African government opted to introduce the off-grid solutions in order to close the gap created by lack of access to electricity by areas that have been identified as unlikely to receive grid electricity over a defined planning period.

1 Banerjee, Sudeshna Ghosh; Moreno, Francisco Alejandro; Sinton, Jonathan Edwards; Primiani, Tanya; Seong, Joonkyung. 2017. Regulatory indicators for sustainable energy: a global scorecard for policy makers. Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/538181487106403375/Regulatory-indicators-for-sustainable-energy-a-global-scorecard-for-policy-makers

2 Lehohla, P. 2017. The state of basic service delivery in South Africa: In-depth analysis of the Community Survey 2016 data. StatsSA. published 29 March 2017

3 Chetty, R. 2015. Smart Grids for Rural electrification in South Africa. Researchgate.net. Accessed: 12 September 2017.

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Chapter 5

Chapter 5

Managing the development of grid infrastructure to support RE deployment

Increasing complexity and changing needs of the diversified power system

A transmission system plays a pivotal role in the context of overall grid infrastructure provision for a country. In the South African context, this means the transmission system enables the provision of electricity by delivering electricity in bulk from electricity generators to load centres located throughout South Africa and the southern African region. At present, the transmission network is owned and operated by the national power utility, Eskom. From there, the distribution networks owned by Eskom and municipalities deliver electricity to end-users.

During the last five years the South African energy sector has experienced the increasing complexity and changing needs of a diversifying power system, largely triggered by the IRP 2010. Continued evolvement can be expected following from the draft IRP 2016 base case update process. As explained in the State of Renewable Energy Report (2015 edition), private market participation in the energy sector with the introduction of IPPs has triggered changes to the Electricity Supply Industry in terms of:

- The spatial locations of independently owned generators are determined by the IPPs and only become known to Eskom upon application for a grid connection to participate in the bidding programme.

- Distributed IPP plants have a two- to three-year construction period, whereas long transmission line projects have a six- to eight-year project life cycle. These differences in delivery timeline need to be proactively managed so that the grid is available timeously, in alignment with the completion times for new power plants.

Wind turbine being assembled

- Future, independently owned generation projects have been determined by a competitive bidding process, which is assessed on an individual project basis. Economies of scale are therefore difficult to obtain and to integrate with network plans.

- The prime development locations for RE, corresponding with high RE resource potential, available land and low population densities, coincide with those areas where limited spare network capacity had been created due to the historical cost optimisation/minimisation approach referred to in the previous point.

- REIPPPP Bid Windows 1 to 4b[i] have utilised much of the available grid capacity in areas of RE IPP interest, such as the Northern Cape, Eastern Cape and Western Cape provinces. Network upgrades will be required if RE development is to continue in certain areas, as driven by the need to procure cost-efficient electricity generation.

- Individual RE IPP generators are typically significantly smaller than the incremental grid capacity expansion. The cost and project life cycle duration of grid expansion can be prohibitive for an individual RE IPP project.

- For this reason grid that supplies more than one RE IPP customer is planned strategically to accommodate the cumulative RE IPP capacity, with the result that the relative cost and project duration will significantly reduce – and, in so doing, help lower electricity tariffs.

These planning challenges stemming from the participation of private sector in the supply of new generation are, however, not unique to South Africa – nor are they overly complex. They do, however, necessitate a transition to a new planning paradigm. Shared grid upgrades need to be proactively planned and developed to accommodate cumulative IPP requirements, with an equitable recovery of costs once these plans are implemented. In response to these multiple dimensions introducing uncertainty, the Eskom transmission planning process follows a scenario-based approach. Key plans driving the 'core' transmission network expansion planning therefore include:

- Integrated Resource Plan (IRP). The Department of Energy (DoE) is accountable for the IRP, which is intended to drive all new generation capacity development. NERSA licenses new generators according to this plan. The IRP covers total resources only, and does not give any spatial information.

- The Eskom Strategic Grid Plan (SGP) formulates long-term strategic transmission corridor requirements, and is based on a range of generation scenarios and associated strategic network analysis. The horizon is 20 years and the plan is updated every two to three years.

- The Transmission Development Plan (TDP) represents the transmission network infrastructure investment requirements and covers a 10-year window. The plan is adapted and modified on an annual basis to accommodate changes in both generation and load requirements and also indicates financial commitments required in the short- to medium term.

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i 4b used to denote the Expedited Bid Window (refer Chapter 3 for additional detail)

BOX 1

Network flexibility to accommodate RE

RE, particularly Solar and Wind, introduces greater variability and uncertainty to the power system, with generation output varying significantly over the course of hours to days, sometimes in a predictable fashion, but often imperfectly forecasted. With global targets for RE increasingly ambitious and complete decarbonisation of the power sector set as an ultimate goal, the impact of variability increases. All power systems have some inherent level of flexibility— designed to balance supply and demand at all times. However, as the share of grid-connected RE grows, so does the need for greater flexibility in the system.

Various options are available for enhancing flexibility in terms of generation, transmission, demand-side resources and system operation. The best options and combination of options to ensure that the power system possesses sufficient flexibility to accommodate the growth of variable renewable generation depend on local conditions and resources. Some of the available measures to improve the resilience of the power system and accommodate more RE include:

1. **Transmission grid interconnectedness.** Greater grid integration and a larger geographic footprint assist with leveling out net variability. By incorporating a larger area with more diverse weather conditions – longer sunlight hours, more even wind distribution – balancing variable sources can more easily be achieved. Because of the extent of the South African power network there is already a very high level of integration possible, but the size of the country and remote location of certain good resources will require further transmission investment to fully exploit the potential.

2. **Intelligent grid infrastructure.** It should also be noted that 'smart grid' technologies enable many of the flexibility measures and innovations for grid integration.

3. **Increased generation flexibility.** On the supply side, flexibility arises from innovations in flexible coal and gas power plants. In several countries, options for converting thermal power plants to provide greater flexibility have been introduced to support the growing share of RE. In South Africa the Majuba power station offers an example of a flexible coal plant re-designed to enable quick start-ups and ramping up so it could participate in the Southern African Power Pool (SAPP), cycling on/off twice daily despite its original baseload design[1].

4. **Storage technologies.** By incorporating storage, excess renewable power can be stored for later use. It is expected to make a modest contribution to power systems in the short- and medium term, by virtue of relatively high cost, and because other grid integration measures can be done first. International studies[2] have shown that investment in storage capacity becomes viable only when RE reaches 40 percent to 50 percent of the energy mix[3, 4, 5, 6]. However, as the technology continues to advance and prices drop, storage capacity may become viable earlier.

5. **Demand-side management and demand response.** Responsive load and demand response innovations provide flexibility by enabling power consumption to vary in response to supply-side variability and grid conditions, and thus allow power demand to play a role in balancing variable renewables. Electric vehicle 'smart charging' is a form of responsive load.

6. **Integration of the power, heat and transport sector.** Sector integration (e.g. coupling power with heating, cooling and transport, etc.) offers significant opportunities for (i) integrating higher shares of variable RE generation while (ii) also expanding the use of RE in other end-use sectors and (iii) increasing efficiency of energy use. Supporting a diversity of energy loads and storage (e.g. electric vehicles), contributes to the balancing of variable RE generation.

These present a small selection of the innovations being explored globally to unlock greater diversity and lower carbon power systems. The most economical combination of options depend on the configuration and characteristics of the individual power system.

Responding to the changing network planning environment

Strategic investment is needed to be able to adapt to greater planning uncertainty and reduce the mismatch between development timelines referred to earlier (two to three years for RE IPPs compared to six to eight years for transmission network). Consequently, the need to identify and invest in critical power corridors for the future transmission network as well as to unlock and create a flexible and robust grid that can better respond to the changing future, has been identified. In response to these changes and associated experiences, the DoE, in consultation with various industry stakeholders such as the Department of Environmental Affairs (DEA) and specifically Eskom, has identified areas of improvement to the planning process in order to cater for these developments.

Eskom, as the national transmission network service provider (TNSP), is responsible for providing (planning) and maintaining the national transmission network. One of the mechanisms available to achieve this is the above mentioned TDP. The TDP is intended to create grid capacity to integrate the generation envisaged in the IRP. The latest plan available for public consumption is the TDP 2018-2027[ii]. While the development of the draft IRP 2016 base case update remain in process (refer Chapter 2), the assumptions that informed the latest TDP were adjusted to reflect actual system values and to take into consideration planned generation development as per the draft IRP. The TDP will be updated again once the revision of the IRP is finalised and all planning assumptions are available.

The TDP process firstly prioritises compliance with the minimum reliability criteria specified in the South African Grid Code for both loads and power stations. Secondly, new generation capacity developed by Eskom and Independent Power Producers (IPPs) must be connected to the network.

Additional large-scale renewable generation (wind and solar energy) as well as additional IPP baseload and cogeneration plants, which will further diversify the country's energy mix and reduce South Africa's carbon footprint, are incorporated in the TDP planning scenarios. Thirdly, new loads (end users) need to be connected to the network, facilitating economic growth and uplifting the lives of all South Africans.

The development plans for the transmission network therefore must be able to adapt to the uncertainty of future load and generation locations. They should identify the critical power corridors and constraints on the transmission network and develop strategies to unlock and create a flexible and robust grid to be able to respond to the changing future needs of the country.

The latest TDP notes a number of initiatives that have been undertaken to facilitate the integration of RE in the national grid planning process. These include:

- Establishment of the Grid Access Unit (GAU) and the Single Buyer Office to facilitate the connection requests of IPP developers and buy the energy, respectively;
- Creation of a simpler, faster connection application process, specifically for all new generation plant, which is applicable to both IPPs and new Eskom power plants;
- Update of the applicable Grid Codes and connection agreements to encompass renewable generation plant;
- Publication of the Grid Connection Capacity Assessment (GCCA) document to guide stakeholders to available network capacity in relation to RE resources throughout the country for any type of IPP project;
- Commitment of resources to work closely with the DoE IPP Office, with the intention of aligning the IPP programme with feasible network expansion plans;
- Introduction of a Self-Build Procedure document that provides IPPs with the option to 'self-build' their own dedicated connection infrastructure as well as shared network in exceptional cases;
- Identification of strategic transmission line routes to unlock network capacity to connect future IPPs and collaborating with the DEA to complete strategic environmental impact assessments (SEIAs) of these routes; and
- Participation in several external independent studies to identify the best resource areas for development such as renewable energy development zones (REDZ) and the impact of the integration of large volumes of RE generation.

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ii Eskom (with thanks to Mr Ronald Marais and the Eskom Grid Planning team) kindly made available the latest TDP, ahead of schedule. The new TDP will only be available in the public domain end-October 2017.

Planning for strengthening and expanding the future national grid under uncertainty

A transmission network study (with horizon of up to 2040) was undertaken in order to inform the last two points mentioned above – identification of the best resource areas for development such as REDZ as well as identification of strategic transmission line routes to unlock network capacity to connect future IPPs. The implications of the change in the potential spatial footprint in generation that emerged from this process are evident in Figure 1.

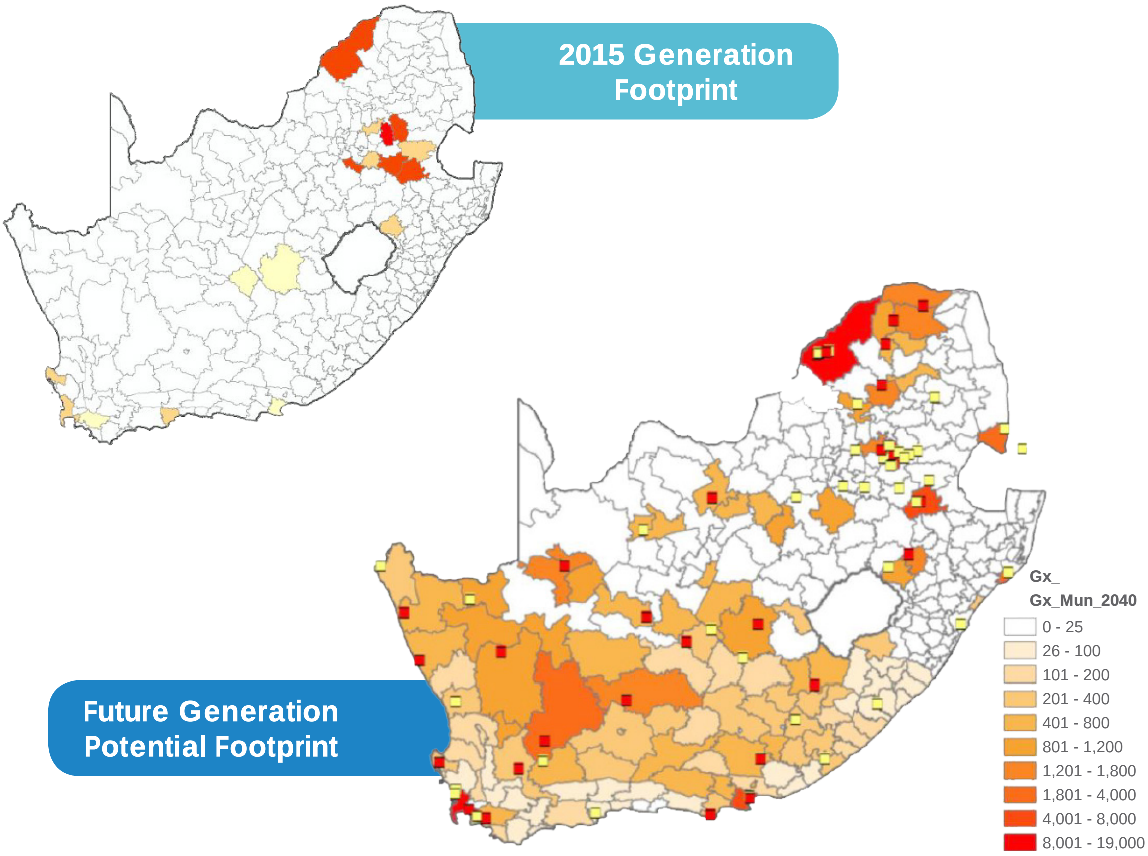

Figure 1: Generation footprint (2015) versus future generation potential spatial footprint in South Africa (where Gx refers to Generation)[7]

The study considered the development requirements of the future transmission grid to accommodate the expected load demand needs and the potential impact of future generation scenarios, using the 2010 Integrated Resource Plan (IRP) as a baseline (this will be updated once the revision of the IRP is finalised). The study identified five main 'commonly occurring' power corridors that would need to be developed under all the potential generation scenarios (irrespective of whether these scenarios focus on any specific generation technologies).

To further inform the above-stated questions, the DEA introduced a Wind and Solar PV Strategic Environmental Assessment (SEA) conducted by the Council for Scientific and Industrial Research (CSIR). The primary objective of the SEA is to streamline regulatory processes for new RE power plants in line with the REIPPPP, and without compromising the environment. In practice this means completing all the environmental studies and securing all the required environmental and related approvals for transmission lines and substations within the five identified corridors (refer Figure 2). The corridors will be 100 km wide and the secured approvals will be valid for extended periods in order to allow the acquisition of line servitudes and substation sites for strategic purposes. These REDZ and corridors were also identified to support Strategic Infrastructure Project 8 (SIP 8; Green Energy in support of the South African Economy) and to facilitate infrastructure development in the country.

National Electrical Grid Infrastructure SEA: Draft Corridors

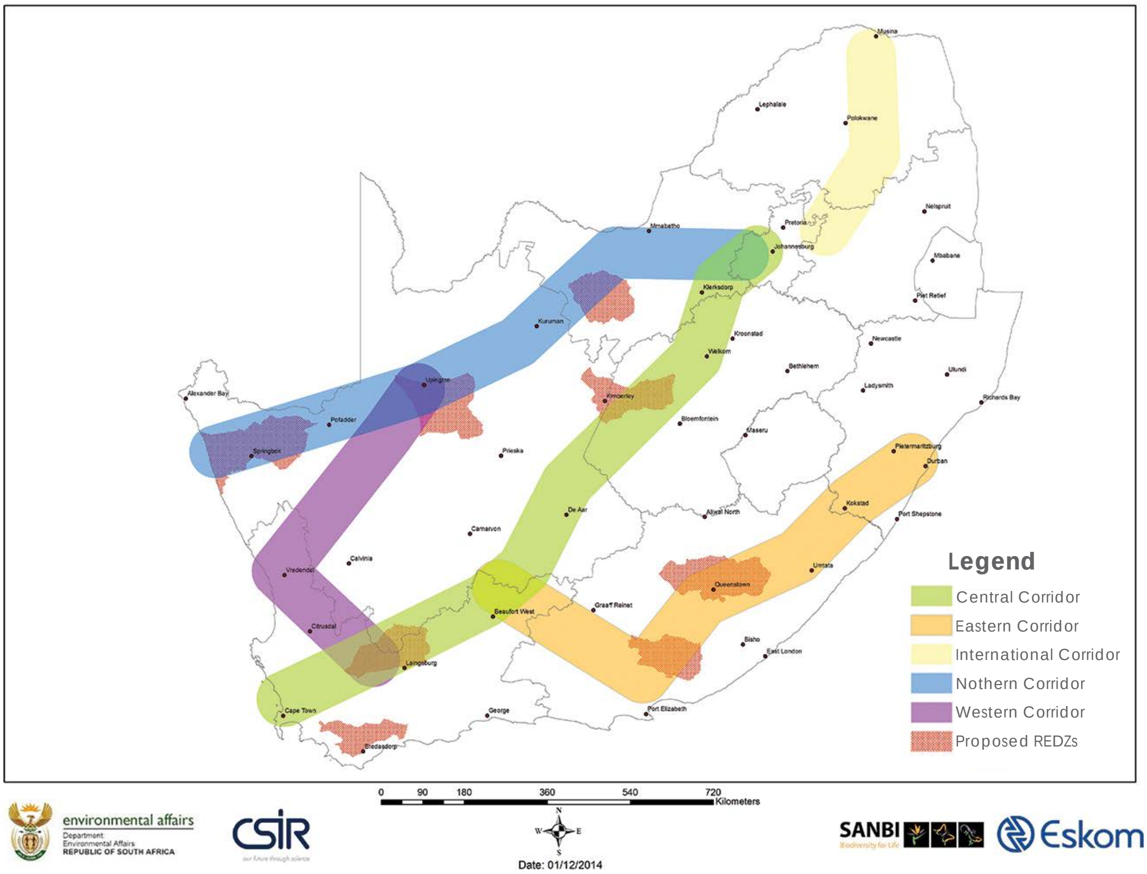

Figure 2: DEA SIP 8 REDZ and strategic transmission corridors   Source: Department of Environmental Affairs

Subsequently, Cabinet approved the gazetting of eight REDZ and five Power Corridors (Wednesday, 17 February 2016) depicted in Figure 2. Following Cabinet approval, this information was published in the Government Gazette for public comment on 13 April 2017. Various comments and responses have been received and are being processed by the DEA in collaboration with various key stakeholders. These REDZ and Power Corridors are geographical areas where Wind and Solar Photovoltaic (PV) technologies can be incentivised, where ‘deep’ grid expansion can be directed and where regulatory processes will be streamlined.

The REDZ act as energy generation hubs, and provide anchor points for grid expansion, thereby allowing for strategic and proactive expansion of the grid into these areas. This should ensure that the grid expansion does not hamper progress of the RE power purchase agreement process.

Recent major TDP projects completed within these corridors and REDZ are depicted below in Figure 3.

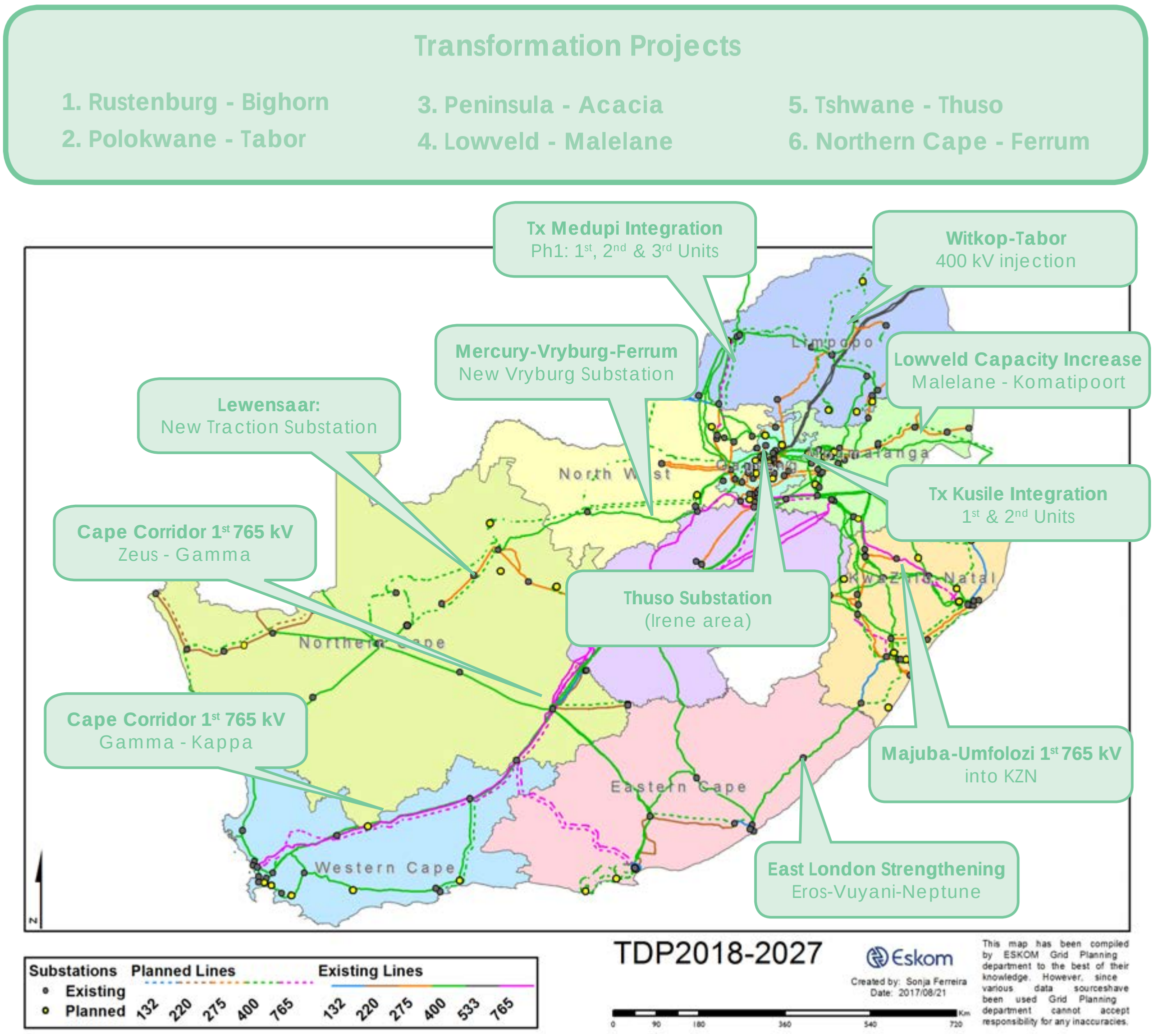

Figure 3: Major TDP projects completed up to October 2015[8]

By October 2015, 42 projects (amounting to 2,142 MW of installed capacity) of RE IPPs from Bid Windows 1 to 3 reflected in the Eskom TDP, had been connected to the grid. The capital cost of these connections were reported as R2.4 billion, less than two percent of the investment for the development of the RE IPPs for the first three Bid Windows[iii].

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iii In the context of power (electrical) grids, 'deep' grid expansion refers to additions or changes required in the higher-up (further away from the end connection) network, e.g. the transmission system that is required in order to connect or expand such areas further away or lower down in the system (end connections). Further down systems (e.g. those closer to remote end users) are not necessarily directly connected to the parts of the network where these 'deep' changes are required

By June 2017, IPP Office reporting showed that 57 RE plants had been connected to the national grid, contributing 3,162 MW installed capacity to the power system. By this date, all RE IPPs from Bid Windows 1 and 2 and approximately 60 percent of the IPPs from Bid Window 3 had been successfully connected to the grid.

At the time of compiling this report, signatures for 37 Power Purchase Agreements (PPAs) from the most recent bid rounds were still not concluded[9]. The grid planning process that informed the most recent TDP, has taken into consideration all projects under Bid Windows 3.5, 4 and 4b. The distribution of these RE power plants and the alignment to the TDP is depicted in Figure 4.

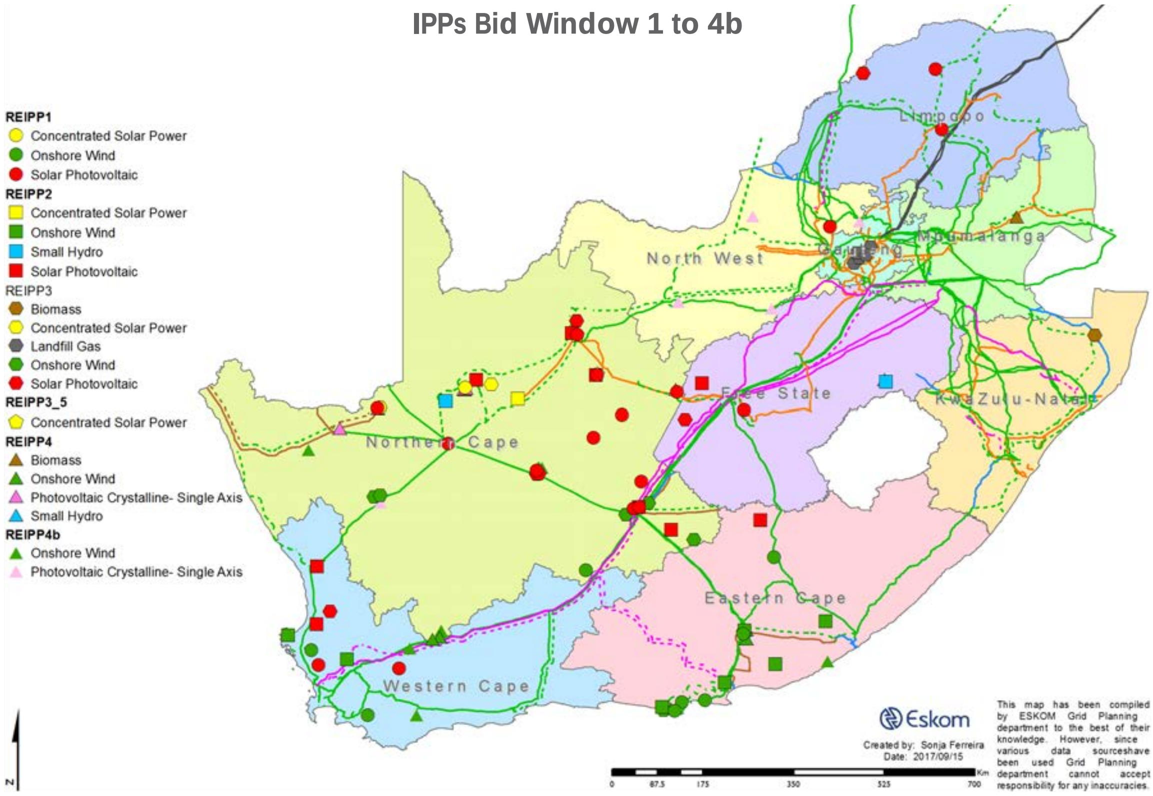

Figure 4: IPP projects connected to date for Bid Windows 1 to 4b[10]

Technology and global developments driving an evolving future grid

Globally, a number of developments are presenting challenges to existing electricity systems. The growing share of intermittent or variable renewable energy (VRE) sources, like Solar and Wind, increased 'electrification' of society and development of smart-[iv] and mini grids as well as distributed generation, are all impacting the consistency, direction and volumes of power flowing through networks. Furthermore, the Paris Agreement concluded at the COP21 conference in December

iv Investment (total project costs) in Bid Windows 1 to 3 reported as R124.2 billion by the IPP Office in 2014, where total project costs are defined as the total capital expenditure to be incurred up to commercial operation in the design, construction, development, installation and/or commissioning of the plant

2015 is expected to accelerate the transition to a low-carbon future, further transforming existing systems.

Recent statistics published by the International Energy Agency (IEA)[11], shows VRE presenting a growing share of electricity generation mix for countries throughout the world (refer Figure 5). The IEA publication demonstrated that significant percentages of VRE are successfully being introduced to existing power systems, but recognised that system operation and flexibility requires due consideration when RE contributes approximately 15 percent and more of generation. The extent of system integration and adaptation that have been introduced to accommodate a growing share of VRE has been grouped into four phases (Figure 5). While generally a higher phase corresponds with higher VRE penetration rates, some countries such as Ireland, proceeded with system upgrades at a lower VRE penetration rate.

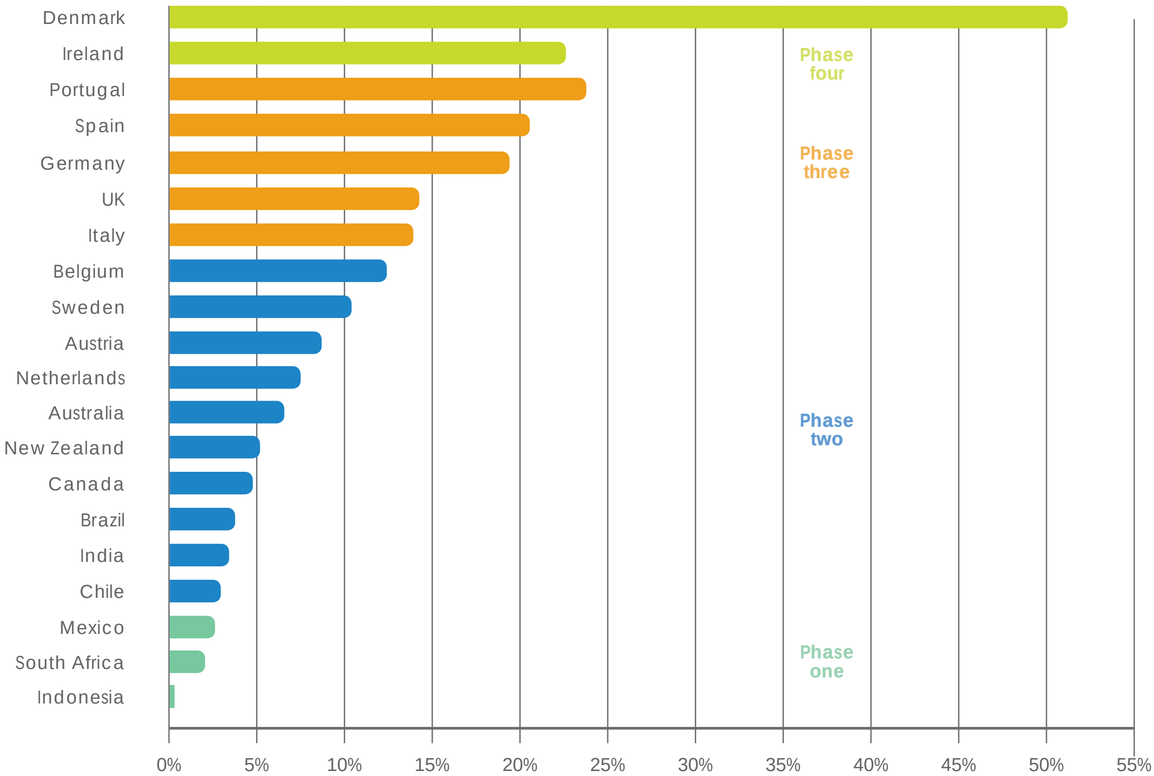

Figure 5: Solar and wind power as percentage of generation for a range of countries

With the exponentially evolving technology, capacity and costs in, for example, the Solar PV and energy storage sectors, major 'disruptive' developments are highly probable in the near future, up to 2040. According to the latest global status report[12] on renewables, the emergence of new business models and technologies are accelerating access to distributed renewable energy (DRE) systems in the developing world, with Solar PV being the world's leading source of additional (net of decommissioning) power generating capacity in 2016.

More Solar PV capacity was installed in 2016 (up 48 percent compared to 2015) than the cumulative world capacity five years earlier. This is equivalent to the installation of more than 31,000 solar panels every hour. The global capacity and annual additions for Solar PV between 2006 and 2016 from the REN21 (2017) is shown in Figure 6.

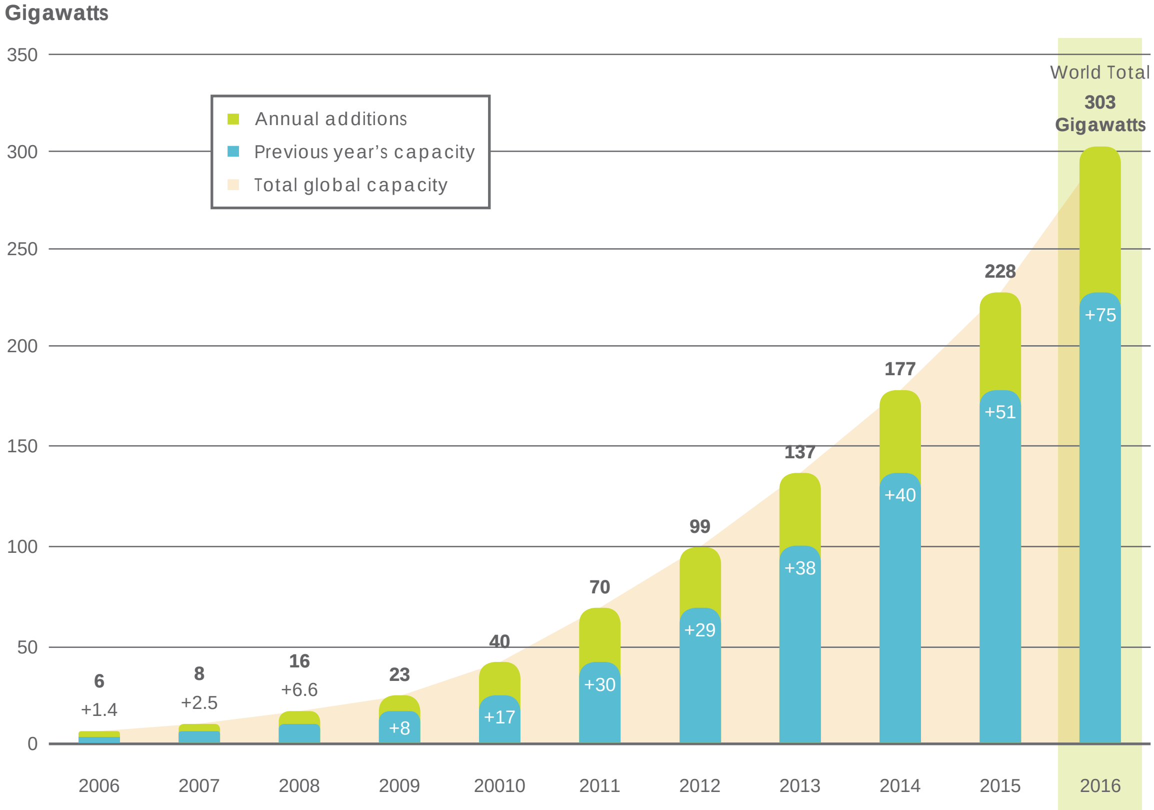

Figure 6: Solar PV Global Capacity and Annual Additions, 2006 – 2016 Source: REN21 2017 edition

Roughly 85 percent of these additions were in five markets – China, United States, Japan, India and the United Kingdom[13]. Such a concentration of Solar PV installations necessitates careful consideration by network operators and planners.

At present, technologies for energy storage range from established, proven concepts to highly innovative and conceptual technologies that are still at the design and proof-of-concept stage. The available technologies are generally categorised as either chemical (e.g. hydrogen), electrical (e.g. capacitors), electrochemical (e.g. batteries), thermal (e.g. molten salt) or mechanical (e.g. pumped hydro), each with its own range of applications and specific uses within the energy system. Applications include peak-shaving, minimisation of curtailment, network investment deferral and avoidance, and providing ancillary services to network operators.

Major roles for storage in the energy system can be summarised[vi] as follows:

- Allowing electrification of transport;
- Increasing energy access off grid;
- Improving energy system resource use efficiency;
- Helping to integrate higher levels of variable renewable resources;
- Maximising self-consumption with distributed generation;

- Supporting greater production of energy where it is consumed, alleviating congestion issues;
- Improving electricity grid stability, flexibility, reliability and resilience.

Evolving energy storage technologies, demand response mechanisms and technological developments in data management and remote monitoring and controlling, are all part of the future reality of electricity systems as the world moves from central design and dispatch to a more diverse, decentralised system.

While energy storage is still mainly in a research and development phase, there are industrial and commercial solutions already available. Costs are also decreasing at approximately 15 to 25 percent per annum[vii]. In the medium- to longer term, when the cost of battery storage further decreases, distributed battery storage that is coordinated with Solar PV would help with operating reserve requirements and cycling costs by storing power during mid-day and feeding it into the system during evening hours.

The implications of energy storage on the power system and network, have been recognised and are being given consideration. In this regard, Eskom has identified the need for 2,000 MW of additional energy storage capacity. In response it has established a battery test and demonstration facility at its Research and Innovation Centre in Rosherville, currently the only large scale battery test and demonstration facility of its kind in South Africa[viii].

Various commercial research and development initiatives are in progress and an energy storage roadmap[14], under chairmanship of SANEDI, is being developed with member organisations, including:

- the Industrial Development Corporation (IDC);
- the IPP Office;
- Council for Scientific and Industrial Research (CSIR);
- Department of Science and Technology (DST);
- Department of Trade and Industry (**the dti**);
- Eskom Research, Testing and Development (ESKOM);
- South African Photovoltaic Industry Association (SAPVIA);
- South African Wind Energy Association (SAWEA);

Both the DoE and NERSA are kept informed, but are not directly active in the work groups.

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vi International Energy Agency (IEA) presentation at SAIREC, Cape Town, 6 October 2015 (http://www.sairec.org.za/energy-storage/). Retrieved from http://www.sairec.org.za/wp-content/uploads/2015/10/Aud2_Energy-Storage_Philibert.pdf

vii Lazard's Levelised Cost of Energy Storage Analysis – Version 1.0 (November 2015); Goldman Sachs 'The Great Battery Race' Equity Research Report (October 2015)

viii http://www.itweb.co.za/mobilesite/news/162478

As the future South African power system moves toward an ever expanding energy mix encompassing multiple options, including those brought by RE – combined with the increased need for service providers to be more aware of, and responsive to, customer needs while also supporting new systems and services under development – business models will require a robust grid platform offering more intelligence and greater integration. Therefore, the role of smart grids as well as distributed and mini grid elements will become ever more important.

Smart grid technology is viewed as a key enabler for the South African electricity supply industry (ESI) to achieve its proposed future energy mix and grid management requirements. Without smart grids, large scale integration between different power supply options will be nearly impossible. But not only are smart grids enablers for the integration of, for example, intermittent RE sources, it enables the use of integrated systems and processes in the municipal environment, thus enabling efficiencies and effectiveness not seen before at this level.

SANEDI Municipal Smart Grid Project

The DoE entered into a Memorandum of Agreement (MoA) with SANEDI to implement a pilot Smart Grid Programme in 10 municipalities across the country through the European Commission funding support. The participating municipalities are: eThekwini, Nelson Mandela Bay, Govan Mbeki, City Power, Thabazimbi, Matatiele, Umsunduzi, Naledi, Nala, and Mogale City.

SANEDI's Smart Grid Programme aims to contribute in four areas:

- Provide a common vision for smart grids in South Africa;
- Facilitate a smart grid knowledge-sharing forum for both the ESI and relevant Government departments;
- Implement applied research pilots within municipalities to introduce various smart grid concepts; and
- Provide strategic policy inputs to DoE, related to smart grids and the ESI.

To date, SANEDI has been overseeing 10 pilot[15] projects across the country, one in each participating municipality. The purpose of these projects was to assess the benefits around management and self-management of electrical power usage, in particular to provide policy and regulatory input through the experience and lessons learned from the pilot projects implemented.

The DoE has identified five priority areas within the electricity distribution industry (EDI) to conduct applied research pilot projects. These five priority areas resulted in the selection of these 10 municipalities to participate in the programme. The five priorities of the department are as follows:

1. Distributed power generation;
2. Enhanced revenue management;
3. Energy efficiency and demand-side management (EEDSM);

Bokpoort concentrated solar power plant near Groblershoop

4. Active network management;

5. Asset management.

Accordingly, the implementation of this smart grid programme resulted in general revenue collection ranging between 20 percent and 30 percent. Among the lessons learnt is that the successful implementation of a smart grids project is based on a thorough understanding and acknowledgement of the dependencies between key divisions within the municipality (Engineering; Information Technology (IT) and Finance) as the roll out chiefly encompasses the three divisions. As a result, a close working relationship should be forged to enable a smooth roll out as well as maximum effectiveness and improvement.

While the national grid planning process is predominantly focused on the main 'formal' networks in the country, mini grids are also starting to be considered in order to provide access to difficult-to-reach communities. A mini grid, in essence, is a scaled down version of a standard electrical grid. Systems can be established around single generation technologies such as Diesel, Solar PV, Wind, Hydropower, or Biomass power generators, or by combining multiple technologies to form a hybrid mini grid. Systems typically are sized in the range of 50 KW to 1 MW. Mini grids can be owned by the communities they serve, though they can also be financed by private sector operators or utility companies. Combinations of these financing mechanisms are also quite common.

Mini grids can also be designed to be 'grid-tied' or interconnected with the main grid, thereby potentially assisting to ease grid congestion by reducing demand loads at key points of constraint, while also providing services such as frequency response, back to the grid. Innovative funding will need to be developed, with the DoE and Eskom playing key roles in the development and operation of mini grids in South Africa. As such, Eskom is developing a number of mini grid pilot projects, while the DoE is presently reviewing regulations for small scale- and mini grid generation[16].

In South Africa there is currently one hybrid mini grid system in the Eastern Cape (Hluleka Nature Reserve) and the other in the Lucingweni community[ix]. The Johannesburg metro is running a pilot project to have grid-tied mini grids for RDP housing[17]. Mini grids can provide residents with, for example, lights, radio, television, cell phone charging, street lighting, telecommunications, and water pumping. Data and information on the pilot hybrid systems is being gathered to analyse their viability and whether they can be replicated throughout South Africa.

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ix The hybrid system in the Lucingweni community is no longer operational

Conclusion

It is evident from the above that the planning and expansion of the national electricity grid face a lot of unknowns in terms of type and location of technologies, generators as well as users of the electricity that needs to be transported via the national grid.

However, the process applied for transmission grid planning is robust and remains flexible to be able to accommodate the various technological and strategic developments internationally as well as in South Africa.

Based on the (relatively) long lead times to create the physical transmission network infrastructure, the current interim strategy is to direct IPP projects towards areas where network capacity is already available, combined with targeting specific geographic areas for IPP projects to optimise on timelines for readiness of the grid infrastructure. Through the REDZ programme, EIAs, servitude acquisition and Water Use License Authorisations (WULA) processes are also expedited. Moreover, future IPP programme time lines could be aligned to the timetables of TDP grid plans.

As smart- and mini grid learnings from various research processes and initiatives become available and storage technologies become more mainstream in future, from a planning perspective consideration to such developments will be given. Where relevant, these will be included in future, updated network plans.

Recent studies[18] confirmed that, in the interim, the South African power system will be sufficiently flexible to handle very large amounts of Wind and Solar PV generation, especially when considering the addition of Closed Cycle Gas Turbines (CCGTs) and Open Cycle Gas Turbines (OCGTs), according to the proposed scenarios in the first draft IRP-2016 base case[19].

Provided plans are timeously implemented, the necessary network infrastructure should be available to facilitate the delivery of South Africa's growing power needs and economic growth.

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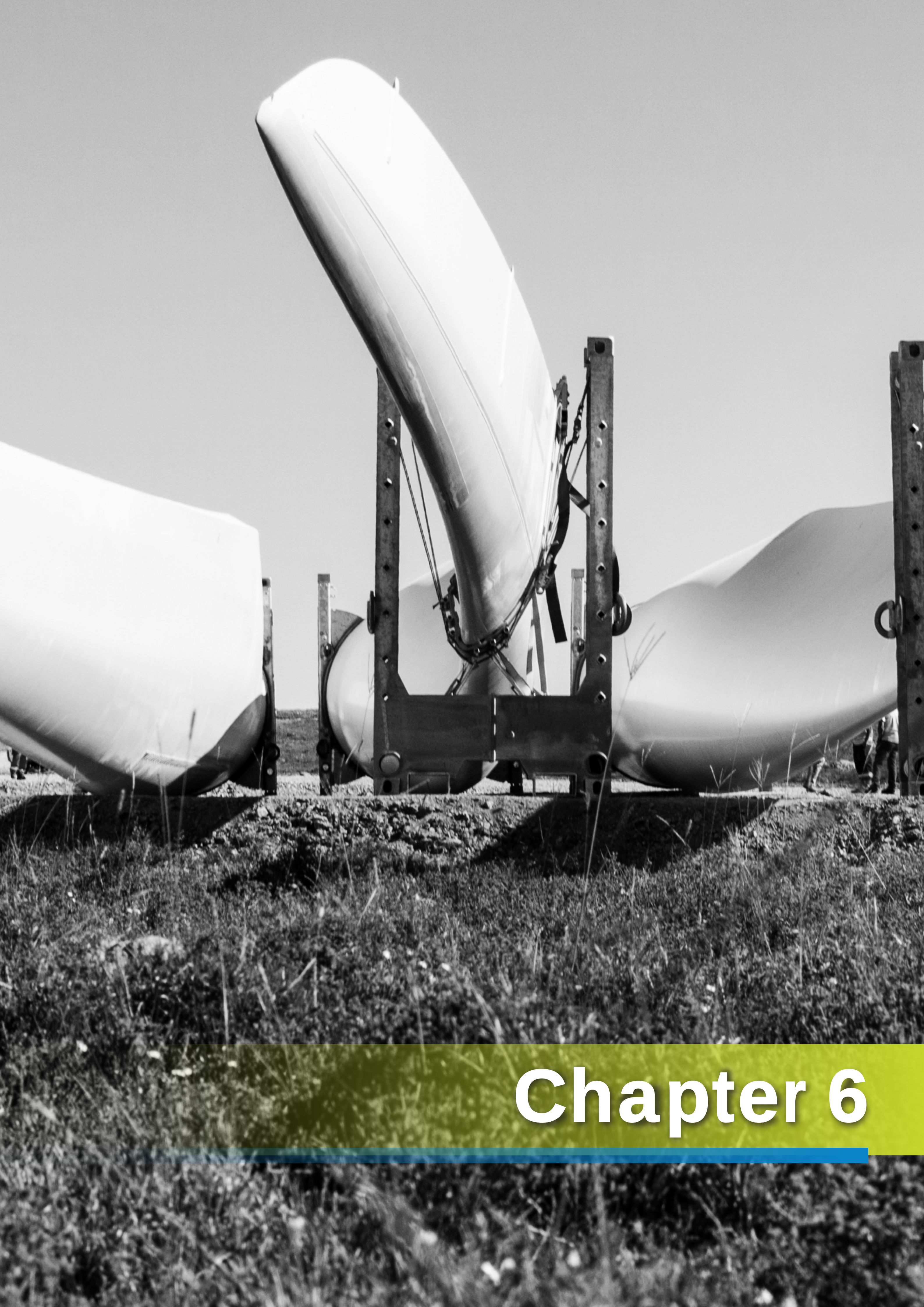

Chapter 6

Chapter 6

Renewable Energy (RE) investment embedding Sustainable Development

Sustainable development is often explained as a harmonious triangle consisting of 'people-planet-prosperity'[1,2].

A twinning of international efforts to move to a low-carbon energy system and efforts to promote sustainable development has been explicit for decades in climate conventions like the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol[i]. At a global level, the importance of embedding sustainability in the energy transition is well understood to the point of becoming axiomatic. There has always been an understanding that each country will define its imperatives uniquely to reflect its unique circumstances[ii].

From the human perspective, the importance of extending access to affordable, reliable and clean energy services to reduce poverty and improve health and living conditions for the entire global population, was previously highlighted in Chapter 4.

Energy is also a critical enabler of economic development. Secure access to modern energy services is equally important for increasing productivity, enhancing competitiveness and for promoting economic growth and prosperity. Modern energy services have underpinned economic development of every advanced economy, and it continues to power opportunity the world over. However, our historic energy system, based largely on fossil fuel sources, is both environmentally and economically unsustainable. Conventional forms of energy consume vast amounts of finite natural resources, including water, while emitting pollutants and greenhouse gases (GHG) with associated health and climate cost impacts[3].

Rapid technology advances and greater affordability of RE is enabling a transformation of the global power system, making it possible to support a thriving economy, provide solutions that can sustainably power every household and protect our environment for current and future generations. RE is central to achieving all three 'people-planet-prosperity' pillars of sustainable development.

South Africa is a country with considerable ambition in terms of improving the lives of its population and of migrating, over time, from a developing country to developed country. This ambition finds

i It is perpetuated in the Paris Agreement, which refers to sustainable development multiple times, among others, to stress the link between climate action and sustainable development/poverty eradication. It also specifically refers to a just transition, saying that it goes hand in hand with the creation of decent work and quality jobs and stresses the need for "education, training, public awareness, public participation, public access to information and cooperation at all levels on the matters addressed in this Agreement". The support of developed countries to developing countries is explicit. In the field of research and development, the Paris Agreement envisions "collaborative approaches"

ii An example of this is the Clean Development Mechanism (CDM), dealt with below, which required that each project should manifestly be promoting sustainable development within the context of the specific country and according to criteria established by that country existing support and rapport in the policy framework in South Africa, starting with the Constitution[iii,4], other pieces of legislation, extending to the Green Economy Accord and Local Procurement Accord (which are aimed at enhancing local manufacturing and localisation). It manifests in the design of the REIPPPP with, for example, its significant emphasis on economic development and socio-economic development plus local content, which currently forms the basis of RE growth in the country.

This chapter investigates investment flows through the lens of sustainable development, first internationally and then within South Africa. In the latter context, attention will focus on localisation and local manufacturing, employment creation, socio-economic development and enterprise development spend, employment equity and other development objectives that are served by RE's expansion in the country.

BOX 1

The Clean Development Mechanism (CDM) – a highly successful prototype of RE development embedding sustainable development

As related above, the international climate conventions (and thus also international law) have for decades envisioned that the path towards deep penetrations of RE and other climate-friendly interventions should respect the broader requirements of sustainable development.

Another principle was that developed countries should 'go first' in the development of new technology (including renewables) and should then quickly transfer successful interventions to developing countries so that the latter could avoid the high-emissions development path that developed countries had followed since the industrial revolution[iv, 5].

Article 12 of the Kyoto Protocol created the Clean Development Mechanism or CDM,[6] which can be described as an international collaboration between developed and developing countries to provide a financial support scheme that allows clean projects in developing countries that would otherwise be 'bottled', to proceed. Each project needs to comply with sustainable development imperatives in the host country and needs to be certified as such by the host government. Plotting the success of the CDM is thus a way to plot the success of embedding sustainable development internationally, within the energy sector.

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iii Section 24 of the South African Constitution states that "Everyone has the right—
(a) to an environment that is not harmful to their health or wellbeing; and
(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that—
(i) prevent pollution and ecological degradation;
(ii) promote conservation; and
(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development"

iv "Recognising also the need for developed countries to take immediate action in a flexible manner on the basis of clear priorities, as a first step towards comprehensive response strategies at the global, national and, where agreed, regional levels that take into account all greenhouse gases, with due consideration of their relative contributions to the enhancement of the greenhouse effect" (Preamble) and "The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and knowhow to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. (article 5)

A global database of CDM projects is available online and a search engine allows some interesting conclusions[7]. A search under "wind"; "hydro", and "biomass" yields 2404, 373 and 482 successful project registrations, respectively (the pre-2012 high point of the CDM preceded the Solar PV boom). It can thus be said that, through the CDM, developed and developing countries have successfully collaborated more than 3,000 times to leverage additional funding to construct RE plants that simultaneously fostered sustainable development in the respective host countries.

In the years after 2012, technology prices for Wind and Solar PV declined so much that RE is becoming 'business as usual'. The aim to develop technology in developed countries and then quickly transfer it to developing countries (so they can follow a clean development path) has been achieved with resounding success.

CDM in South Africa

In the 15 years following the 1998 White Paper on Energy, pioneering work was done to build "first-of-kind" plants in Wind and Biogas, while Hydro saw new activity. The CDM was utilised to co-fund some of these projects that had to compete against (at the time) very cheap (yet carbon intensive) electricity. Through the DoE's Designated National Authority (DNA) sustainable development criteria for the CDM[8], a broader social agenda was gradually embedded in the emerging renewables industry. These related, among other things, to job creation and contributions towards poverty alleviation[v, 9].

The full list of South African CDM projects can be viewed by following the instructions in the footnote below[vi].

The existing South African CDM projects will continue to be monitored by the DoE and will likely continue periodic verification, especially if the mooted carbon tax regime allows offsets. New projects are likely to be few, but the CDM has achieved its purpose. RE is now affordable without support schemes. In cases still requiring support, the Green Climate Fund is just one example of the financially far stronger support mechanisms available internationally than have ever existed before.

v The PetroSA Project Design Document (PDD), p 2 states: "The project will create work for 60-100 people in the planning/construction phase and long-term work for one or two people in operating/maintaining the plant. On a social level the project will lead to the payment of a royalty by MethCap SPV 1 to the local municipality called Eden District Municipality, which payment has been earmarked specifically for poverty alleviation in what is not a rich region of South Africa. The royalty is expected to be in the order of R100,000 per annum and will lead to social upliftment initiatives as identified and chosen by the local authority. The District Municipality will report back annually to the developer on how the funds were spent. The environmental benefit from the project will be the more efficient use of energy and displacement of some grid emissions in South Africa." See also the PDD for the Bethlehem Hydro project stipulating the following sustainable development benefits: "At a local level the project will lead to increased economic activity in the area. In terms of job creation the project will create 40 skilled and 100 to 160 unskilled job opportunities during the construction phase, which will last approximately 12 months. Three full-time permanent jobs will be created once the project goes to implementation"

vi To see all CDM projects for South Africa, go to https://cdm.unfccc.int/Projects/projsearch.html. Leave all fields untouched as they are while only choosing 'South Africa' in the fifth field headed 'Host Country'. Go to the bottom of the page and click on 'search', then wait a few seconds and scroll down again to see the list of 60 projects

International investment trends

Recognition of the growing value of RE has been reflected in international investment trends. Global investment flows into renewable electricity grew to $286 billion per annum (2015 data) (refer Figure 1). For order of magnitude, this is more or less equal to the GDP of South Africa[10]. The total investment was more than double the $130 billion allocated to new coal- and natural gas-fired generation capacity[11].

International Energy Agency (IEA) data shows that investments in renewable electricity rose from 16 percent in 2014 to 17 percent of total global electricity investment in 2015 (despite lower costs). Investment in networks increased from 12 percent to 14 percent (this is likely correlated with the growth in renewables, given its dispersed nature) while investments in energy efficiency (EE) increased from 10 percent of total spend in 2014 to 12 percent in 2015[12].

Further technology cost reductions achieved for Solar and Wind by international procurement programmes during 2016 (refer Chapter 3), coupled with global climate commitments, should see this trajectory continuing and even accelerating[vii, 13].

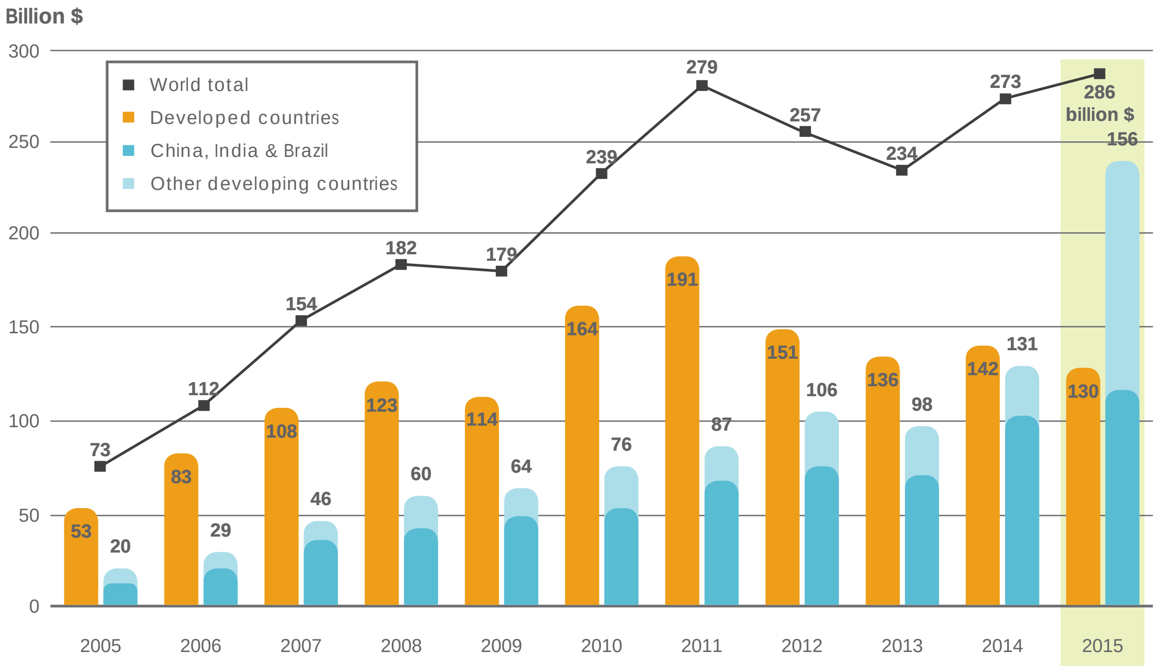

Figure 1: Global annual new investment in RE and fuels in developed, emerging and developing countries, 2005 - 2015[14]

vii Europe's energy utilities (3,500 utilities with a combined value of over €200 bn) from 26 of the EU's 28 member countries, have signed a pledge in April 2017, that no new coal-fired plants will be built in the EU after 2020

An interesting consequence of rapidly declining RE technology prices has been that the most recent, dramatic growth in the RE sector has been achieved with reduced investment[viii, 15]. The reported investment for 2015 has therefore delivered progressively more infrastructure and capacity. A comparison of annual investments with the capacity growth (refer Figure 2) shows the continued growth trend for installed capacity while investment slowed and flattened out over the period from 2011 to 2015.

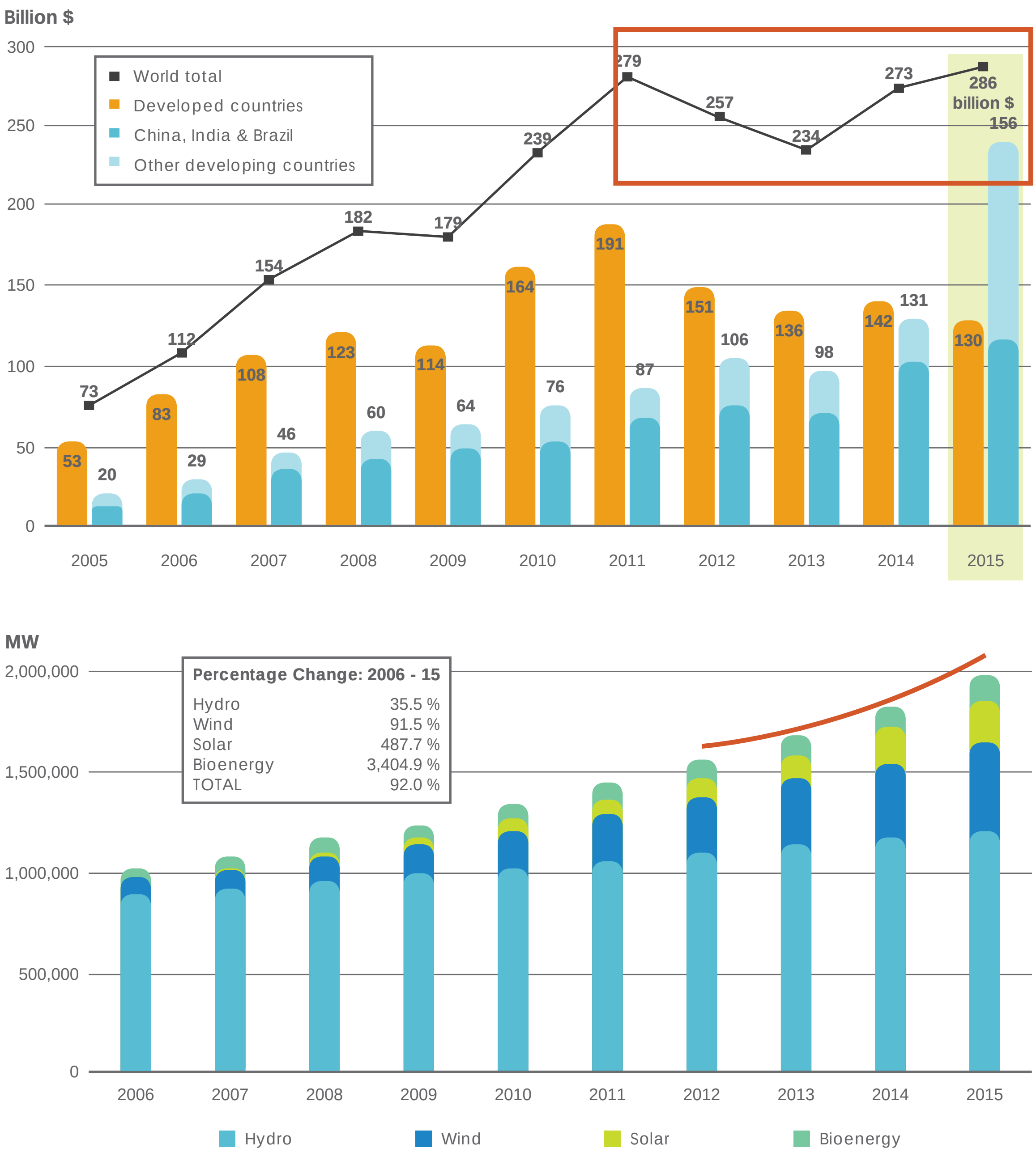

Figure 2: Comparison of annual new investment[16] with RE capacity growth[17], 2011 - 2015

viii The 2016 REN21 Global Status Report (ibid, page 99, note 2) stated: "Note that declining costs of some RE technologies (particularly Solar PV and Wind power) have a decremental impact on total investment (all else being equal). Thus, growth in investment (monetary) does not reflect actual growth in installed renewable power capacity." Bloomberg New Energy Finance reported that the cost of solar generation worldwide dropped on average 17 percent in a year and the average costs for onshore wind 18 percent

Indeed, in the 2017 version of the Global Status Report, this exact trend is revealed to continue, to the extent that annual investment dropped by 23 percent from $286 billion to $241.6 billion in 2016[18], while total global renewable power capacity was up almost 9 percent compared to 2015[19].

While growth is still accelerating, it has been remarkable for over a decade. In 2005, total global investment for the year stood at $73 billion, split 53-20 in favour of developed countries. In 2015, the annual total stood at $286 billion, split 130-156 in favour of developing countries. This status was maintained in 2016[20].

If one looks only at the investment occurring in developing countries in 2015, there has been, in just 11 years, an increase from $20 billion annually to $156 billion annually.

Within the African context, annual investment in renewables has grown from less than $1 billion in 2005 to $12.5 billion in 2015, and increased in the short term (2015) by 58 percent over the $7.9 billion in 2014.

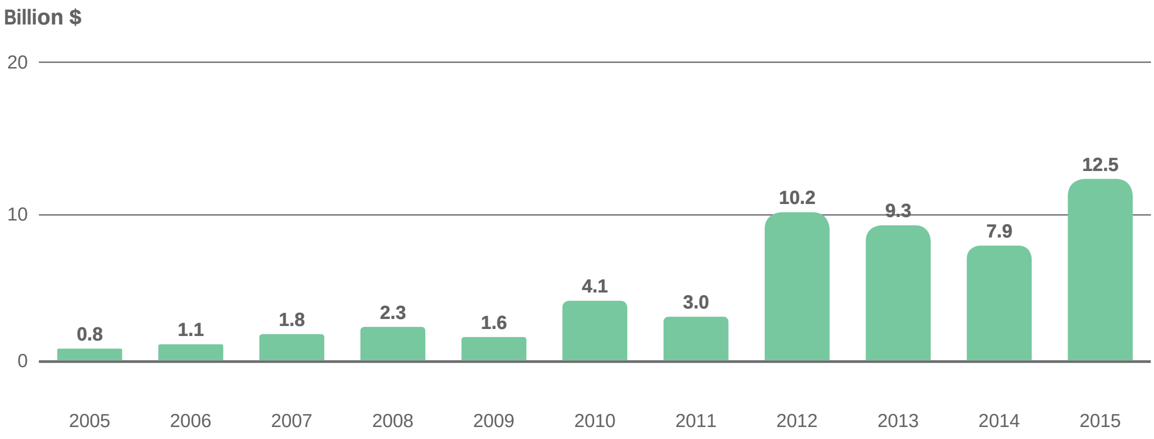

Figure 3: Annual new investment in RE in Africa and middle East, 2005 – 2015

With more than half a billion Africans in Sub-Saharan Africa still requiring access to electricity, there is considerable scope for additional growth[21].

Employment creation internationally

In addition to the direct economic benefits of secure, affordable and clean energy, growth in the RE sector is also opening up new markets and creating new jobs.

As the installed capacities of RE internationally increased dramatically over the past few years, employment figures also grew rapidly.

In 2014, when REN21's Global Status Report was launched using 2013 data, the number of global jobs in RE was reported to be about 6.5 million[22]. In the 2016 edition using 2015 data, this number has increased to over 8 million (an increase of about 20 percent in two years)[23].

REN21's latest report (GSR 2017) has just been published using 2016 IRENA data, and it shows that employment figures are up again from 8.1 million to 9.8 million jobs. The directly comparable data was up to 8.3 million and there was an addition to the data in the latter year of 1.5 million RE jobs not attributable to any specific renewable technology[24].

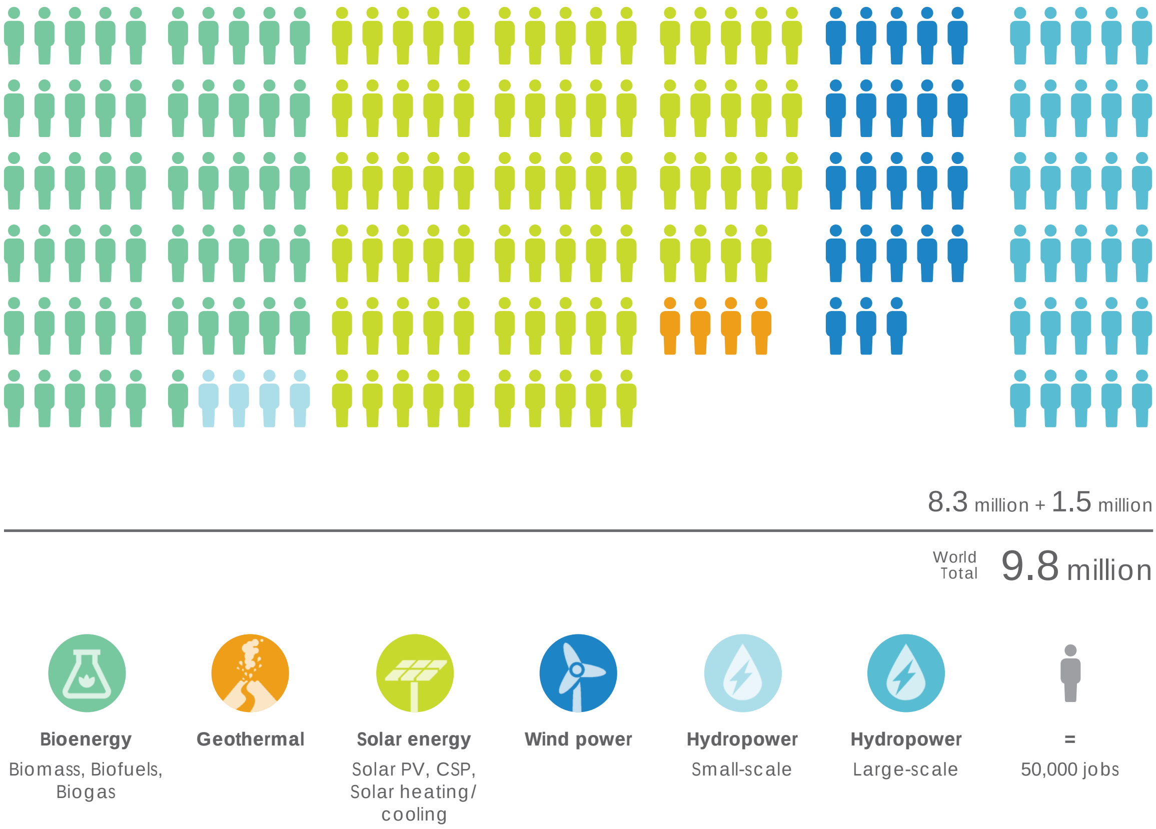

Figure 4: Employment numbers in RE, 2016[25]

As appears below, in the context of South Africa, the inclusion of renewables in the future energy mix is expected to contribute significant employment opportunities. The anticipated number of jobs is likely to be commensurate with the targeted size of the sector, and should reflect the strong employment numbers already being reported internationally.

South Africa successfully embedding sustainable development opportunities in the REIPPPP

South Africa became a global pioneer in explicitly designing a RE procurement programme (REIPPPP) that would pursue a range of sustainable development objectives in addition to low prices for RE. Deliberate efforts led to the successful integration of the RE procurement framework with Government's National Development Plan (NDP) and also with its set of 18 Strategic Infrastructure Projects (SIPs) that are intended to transform the economic landscape of South Africa, create a significant number of new jobs and strengthen the delivery of basic services to the people of the country.

The sustainability drive in the REIPPPP manifests through local ownership, local manufacturing, employment creation and socio-economic development/empowerment. Since the previous version of this report in 2015, both positive and negative developments have been noted. The design of the REIPPPP has continued to enable the simultaneous and successful pursuance of multiple sub-objectives[ix] while the delay with the further the roll-out of the programme and with financial close for successful bidders in Rounds 3.5, 4 and beyond, has seen reverses from previous gains in job creation and localisation.

Developments in each of these four categories are discussed in the subsequent sections.

Notwithstanding the acclaim earned by the REIPPPP for its approach to broaden the developmental benefits associated with a Government-led, energy infrastructure procurement programme, some procurement measures were not adequately effective in achieving the intended economic transformation and embedding sustainable development. A review of the programme impacts and ongoing monitoring of the programme performance against targeted developmental objectives have enabled an assessment and refinement of the procurement approach that will inform future bid rounds (refer Box 2, Further refinement of the procurement philosophy and approach of the REIPPPP).

BOX 2

Further refinement of the procurement philosophy and approach of the REIPPPP

In addition to procuring competitively priced, clean energy infrastructure, the REIPPPP was structured to contribute to the broader national development objectives of job creation, social upliftment and broadening of economic ownership. Accordingly, the procurement requirements specified required contributions and commitments from interested bidders.

Compliance monitoring at project level combined with ongoing monitoring and reporting at programme level have enabled Government to critically assess the overall programme impact against the intended outcomes. The deliberate inclusion of feedback loops into the process allows for reflection on specific design elements, an interrogation of suboptimal performance or unintended consequences and subsequent refinement of the procurement approach. The staggering of bid windows additionally allows for emerging economic and socio-political priorities to receive greater emphasis in the amended procurement design.

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ix The IPPPP Office defines their mandate as "...to secure electricity from renewable and non-renewable energy sources from the private sector. However, energy policy and supply is not only about technology, but also has a substantial influence on economic growth and socio-economic development. As such, the IPPPP has been designed to go beyond the procurement of energy, to also contribute to broader national developmental objectives such as job creation, social upliftment and the broadening of economic ownership". See latest report –quarterly report as at 30 June 2017, page 2

x The IPP has Eskom's balance sheet and credit rating as a primary recourse and security, with a Government Guarantee then giving further comfort that Government would pay if, for whatever reason, Eskom were unable to do so. There is high certainty regarding the future revenue stream and ability to cover the costs of electricity purchased from IPPs, because of the inherent electricity demand in the economy and the expectation that electricity sales will continue at the current level and potentially grow to support a growing economy

Learnings from the early bid rounds were already reflected in Bid Window 4 and will further shape the procurement approach of Bid Window 5, which is planned for release to the market during the last quarter of 2018. Securing active BEE participation and tangible socio-economic transformation are expected to form the cornerstones of this procurement round.

Some of the procurement elements that are under scrutiny, include:

- **Ownership.** Building on the shareholding secured in the first bid windows, the focus in subsequent bid rounds will increasingly be on expanding the role of black South Africans in the programme, not only as shareholders in the IPPs, but also more active involvement throughout the value chain, growing South African project developers and a pool of black industrialists.

- **Local industry and manufacturing.** The focus has shifted from "local content" to encouraging local manufacturing along the entire value chain, including component manufacture and supply, construction and operation and maintenance.

- **Enterprise development and socio-economic development (ED/SED).** Commitments will be directed more effectively to achieve a broader impact aligned with the NDP and municipal Integrated Development Plans (IDPs). Amendments to the procurement requirements will also seek to achieve a more even distribution of ED/SED benefits over the life of the RE plant.

- **Community benefits.** In the initial bid windows, community participation generally took the form of ownership by a community trust. This format presented numerous challenges, prompting an investigation into alternates that seek to achieve greater community participation and engagement, realising community benefits earlier and distributing benefits to the community more evenly over the life of the plant.

- **Refinancing conditions for BEE shareholders.** The original rules pertaining to shareholding proved too restrictive, preventing BEE partners from early / easy cash in of shares and leveraging these assets for reinvestment. Conditions are being reviewed to address this constraint.

The bid evaluation criteria, processes and procedures are also under review, with the aim of:

- Ensuring the integrity of bids against long-term SE development objectives;

- Establishing appropriate indicators to measure and monitor contributions and progress;

- Ensuring, as best possible, sustainability of impacts beyond the monitoring period.

Experience from the first bid rounds also brought other, related issues to the fore that would require consideration to effectively facilitate the targeted transformation and empowerment benefits to be realised. Among these are (i) availability of affordable financing instruments for BEE partners / shareholding and (ii) support mechanisms for black industrialists that will enable larger and more active participation. While not under the direct control of the procurement process, the appropriate Government entities and other relevant stakeholders will be engaged to help unlock these barriers.

De Aar Solar Power PV plant near De Aar

Investment attracted

South Africa's current REIPPPP enables the building of a new infrastructure sector with limited impact on the fiscus. It is funded based on project finance, with a smaller number of projects being built with corporate finance. In the former case, the equity component is approximately 25 percent; in the latter, it is 100 percent. In neither scenario is the fiscus required to contribute capital up front. The electricity tariff is used to compensate the IPP over the lifetime of the project. The only impact on the country's balance sheet is a low-risk contingent liability for guaranteeing Eskom's performance as off-taker[x].

If Government, through the national utility, were to build the renewables fleet in the present regulatory regime, it would effectively be on the country's balance sheet and would incur a very large opportunity cost. The REIPPPP means that South Africans benefit from clean energy, procured cost effectively with minimal impact on the national fiscus and economy – a truly remarkable feat.

The REIPPPP has attracted investment of a different order than what existed before in RE in South Africa. Several RE power plants in the Hydro, Biomass, Biogas and Wind sector did exist in South Africa prior the introduction of the REIPPPP. Development of this infrastructure presents a significant prior investment in the sector. A rough calculation suggests the total replacement cost (new) of pre-existing investment (coming mostly from public funding) across technologies over several decades would, in 2015, have been approximately R35 billion.

The magnitude of investment into RE over several decades was greatly expanded within only a few years when the REIPPPP came into force. Within six years, the REIPPPP has leveraged total investment of more than R200 billion – and did so drawing on private funding. This has been one of the reasons why the REIPPPP became an internationally admired and followed model.

Table 1: Comparison of aspirations for 2030 between IRP 2010, draft IRP 2016 and IRP 2016 scenarios

Technology	ESTIMATED replacement cost
Hydro (two largest plants)	R25 billion[xi]
Biomass (embedded generation capacity)	R10 billion[xii]
Biogas	R30 million[xiii]
Wind	R200 million[xiv]

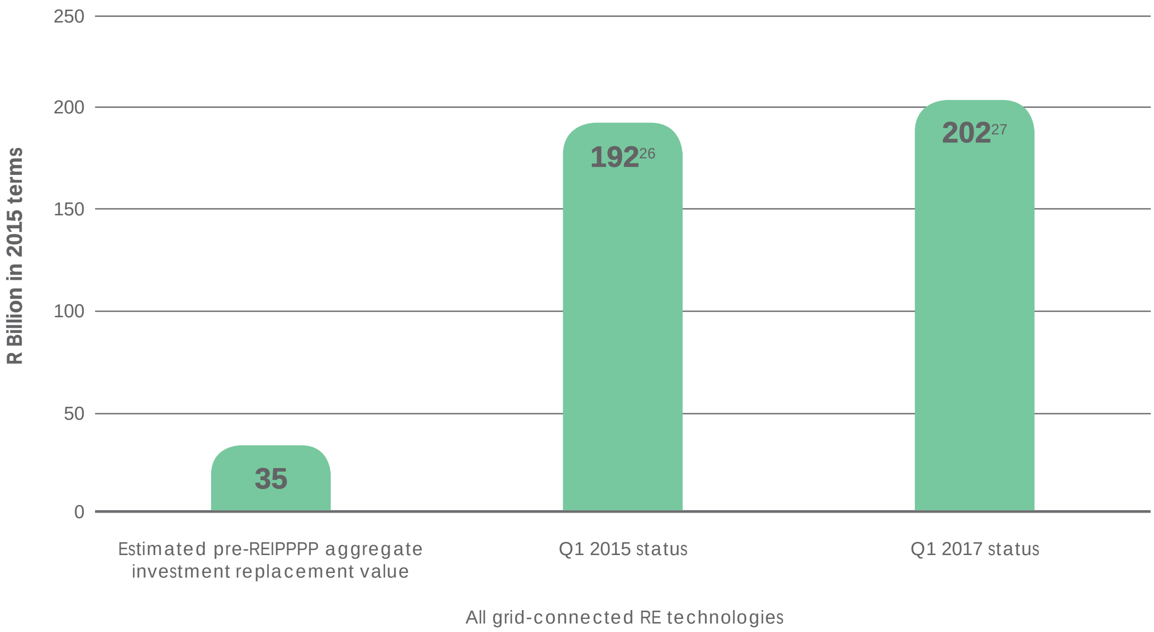

Figure 5: REIPPPP Investment growth

Through the REIPPPP, 6,422 MW of electricity has been procured from 112 RE Independent Power Producers (IPPs) in seven bid rounds. By 2017, the combined investment **commitment** (total project costs[xv], including interest during construction) of projects under construction and projects in the process of closure, is R201.8 billion[xvi].

With the pace of the REIPPPP slowing, as previously discussed, investment commitments have grown only with the addition of the small-scale IPP procurement programme, adding approximately R10 billion to the very impressive totals reported in 2015. Of these commitments, those subject to Bid Windows 1 – 3.5, (i.e. approximately R145,5 billion [Figure 6]), have been realised.

xi The cost was calculated for the two largest plants in South Africa. For the cost of replacement, see https://www.irena.org/documentdownloads/publications/re_technologies_cost_analysis-hydropower.pdf, page I, retrieved 6 June 2017

xii The cost was calculated for the 606 MW of pre-existing biomass capacity described in Chapter 3. For the cost of replacement see https://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-BIOMASS.pdf, p i, retrieved 6 June 2017

xiii The PetroSA Biogas-to-Energy Plant in Mossel Bay, calculated with reference to original cost in 2007

xiv The replacement cost for the approximately 10 MW installed at Klipheuwel, Darling Wind Farm and Kouga, using present wind industry benchmarks

xv Total Project Costs: Total capital expenditure to be incurred up to the Commercial Operation Date (COD) by the Seller in the design, construction, development, installation and/or commissioning of the project (inclusive of VAT and revenue)

xvi This includes total debt and equity of R200.4 billion, as well as early revenue and a VAT facility of R1.4 billion

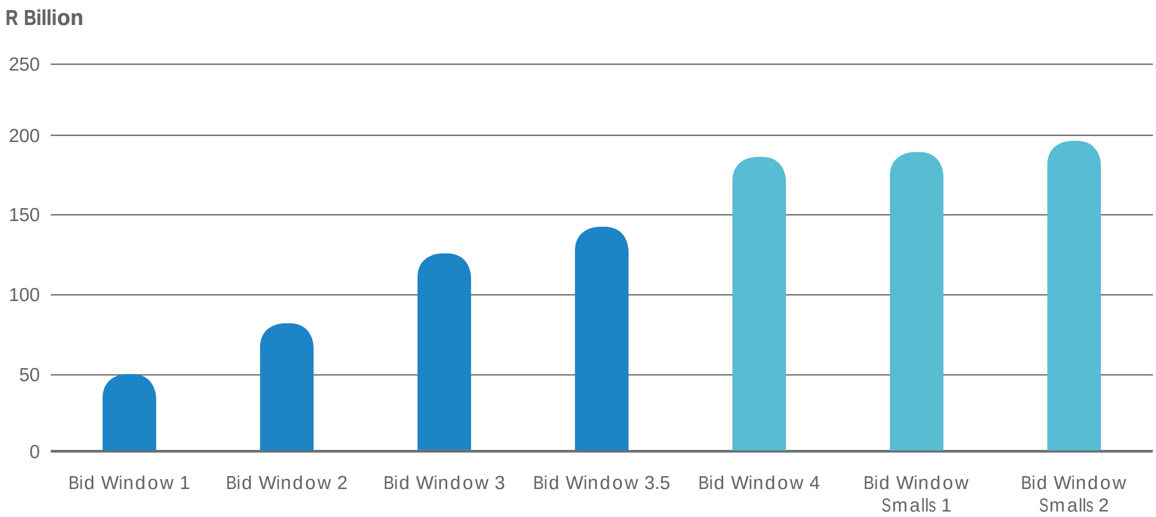

Figure 6: Cumulative investment committed *(BW4 onwards)* and realised *(BW 1 – 3.5)* across Bid Windows[xvii]

Although no new bid rounds were opened in the preceding two years, South Africa has already seen a similar trend to that of the global market, where the same investment buys more RE infrastructure (Figure 7).

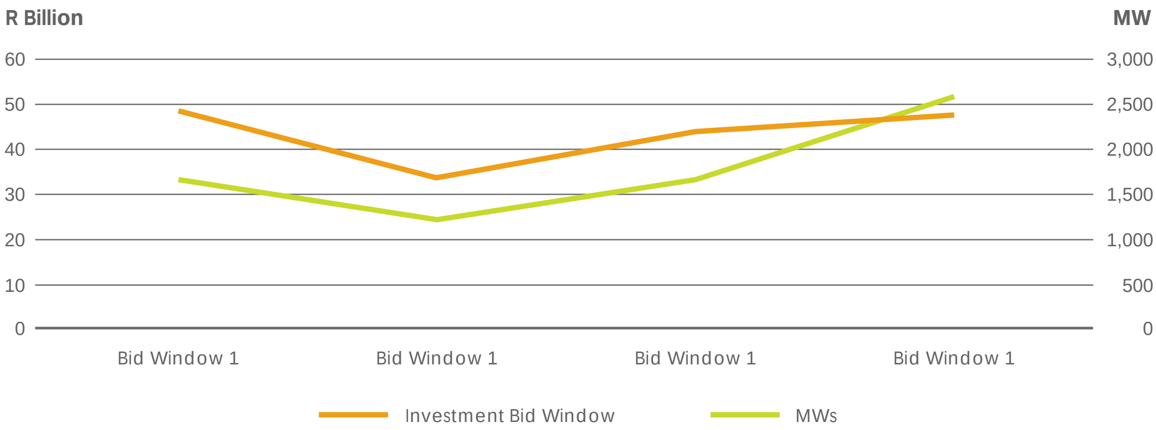

Figure 7: Comparative capacity for investment made per Bid Window[xviii]

An analysis of the funding sources[xix] and shareholding, highlights the broad spectrum of participation and benefits that emanate from this investment. Of this total investment, R48.8 billion originates from foreign investment and financing (Figure 8). This represents more than double the inward FDI attracted to South Africa during 2015 (R22.6 billion)[28], as reported by the South African Reserve Bank (SARB).

xvii Smalls 1 (BW1S2) and Smalls 2 (BW2S2) refer to the two bid rounds held for RE plants smaller than 5 MW

xviii Bid Window 3.5, that was technology specific, i.e. CSP is not included in the analysis

xix This analysis is based on financial close for BW1, BW2, BW3 and BW3.5 and RFP for BW4, 1S2 and 2S2. Note this may result in minor discrepancies with reported numbers elsewhere in the report

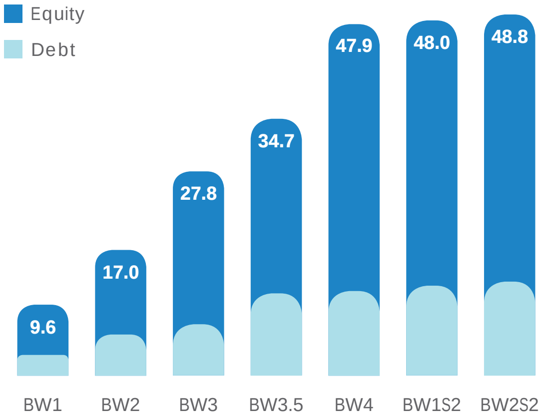

Figure 8: Total foreign direct investment attracted *(shown cumulative)* of total committed investment[xx]

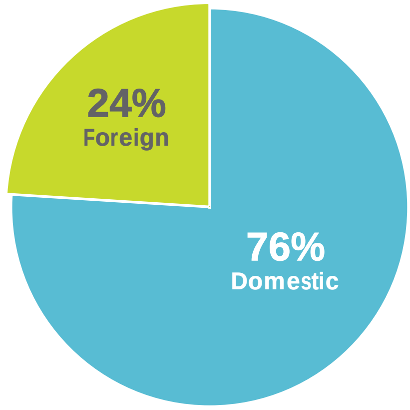

Figure 9: Foreign and domestic equity and financing shares in the REIPPPP

The approximately 24 percent foreign equity and financing (Figure 9) makes an important contribution towards the economy and national development objectives to grow FDI[xxi].

Foreign financing and investments (equity and debt) recorded for the REIPPPP, originate from a variety of countries across the globe, with Europe and the United States (USA) representing the largest sources of finance. A study analysing FDI identified at least 18 different countries, including two from Africa, that have participated in providing financing and/or equity to IPPs (refer Figure 10).

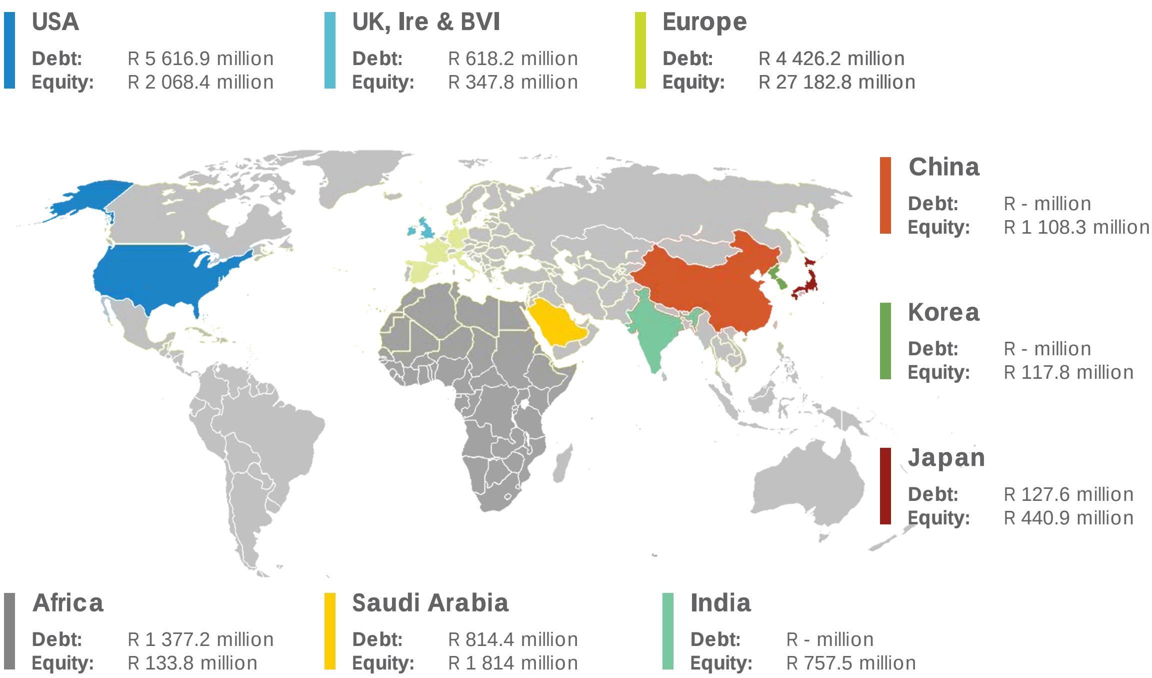

Figure 10: Sources of foreign equity and debt *(inclusive of UK, Ireland and British Virgin Islands)*

xx Where BW1S2 and BW2S2 refer to the two two-phased bid rounds held for RE plants smaller than 5 MW

xxi The NDP (Outcome 11) set a target of a R230 billion increase in FDI (facilitated by **the dti**) by 2019

The breakdown across European countries of origin, are as follows:

Country	Debt	Equity
Germany	R 1 854.2 million	R 1 113 million
France	R 1 250 million	R 2 547.8 million
Italy	n/a	R 13 934.5 million
Luxembourg	R 560 million	R 892.1 million
Netherlands	R 762 million	R 2 769.6 million
Norway	n/a	R 1 107.7 million
Spain	n/a	R 4 818 million
Not attributable	n/a	R 1 876.8 million

REIPPPP financing originating internationally, demonstrates how the success of the initiative has made South Africa prominent as an international RE investment destination. The investments are distributed throughout all the provinces (Figure 11), as emerges from the latest IPPPP Office report[29].

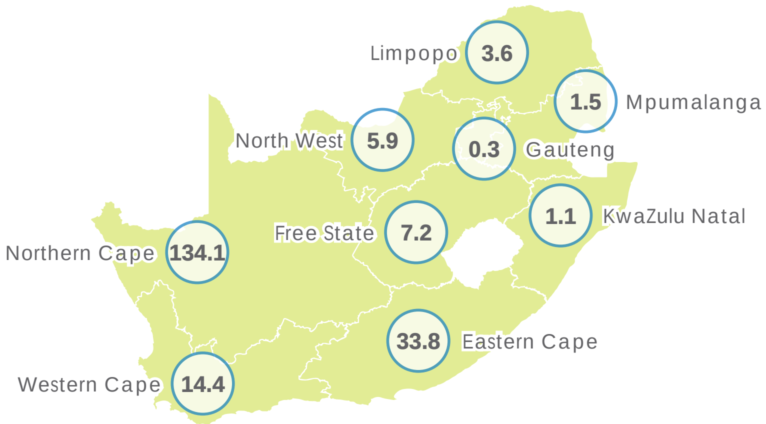

Figure 11: Geographic distribution of investment flows (R Billion)

The distribution across all provinces is mirrored by a distribution across the major RE technologies feasible at this time in South Africa. In the REIPPPP, Wind, Solar PV and Concentrated Solar Power (CSP) have attracted the most significant share of the investment in the first seven Bid Windows.

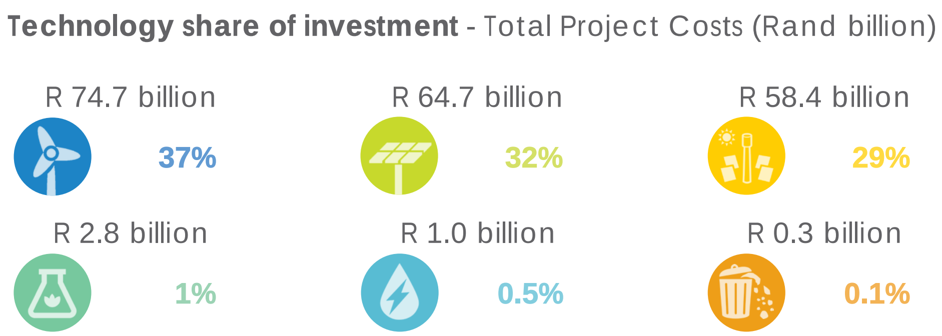

Figure 12: Relative share of investment per technology in the REIPPPP

An international trend, also manifesting in South Africa, sees investment flows being concentrated in the two super successful renewable technologies – Wind and Solar PV. In the global market, the significant price drop in these two technologies has led to investment in them outpacing other RE technologies[30].

Similar cost trends would be expected in South Africa, and would most likely also inform development planning for the electricity sector.

Investment data for distributed generation, and particularly the fast-growing rooftop Solar PV market, is not readily available.

In closing the section on investment attracted, mention must be made of investment that was originally attracted yet not fully realised as a result of delays in the REIPPPP bid round 3.5 and further. Data compiled by GreenCape and the South African Renewable Energy Council (SAREC), after interviews with market participants, shows the following:[31]

- R56 billion in infrastructure investment was delayed significantly, with some of it possibly abandoned[xxii];
- An investment of R13 billion in local communities has to date failed to occur;
- The leveraging of R6 billion in community dividends from community shareholding (for 37 communities over project lifetimes) has to date failed to materialise;
- Investment benefits for black SA-owned IPPs (to the value of R42.31 billion) has to date failed to materialise.

No comparative analysis has been done by independent reviewers to confirm these numbers, but quoted values roughly correspond to the investment and developmental commitments associated with the most recent, unresolved bid rounds.

Local manufacturing

The NDP, IPAP and Green Economy Accord identified the opportunity for growing South Africa's Green Economy. Extensive work has been done by **the dti** to identify opportunities for localisation, with two distinct, multi-stakeholder studies devoted to Solar PV and Wind, respectively.

In the wind industry, a possible local content level of 68.6 percent was envisioned in **the dti's** "The wind energy industry localisation roadmap in support of large-scale roll-out in South Africa"[32] (refer Figure 13).

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xxii See Figure 6 above for the total investment in bid rounds 4 and further

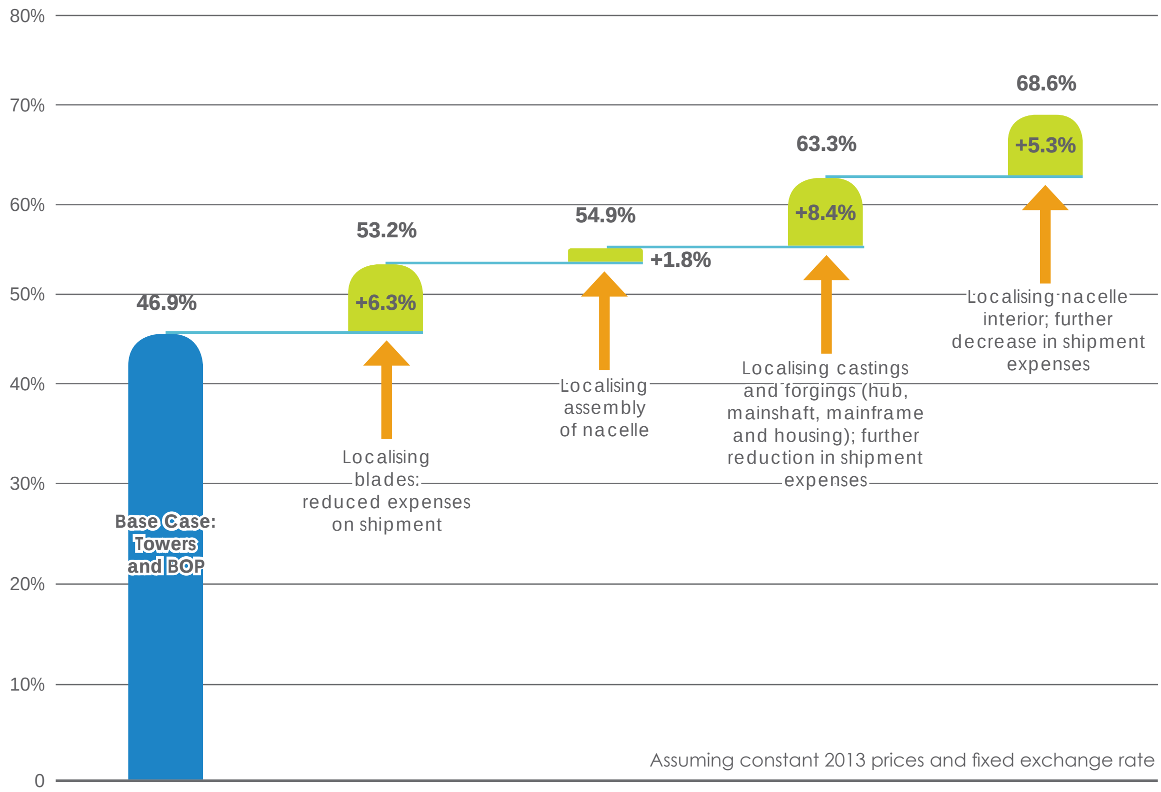

Figure 13: Optimal level of localisation as defined by the wind energy industry localisation roadmap (**the dti**, *2013)*. Balance of plant = BOP

In the case of Solar PV, the local content levels are already well above 50 percent[xxiii, 33] and will rise much further in the event of a large PV industry by 2050. While the exact levels are hard to predict, the following table from **the dti** roadmap gives an indication of what might be possible beyond transport, labour and balance-of-plant (BOP):[34]

Table 2: Local content assumptions for utility-scale projects using single axis trackers

Key component	Local content percentage per component			
	Baseline	Imminent	Low road	High road
Crystalline module	24%	28%	37%	90%
Inverter	0%	36%	77%	87%
Trackers	80%	80%	80%	80%
Wiring	10%	100%	100%	100%
Balance-of-plant	90%	90%	90%	90%
Total	**50%**	**59%**	**66%**	**88%**

xxiii Reported by the World Bank as 53.8 percent in bid round 3

The REIPPPP procurement requirements have promoted this ambition by setting/specifying a minimum local content threshold. In principle, an economic multiplier effect can be achieved by the broader investment in the local economy and through recipients again spending funds received with other businesses (illustrated Figure 14).

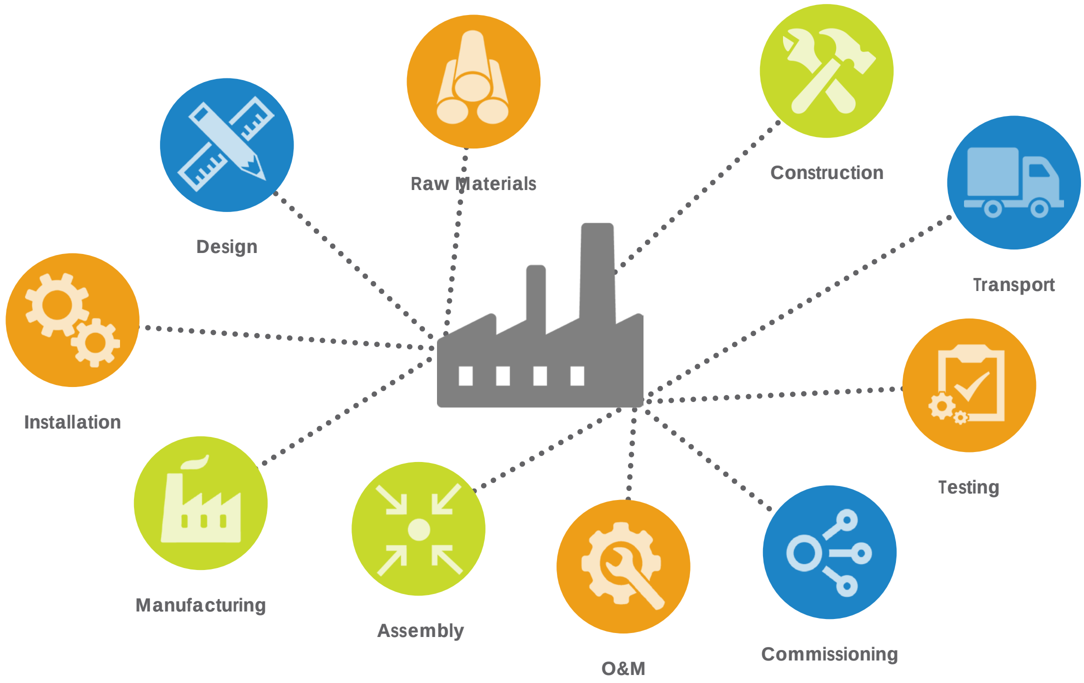

Figure 14: The support of various supply chain elements in RE in South Africa (Source: IPPPP Office). O&M = Operations and Maintenance

The REIPPPP localisation thresholds have consistently been moving up (refer Figure 15), while localisation achieved is converging on the target in the Local Procurement Accord[35].

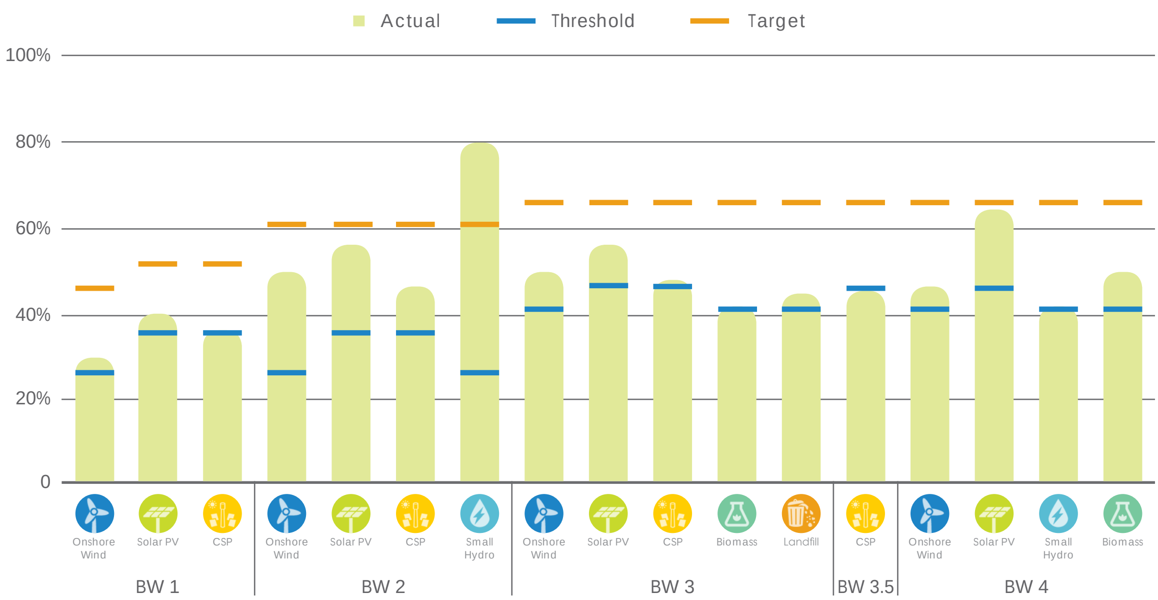

Figure 15: Local content requirements and achievements of the REIPPPP[36], across Bid Windows

By 2015, considerable success had already been achieved: at least 12 new industrial facilities, capable of supplying utility-scale projects, were known to have been established in the country in direct response to the REIPPPP, with the establishment of two more large manufacturing concerns in the pipeline (refer Table 3). Seven of the 12 facilities had been established during 2014 and 2015, implying a growing confidence in the sustainability and growth prospects of the local market – fundamental to attracting local investment.

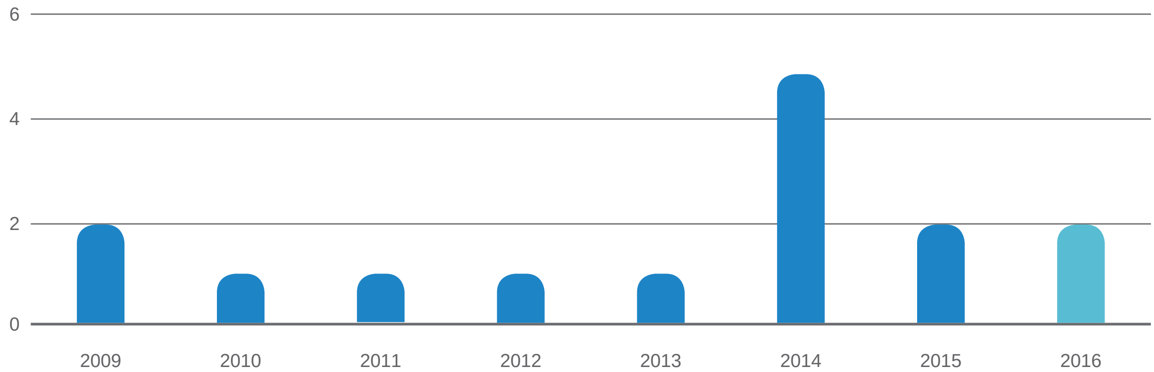

Figure 16: Establishment dates of REIPPPP suppliers (number of facilities established per year[xxiv]) as at end 2015[37]

Among these were very inspiring success stories in localisation at specific project/company level:[38]

- In 2014, Spain's Gestamp Wind opened Africa's largest wind tower factory in Atlantis, in the Western Cape. The facility was designed to deliver 150 towers per annum, but soon expanded to increase delivery capacity in order to meet the growing demand. In turn, increased production volumes required more materials and components to be supplied.

- The establishment of the Gestamp Renewable Industries plant was followed by Resolux, a Danish company that, among others, manufactures mechanical and electrical internals for wind turbines. Resolux established a local manufacturing facility in Atlantis towards the end of 2015. The company supplies components to 70 percent of the wind turbine manufacturers in the world. Thus, while the initial focus of Resolux's local facility was to manufacture and supply internal components for wind towers to Gestamp, the growing number of local tower and turbine manufacturers in the country offer enormous opportunity for their growth.

- The South African Renewable Energy Business Incubator (SAREBI) was established in Atlantis in the Western Cape in 2012 as a business incubator to encourage local entrepreneurs in the sector.

- At the Gouda Wind Farm project, 46 turbines weighing 170 tonnes each, were mounted on 100-meter high concrete towers made entirely in South Africa with a 97 percent local content level, creating 116 jobs over the period of 10 months. The quality management for the manufacturing was overseen by a 100 percent woman-owned South African company, Concrete Growth.

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xxiv 2016 projection based on indicative industry data at the time, December 2015

- A 100 percent black-owned rigging company moved 782 abnormal loads of massive, precision-engineered, prefabricated concrete tower sections from Cape Town Airport Industria to the Gouda Wind Farm site, situated approximately 115km from the city, for final assembly.

In the case of Solar PV, imports started to be offset by significant exports as South Africa became a significant player in the assembly of PV panels. Exports of PV modules followed from a low base (of approximately 0.06 billion Rand) in 2014, increasing to more than 1.3 billion Rand in 2016 (Figure 17). This represents more than a 20-fold increase in PV exports within two years.

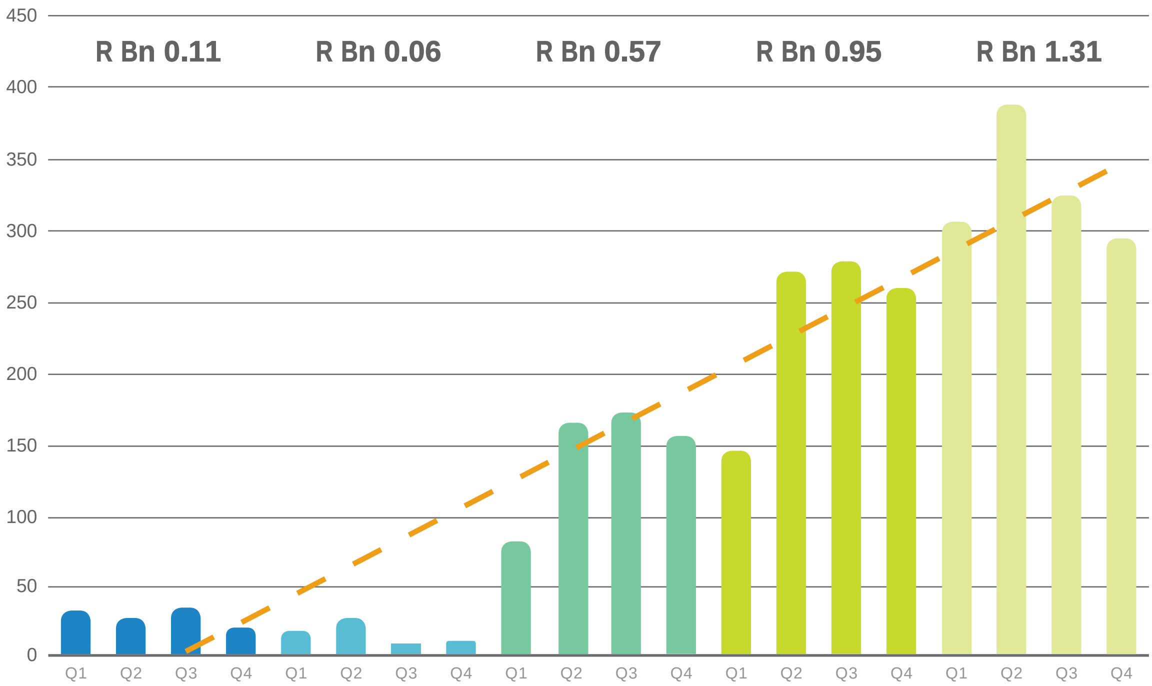

Figure 17: South Africa's quarterly exports of photovoltaic (PV) solar cells and panels[xxv]
(value of exports in R million)

The completed products have been exported to a range of destinations, but mostly the USA and Europe, as reflected below:

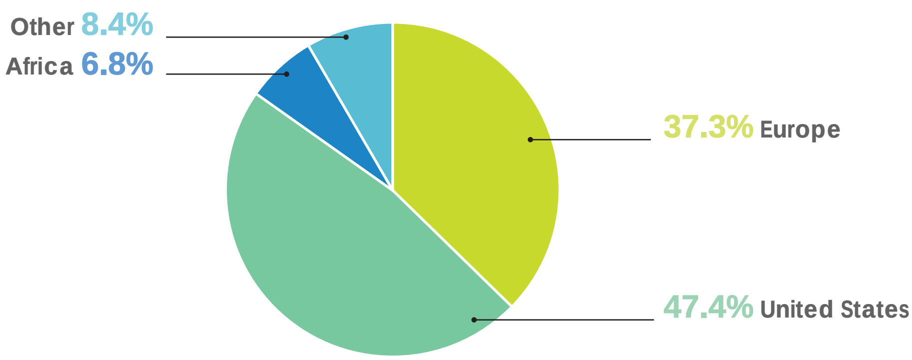

Figure 18: Major destinations of PV exports from South Africa

xxv PV cells, whether or not assembled into modules or made up into panels, as recorded for customs tariff code H85414010

It is likely that these developments are exactly what was envisaged by the Green Economy Accord. However, the success and sustainability of a local manufacturing industry depends on steady growth and development in the country and/or region. Wind power especially implies large and heavy pieces of equipment that are costly and complex to transport. For this reason, local manufacturing in the Wind supply chain is even more dependent on the South African market for regular orders than similar plants in the PV supply chain. Until the regional market starts to mature and match the local one in size, wind towers (and in future, blades, and possibly locally assembled turbines) are not practically exportable.

Delays with REIPPPP rounds 3.5 and further have had severe adverse effects on these newly established local industries. Of the original 12 new manufacturing businesses reported at the end of 2015, six have closed or suspended operations, operations at four are under review and five of the investments planned at the time had been suspended (refer Table 3).

Table 3: Status of local RE manufacturing facilities and investments

Company	Business focus	Employment	Status
SMA*	Inverter manufacturer	10	Closure announced August 2016
Resolux*	Manufacturer of mechanical and electrical internals for wind turbines	Up to 80	Closed
Sunpower*	Solar PV manufacturing	50	Continued operation under Board review
DCD Wind*	Wind tower manufacturer	250	Continued operation under review[xxvi]
Gestamp Renewable Industries*	Wind tower manufacturer	220	Continued operation under review
Solaire Direct*	Solar PV panels	50	Closed
ILB Helios*	PV modules and inverters	100	Continued operation under review
Rioglass	Mirror assembly line	50	Closed
Jinko Solar*	Solar panel manufacturer		Closed
Concrete Growth*	Manufacturer of concrete wind towers	116	Suspended
ArtSolar*	Manufacturer of PV Modules	160	Operational
PiA Solar*	Mounting systems supplier and installer	-	Operational
Absolute rigging*	Specialist transportation company (abnormal loads for REIPPs)	-	Operational
LM Blades	Turbine blade manufacturer	100	Investment decision suspended
Suntech	Solar PV manufacturer	300	Investment decision suspended
Canadian Solar	Solar PV manufacturer	100	Investment decision suspended
Gamesa/Siemens	Wind turbine components		Investment decision suspended
Redstone project	Manufacturer of heliostat fields	100	Investment decision suspended

Where *, indicates the 12 facilities originally recorded in 2015

xxvi DCD Towers had announced closure of the wind tower manufacturing plant in Coega IDZ. An offer to purchase the facility was received and subsequently placed on hold, pending clarity on the future of the REIPPPP

From the above list, it is evident that only businesses that were able to shift their focus to non-utility-scale projects, such as rooftop Solar PV, or could diversify into other sectors, have maintained their presence in the market.

The combined impact of these closures is substantial. At least 190 jobs have been lost, 600 forfeited, and a further 620 are in jeopardy. R2.84 billion investment has been suspended and more than R1 billion invested in the manufacturing sector has been lost or is at risk.

Employment creation

The benefits of employment creation through RE is not confined to the REIPPPP. Because of above localisation an entire value chain is impacted. There is both direct and indirect job creation.

Moreover, significant opportunities are being created in rooftop Solar PV that are presently not formally being captured.

Nevertheless, employment for South African citizens in the construction and operation of REIPPs continues to grow, with more than 31,000 job years[xxvii] created to date.

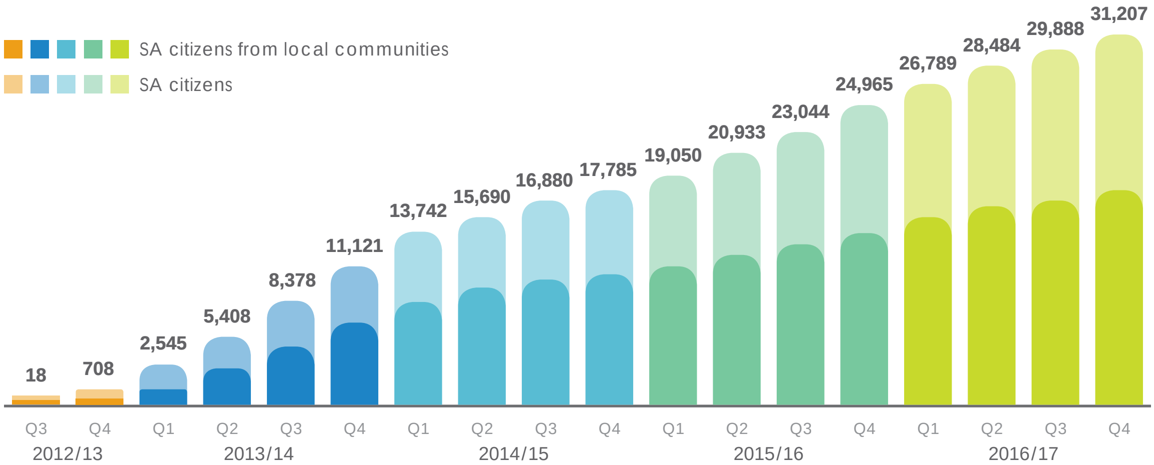

Figure 19: Employment creation (job years) through the REIPPPP

A steady and continuous procurement process would see these opportunities recur and expand annually, gradually turning 'job years' into a comparable number of 'jobs'.

Of specific interest was a recent study carried out by Altgen on Wind Turbine Service Technicians, in which it was found that a permanent position is created for every 10 MW wind power installed[39]. This is a high quality job requiring considerable training and paying an average montly salary of approximately R20,000. In terms of a just transition to quality work, this is a prime example. One more rung up the ladder, industry has recently been inquiring from SARETEC whether existing Wind Turbine Service Technicians can be further trained to become Wind Farm Managers[40].

xxvii Employment/job creation in the REIPPPP is measured in job years (equivalent of a full time employment opportunity for one person for one year)

The wise management of clean energy investments can fundamentally change the economic and social landscape for the better.

This point is underlined when considering the employment impact of the delays in the REIPPPP:[41]

- 13,500 construction jobs did not materialise;
- These would have been followed by significant numbers of Operations and Maintenance jobs, which did not occur (definitive data unavailable);
- IPPs/developers employed 865 people at the time of the survey and it was projected that 252 would lose their jobs before the end of 2017;
- The R115 million SARETEC training facility at the CPUT suspended further training of Wind Turbine Service Technicians because there wasn't a prospect of placing graduates until the REIPPPP was moving again[42].

Socio-economic development and empowerment

One of the unique features of the REIPPPP is that it encourages IPPs to respond in meaningful and tangible ways to the socio-economic development imperative of disadvantaged communities in South Africa.

The bid evaluation score card allocates a weight of 30 percent to Local Economic Development objectives such as enterprise development and socio-economic development. Moreover, in an approach that reflects the international thinking on climate justice,[43] the REIPPPP specifically aims to address South African imbalances of the past through Broad-based Black Economic Empowerment (BBBEE) objectives.

This programme, which has fittingly gained international acclaim, requires IPPs to contribute at least 1 percent of their revenues (with 1.5 percent as the target) towards Socio-Economic Development (SED) initiatives. What is gratifying is that the current portfolio of procured IPPs have, on average, committed to contribute approximately 2.2 percent of their revenues towards SED projects.

These contributions are expected to accrue over the 20-year life span of IPP projects. To date, they have mostly been utilised for improving healthcare, education, skills development and associated infrastructure; as well as promoting social welfare.

In addition, some IPPs also contribute approximately 0.6 percent of their revenues towards Enterprise Development (ED) initiatives to help grow local businesses, while stimulating the economic growth of communities that need it the most.

All procured REIPPPP projects have committed to spend a total of R20.6 billion and R6.4 billion towards SED and ED initiatives, respectively, over the 20-year term of their projects. The 56 operational projects have contributed R357.4 million towards SED and R115.2 million towards ED to date.

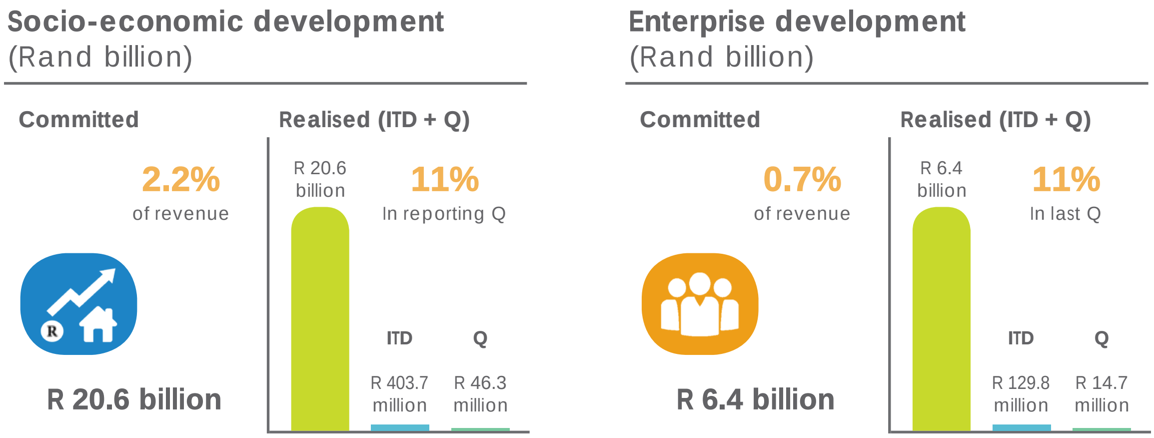

Figure 20: Socio-economic and enterprise development commitments and spend under the REIPPPP.
ITD = Inception to date, Q = Quarter

The geographic distribution of REIPP projects and committed benefits are spread wide across the nine provinces:

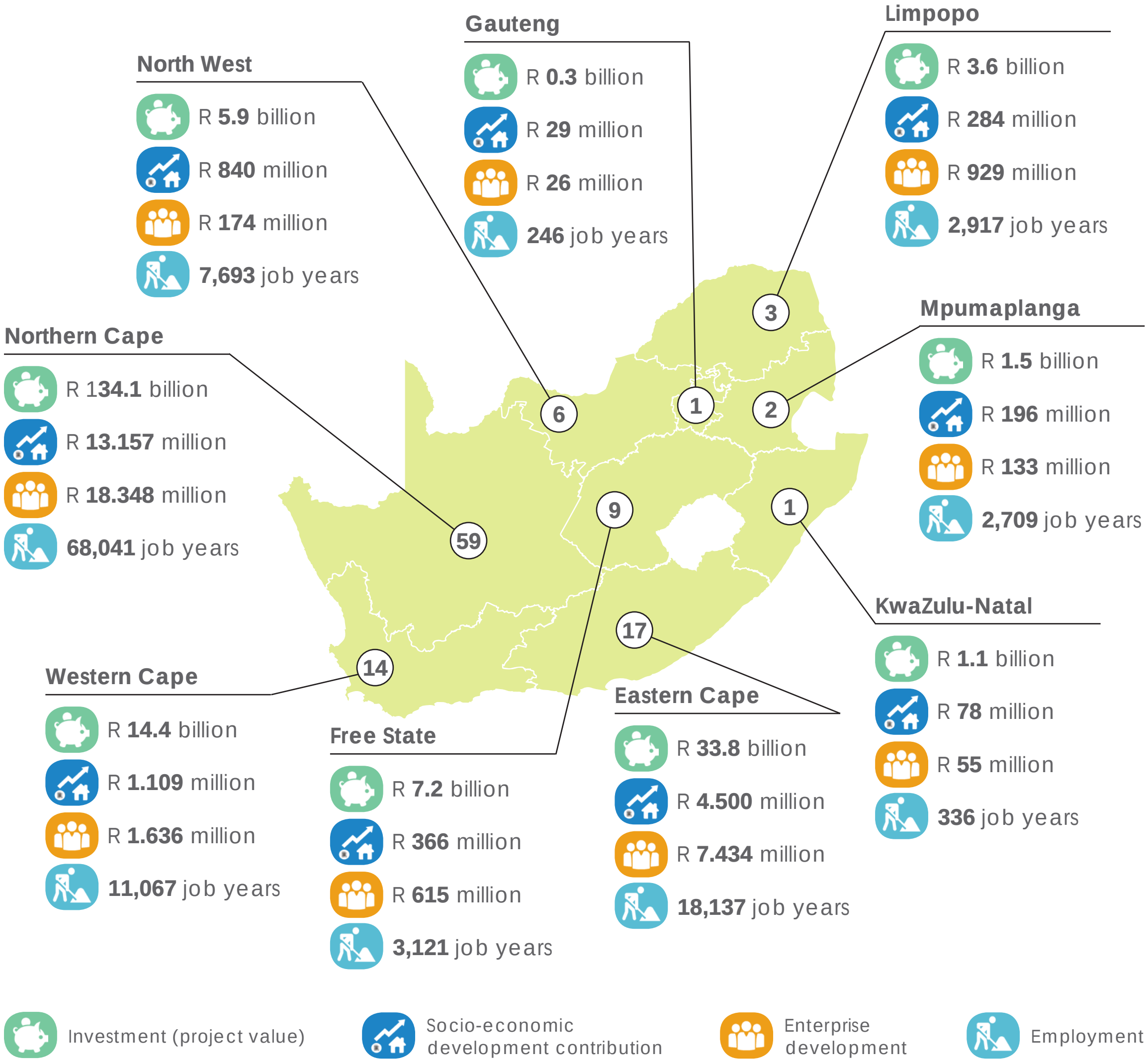

Figure 21: Committed development contributions per province

Regarding social justice, impressive gains have been made on BBBEE goals. To date, BBBEE participants have a total equity participation of more than R 20 billion, totalling nearly 30 percent of all equity.

For projects that have reached financial close, black South Africans hold 31 percent of the shares across the complete supply chain (see Figure 21) while local communities hold 11 percent equity in the IPPs. Across the entire portfolio, including those projects that have not yet reached financial close, BBBEE participation represents R20.12 billion, more than 29 percent of total equity in the REIPPPP.

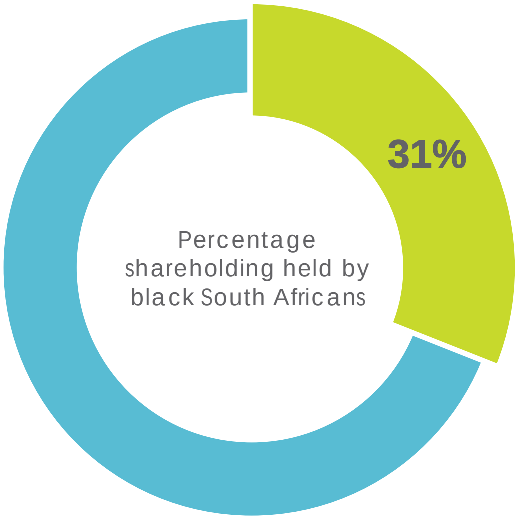

Figure 22: Equitable shareholding in REIPPs as achieved[xxviii]

The BBBEE spend in total in the REIPPPP has now reached more than R40 billion[44]. This is 88 percent of the total procurement spend reported at the end of March 2017.

The metric for 'women-owned vendor procurement' has seen its threshold value move from five percent to 10 percent. The REIPPPP rules are continually reassessed by the IPP Office with the aim to further enhance its positive impact on South Africans.

Development beyond the REIPPPP

As mentioned in Chapter 3, rooftop Solar PV has been growing extremely quickly. While empirical data is not as yet available, job creation and up-skilling is implicit in this growth. Rooftop Solar PV and the REIPPPP have never really grown in concert – the former picked up as the latter was slowing down. If both should grow simultaneously, it is likely to create optimal conditions for supply chain development in Solar PV and for local manufacturing or assembly.

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xxviii 'Achieved' refers to those projects that have successfully reached financial close. This includes projects in Bid Windows 1, 2, 3 and 3.5. One project in Bid Window 3, one in Bid Window 3.5 and all projects in Bid Windows 4, 1S2 and 2S2 have not reached financial close as at September 2017

Some moves are afoot from municipalities wishing to buy wheeled electricity directly from IPPs[xxix]. This additional demand would contribute further growth in the RE market and the opportunity for local manufacturing and employment.

There are also advanced plans to embed smaller RE plants within municipalities and metros, again expanding the market and creating possibilities for SED and ED benefits on a broader scale. For instance, a micro-scale Solar PV programme was launched in the Nelson Mandela Bay Municipality (NMBM), with the aim of generating 25 MW of power. Plans are afoot to roll out similar programs in three more municipalities in the coming 12 months. Further examples of innovative distributed and embedded generation and trading initiatives under investigation and development by municipalities, are included in Chapter 8.

Finally, it is likely that the first procurement or pilots of electricity storage at a national or sub-national level will occur by 2020 (refer Chapter 7). Studies have shown the greatest need to be in ancillary services, behind the meter, but a pure storage application is likely at least to be piloted[45, 46] and will create comfort with policy makers that we'll be able to deal with the penetrations of RE a few decades from now.

Projections and prospects into the future

The lower and upper limits of the ultimate RE industry size in South Africa can be described as 'large' and 'extremely large'. A projected RE industry of 55,250 MW by 2050, as per the draft IRP 2016 base case, would constitute an industry approximately 40 times larger than the one we have now, having cost approximately R145 billion. Even if technology prices dropped much further, the investment required by 2050 is immense, the employment and community development opportunities are transformational and the empowerment potential is such that, in the context of energy, it gives a much broader meaning to the word.

Localisation under these conditions would easily reach the maximum levels identified in **the dti** studies, as referenced. The bulk of the multi-trillion rand industry by 2050 will have been created by spending on local suppliers, and manufacturers employing a local labour force.

In terms of employment creation, the CSIR has used the McKinsey study done for the IEP, to model the employment numbers in various future energy scenarios. It appears that, by 2030, in the most coal-intensive scenario, approximately 93,000 – 153,000 people work in the entire energy sector. By 2050, the most jobs are created by the deepest penetration of renewables – approximately 331,000 with the lowest cost scenario (still lots of RE) close behind and the coal-intensive scenarios lagging[47]. This shows that the renewables transition will also increase jobs.

Given that the community development benefits flowing from the REIPPPP have so far been about 10 percent of total project costs through all the bid rounds of the REIPPPP (R20.6 billion of approximately

xxix The City of Cape Town is explicitly pursuing more than 200 MW of Wind and Solar power in this manner after commissioning a city-level Integrated Resource Plan that suggested such a route, while City Power in Johannesburg is understood to be in support of the idea

R202 billion) the aggregate community benefit of an RE sector up to 40 times larger than the present is difficult to visualise in the fullness of its positive impact.

The development of RE in South Africa presents a major opportunity that will allow a significant number of South Africans to take part and benefit, irrespective of the exact business models that emerge over time[xxx].

Conclusion

The economy is integral to sustainable development and sustainable development to the economy.

The deployment of RE fuels economic growth, creates new employment opportunities, enhances human welfare, and contributes to a climate-safe future.

Through the REIPPPP, South Africa has explicitly joined and multiplied the objectives of sustainable development in the procurement system. After a quick expansion, a period of consolidation has set in. While new activity has slowed, the sophistication of the program has continued to evolve. Delays in signing PPAs for the most recent Bid Windows have negatively impacted on the emerging industry. This is, however, a short-term issue expected to be resolved shortly. The finalisation of the IRP 2016 should also provide investors and developers with a long-term view on the planned market size and development timelines. Despite the recent slowdown, South Africa has, for the moment, maintained its global vanguard status among developing countries.

More recently, the market has shifted into an extraordinary position where more RE infrastructure is costing less. RE is therefore becoming the elusive holy grail of sustainable development, delivering more power, costing less and benefitting/including more people in wide economic and socio-economic benefits.

South Africa is uniquely placed to build on the already successful REIPPPP and maximise the benefits from this market transition. In our case, modelling shows that the lowest cost energy future has a very high penetration of RE and simultaneously scores the highest in job creation, conserves the most water and leads to dramatically reduced greenhouse gas (GHG) emissions.

Bokpoort concentrated solar power plant near Groblershoop

xxx The existing discussions focus on the future balance between private and public ownership, FDI or local ownership, IPPs or a state-owned renewables programme, and to a lesser extent project finance or balance sheet finance. Perhaps the most generic undertone of these discussions is where to put the balance between lowest cost electricity and an expansion of the benefits of the REIPPPP while allowing costs to rise slightly. Thus, the debate is to a large extent about 'value' vs 'cost'

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Chapter 7

Chapter 7

Innovation Powering Change and Development

A decade ago, the potential of RE was widely acknowledged, yet most mainstream projections did not predict the extraordinary expansion of renewables that was to unfold. Several factors set the foundation for, and contributed to, the rapid market growth. One contributing factor has been the remarkable technology advances and innovations achieved in RE.

The invention of the windmill is attributed to Heron of Alexandria in the first century AD. This first windmill closely resembled windmill technology built until the 13th century in Western Europe, but harnessed wind energy to power an organ – the musical instrument, that is. During the centuries that followed, windmill design remained relatively unchanged until the 19th century (1887), when it was first used to generate electricity. Because it was used to generate electricity, the technology was renamed to become a wind turbine. The 20th century saw numerous innovations, exploring vertical and horizontal axis configurations and blade types, until the modern wind turbine was created during the mid-20th century[1].

After 21 centuries, the development of wind power technology accelerated considerably during the next three decades. In 1980, almost 100 years after the first wind turbine design, wind technology started its rapid evolution. Advances in tower height, rotor diameter and generation capacity (Figure 1) improved the energy yields possible from a single tower by a factor of 500[2]. In the past 10 years alone, generation capacities more than tripled[3].

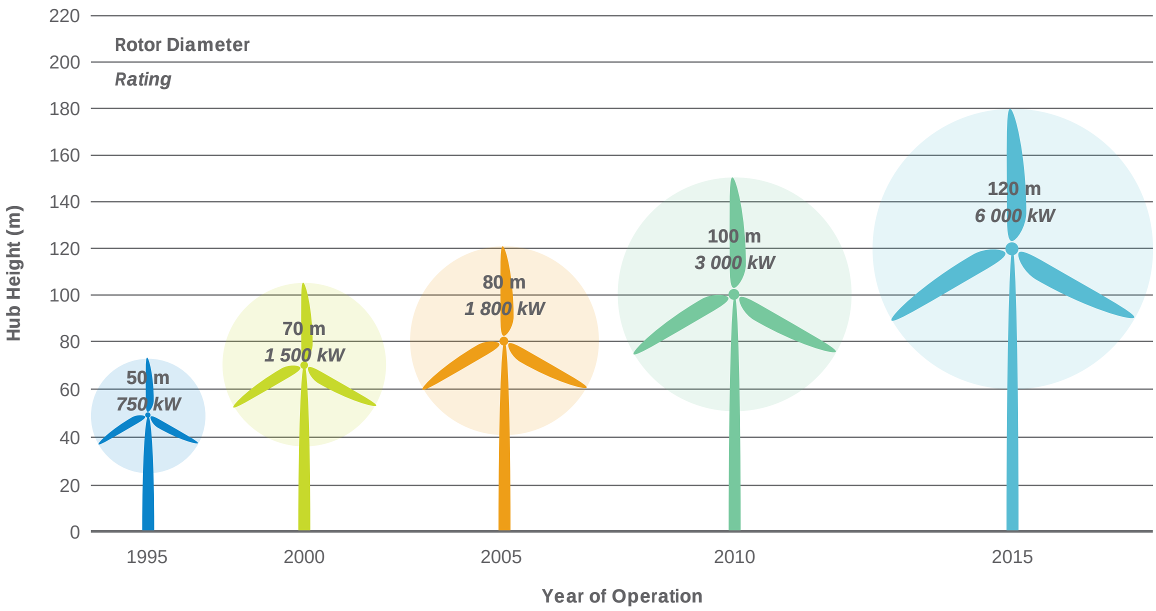


Figure 1: The evolution of wind turbine size and generation capacity

A similar trend can be seen for the technology improvements of Solar PV panels, achieved since their inception in the 20th century. Efficiency, size and cost for solar panels dramatically improved in the last five years (refer Figure 2)[4].

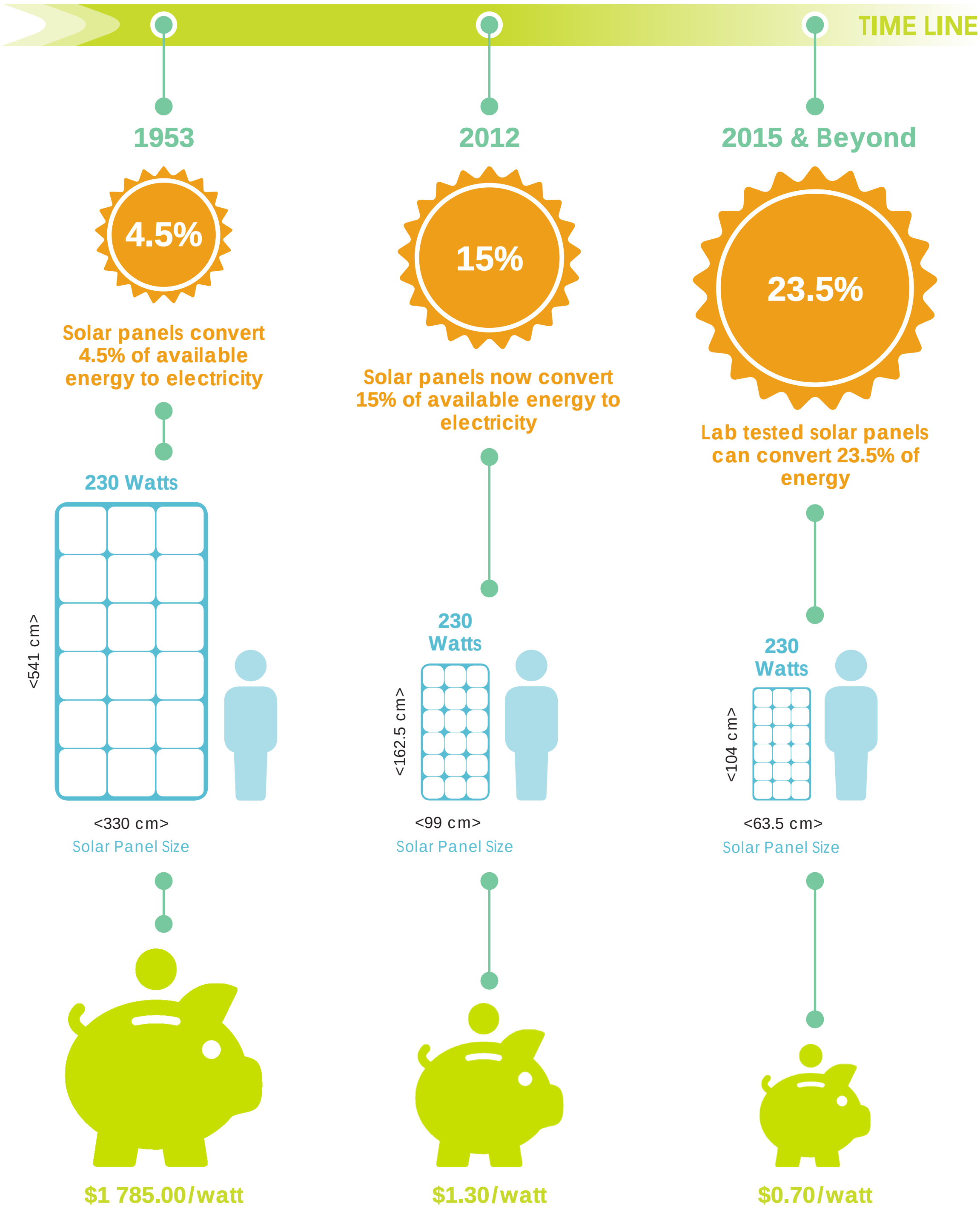


Figure 2: Technology improvements in solar panels, 1953 - 2015

Technology costs reduced commensurate with technology improvements. Between 2010 and 2015, Solar PV panel production costs decreased 72 percent, making Solar PV cost competitive with fossil fuel-generated power across many markets globally[5].

Among other factors, this breakthrough can be ascribed to an intensified research and development (R&D) focus in the sector. The SunShot Initiative[6], launched by the United States Department of

Energy in partnership with SunPower, clearly demonstrates the benefit of focused investment, both in terms of financial and intellectual capacity, in technology innovation.

When the SunShot initiative was launched, it targeted R&D efforts, in collaboration with public and private partners, with the aim to make solar energy cost competitive with conventional forms of electricity by 2020. SunShot funded cooperative research, development, demonstration, and deployment projects by private companies, universities, state and local governments, nonprofit organisations, and national laboratories in order to drive down the cost of solar electricity.

At the time, utility-scale solar cost close to $4 per watt. SunShot targeted a 75 percent decrease in total costs of Solar PV energy systems to achieve $1 per watt by 2020; the objective was reached three years early. This has prompted the US Department of Energy to set more ambitious targets beyond 2020[i].

While other market forces also contributed to declining technology costs, such a convergence of focus and effort from investors, entrepreneurs and researchers has undoubtedly contributed towards the acceleration of technology innovation and cost advances[7].

More recently, the challenge of energy storage is bringing together world-leading scientists, engineers, and manufacturers with an important mission: develop cost effective, clean energy storage technologies for transportation and the electricity grid that can deliver on global decarbonisation goals. The rapid progress made in the RE sector suggests that the world can expect to see technology cost reductions and continually improving performance of existing, new and emerging storage technologies as the R&D community shifts and intensifies its focus in this area. This is an exciting prospect for the continued transition of the global energy system.

The value of research and innovation include, among others, lower technology costs and improved efficiencies. This chapter discusses some of the benefits that are being realised through R&D progress in South Africa as well as the opportunities opening up for study, skills development and employment.

Solar panels on the campus of Arizona State University in Tempe - Arizona Sunshot initiative

i In November 2016, the SunShot Initiative announced further cost targets to be achieved by 2030: $0.05 per kWh for residential Solar PV, $0.04 per kWh for commercial Solar PV, and $0.03 per kWh for utility-scale Solar PV

BOX 1

R&D funding trends and challenges

Despite, or perhaps because of, the inroads made by R&D in the RE sector, 2016 saw a decline in global R&D spend on renewables. The overall reduction was ascribed to lower R&D investment from corporates. Surprisingly, Government spending in renewable energy R&D increased globally by 25 percent to a record $5.5 billion – the first increase in three years.

In South Africa, the latest available statistics[8] similarly reflects Government as the biggest funder of R&D in the country.

In recognising that innovation adds critical momentum to the structural economic change that is needed for economic growth, job creation and improved quality of living, the South African government is actively seeking to increase[9] the country's investment in R&D by 100 percent, from R29 billion in 2014/15 to about R60 billion a year by 2020. In terms of percentage of gross domestic product (GDP), this would involve an increase from 0.77 percent to 1.5 percent.

Compared with international figures, R&D expenditure in the country needs greater investment. In 2014/15, R&D spend represented 0.77 percent of GDP, well below the Organisation for Economic Cooperation and Development (OECD) average of 2.3 percent and far below that of the top 10 investing countries (average 3.3 percent of GDP)[10].

The Department of Science and Technology (DST) identified several contributing factors, including insufficient public funding, suboptimal coordination of science, technology and innovation efforts across Government, as well as the worsening economic climate, which has constrained private sector R&D activity.

Consequently, the DST is focusing on improving the coordination of public funding for research, development and innovation with the expectation that this will also stimulate increased private investment. During 2015/16, a DST-National Treasury task team was also formed to identify ways in which to increase South Africa's gross expenditure on R&D in order to reach the target of 1,5 percent of GDP.

In October 2016, the DST launched the South African Research Infrastructure Roadmap[11], which is intended to promote the outcomes and quality of research and maximise the return from investment in research, scientists and researchers in the country. The overall objective of the roadmap is to provide a strategic, rational, medium- to long-term framework for planning, implementing, monitoring and evaluating the provision of research infrastructures necessary for a competitive and sustainable national system of innovation.

Despite challenges with securing R&D investment, South African researchers are publishing record levels of high-quality research. Between 2012 and 2015, the country's output in journals in the Nature Index grew by more than 40 percent[12]. The Nature Index tracks the affiliations of high quality scientific articles. Updated monthly, the Nature Index presents research outputs by institutions and country. Recognition by this prestigious Index brings with it international recognition for South African authors and researchers, which in turn unlocks greater prospects for research funding.

National energy R&D and Innovation direction

It is evident, based on the experience from RE technologies, that concerted R&D effort has the power to drive change and development. Theoretical and empirical studies[13], covering countries across the world, have recognised the impact of various forms of R&D on economic growth, directly linking it to a number of innovations, skilled labour force, and productivity of research.

Likewise, the Sustainable Developments Goals (SDG) identify proactive innovation as key to phasing out of energy poverty in developing countries by 2030. The SDG state that addressing energy poverty will require viable, sustainable energy access solutions for energy-poor people in developing countries to be identified, demonstrated, replicated and scaled up. Energy innovation is therefore recognised as a crucial stepping-stone to realising social and energy justice, and for leapfrogging obsolete technologies towards a more sustainable energy future. Investment in energy innovation fills critical gaps in the innovation cycle, creates jobs, lowers energy costs and makes our energy systems safer and more reliable.

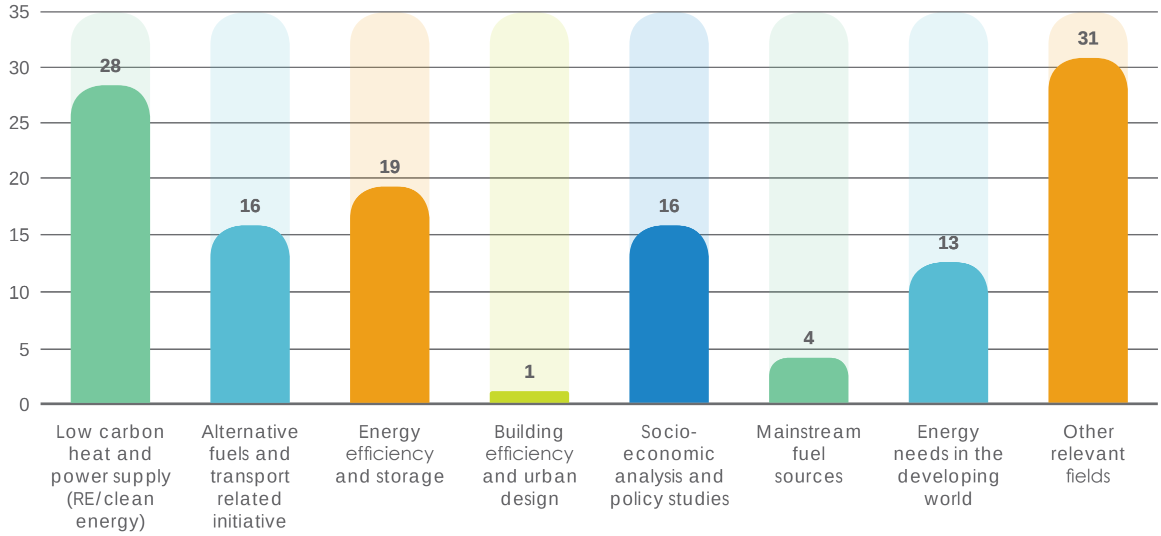
Despite significant progress made with RE in South Africa, successful deployment of renewable and clean energy technologies on a large scale still require significant research and innovation at technology level, both for adapting appropriate solutions to the South African context and from an energy system integration perspective.

Correspondingly, the DST, which provides leadership, an enabling environment and resources for science, technology and innovation in support of South Africa's development, has identified the importance of supporting R&D that addresses energy systems challenges of universal access, security, and environmental impact. In this respect, the DST provides strategic guidance and financial support to the development of low carbon technologies (e.g. Solar) that will contribute towards economic growth and universal access to modern energy services for all citizens, without compromising environmental protection needs and policies.

This strategic direction is evident in the energy portfolios of research institutes, research centres and academia. A study commissioned by the GIZ in 2016, examined the focus of energy research in the country[ii]. The study focused on the scope of existing collaboration and partnerships between

ii The survey targeted the 26 public higher education institutions (HEIs), as well as other private and public organisations that conduct, or have the mandate to do, energy or energy-related research. Responses were also received from institutes not currently collaborating with German partner institutes

German and South African research institutes, but in the process collated a comprehensive overview of current energy research activities (Figure 3), priorities and plans[14].



Source: Calculations based on survey result

Figure 3: High-level energy research sectors of interest to participating institutions *(number of topic mentions)*

Out of the wide range of energy-related topics, renewable or clean energy, energy efficiency (EE), energy storage, green transport and socio-economic analysis and policy studies featured strongly in the research portfolios of respondents. The survey also highlighted that RE, energy storage, decentralised power generation, distribution and localisation, micro grids and smart grids have emerged as important industry trends expected to inform future R&D.

The emphasis on all areas of alternative and sustainable energy solutions suggests that South Africa's research environment is well attuned to the global transformation of the energy sector, yet cognisant of local challenges, the country's energy resources and requirements.

The study also highlighted the challenges involved in progressing research through demonstration and commercialisation to bridge the gap to market. The funding requirement associated with pilot projects, demonstration and particularly full commercialisation often prohibits even viable solutions from progressing beyond applied research. In the interest of local industrialisation, one of the country's priority development objectives, these later stages are of critical importance.

A Government agency, dedicated to energy research, development and innovation, was established in 2011 through the 2008 Energy Act. The South African National Energy Development Institute (SANEDI), pursues energy innovation, knowledge and skills for less carbon intensive, more environmentally sustainable, affordable and efficient energy systems. The institute works alongside other organisations, academia, science councils and Government agencies active in this and related areas, to promote, coordinate and potentially steer energy research and development activity in the country.

SANEDI focuses on solutions that make optimal use of local resources, that diversify energy production and create an environmentally sound energy sector. Accordingly, its portfolio incorporates programmes on EE, RE, green transport and smart grids.

In terms of RE, SANEDI aims to facilitate and co-ordinate R&D and demonstration through international cooperation and information exchange, leading to the deployment and commercialisation of sustainable, efficient, reliable, cost competitive and environmentally sound RE technologies. The Renewable Energy and Energy Efficiency Partnership (REEEP) and the Wind Atlas of South Africa (WASA) are examples of initiatives developed through international collaboration.

In order to accelerate the research path of scientific innovation, to market viable alternatives and grow the pool of energy scientists, SANEDI has established centres of research and development that focus on coordination in the research, development and innovation space of the energy sector, promotion of technologies, skills development and collaboration. One such centre is the Renewable Energy Centre Of Research and Development (RECORD).

Collaboration and coordination of RE research in South Africa is being pursued through a variety of avenues. Among others, RECORD provides limited funding for applied RE research conducted at various institutions in South Africa. To ensure efficient use of funds, RECORD coordinates this RE research according to national priorities and stakeholder objectives through its research platforms. These expert, technology-specific research platforms intend to coordinate and drive collaborative research among the key researchers, stakeholders and role players within certain sectors. The platforms help members identify and reach concurrence on research priorities and assist with leveraging funding towards this research. They also foster collaboration between stakeholders, through collaborative funding and sharing of resources, to ensure that applied research is not

Metrowind van Stadens wind farm near Port Elizabeth duplicated within the same field. Since 2013, seven platforms had been established, including the Solar Water Heating Research Platform, the Photovoltaic Research Platform, the Wind Energy Research Platform and Energy in Agriculture Platform.

RECORD facilitates mutually beneficial interaction and information exchange between stakeholders in the RE sector in South Africa, as well as at an international level. The RECORD website (www.record.org.za) publically shares a wealth of studies, research results and other important documents in support of business development in the sector.

SANEDI, and RECORD in particular, also actively contribute towards RE skills development in South Africa. Skills development and training are structured to service the growing RE sector in South Africa. Initiatives, developed and implemented in cooperation with a variety of actors, are pitched at various skill levels (refer section on exciting new careers and areas of study below).

Innovation employed to power economic growth

Recognising the potential of creating a new, green industry, the DoE in association with the DST, commissioned the development of a Solar Energy Technology Roadmap that incorporates a component focused on solar energy research, development, and innovation (RDI). The RDI component is envisaged to support South African innovations in solar energy that will assist Government in dealing with the triple challenge of poverty, inequality and unemployment through stimulating local manufacturing and capacity development in the solar energy industry.

In 2016, the DST appointed SANEDI to implement the solar RDI roadmap over a three year period. Through this project, the SANEDI team is working closely with the DST to develop local skills in engineering, research and industrial development.

The Roadmap prioritises the following six thematic focal areas:

- **Strategic Planning.** Through informing Government energy planning processes on solar energy potential and providing the necessary policy inputs that support increased inclusion in national and regional energy systems.

- **Energy Systems Integration.** Making sure that technology barriers towards intensified inclusion of the intermittent solar energy technologies are addressed through cost-effective measures that include hybridisation, shaving, and decentralised systems.

- **Solar Thermal.** Increasing the local solar thermal energy content and leveraging South Africa's industrial competitive advantage through new technologies that add value to the national energy mix.

- **Solar Heating and Cooling.** Diversifying the use of solar water heating, e.g. for space heating in the domestic sector to decrease the electricity demand during low-temperature seasons. Also, space heating together with manufacturing or low-temperature process heat applications will be looked at on a commercial scale.

- **Solar Photovoltaic.** Supporting the development of cost competitive solutions for beneficiation of metallurgical grade silicon to Solar PV grade, therefore improving locally based innovation integration.

- **Industry Stimulation.** Assisting the localisation of components that allow product offering diversification by existing industries and the establishment of new industry. The emphasis will also be on supporting technology adoption through demonstration of solar energy technology solutions in various sectors.

Another notable example of clean energy innovation being deliberately utilised to unlock economic development, is the DST's Hydrogen South Africa (HySA) RDI programme. It is a natural resource value-added processing project aimed at increasing the market for South Africa's platinum reserves by helping stimulate the development and global adoption of fuel cell technology, employing a platinum catalyst, as a source of clean energy[15].

A primary objective of HySA is to make South Africa one of the most important sources of catalysts worldwide, with a market share of 25 percent by 2020. This target is intended to ensure the local beneficiation of platinum, the commercialisation of local intellectual property, the establishment and exploration of a domestic fuel cell manufacturing sector, the potential to explore the use of fuel cell technology in niche markets (thereby making South Africa one of the foremost centres for fuel cell technology), and, consequently, creating jobs.

The DST developed HySA, formally launched in 2008, as a 15-year RDI strategy. The programme consists of three phases: the first two focus on capacity building and demonstration, whereas the final phase (2018 – 2023) will aim at commercialising relevant South African innovations[16].

To deal with the technological challenges facing the development and deployment of commercially viable hydrogen fuel cells, the DST set up three centres of competence (CoCs) to work in the three focal areas required to achieve the technological goals of the programme. These CoCs are HySA Catalysis, in partnership with the University of Cape Town and minerals beneficiation science council, Mintek; HySA Infrastructure, in association with the CSIR and North West University; and HySA Systems, hosted by the University of the Western Cape. The activities of these CoCs are coordinated by the HySA Programme Office, hosted by Mintek.

South African innovations in the making

It is truly an exciting prospect that some of the country's brightest minds are applying themselves to find solutions relevant to local circumstances. Of these, seven inspirational energy RDI projects, and the institutes driving them, are highlighted here.

Council for Scientific and Industrial Research (CSIR) Energy Centre, Energy Autonomous Campus (EAC) initiative

The CSIR undertakes directed, multidisciplinary research and technological innovation that has the potential to contribute to a vibrant economy and employment opportunities. As a state-owned entity, the CSIR plays a key role in supporting Government's programmes through directed research that is aligned with the country's priorities, the organisation's mandate and its science, engineering and technology competences. In 2015, the CSIR established a new research unit, the CSIR Energy Centre, to drive research and development in RE and other energy solutions for South African applications.

A key initiative of the Energy Centre is the Energy Autonomous Campus (EAC), which is exploring the realities and practicalities of a 100 percent RE future – and the journey towards achieving this aspiration. The initiative entails a comprehensive demonstration facility being developed to test and demonstrate an array of RE solutions and integraton concepts to assist the CSIR in understanding the most cost effective option for specific applications, the advantages and drawbacks of certain technologies, and combinations thereof, and the risks related to different methods of implementation.

The EAC is actively testing and demonstrating numerous RE and storage innovations, including hybrid generation, electric vehicles and power-to-gas storage. For more mature technologies, such as Solar PV, a variety of different components and different technologies are being tested and monitored to determine what technology is more promising regarding output and investment cost. Besides generation and storage (refer insert below), the EAC is enabling issues of grid infrastructure, system integration, network management, demand-side management and demand-shaping protocols[17] to be examined and validated. Ultimately, the intent is to transition the entire campus onto a smart power grid using natural resources for all its power requirements – a veritable acid test in the making.

BOX 2

South Africa energy storage, technology and market assessment study

One of the important components that is piloted by the EAC, is an energy storage facility that will simulate storage in a grid environment. The CSIR is collaborating with Eskom to develop the pilot project, which will be informed by a comprehensive study on energy storage business cases for South Africa, titled 'South Africa Energy Storage Technology and Market Assessment' and was concluded early in 2017.

The study was initiated by SANEDI and the Industrial Development Corporation (IDC), with funding support from the Unites States Trade and Development Agency (USTDA). It was overseen by a steering committee that consisted of representatives from Eskom, the IPP Office, Energy Intensives User Group (EIUG), **the dti**, DST, IDC, South African Photovoltaic Industry Association (SAPVIA), South African Wind Energy Association (SAWEA), CSIR, City of Johannesburg and NT.

The objective of this study was to show the benefit of energy storage technologies in the South African energy context. This effort included market research; technical, economic and financing assessments; developmental, environmental and legal/ regulatory assessments; and a plan that recommended steps, milestones and timelines for the adoption of energy storage technologies in South Africa through 2030. The focus of this study has been on utility-scale (more than 1 MW) energy storage technologies. The report has been requested by **the dti**, DST and IPP Office to inform future planning and decision making.

The long-awaited study, completed in March 2017, was formally launched in August 2017.

Demonstration installations include the most popular technology options, as well as any other feasible new technology. Feasibility is a qualifying criteria for installation; any energy project undertaken as part of the EAC is required to have a thorough business case that was approved by an executive committee of the CSIR.

This practical installation initiative is providing a comprehensive testing platform of every aspect of importance to effectively incorporate a growing share of RE in the South African power system. Data gathered on this experimental basis will be invaluable to inform more accurate decision making and planning by all stakeholders.

University of Cape Town (UCT) project to develop a low cost, hybrid electric power generator

As seen in Chapter 4, innovative electrification solutions remain a priority focus area in the country. The Department of Electrical Engineering at University of Cape Town (UCT) is collaborating with the Energy Research Centre (ERC) to develop a low cost, hybrid electric power generator, offering a potentially promising solution for remote, rural electrification where sparse population densities and the high cost of infrastructure present challenges.

Researchers are in the process of constructing and testing an Advanced High Efficiency Turbine (AHET) prototype in the field that can be powered by various thermal and, mainly, sustainable energy sources. The generator is designed to operate with biogas, natural gas and bio-diesel in addition to solar thermal energy. The aim is to develop a cost effective, clean energy solution that can support advanced agriculture projects for high-yield food production, including hydroponic farming and intensive fish farming.

The ERC at UCT hosts an interdisciplinary faculty (engineering, economics, history, statistics, political studies, and physics) that is focused on developing insights into energy challenges pertinent to Africa. The major research focus areas are energy, poverty and development; EE; energy systems analysis and planning; energy, environment and climate change; and RE. Currently, the Centre offers two Masters programmes: MSc (Eng.) in Sustainable Energy Engineering and MPhil in Energy & Development Studies.

Cape Peninsula University of Technology (CPUT) investigation of sustainable biogas production from waste bio-resources

Modern forms of bio-energy remain underexplored as a RE resource in South Africa. Compared with countries such as India, South Africa has seen limited innovations focused on making bioenergy solutions more broadly available. The CPUT Bio-resources Engineering Research Group (BioERG) recognised the latent potential in this area and are setting out to solve some of the barriers to implementation. Their current focus is on exploring various waste and non-food energy crops in combination with various anaerobic digester technologies to harness sustainable biogas production in South Africa. The group currently has four post graduate students working on conversion of waste from abattoirs, food plants and energy crops (such as cassava and sugar beets), to energy. BioERG collaborates extensively across academic and research institutions active in the waste-to-energy sector.

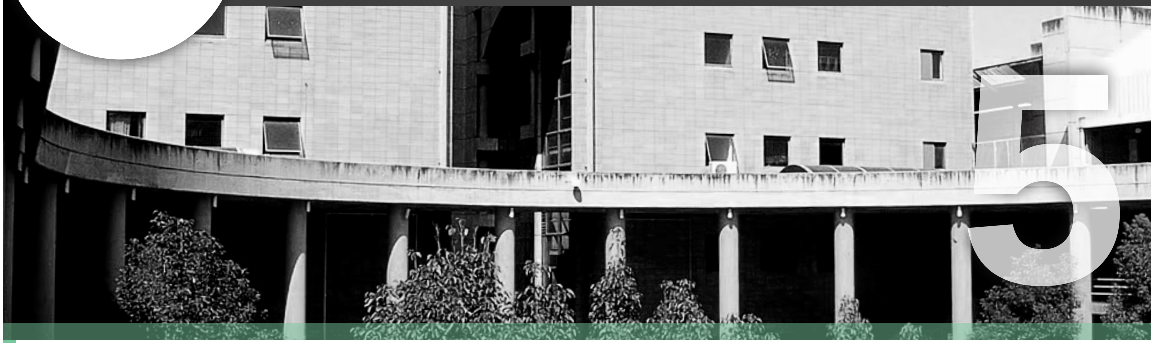
Students are also exposed to, and encouraged to get involved with, this field of study during their undergraduate years. The hope is that some of the students, now familiar with the various technologies, can become future proponents for, or operators and managers of, biogas facilities in the country.

University of Stellenbosch (US) exploring biofuels and bioenergy-from-waste bio-resources

Similar bioenergy aspects are being explored by the University of Stellenbosch. The current focus is on waste-to-energy, including paper waste, fruit waste, waste plastics, agricultural residues, agro processing residues and waste tyres. Biochemical (fermentation, anaerobic digestion) and thermochemical (pyrolysis, gasification) methods are being used to convert the aforementioned wastes to energy and other valuable products. Various potential combinations of feed stocks and conversion technologies are being assessed in terms of feasibility and sustainability. Feasibility considers technical process performances, and the optimisation thereof up to pilot-plant scale. Technical performances from own, pilot plant research is combined with reported values from literature to develop simulations of industrial production facilities (factories), through rigorous modeling of mass- and energy-flows, and the associated equipment and utilities sizing. The latter technical information is then used to develop economic models, to determine which of these opportunities are viable investments, as well as assessments of environmental impacts, social and job creation benefits.

The research group also has a strong focus on biofuels and other clean energy fuels and aims to develop technologies required for commercial production of second-generation bio energy from lignocellulosic biomass in South Africa. The group, consisting of 18 Masters and 17 PhD students, as well as seven postdoctoral researchers, is presently working on the design and construction of an industrial-scale demonstration facility for a new waste-to-ethanol technology. This facility will be mobile in nature, and will allow technology development and demonstration to be completed on industrial sites, subject to typical industrial operations. This is an essential step in moving the technology from the laboratory to industrial practice, and eventually commercialisation.

Vaal University of Technology (VUT) exploring water and energy solutions



Both water shortages and water quality are anticipated to be major areas of concern for South Africa in the near future. Given the water energy nexus (with water critical for energy production and energy critical for water purification, treatment, and reticulation), significant scope exists for further R&D and innovation in this area.

It is in this context that the VUT established the Centre for Renewable Energy and Water (CREW) with the aspiration to address regional, national and global challenges related to RE and water. The research centre operates across multiple faculties, drawing heavily on the Science, Engineering and Technology departments.

Currently, CREW is managing four national and three international projects, all in the field of water and RE. Research activities span the spectrum, from fundamental and applied research to demonstration in collaboration with industry and municipal partners. Collaboration with municipalities is largely focused on anaerobic digesters supporting waste beneficiation to produce both fertiliser and energy in the form of heat or electricity. Through fertiliser production and irrigation, this research is linking up with agriculture and food production, tying in with the broader food-energy-water nexus.

Prof Ochieng Aoyi, Director of CREW, emphasised the significance of innovation in this area: "The quality of life invariably depends on the availability of affordable, clean water and energy, and these can be considered the essential ingredients of development in general, and for food production in particular. The continuing increase in the world's population, especially in Africa, has caused stress on these natural resources. Naturally, science, engineering and technology (SET) is expected to play a leading role in driving the process of developing environmentally friendly technologies."

North-West University (NWU) solar powered food production for Africa

The SUNfarming Food & Energy project is a partnership between Germany-based PV specialist SUNfarming and the North-West University (NWU) in Potchefstroom. The project, run by NWU and co-financed by the German government, promotes growing affordable and nutritious food in local municipalities, effectively addressing household food and nutrition insecurity. Also, the project focusses on the application of technological engineering solutions to take traditional, small-scale vegetable farming to new heights.

Special agrosolar greenhouse structures are used to grow vegetables. While vegetables are grown, the solar panels mounted on top of the tunnels generate electricity. Solar tunnel production gives a much higher yield than conventional farming. Furthermore, no soil is required (organic fibres are used) to grow the agricultural produce and water economy is increased through drip irrigation.

This food and energy project is a first of its kind in Africa. It can create between 50 and 60 employment opportunities per project and offers an income opportunity that combines food production and energy generation – simultaneously addressing three of Africa's greatest challenges.

As a locally grown innovation, it has the potential to serve the entire region. SUNfarming's goal is to roll out the project to all universities and schools in Africa, and it is currently collaborating with Kenyan, Ghanaian, Zambian and Botswana universities to achieve its objective[18].

The Unit for Energy and Technology Systems (UETS), incorporating the previous Energy Research Group, is a multi-disciplinary energy research group, situated in the Faculty of Engineering at the NWU. The centre focuses on research in, and development of, energy and technology systems that are relevant to society, the environment and the country.

Durban University of Technology (DUT) energyDRIVE creating awareness, capacity and skills

The DUT Industrial Energy Efficient Training and Resource Centre (IEETR) conducts research in areas of renewable and sustainable energy. Research projects include development of innovative RE technologies and applications to provide for community energy needs and to minimise the use of conventional energy and its impact on the climate.

Awareness, innovation, development, empowerment and entrepreneurship are some of the priority focus areas for the centre. The centre uniquely assists SMEs and individuals in pre-assessment, funding and designing of their innovative RE projects. In this way, the centre's skills and capacity are effectively leveraged to unlock the innovation and creative potential of more South Africans.

The DUT has teamed up with the Energy and Water Skills Education and Training Authority (EWSETA) to develop energyDRIVE – a mobile RE technology unit. The unit consists of a custom-built truck that will be used for roadshows throughout the country at rural schools and technical and vocational education and training colleges to educate communities on the benefits and uses of RE technologies. The truck, a first for South Africa, was designed by DUT and features a solar roof structure, a wind turbine system, a biodigester, a battery bank television, display cupboards, interactive energy demonstration models and an EE unit. The energyDRIVE truck makes it possible for communities and learners to practically see how renewable technology works, how it can help them with energy access, and how they can use waste to generate energy; for example to power a stove.

In addition, energyDRIVE demonstrates effective public-private sector collaboration to fund research and innovation in energy. The truck is sponsored primarily by EWSETA, but private sector sponsors include Nedbank, Caltex-Chevron and utility metering solutions manufacturer Conlog. Other participating partners and sponsors include the South Africa Wind Energy Project Phase 2 (SAWEP 2), funded by the Global Environment Facility and the DoE, SANEDI implemented by and the UNDP South Africa Country Office[19].

Also, the energyDRIVE project promotes skills training courses in energy-related fields. Candice Moodley, corporate services executive at EWSETA, says, "[The youth] have probably never heard of these careers and this truck [will] create awareness and exposure where they would not have had that opportunity before. Education will open their minds to future possibilities." She added that a mobile RE unit will allow EWSETA to reach a larger number of stakeholders, particularly those in rural areas, who would otherwise not be exposed to the types of RE technologies on display at career days and exhibitions generally held in urban areas[20].

On 3 November 2017, the mobile unit will depart from Durban on an educational road trip and arrive in Cape Town on 13 November. On route, it will spend time with host communities in rural areas and engage with more than 2,500 rural high school learners living close to wind farms. SAWEA has partnered with the DUT and CSIR to make this road trip possible. Participating wind farms will each fund a portion of the road show as well as host field trips for participating learners. Once in Cape Town, the energyDRIVE vehicle will spend time at the WindAc Africa student workshop (14 – 15 November) and at SARETEC.

Exciting new careers and areas of study

RE is changing the way South Africa is being powered and, in doing so, is opening new fields of study and employment. With the expansion of RE comes the opportunity for 'green jobs' – generally well-paying employment in an environmentally beneficial industry. In this manner, this fledgling sector can contribute to the national goal of "Decent employment through inclusive economic growth", as defined in Outcome 4 of the NDP.

The rapid evolution of RE is giving rise to a new marketplace – one in which innovative and profit-able business models continue to develop and new businesses are incubated to become major industrial and manufacturing players and employers of the future. This is, in turn, creating supply chains that provide further entrepreneurial and employment opportunities for the previously disadvantaged as well as procurement opportunities for micro and small businesses.

Because of its tremendous growth and employment potential, the Green Economy is one of the priority sectors recognised by both the Industrial Policy Action Plan (IPAP) and the New Growth Path (NGP), enabling prioritisation of youth in job creation and the strengthening of entrepreneurship. However, as the sector evolves, it is demanding a new skill set[21]. Not only for the manufacturing, construction, operation and maintenance of new 'green' technologies and facilities, but also to explore additional technology innovations, as seen in the preceding section, and opportunities for business incubation and entrepreneurship. Because opportunities in the RE sector are not exclusive to big businesses, it offers much greater potential as a platform for skills and youth development. In addition to expanding the number of opportunities for young South Africans to secure gainful employment, the sector is stimulating entrepreneurship, allowing young people to create their own jobs.

South Africa has recognised the importance of skills development to service the growing RE sector and is driving cooperation with a variety of actors who provide training at different levels. As a consequence, a growing offering in industry-related training and development opportunities is already evident in the country.

As we have seen, universities and universities of technology in South Africa have introduced targeted programmes at tertiary level focussed on RE research and innovation as a response to this growing field of study. These programmes are most often implemented in close collaboration with industry partners to facilitate the integration of innovative developments with private sector interests.

More broadly, the National Research Foundation (NRF)[22], in line with draft DST energy research focal areas, is promoting R&D related to clean energy. Funding support is made available for Masters and Doctoral candidates who want to do research in the following focus areas:

- Cleaner fossil fuel development, including clean coal technologies;
- Renewable energy (bioenergy, including biofuels, solar energy, wind energy, etc.);
- Energy impact on the environment;
- Energy for socio-economic development;
- Energy system planning and modelling; and
- Energy policy research.

RE learning is also being incorporated in curriculums at all Technical Vocational Education and Training (TVET) Colleges throughout South Africa. As part of the national rollout, TVET Colleges introduced the Renewable Energy Technologies (RET) elective, along with the first intake of students, in 2015. Currently, 15 TVET colleges countrywide are offering the RET elective as part of their three-year electrical engineering training programme.

Leading up to 2015, significant effort was focused on the professional development of TVET lecturers to enable the promotion and introduction of these new, green skills at college level. Teacher training and study tours were made possible by the GIZ and the Department of Higher Education (DHET).

The South African Renewable Energy Technology Centre (SARETEC) – an initiative of DHET[iii] – is the first national RE technology centre in South Africa. It has been established at the Cape Peninsula University of Technology (CPUT)[iv] in Cape Town and consists of a state-of-the-art centre with a turbine hall, auditorium, laboratories, workshops, lecture theatres and offices. SARETEC offers specialised industry-related and accredited training for the entire RE industry, along with tailored short courses and workshops. The purpose of the centre is to train technicians to service the growing number of RE projects in the country. By developing local skills and capacity to service the industry, South Africa creates green jobs for locals rather than paying expensive Euro rates for international technicians.

Since 2013, 63 wind turbine technicians have been trained through this initiative (Figure 4). The 2016 group of trainees were the first technicians to receive training at the SARETEC facility in Cape Town.

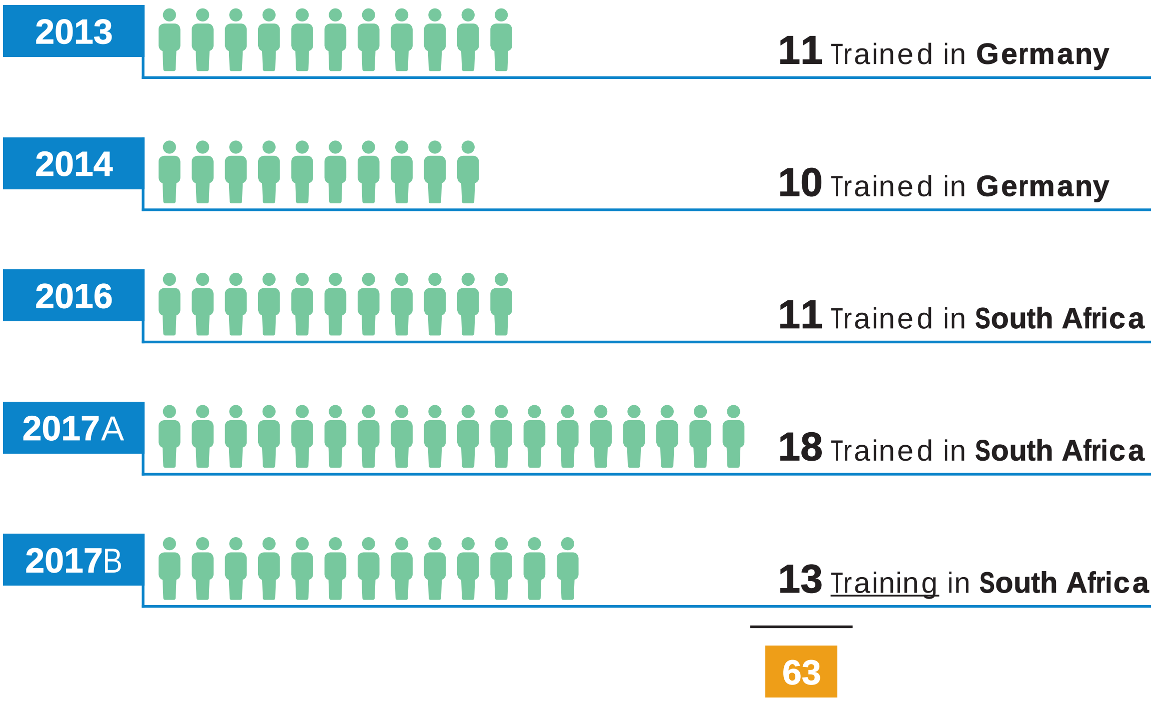


Figure 4: Wind technicians trained by SARETEC

It is unfortunate that some of the most recent trainees have not yet been absorbed by the local industry. This slowdown in new employment opportunities has been ascribed to uncertainty regarding the immediate future of new RE development in the country.

SARETEC qualifications enjoy international recognition and accreditation; it provides young, qualifying South Africans with the opportunity to gain work experience abroad. Severe global shortages of technicians[v] allow easier entry to the job market while providing new graduates with critical work experience – one of the primary hurdles for new graduates to find employment.

iii DHET funding via National Skills Fund with substantial support from the German Ministry for Economic Cooperation and Development through the South African-German energy programme (SAGEN), implemented by the GIZ, the South African National Energy Development Institute (SANEDI) and GreenCape

iv Bellville campus, Cape Town, South Africa

v As an example, a shortage of 7,000 qualified personnel was reported for the European wind energy sector in 2013; this figure is projected to increase to 15,000 by 2030. European Wind Energy Technology Platform (TPWind). Workers wanted: the EU wind energy sector skills gap. 2013

Bokpoort concentrated solar power plant near Groblershoop

This RE training programme and facility are of a world class standard, increasingly offering an opportunity to extend training to international students at comparatively affordable rates.

SARETEC also hosted a two-day biogas training course for plant operators in October 2016, attended by 35 students. It was presented by five trainers (two local, two resident and one international), offering a wealth of diverse experience. The training is linked to the national biogas platform, led by the DoE and the South African Biogas Industry Association (SABIA), and was made possible by funding from the GIZ, which provides secretarial services to the National Biogas Platform. Based on the participation and perceived value of the course material, the option to institute it on an annual basis is currently under investigation.

A growing interest in RE-related training and career opportunities is evident from both the escalating number of participants in the wind technician training and SARETEC's diversifying areas of study, as seen above.

In another collaboration between the DHET, DST and GIZ, formal, practice-centred Solar Water Heating (SWH) installer-training programmes are also being developed for TVET colleges. The initial focus is on building capacity within the colleges to offer the programmes. A first group of 50 trainees, selected from among assistant installers, will be trained as installers against the appropriate qualifications as an implementation pilot. Industry bodies, including the Institute of Plumbing, South Africa (IOPSA) and Plumbing Industry Registration Board (PIRB), and relevant Sector Education and Training Authorities (SETAs), including the Energy and Water SETA (EWSETA) and Insurance SETA (INSETA), will support the quality assurance process for this training programme.

The insurance industry involvement is because water-heating appliances are a key part of short-term insurance and associated claims, with SWH being one of the few energy-compliant water heating options as required by new building standards and municipal bylaws. The capacity and capability of the plumbing supply chain, responsible for both initial and replacement installations, are therefore of importance to the insurance industry.

Also, in the interest of developing and promoting training and implementation strategies for solar thermal technologies in southern Africa, the SOLTRAIN project was initiated in 2009. SOLTRAIN, which is now in its third phase, focuses on four crucial areas: raising awareness around solar thermal energy; building competence in solar thermal technology; creating technology platforms; and demonstrating working installations.

Installation subsidies and technical courses are offered to increase knowledge about the systems. A secondary focus is on job creation at small and medium enterprise level and to initiate and/ or strengthen political support mechanisms for solar thermal systems. This project is financed by the Austrian Development Agency (ADA) and implemented by the Institute for Sustainable Technologies, Austria (AEE INTEC), in cooperation with project partners from South Africa (SANEDI, and Stellenbosch University), Namibia, Botswana, Zimbabwe, Mozambique and Lesotho. During the current phase, 2,850 people have received training and 300 SWH systems have been installed.

Likewise, interest in the sector and clean energy solutions has prompted industry-led training initiatives outside the formal skills development and education framework. The South African public, and youth in particular, are increasingly demonstrating an interest and demand for practical, clean energy-related knowledge and support for entrepreneurs. Entrepreneurship is often recommended as a solution for unemployment and a means to enlarge the economy by innovative enterprises. The relevance of entrepreneurship to economic development is well established, and it is well recognised that education and training opportunities play a key role in cultivating future entrepreneurs.

Imvelisi[23] is an innovative partnership between GreenMatterZa and the South African Young Water Professionals Network (YWP), and a pioneering response to the needs of prospective entrepreneurs in the environmental and water sector. The programme is funded by the DST with the objective of supporting the business development of young water and biodiversity innovators and their ideas. This initiative was started for the water sector, but has many touchpoints with, and relevance to, the RE sector.

The Imvelisi Programme is a conceptualisation phase training intervention for aspirant enviropreneurs. The purpose of the programme is to provide young people with a streamlined innovation support system that helps participants through the formation phase of business development and prepares them for pitches to mentors, incubation programmes, and early stage entrepreneurship investors.

In another display of interest in RE research and development, the sixth annual Windaba Conference, hosted by the South African Wind Energy Association (SAWEA), expanded into a Wind Energy Week. For the first time in 2016, it included an academic conference for the sector, named 'WindAc Africa'. This new academic sister event invited presentation of scientific papers and boasted representation from 32 universities and institutions, 120 attendees and 40 speakers and chairs. In this manner, WindAc is creating a platform for discussions that bridge geographical borders, encourages knowledge sharing and envisions a future for wind power that takes into account opportunities for innovation and the sharing thereof. Following the successful inaugural conference, a second *Academic hour for wind power* at WindAc Africa will be hosted in 2017.

Conclusion

RE is changing the way the world, and South Africa, is being powered and, in doing so, it is opening new fields of study and employment. Development of the RE sector can represent an important vehicle for the economy in terms of spillovers on related sub-industries, job creation, scientific research and new business opportunities. South Africa has a proud history of scientific discovery and innovation[24]. As research institutes apply their intellectual capacity to solving the most immediate questions, we can hope to see more innovation and, with that, stimulus for the budding Green Economy.

The expansion of RE brings with it the opportunity for 'green jobs' – generally, well-paying employment in an environmentally beneficial industry. Through this, the developing new sector can contribute to the national goal of "Decent employment through inclusive economic growth", as defined in Outcome 4 of the NDP.

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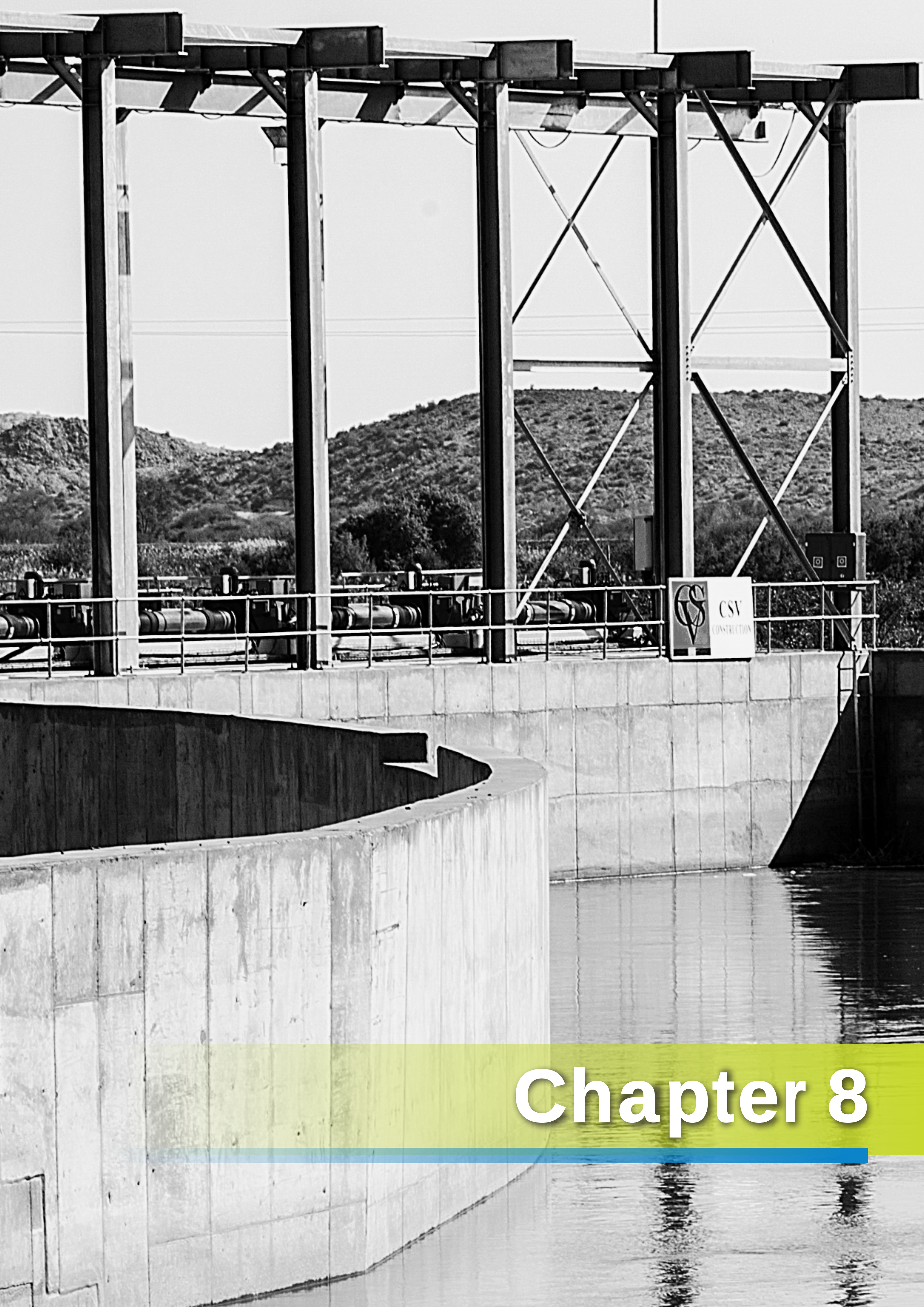


Chapter 8

Chapter 8

The role of Local Government in RE supply and management

A local REvolution

Wind and sun are available everywhere, so RE can be economically harnessed at a small scale across the country. Similarly, a variety of waste by-products, including waste heat, wastewater, municipal solid waste and agricultural wastes, are readily available wherever there is economic activity or human settlements. Intelligent network infrastructure is further facilitating the integration of distributed power sources.

This wide distribution of energy sources, coupled with exponential adoption rates, is radically changing the traditional structure and scale of the power system. Even so, the greater transformation is the democratisation of the electricity grid, enabling a network of independently owned and widely dispersed energy generators, with the economic benefits of electricity generation as widely dispersed as the ownership. These developments are empowering consumers, including local governments, to become more active participants in the energy supply chain. To a large degree, the metamorphosis is similar to personal computers replacing mainframes, Wikipedia and the internet supplanting the library encyclopaedia, or mobile phones superseding fixed line telephones.

The potential for local ownership and economic benefits from energy generation has never been greater. Because it is dispersed and typically connects into distribution level grid infrastructure, this presents Local Government with both opportunities and challenges. Affordable distributed generation options can power remote places, reduce network losses and infrastructure investment, alleviate grid congestion, diversify the energy mix and introduce resilience. But, it also brings about challenges associated with aging infrastructure, multi-directional power flow and communication, system integration, changing a century old business model and the evolving role of the municipality in this context.

BOX 1

Private sector RE initiatives and installation data

Industry developments have enabled the private sector in South Africa to take a leading role in establishing RE capacity. As suggested in Chapter 3 and discussed later in this chapter, Small-Scale Embedded Generation (SSEG) is promising to contribute a significant share of the country's RE capacity in future. At present, limited official data is available to quantify and credit the extent of the private sector initiatives. Some municipalities do maintain project registers, capturing systems known to have been commissioned in the municipal area. The PQRS database (refer Chapter 3) collates data for rooftop PV systems that are voluntarily submitted to the database. Estimates based on aerial photographs suggest, however, that the extent of private sector activity may be far greater than recorded by any of these sources.

Inadequate data will impact forecasting and planning for new energy infrastructure at a national level. This has seen Government embarking on processes to develop regulations to close this gap. The Energy Management Plan (EMP), which is still in draft format, is one such document that may contribute to better information regarding RE market penetration. The requirement for entities to develop and submit an EMP, detailing baseline consumption and planned interventions, will be targeted through an amendment of the Regulations on the Mandatory Provision of Energy Data (previously promulgated on 24 February 2012). The Licensing Exemption and Regulation Notice for SSEG that was published on 10 November 2017, as highlighted in Chapter 2, should offer another mechanism for improved record keeping and data for planning.

The rapid growth of distributed RE requires utility planners and National- and Local Government to examine what the new rules of electricity generation and distribution will be in an age where households and businesses will be both producers and consumers of electricity. If given due consideration, South Africa can unlock the full economic potential of distributed generation and the potential of people to participate in the clean energy future.

This change to local energy supply and services is inevitable and likely to accelerate with resolution of policy issues, increasing affordability of new technologies and escalating electricity prices. It demands active engagement from role players in the energy sector, particularly at Local Government level, to effectively steer this transition.

BOX 2

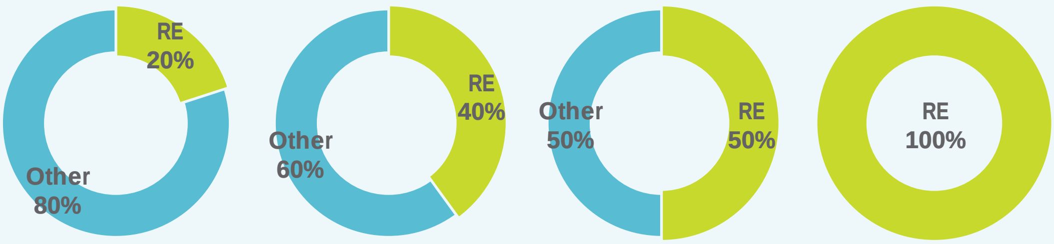
Cities, clean energy and climate change

The pivotal role of cities and towns in the global energy transition and in shaping the planet's energy future is becoming increasingly evident.

COP 21, hosted in Paris in December 2015, was of particular significance to Local Government. The Climate Summit for Local Leaders, held in parallel to the Paris climate negotiations, constituted the largest global convention of mayors, governors and local leaders to date. This event emphasised the vulnerability of Local Government, and the communities they are responsible for, to climate impacts. It also highlighted the role of Local Government in protecting the planet, people and ensuring a sustainable future. Deliberations[i] recognised that local governments are uniquely poised to connect with their residents, are more agile and can be more responsive to change than national governments. The Summit culminated in the Paris City Hall Declaration with nearly 1,000 local authorities from around the world, pledging support for 100 percent RE and 80 percent reduction in emissions[1]. They also called

i As reported by Gregory Scruggs for Citiscope, December 5, 2015 for city-level climate coordination and horizontal integration to facilitate learning, and unlearning, from peers.

South African Local Government was well represented at the Summit[ii] and many have joined the growing list of global cities and towns with ambitious goals for clean energy and RE adoption.



City of Cape Town (2020)[2] | eThekwini Municipal Area (2030)[3] | City of Tshwane (2030)[4] | City of Johannesburg (2050)[5]

The commitment of Local Government in South Africa to sustainable energy, goes back much further than COP 21. South African towns and cities have proactively engaged in numerous international initiatives and global networks dedicated to developing locally relevant solutions, shared knowledge, tools, materials and driving sustainable change:

Global network / initiative	Focus	Number of South African signatories
Mexico City Pact	Global cities covenant on climate	12 municipalities
Carbon Climate Registry	Central repository of the Compact of Mayors launched at the Climate Summit 2014	9 municipalities
Compact of Mayors	Coalition of city governments addressing climate change. The initiative of voluntary city pledges to reduce GHG emissions and enhance resilience to climate change	At least 13 municipalities
C40 Cities Climate Leadership Group	Network of megacities committed to addressing climate change	4 cities
Local Governments for Sustainability (aka ICLEI)	Global network of over 1,500 cities, towns and regions committed to building a sustainable future	21 municipalities, including all 8 metros

National networks have also prioritised city level coordination and collaboration in the interest of sustainable energy and climate change. The South African Cities Network (SACN) is a network of South African cities and partners that encourages the exchange of information,

ii The South African Local Government delegation represented 11 metropolitan, district and local municipalities across South Africa as well as supporting organisations such as the South African Local Government Association (SALGA), the South African Cities Network (SACN) and ICLEI-Africa experience and best practices on urban development and city management. Under the sustainable cities focal area, the emphasis is on creating greener and liveable cities by promoting sustainable energy, improving waste management and water management, and mitigating climate change effects. The network has collated extensive resources to support local authorities with informed energy planning and decision making, available on the SACN website (http://www.sacities.net/sustainable-energy).

Similarly, the Local Government Partnership for Climate Change (LGP4CC), a partnership programme between SALGA, SACN and all municipalities, is facilitating engagement and capacity building at local authority level with the focus on enhancing Local Government's response to climate change.

Local governments are also actively building capacity on sustainable energy with at least 17 cities and towns having developed energy and climate change mitigation strategies[7]. A 2015 analysis[8] of municipal Integrated Development Plans (IDPs) noted that at least 50 percent of all municipalities mention climate change or sustainable energy and have identified related projects. The study showed that the number of municipalities with budget allocations earmarked for climate change or sustainable energy projects had almost doubled between 2012 and 2015.

Adding a local energy dimension

Local governments are tasked with the provision of services in a sustainable and equitable manner, the facilitation of social and economic development and the promotion of a safe and healthy environment for all residents. Changing demographics, technology developments and economic and social challenges are prompting a transformation in all areas of Local Government service delivery that will accelerate between now, 2025 and beyond.

In South Africa, Local Government is one of three spheres of Government (refer **Box 3**) and mainly concerned with service delivery required for the efficient running of towns and cities. Local Government is directly faced with tremendous development challenges and opportunities and uniquely positioned to take a leading role in South Africa's economic revival and development. The planning decisions and infrastructure investments made by Local Government over the next few decades will determine the sustainability and prosperity of South African towns and cities; indeed, the national economy.

BOX 3

Local Government in South Africa: a brief introduction

The Constitution of South Africa defines three spheres of government in South Africa i.e.: (i) National Government, (ii) Provincial Government, and (iii) Local Government.

Local Government in South Africa consists of municipalities. The whole of South Africa is divided into municipalities of various types. The largest metropolitan areas are governed by metropolitan municipalities (metros), while the rest of the country is divided into district municipalities, each of which consists of several local municipalities. The essential difference between the types is that metro municipalities have full executive and legislative autonomy while district municipalities share executive and legislative powers with their respective local municipalities.

Since the boundary reform at the time of the municipal elections of 3 August 2016 there are eight metropolitan municipalities, 44 district municipalities and 205 local municipalities[9].

Local Government is regulated by Chapter 7 of the Constitution. Section 152 of the Constitution sets out the five basic objectives of municipalities:

- to provide **democratic and accountable government for local communities**;
- to promote **social and economic development** of their communities;
- to promote a **healthy and safe environment**;
- to **encourage the involvement of communities** and community organisations in the matters of Local Government by consulting with the community and letting the community participate in the decision-making process; and
- to **provide basic services to communities in a sustainable manner** – services such as water and sanitation, electricity, refuse removal, health and fire-fighting services, public transport and roads and parks.

Integrated Development Plans (IDPs) are key planning documents for Local Government. The IDP is a five-year plan, linked to the budget, that provides an overall framework for development for the municipal area. The plan identifies the priority initiatives over the planning period towards delivering on the above-stated objectives. All capital investment and infrastructure projects, including those related to EE and clean energy initiatives, should be included in the integrated planning process and reflected in the IDP.

Service Delivery and Budget Implementation Plan (SDBIP) is developed on an annual basis to present a detailed one-year implementation/operations plan, of functions which the municipality is responsible to implement and that gives effect to the implementation of the Integrated Development Plan (IDP) and the approved budget for the specific financial year.

Affordable, reliable energy underpins the ability of municipalities to deliver essential services and promote local economic development. Local Government can and do have a significant impact on both energy production and energy consumption and, as highlighted already, are important role players in the transformation of the energy sector. Local Government is in turn impacted by the sector transformation, that changes the traditional market and business models, but brings with it the opportunity for municipalities to participate more actively in cost effective, sustainable energy solutions and improved service delivery. Proactive engagement with energy production and supply is inherent to the roles and responsibilities of municipalities awarded by the Constitution (refer Box 3) and not new (refer Box 4). Many municipalities used to generate their own electricity. A few still have generation licenses.

BOX 4

History of municipal power generation and distribution

From 1895 to the 1960s, municipalities in South Africa were responsible to build generation plants to supply residents and small businesses with electricity. During this period, large municipal power projects such as Orlando (550 MW) and Kelvin (600 MW) Power Stations in Johannesburg and Salt River I and II in Cape Town (90 and 240 MW), were commissioned to keep up with the growing demand. The Electricity Act of 1922 created the Electricity Supply Commission (Escom) that was officially established in 1923.

In the 1970s, the Margate Agreement[10] determined that electricity generation and transmission in the country will be undertaken by Eskom (then still called Escom). Municipalities would only retain control of electricity distribution in their area of distribution. Consequently, municipal energy services in the most recent decades have been focused on electricity distribution and reticulation.

Energy sector developments are bringing about a significant shift, again expanding the potential scope of municipal energy services.

The extent to which the opportunities and challenges affect Local Government depend on the available capacity and resources and the most pressing, immediate service delivery needs within the municipality. This varies across the respective levels of Local Government. On average the metros have 387 people living per square kilometre compared to 64 in local municipalities[11]. Low population densities, most predominant in poorer rural areas, generally translate to limited municipal income, limited financial and human resources, sparse infrastructure, and widely-dispersed service delivery requirements.

In terms of electricity services and infrastructure, metros and large towns have already provided 88 percent of households with access to electricity. In comparison, smaller municipalities (categories B2 – B4), on average, lag by two- to three percent[12].

Figure 1: Percentage of households with access to electricity by municipal category[iii] (StatsSA)

Electrification levels among local municipalities are, however, not uniform, with backlogs[iv] concentrated in remote, rural areas (Figure 2).

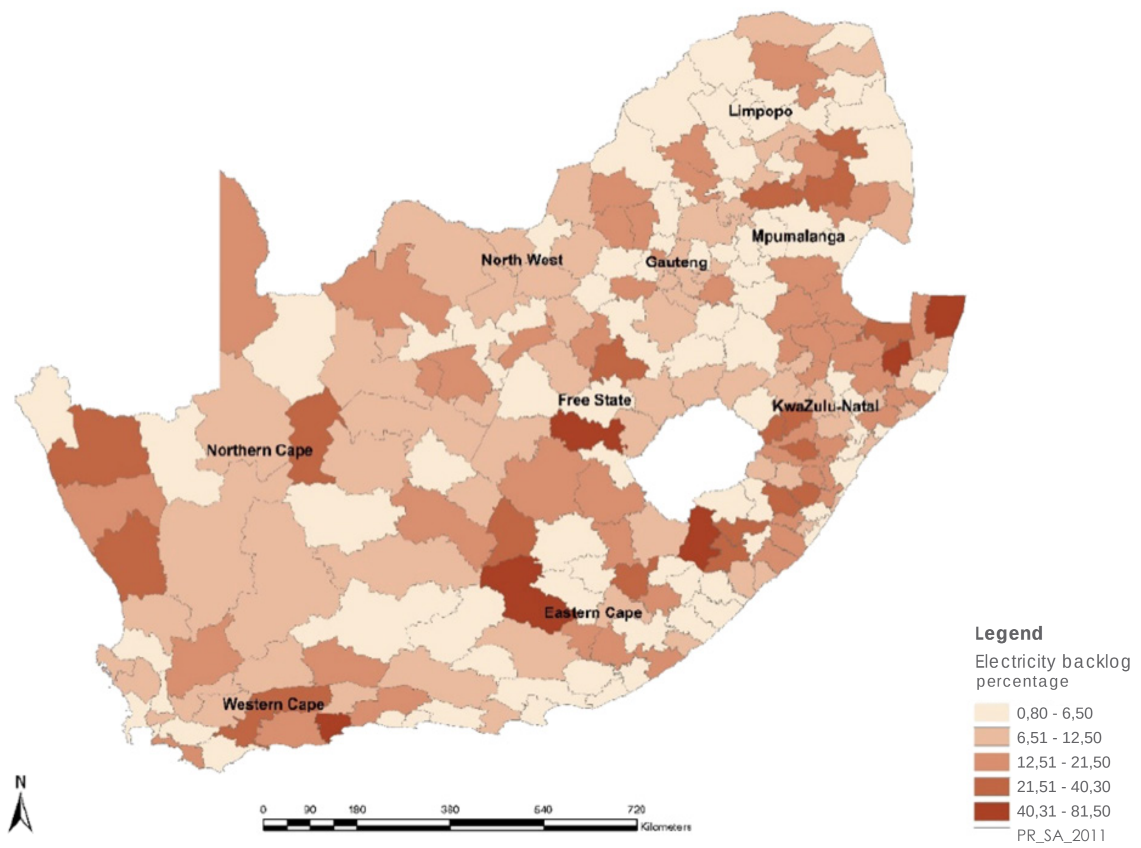


Figure 2: Backlog in electricity services across demarcated municipal areas *(StatsSA)*

iii Municipal Infrastructure Investment Framework (MIIF) classification: TYPE A Metropolitan municipalities (metros); TYPE B1 Secondary cities, local municipalities with the largest budgets; TYPE B2 Local municipalities with a large town as core; TYPE B3 Local municipalities with small towns, relatively small population, significant proportion of urban population but with no large town as core; TYPE B4 Local municipalities that are mainly rural with communal tenure and with, at most, one or two small towns in their area

iv The definition of backlog as defined in the Eskom Universal Access to Electricity Business Plan includes all existing housing units that do not have access to electricity (i) 'Brown fields' or Infills – Potential connections that are within a range of 300-550m of existing pre-paid distribution transformers; (ii) 'Green fields' – Potential connections that are outside these respective boundaries; (iii) Known formal housing projects as provided by regional planners.

Creating sustainable cities

In comparison to the smaller, local municipalities, metros and larger towns are better equipped to leverage the developments in the energy sector towards building a sustainable future. Despite higher levels of electrification (Figure 1), cities are facing the highest levels of consumer dissatisfaction[v] with existing electricity services[13]. Such expectations of service levels are commensurate with the economic gains and losses at stake in urban areas.

Akin to global trends, South African cities have been driving growth and development, generating almost two-thirds of the country's economic activity and just over half of national employment[14]. A report published in 2015 by Sustainable Energy Africa showed that 18 South African cities and towns are home to more than half (52 percent) of the population, confined to less than five percent of the country's land area. These 18 urban centres produce approximately 70 percent of South Africa's economic wealth, while consuming more than 33 percent of national energy, more than 45 percent of national electricity and 52 percent of the national fuel usage.

Energy is an acknowledged essential to support this scale of economic and socio-economic activity. Even so, unabated consumption of fossil fuels is also recognised as a threat to economic and environmental sustainability and the attractiveness of these urban centres.

Clean energy solutions, encompassing the efficient use of energy and renewable sources of energy, offer an opportunity to support economic activity, to provide modern services and sustainable service delivery and create better living spaces by improving air quality, reducing carbon emissions, reducing congestion, contributing to job creation and feeding into the Green Economy. South African cities have recognised this and are actively developing and implementing strategies and plans to create more sustainable environments.

Internationally, cities have become among the fastest moving governmental actors adopting RE technologies and joining in the global energy transition. This transition is cutting across the entire urban energy landscape, from buildings to transport, to industry and power. South African cities are seen to do the same, actively exploring appropriate options to promote green transport, fuel switching, integrating small-scale embedded generation, while also investigating opportunities for cost-competitive, distributed generation for municipal supply.

Challenges and opportunities in local municipalities

In the most rural, sparsely populated areas of the country the local municipalities are the least capacitated and rely more heavily on districts to support the delivery of municipal functions. Rural municipalities also have higher staff vacancy rates than more urban counterparts. The last State of Municipal Capacity Report published by the Municipal Demarcation Board[15] also emphasised the gulf between the technical capacity of the metros and that of the most rural municipalities. At the time, 44 percent of the rural district municipalities did not employ any engineers.

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v Only 63.6 percent of households in metros were satisfied with electricity services, i.e. below the national average of 64.8 percent


Hopefield wind farm near Hopefield

As mentioned earlier, access to electricity remains a challenge for local governments in sparsely populated areas. In many of these rural areas, electricity services are shared between Eskom and the local municipality. Municipalities provide electricity services to the majority of households in the Free State (78,4%), Northern Cape (70,7%), Gauteng (60,5%) and Mpumalanga (58,7%) while Eskom is most active in Limpopo (79,7%), North West (67,3%) and Eastern Cape (63,75%). This means that municipalities are dependent on Eskom for the provision of electricity services in their areas of jurisdiction and have no direct control regarding timing of service delivery.

Chapter 4 highlighted how the emergence of affordable, distributed energy solutions is creating an opportunity to extend service delivery to under serviced areas. It is also creating opportunities for innovative service delivery partnerships with citizens or private sector organisations. However, given capacity challenges, local municipalities will be most stretched to leverage potential opportunities and accommodate the changing technical and business requirements.

The need for an enabling policy environment

Considering these energy sector developments, opportunities presented by distributed generation as well as municipal constraints, Local Government, through the South African Local Government Association (SALGA), has appealed to National Government to be acknowledged as an active player in the energy services sector and a resource in terms of the country's integrated resource planning[16].

Chapter 2 raised several key regulatory and policy decisions that are currently unresolved, thereby limiting the participation by local governments in alternative energy and cleaner mobility solutions and rendering municipalities vulnerable to the changing energy landscape. Without clear, new rules, the RE future will develop according to an outdated paradigm with potential economic benefits remaining underexplored.

As an interim solution, NERSA has agreed since July 2016 to approve municipal Small-Scale Embedded Generation (SSEG) tariffs on a case-by-case basis while waiting for the regulations to be finalised. It is based on the understanding that the interim tariffs and processes will be adapted to the regulations once published.

Besides matters related to resource planning and SSEG that are currently under scrutiny, the policy position with regards municipal generation requires further clarity. Conflicting opinions exist as to whether the current policy and legal framework allows municipalities to pursue local generation or procurement options. Some legal practitioners[17] suggest that Section 151 of the Constitution provides the framework for municipalities to govern their own affairs, as regulated in detail by the Municipal Finance Management Act, Municipal Structures Act and Municipal Systems Act. This legislation would permit local utilities to conclude power purchase agreements with Independent Power Producers (IPPs); the Electricity Regulation Act does not exclude the possibility of local authorities making money from electricity jointly with IPPs.

The Electricity Regulation Act (ERA) does not place limitations on who may apply for generation licenses, including power purchase agreements (PPAs) and generation by municipalities. However, Section 34 of the ERA empowers the Minister of Energy, in consultation with the National Energy Regulator (NERSA) to determine how, when and who may generate and purchase new electricity. In 2007, the Minister, acting in terms of Section 34, determined that Eskom would be the **sole** purchaser of electricity[vi,18]. Eskom Holdings SOC Limited is accordingly the sole entity empowered to purchase energy and enter into PPAs with IPPs. If interpreted in this way, it would effectively exclude municipalities from entering into PPAs with IPPs and if a municipality or an IPP were to produce its own electricity, it would have to do so for its own consumption. As a result, the City of Cape Town, together with a number of other municipalities, have applied for a Section 34 determination to allow them to procure RE directly from IPPs[19]. The outcome of this application remains undetermined.

In April 2017[20], the Cape Town mayor announced that the city will be taking legal action against the Minister of Energy to secure its rights to purchase power directly from renewable IPPs. The city indicated that this decision was founded in the responsibility of the city for the growth and wellbeing of local economies and citizens.

An urgent resolution will hopefully enable municipalities to participate as legitimate partners in the sector and deliver an appropriate service in relation to their communities and finances.

Local Government showing leadership

Despite remaining policy uncertainties, several South African cities and towns are proactively engaging with the opportunities at pilot scale and/or embarking on innovative clean energy initiatives within the existing framework.

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vi This decision has never been revoked

Pilot projects span a range of technical applications, exploring innovative clean energy solutions in the areas of:

- EE and demand-side management;
- Municipal-owned RE generation;
- Distributed generation, both small scale and utility scale;
- Sustainable energy solutions to improve energy access and alleviate energy poverty; and
- Cleaner mobility.

Through established networks and SALGA, experiences are shared so they might be adopted more broadly, but may also inform national policy positions and frameworks.

Energy efficiency (EE) and demand-side management

Energy efficiency has the potential to deliver 49 percent of global emissions reductions[21]. EE has been called the 'first fuel' of economic development, which should be invested in ahead of more complex and costly energy solutions. The notion of 'energy-efficient prosperity' was defined by the IEA and is especially relevant for developing countries, which can most benefit from investing in EE improvements that provide affordable and reliable services, while supporting a strong economy and improved quality of life over the long term.

Analysis by the IEA[22] has shown that, if EE investments were scaled up, they would have the potential to reduce South Africa's need for additional electricity generation capacity by 18 percent in 2030. They could also allow the country to avoid burning 25 million tonnes of coal, equivalent to 275,000 railcars full of coal.

For a growing economy such as South Africa's, meeting energy demand also means improving both energy access and energy security. The IEA suggested that the use of available energy efficiency measures could achieve universal provision of modern energy services with 50- to 80 percent less energy.

The South African policy framework recognises EE as a key element of a sustainable energy system and a national priority, as reflected in both the NEES and the IRP (refer Chapter 2). Objectives and targets stated at national level must, however, be complemented by action at the local level. Local governments can take a leading role in a range of energy interventions, both in terms of own infrastructure and operations and by encouraging EE within their domains.

Improving the efficiency with which energy is consumed must be a priority as it supports greater economic activity in the municipal area using less natural resources and at lower costs. Internal efficiency (public facilities) should be the highest priority as this reduces operational expenses and contributes to energy savings and environmental benefits. In 2009, National Treasury and the

DoE initiated the Municipal Energy Efficiency Demand-Side Management (EEDSM) programme to support EE measures for Local Government facilities. Detail of the support available through this programme is available (page 170, ref EEDSM under DoRA).

Local governments can also influence the way residents consume energy. Such initiatives are being implemented through awareness campaigns; information portals; technology exchange programmes; or by adopting, monitoring and enforcing building regulations for new construction.

Droogfontein solar power PV plant near Kimberley

eThekwini Metro Municipality Energy Efficiency and Demand-Side Management (EEDSM) case study[23]

The eThekwini Metro Municipality has prioritised EE within a holistic sustainable energy policy and strategy framework that incorporates their Energy Strategy (2008), Internal Energy Management Policy (2012) and Durban Climate Change Strategy (2015). Implementation of the metro's sustainable energy objectives is a function of the Energy Office, established in 2009. Within this context, the metro promotes EE through education, awareness, EE technology and internal efficiency programmes.

eThekwini operates more than 2,000 municipal facilities, including office buildings, clinics, swimming pools and depots, among others. Efficiency upgrades and interventions have already included a conversion to LED traffic and street lighting; efficient lighting in public buildings; and efficient pumps and motors at wastewater treatment plants. The metro successfully accessed R45 million from the EEDSM fund, supplementing municipal funds to implement these interventions.

One of the more recent efficiency upgrades was completed for the eThekwini Health Unit headquarters building. The Health Unit is located at Masinga Road in Durban and operates from 07h00 to 17h00 weekdays. The building spans 11,200m^2 and consists of a four story office block, two laboratories, a large auditorium, several large store rooms and a defunct cold store.

A lighting retrofit for the Health Unit building was approved under the Division of Revenue Act (DoRA)-funded EEDSM programme. The retrofit entailed the replacement of old, inefficient lighting with modern, EE task-sensitive lighting combined with occupancy and light sensors in selected areas. The improved lighting system allowed the number of lamps and light fittings to be reduced without compromising the required light levels.

The solution was implemented at a total cost of R1.028 million[vii] (including installation costs and the development of a baseline for monitoring and evaluation). The efficiency upgrade reduced the peak demand for the building by 18 percent and annual consumption by 172 MWh. The resultant saving on electricity costs is R 224,000 per annum, which will recover the investment in just more than four years.

Municipal-owned RE generation

Local governments own and operate a variety of facilities with potential for clean energy generation that can effectively contribute to the energy needs of the municipality itself. Within Local Government, energy is typically consumed for water and wastewater treatment, solid waste management, public buildings, street and traffic lighting and the fleet of municipal vehicles. Rooftop Solar PV, Waste-to-Energy and Biogas readily offer viable, clean energy solutions to power municipal activities. Opportunities for small Hydro, Wind and Biomass may also exist and would depend on the resources available within the municipal area.

The quality of solar resources throughout the country, combined with steadily falling technology costs, make rooftop Solar PV a viable generation option for most Local Government facilities with adequate roof space. Switching to solar energy provides cities and towns with an opportunity to reduce their operating costs, decrease greenhouse gas emissions, add green jobs to the local economy, and encourage their residents and businesses to switch to solar by acting as an example. Small-scale Solar PV installations and the associated services, is expected to offer significant employment opportunities. The economic opportunity extends to the supply chain, including manufacturing and assembly of PV panels and components.

Illustrating the growing interest in Solar PV solutions for public buildings, Gauteng Province announced in 2015 that they will be installing rooftop solar panels on the eight million square meters of rooftop space available on Provincial Government buildings. This is expected to provide between 300 MW and 500 MW generation capacity. The Gauteng Department of Infrastructure Development initiated the Rooftop Solar Photovoltaic (PV) Rollout Programme under their integrated demand management plan in 2015 and registered it as a potential PPP with National Treasury. In the 2017 State of the Province Address[24], the commitment to invest in green and sustainable energy infrastructure was reiterated. It was reported that the rooftop Solar PV Project is underway, currently seeking to roll-out solar panels at 16 health facilities in the province.

eThekwini Municipality, Ushaka Marine World Solar PV case study

In January 2017, the eThekwini Municipality launched the uShaka Marine World Theme Park Solar PV project[25]. The total project has seen the installation of Solar PV panels on five municipal buildings as a pilot project that aims to promote the use of embedded rooftop Solar PV generation in eThekwini and reduce the dependence on the national energy grid. The combined annual power output from all five pilot installations is projected to be 426.75 MWh, translating to R337,396 of cost savings during the first year.

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vii Not including VAT

The project allows the municipality to test its own policies and practices and serves as an example for the private sector and other municipalities to learn from. The installation provides opportunities for learning about various aspects such as electricity generation profiles at different times of the day and year, the various technologies and sizes, quality control, monitoring and evaluation of electricity. The lessons learnt will feed into policy development to expand the number of RE installations in eThekwini.

Bokpoort concentrated solar power plant near Groblershoop

uMhlathuze Municipality, Empangeni Library case study

On a smaller scale, Solar PV was installed in the uMhlathuze Municipality, KwaZulu-Natal, to power the Empangeni Library. The facility is used on a daily basis by the surrounding community, providing support to the local economy through access to knowledge and internet facilities.

Solar energy is captured by 28 solar panels that can provide an estimated 7,1 kilowatt peak (kWp). The power is stored in eight batteries and connected to an inverter. This allows the library to run their lights and dedicated computers. The Solar PV installation was combined with EE measures for an optimal energy solution. The showcase project included the retrofit of 337 tube lights to LEDs that resulted in a 60 percent reduction of energy use for lighting. As part of an awareness campaign around EE and RE, the library created a permanent exhibition showcasing practical, sustainable solutions and EE technologies, including a Wonderbag, mobile solar light and compost bucket.

The project was supported by the Urban Low Emissions Development Strategies (Urban-LEDS) initiative in South Africa, which focuses on a range of practical projects that engage local communities to improve their living conditions and simultaneously contribute to reducing local GHG emissions and adapting to climate change.

The value of this project was confirmed by Tumelo Gopane, Deputy Municipal Manager[26], who said "this showcase project helps to provide a shining example of what can be done in municipal buildings. We are already addressing the traffic lights and street lights, so now we also need to consider the lighting requirements in the various municipal buildings."

Camdeboo Local Municipality Wastewater Treatment Works case study

In Nieu-Bethesda, a Karoo village in Camdeboo Local Municipality, Solar PV was introduced to power a wastewater treatment facility that radically improved service levels for the community. Before the construction of the Nieu-Bethesda wastewater works, the community relied on septic tanks, VIP toilets or the bucket system for their sanitation needs. When the eradication of the bucket system was initiated, Camdeboo and Sarah Baartman District Municipality partnered to create a more sustainable sewer management system. They had to move away from a decentralised to a centralised system, introducing a system that transports household waste from the households through a network of sewer pipes, to a municipal treatment plant. By developing this system, the municipality could ensure that all households had access to a water-borne sewer system with an indoors flushing toilet[27].

The waterworks were kept off-grid with the installation of 11 kW Solar PV panels and a solar water heater to provide hot water to the building at the wastewater treatment plant.

Municipal solid waste presents another significant energy resource. Waste with a high organic content generates methane gas as it decays. The methane gas of landfilled waste can be captured and harvested as an energy source. Alternatively, the waste can be diverted from the landfill site and incinerated for power production. It can therefore be used to generate power and contribute to waste management and methane gas emission reductions.

Contrary to the intermittency of RE sources such as Solar and Wind, Waste-to-Energy and Landfill Gas plants typically operates at 70 percent[viii] capacity factor, providing power consistently throughout the year.

Waste-to-Energy and Landfill Gas power plants offer a more sustainable energy solution. Methane destruction significantly reduces carbon emissions. The burning of waste using modern technology generates lower emissions compared to coal-fired power stations. Because the plants are in close

Bokpoort concentrated solar power plant near Groblershoop

viii US Energy Information Administration, data tracked from 2011 – 2013 for 16 different fossil and non-fossil fuel technologies proximity to the consumers (distributed generation) it has lower technical losses. The combined impact contributes far lower emissions than the current grid supply.

Diversion of the waste for power production saves landfill fees and landfill space (capital deferral for the development of new landfill facilities). The new power production facility also offers employment creation and socio-economic development benefits.

Similarly, municipal wastewater treatment facilities offer opportunities for energy production from biogas plants or co- or tri-generation installations. Such facilities are generally feasible for wastewater treatment facilities that process 25 Megalitres (ML) per day, or more.

Energy solutions that harness energy from waste and wastewater reduces GHG from the solid and liquid waste, producing lower emitting energy forms, contributing significantly to reduced climate impacts. Such projects are increasingly being adopted by municipalities in South Africa.

Ekurhuleni Metropolitan Municipality, Landfill Gas-to-electricity case study[28, 29]

In the 2015 State of Renewable Energy Report, the pioneering eThekwini Landfill Gas-to-electricity project at the Bisasar and Marianhill landfill sites (commissioned in 2008 and 2006, respectively) was showcased. More recently, the Ekurhuleni Metro implemented an equally successful project at its Simmer and Jack landfill site in Germiston.

A 1 MW power plant was commissioned by the municipality in September 2014 to generate electrical energy from waste collected from residential areas and businesses in the municipal area. The decomposing waste produces methane gas, which is collected through pipes and flared, producing electricity and reducing the volume of methane gas released into the atmosphere. The power from the landfill site is connected to the electricity network at the Wychwood Substation in Germiston, displacing the need for power from the national grid. By March 2016, the Local Government programme for climate change[30] reported that the project had generated more than 3 million kWh of electricity and has contributed to the avoidance of 664,488 tons of CO_2 emissions. As part of its plans to generate its own clean energy, the municipality intends to replicate this power project at other landfills sites in Ekurhuleni. The project, which is still in its planning stages, is estimated to cost the municipality R22 million and may be implemented at the Rietfontein landfill site in Springs, the Weltevreden landfill site in Brakpan and the Rooikraal landfill site located in Boksburg.

Johannesburg, Northern Works Wastewater Treatment plant[31, 32] case study

In 2012, Joburg Water commissioned a 752 kilowatt electric (kWe) Biogas combined-heat-and-power (CHP) facility at its Northern Works Wastewater Treatment plant.

The Biogas CHP plant consists of three 376 kWe generators (two operational and one on standby) that are designed to run continuously, i.e. 24 hours of every day of the year. The wastewater plant processes 244 ML of sewage every day, from which this Biogas CHP unit generates approximately 10,080,000 kWh per year.

The project was implemented as a capital project, with a contractor appointed to design, build and operate the plant. Performance and operational responsibility resides with the contractor while the asset is owned by the City. The Biogas CHP unit was constructed for approximately R55 million and payback is estimated to be six years.

The City of Johannesburg has six wastewater treatment facilities with a combined potential to establish 8.8 MW[ix] capacity[33]. The energy generated from these plants will offset or supplement the power requirements from the national grid.

Small-scale distributed generation

As consumers are gaining the tools for greater autonomy in shaping their electricity solution, they are increasingly involved in designing and customising energy products for their needs and preferences and seeking options to buy and sell energy via a variety of business partners. Escalating electricity tariffs are accelerating this development, empowering customers to lead a large part of the industry transformation.

This is evidenced by the growing interest in, and uptake of, small-scale RE solutions seen in municipal areas. Solar PV technology is a particularly attractive option for private building owners. Embedded or distributed generation plants that are smaller and closer to the end user offer numerous technical benefits for the electrical network, but also bring complications related to the integration and management thereof.

Within the current, evolving policy and regulatory framework, Local Government has responded in different ways to accommodate this growing trend. By introducing appropriate processes and tariff structures, municipalities are better able to coordinate installations, ensure grid safety and manage the impact on electricity revenue. By November 2016, 26 Municipalities were known to have actively engaged with SSEG. Among these, 621 installations had been recorded, totaling more than 38 Megawatt peak (MWp) of installed capacity. This represents an average installation size of around 62 kWp per site. These numbers have grown by 235 percent in only nine months (refer Figure 3).

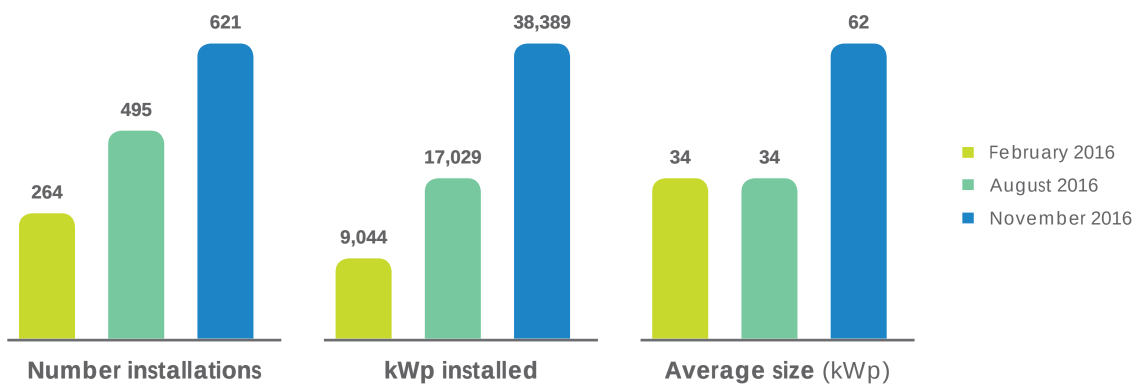

Figure 3: Growth in recorded installation numbers[34] as recorded by SALGA and GreenCape

ix Revised down from initial 17.5 MW capacity estimate

Figure 4 provides an indication of the distribution of the 26 Municipalities that are allowing SSEG, have NERSA approved SSEG tariffs and/or are designing their own relevant rules, regulations and by-laws[35].

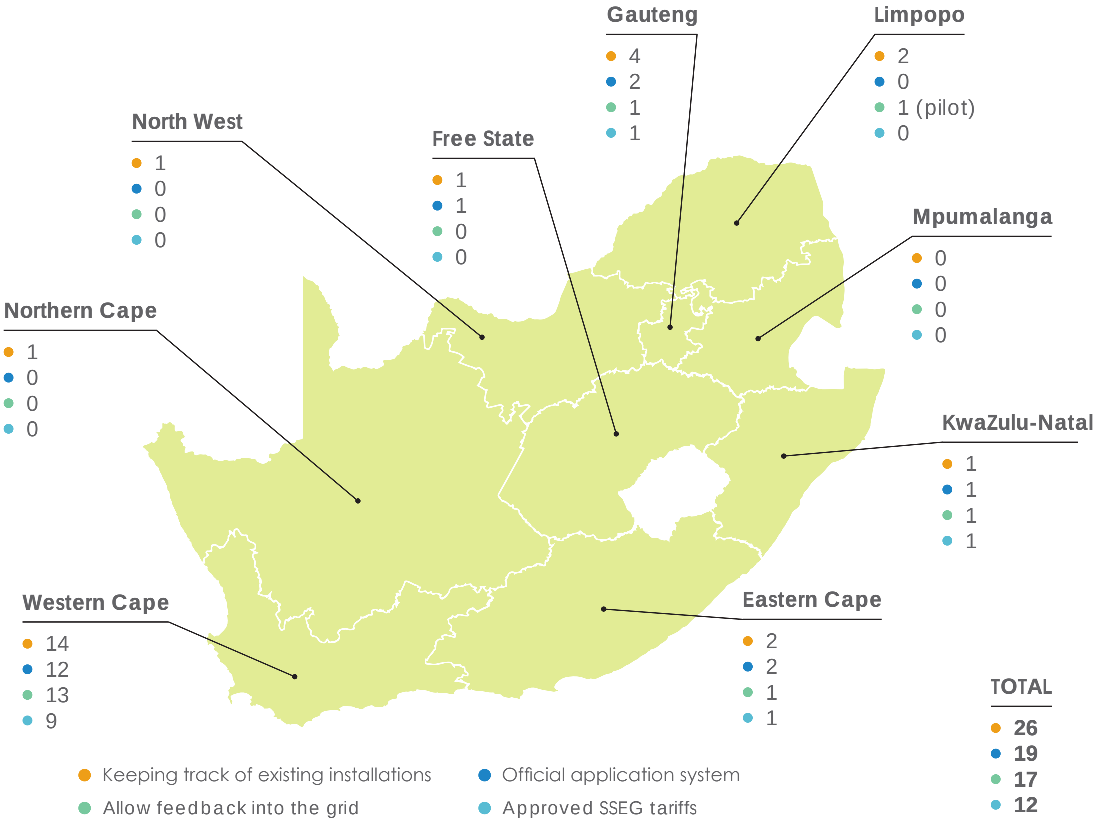

Figure 4: Mechanisms introduced by Municipalities to coordinate and support SSEG installations

Municipalities in the Western Cape are leading the list because of support provided from GreenCape. This non-profit organisation was established by the Western Cape Government with the objective of driving widespread adoption of economically viable Green Economy solutions in the province. GreenCape recognised the economic potential of this fast-growing market, which is estimated at R2bn for the period 2016 to 2019. The market, which includes installation, operation and maintenance of rooftop Solar PV, further offers the potential to create 3,000 medium- and low-skilled jobs over the period.

GreenCape introduced a Smart Electricity project that focused efforts to create an enabling environment for rooftop Solar PV and other SSEG technologies. To date, the programme has designed a generic municipal SSEG wireframe[x], raised awareness among municipalities of the likely technical impact on their grids as well as the potential impact on municipal revenue. The project has also highlighted the need for capacity building and support within municipalities.

Based on this initiative, the Association of Municipal Electricity Utilities (AMEU), with support from Sustainable Energy Africa (SEA), GIZ, SALGA and GreenCape, developed a standardised set of

x A model or diagram focused on functionality, showing how elements fit or work together documents (application forms, contracts, guidelines), to assist municipalities in adopting SSEG processes. This set of documents has been published and are available on the AMEU website.

Since July 2016, NERSA agreed to approve municipal SSEG tariffs as an interim solution and on a case-by-case basis, while waiting for the regulations to be finalised, with the understanding that the interim tariffs and processes will be adapted to the regulations once published.

Those municipalities that have identified sustainable energy and climate change as strategic priorities in their development planning, are proactively facilitating, and even encouraging, the implementation of small-scale embedded RE within their jurisdictions. For example, the eThekwini Municipality developed an online solar map and a tool to assist developers and homeowners with Solar PV projects. The tool allows a customer to evaluate the costs and benefits of an installation based on the building location on the map.

Utility-scale distributed generation

RE developments also create opportunities for municipalities to consider developing or accessing sustainable energy solutions that will provide a reliable, secure and affordable supply of electricity in the future.

Assuming current legal impediments and uncertainties can be resolved, municipal power generation becomes a renewed option. Local generation capacity could be developed as capital projects, in partnerships with the public sector or accessed through procurement agreements with IPPs. At national level, the REIPPPP has been a tremendous success, creating a blueprint that allows RE to be procured cost effectively from IPPs. This model provides a framework that would enable Local Government to effectively procure clean energy at a larger scale.

As we have seen earlier, municipalities have a history of delivering complete energy solutions before the power system in South Africa was centralised. The potential for municipalities to again become generators or procurers of their own power is significant because it decentralises power generation, which is emerging as a key risk-mitigation strategy around the globe.

Another important consideration is that generating power closer to where it will be used makes sense in terms of physics: the longer the transmission lines, the greater the loss of energy. Long power lines also add a heavy maintenance burden, which is why modern power generation plans focus on small-scale plants, connected by a smart grid.

Furthermore, if municipalities embed local economic and socio-economic development objectives within their projects, in line with Government supply-chain regulations, local suppliers get work, skills are transferred and long-term jobs are created. This creates opportunities for municipalities to stimulate the local economy, boost their revenues and/or develop new revenue streams while participating in the transition to the low carbon economy.

Bokpoort concentrated solar power plant near Groblershoop

Nelson Mandela Bay Municipality Power X case study

While uncertainty remains, the Nelson Mandela Bay Municipality (NMBM) has opted for a different route, entering into a PPA with Power X, an independent electricity reseller. In 2009, Power X obtained a bulk electricity trading license from NERSA to purchase RE power from independent generators and sell it on to end users. In January 2014, this trading license was renewed and extended for 15 years.

With the help of PowerX and its National Trading License, municipalities can attract private sector investment and stimulate the generation of power within the municipal grid network. Under long-term agreements, green energy can be bought from IPPs, like wind or solar farms, by PowerX and then introduced into the municipal power grid. PowerX acts as the off-taker, deflecting any additional financial obligation from the municipality. The municipality is paid a 'rental' or 'wires' fee per kWh for every electron transacted on its network, increasing annually with inflation. IPPs benefit from a simpler and more cost-effective grid interface while the municipalities benefit from the investment in the grid network and upgrading thereof, grid stability, cost avoidance and associated local economic development.

The innovative energy exchange project was launched in NMBM in July 2016. By introducing this agreement, it will for the first time be possible for prepaid electricity meter customers to have the option of buying either 'black' energy – generated from coal and supplied by Eskom – or 'green' energy.

Using this mechanism, a micro-scale Solar PV program (fully subscribed) was introduced in NMBM with the aim of generating 25 MW of power. Similar projects are planned in three more municipalities in the coming 12 months. PPAs were also signed for larger projects exceeding 175 MW in total. With this combination of exchange projects, PowerX will have procured the full allocation made available to it for trading in the metro.[36]

This agreement has, however, strengthened the argument that municipalities should accordingly be entitled to a similar bulk trading license, which would open the door for municipalities to contract directly with IPPs.

Solutions for energy access

Municipalities are also deploying alternative energy services for unelectrified communities. Chapter 4 showcased several examples where RE is enabling energy access. In these instances, RE allows municipalities to meet energy requirements and deliver services to the community, support economic growth and development, and promote a safe and healthy environment for residents.

Cleaner mobility

The importance of cleaner mobility solutions is gradually being recognised in South Africa. The transport sector consumes 30 percent of all energy in the country. The 2015 State of Energy in South African Cities report showed that, at Local Government level, municipal vehicle fleets contributed a similar percentage (24 to 35 percent) to municipal energy use. Transport EE is also exceptionally poor, with only 15 percent of fuel energy translated to kilometers (85 percent heat and other losses). Considering that vehicles are underutilised, generally carrying only one person at a time, these inefficiencies are multiplied. As in the rest of the world, traffic congestion and pollution have become some of the biggest challenges for cities throughout South Africa.

In recognition of the growing challenges, the United Nations Industrial Development Organisation (UNIDO) partnered with the SANEDI to promote cleaner mobility solutions in the country. During 2016 and 2017, UNIDO and SANEDI have been actively engaging with the Department of Transport and various cities to explore and introduce cleaner mobility options.

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City of Johannesburg Eco-Mobility case study

The City of Johannesburg, in partnership with Local Governments for Sustainability, also known as the International Council for Local Environmental Initiatives (ICLEI), embarked on a month long campaign during 2016 to promote eco-mobility and urban transport systems. During this month, citizens were encouraged to use alternative modes of transport such a public buses, trains, bicycles and light electric vehicles, or engage in car sharing and car pooling options.

West Street, which is the central axis of Sandton and considered to be the richest square mile in South Africa, was turned into an eco-mobile boulevard. The number of pedestrians increased to five times the normal volume, with almost 2,500 people walking on West Street during peak hours. By giving priority to walking and cycling on streets and public spaces, it was shown that walking is safe, comfortable and beneficial to one's health. It also allows engagement with one another and with the environment.

City of Tshwane Eco-Mobility case study

The City of Tshwane has also been active in the eco-mobility space, which features strongly in its sustainability outreach programme, known as Tshwane Green. The aim of this outreach programme is to approach each key sector – individuals, households, communities, schools, businesses and municipal officials – with a targeted strategy to inculcate behaviour change.

Between 2014 and 2016, the municipality's City Sustainability Unit (CSU) initiated a variety of innovative events to promote eco-mobility. A first event on the 'eco-mobility programme' was a fun ride known as the Tshwane Green Ride in October 2014 that covered the distance between Mamelodi and Rietondale. This event gave high profile exposure to the first township-based cycling club, known as Tshwane Urban Riders. Through a partnership with Tshwane Urban Riders a year later, the CSU facilitated the establishment of a cycling club in Eersterust, a historically disadvantaged community in the east of the City, equipping the community with a fleet of bicycles that now sees children riding regularly on the weekends.

The Earth Hour Capital Challenge held in March 2015 followed the success story of the Tshwane Green Ride. It raised the profile of public transport as a means to support low-carbon development. Students from the Tshwane University of Technology were paired with city officials and required to use all available modes of public transport to navigate a series of destination checkpoints.

The winning team was the one that emitted the lowest emissions. The event was organised in the run-up to the announcement of Tshwane as South Africa's Earth Hour Capital, 2015. The City was selected by a panel of international experts in recognition of its sustainability initiatives. The latest initiative in this eco-mobility programme is the procurement of 10 electric vehicles to form part of the city's messenger fleet, and solar powered charging stations that are being installed throughout the city.

In September 2017, the city launched a Tshwane Metro Police bicycle unit. The unit is a result of a partnership that began a year ago between the city and the Hatfield City Improvement District

Droogfontein solar power PV plant near Kimberley

(CID). The CID is a non-profit organisation made up of properties in the area. Bicycles were funded by the business community within CID. The unit will start with just 20 officers who volunteered to join, but is expected to be expanded to other parts of Tshwane, including the city centre. The initiative is expected to improve safety in the city and attract investment while using green transport.

Support available to Local Government

Support to Local Government that could guide decision-making and limit financial losses or unnecessary costs associated with the learning curve, would assist to smooth the energy transformation at this level. At present, there is limited National or Provincial Government support in the form of funding, available to municipalities to promote RE, per se. Incentives and grant programmes that are available and related are either focused on EE or more broadly on infrastructure (refer to EEDSM under DoRA and MIG Fund below). The SSEG resource pack developed by GreenCape and the related support services they offer, have already been highlighted (page 164, ref small-scale distributed generation). Additional programmes, aimed at developing knowledge and skills related to sustainable energy and climate change, include:

EEDSM under DoRA

The Municipal Energy Efficiency Demand-Side Management (EEDSM) is a programme established in 2009/10 as part of National Government's efforts to reduce energy consumption. The programme is fully funded by National Treasury through the Division of Revenue Act (DoRA) and managed by the DoE. Through the programme, funding is made available as a grant to municipalities for the implementation of EE measures in the infrastructure sector. The grant covers 100 percent of agreed technical EE measures, including planning and management costs associated with an intervention.

The DoE administers allocation on an annual basis, inviting proposals from municipalities interested in retrofitting qualifying energy efficiency appliances and technologies, including:

- Energy efficient traffic and street lighting or high mast lights;
- Building lighting;
- Heating, ventilation and air conditioning (HVAC);
- Pumping of fresh water; and
- Wastewater treatment and biogas.

The programme has made a significant impact since inception. Between 2009/10 and 2014/15, more than R1.2 billion was spent, providing support to 60 municipalities across all nine provinces. Participating municipalities retrofitted:

- 43,121 traffic lights
- 459,172 street lights
- 407,988 office lamps
- 1,495 lights on high masts
- 230 pumps

A total of 499 GWh of energy savings have been reported for the period, resulting in a cumulative reduction of 507,350 tons of CO_2 emissions.

Municipal Infrastructure Grant (MIG) Fund

The MIG was established in 2014/15 to provide capital finance to municipalities for the development and maintenance of basic municipal infrastructure. The expectation is that access to infrastructure will improve opportunities for poor communities to engage in the economy. The grant is therefore targeted at poor households and, to a limited extent, micro enterprises and deserving institutions.

Both asset management and infrastructure development related to electricity are covered under the MIG Policy Framework (2004). Electricity or alternative energy sources to provide for street or community lighting, water supply and sanitation facilities, are among the infrastructure investments that qualify for the grant.

Municipalities are required to develop an approved infrastructure capital plan that is linked to the integrated development plan to access this grant funding. The Department of Cooperative Governance and Traditional Affairs (COGTA) administers the fund and coordinates support at national, provincial and local level for the programme.

Early in 2017, an information guide[37] called 'How to include Energy Efficiency and Renewable Energy in Existing Infrastructure Grants' was published by SALGA. This helpful booklet, which is available on the Urban Energy Support website (http://www.cityenergy.org.za/) free of charge, aims to:

- Raise awareness regarding EE and RE interventions that reduce municipal consumption;
- Provide guidance on which EE and RE interventions can be financed with specific infrastructure grants; and
- Encourage municipalities to think more broadly about the use of grant funding for EE in their existing infrastructure programmes.

Department of Environmental Affairs (DEA) Local Government Support Programme[38] for Climate Change

In 2009, the DEA, in collaboration with SALGA and the provinces, initiated a coordinated Local Government Support Programme designed to provide support to municipalities in performing their environmental functions or enhance municipal performance with respect to these functions. Support is packaged around thematic areas[xi] and can consist of financial and/or technical support (provision of human resource, development of tools, advisory services) and infrastructure.

Under the Climate Change theme, technical support is provided to Local Government to build capacity (technical capacity), assess municipal vulnerabilities and develop local adaptation

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xi Thematic areas include Air Quality Management; Climate Change; Biodiversity and Conservation; Waste Service and Management; Municipal and Environmental Planning; Coastal Management; and Environmental Compliance responses/plans that are mainstreamed into municipal IDPs. The programme has developed a range of tools and resources that includes climate change vulnerability assessments workshops and tools, draft Municipal Climate Change Response Plans and stakeholder and IDP integration plan workshops and tools. It also includes the 'Let's Respond to Climate Change Guide and Toolkit', produced by DEA, to support Local Government with mainstreaming climate change actions in service delivery. The toolkit provides a step-by-step guide on how municipalities can integrate climate response action in governance systems.

Urban Energy Support

The Urban Energy Support network is an initiative led by Sustainable Energy Africa (SEA) and SALGA, supported by ICLEI and the SACN and sponsored by the United Kingdom and Danish governments as well as Brot für die Welt, a German Development Services agency.

Urban Energy Support offers an extensive information portal of relevant documents and resources, with an emphasis on practical tools and guides to support the transition towards sustainable local energy development and a low carbon trajectory for the country in the context of global climate change. All content is available free of charge and can be accessed at http://www.cityenergy.org.za/index.php

Training and capacity building

In October 2016, GIZ awarded a training project to SUNCYbernetics' Solar Training Centre[39] and the NWU Engineering faculty. The training project, which is accredited with the Engineering Council of South Africa (ECSA), was initiated to develop and present a customised, two-day technical Solar PV training course to municipal officials.

The training is designed to improve the municipal officials' knowledge to:

- Understand how Solar PV works;
- Empower them to assist, guide, and manage integration of Solar PV on their distribution grid;
- Give insight on the status of relevant standards, guidelines, and regulations;
- Equip the trainees with necessary documents to help ensure safe and reliable Solar PV systems, and ultimately;
- Build relevant skills by practically applying everything discussed and learned.

The latter includes site visits to installed Solar PV systems, visiting the Food & Energy training centre, and the HySA Infrastructure Centre of Competence Solar-to-Hydrogen facility situated at the engineering faculty of NWU.

Hopefield wind farm near Hopefield

By mid-2017, more than 60 officials from nearly 40 municipalities had been trained. In the second semester another 90 officials participated in the training programme and a final training session for the year is scheduled for November.

It is evident from the large numbers of municipal officials that participated in training during the first 10 months of 2017, that there is an enormous need for expert RE training.

The role of RE in fostering new business models

Historically, the establishment of generation capacity was the domain of power utilities. Evolving policy, technology developments[xii] and price trends have enabled more and more consumers to establish their own generation capacity. Consumers also have the right and ability to utilise the network to wheel power to third parties while some consumers use the network as a temporary storage facility. This environment has created space for new market players and service providers to engage with consumers for on-site services, thereby displacing part of, or all, traditional utility services.

For many utilities, these developments have led to a decrease in the volume of electrons transported through the transmission and distribution networks. Likewise, both Eskom and many

xii Embedded generation is included as an important area in the Integrated Resource Plan (IRP) and is recognised as an important demand-side measure for Government and particularly the DoE, but there is currently no policy to promote it

municipalities in South Africa have observed a slowdown, stagnation and even a decline in electricity sales that cannot be ascribed to the economic slowdown alone[xiii].

Dispersed resources present a further challenge for network planning and integration, scoping of infrastructure requirements, forecasting demand requirements for a supply area and balancing supply and demand. If connected to the grid for supplemental supply, these facilities require network infrastructure and maintenance, incurring costs despite reduced sales and revenue, therefore bringing the established tariff approach into question.

In South Africa, this has been occurring without regulatory clarity and without a fully considered enabling environment. This is expected to change shortly with resolution of suitable tariff structures and the SSEG regulations that are under development (refer Chapter 2). However, as the enabling environment is clarified and streamlined and technology become ever more affordable, the trend may further accelerate.

Traditional business models have a strong link between revenue and sales volumes, i.e. a charge imposed for every kilowatt hour consumed. Typically, a range of services and infrastructure costs are incorporated within this rate. Reduced sales therefore have a direct bearing on revenue and sustainability of utility services. Paradoxically, tariff increases to counteract revenue losses may encourage more consumers to pursue alternatives, hence exacerbating the problem. The

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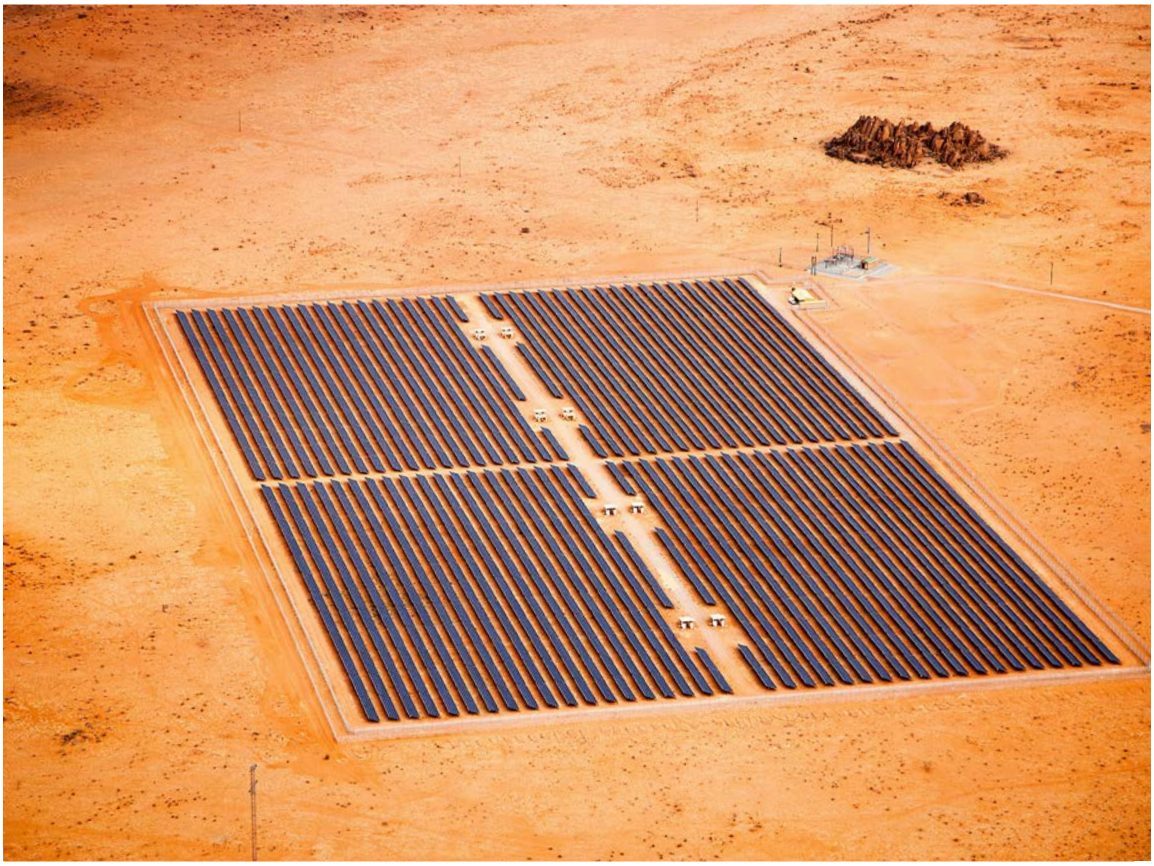
xiii It should be noted that a variety of factors, including slow economic growth, energy efficiency, structural changes in the economy, among others, all contribute to lower reported sales figures old business model of volumetric sales is becoming obsolete and municipalities are forced to re-evaluate their long-term business models accordingly.

These developments are not unique to South Africa and have been driving utilities world-wide to test and develop a variety of new technologies, business models, and customer-facing programmes.

Significant work has been done in South Africa to investigate alternative business models. Designing and implementing appropriately structured tariffs have been the first steps to limit the revenue impact. In 2014, SEA, with funding from the Renewable Energy and Energy Efficiency Partnership (REEEP), developed a comprehensive model to quantify the impact of localised EE and RE on municipal finances.

Through this work, two cost benefit analysis tools, for Solar PV and EE respectively, were made available to municipalities at no cost. GreenCape has subsequently published Basic Tariff Guiding Principles, aimed at supporting municipalities with designing appropriate SSEG tariffs. A collaborative initiative led by AMEU and supported by several municipalities[xiv], SEA, GreenCape, GIZ and SALGA, produced a comprehensive SSEG Resource Pack. The resource pack, that is published by the AMEU, contains a document detailing Requirements for SSEG, a generic supply contract and various templates. And, as indicated earlier, NERSA has agreed to approve municipal SSEG tariffs as an



BioTherm Energy Konkoonsies solar PV plant near Pofadder

xiv City Power, City of Tshwane, eThekwini, Nelson Mandela Bay, Buffalo City, City of Cape Town and Ekurhuleni and Centlec interim measure, pending finalisation of the relevant regulations. This wealth of resources provides valuable support to municipalities.

The primary focus to date has been on securing a revenue neutral position for municipalities in the fast-changing electricity landscape. It is duly recognised that the nature and extent of the sector transformation call for greater innovation and adaptation by municipalities if they are to effectively navigate the energy transition and ensure long-term relevance and sustainability. Work has also started on defining the new Municipal Energy Utility, crafting innovative business models structured around value rather than volume and alternative revenue streams.

Key opportunities and constraints have been the urgent topic of workshops and think tanks between industry and municipal stakeholders. In January 2017, a study was published by SAGEN[40], sharing various municipal business models relevant to the energy and electricity sector. A review of business models was also produced by Trade & Industrial Policy Strategies (TIPS), the Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University and World Wide Fund for Nature South Africa (WWF-SA) and published as a discussion paper in March 2017[41].

RE is creating opportunities for electricity to be distributed in a way that benefits all. It is opening doors for community and municipality partnerships in SSEG, municipal generation and procurement from local power generators. Network intelligence is in turn creating opportunities for value-added services. The extent to which South African municipalities will be able to exploit these new opportunities and business models, will largely depend on the responsiveness and agility of the political and administrative framework.

Conclusion

The RE revolution is opening opportunities for decentralised energy generation and `green' economic growth. It also creates new opportunities for addressing energy poverty and energy inequality. The result is an historic opportunity to democratise energy, develop energy efficiency, energy self-reliance and renew local communities.

Local governments, concerned with securing least-cost energy services and ensuring affordability of energy for their consumers, have proactively engaged with a range of emerging, clean energy solutions. Pilot initiatives have tested and demonstrated the technical viability of various small- and mid-size RE solutions.

The emergence of SSEG has further prompted the urgent review of traditional municipal business models and tariff structures. Yet, there remains an urgent need for revised policies and rules that will make the enormous, associated economic, socio-economic and sustainability opportunities fully accessible to all communities.

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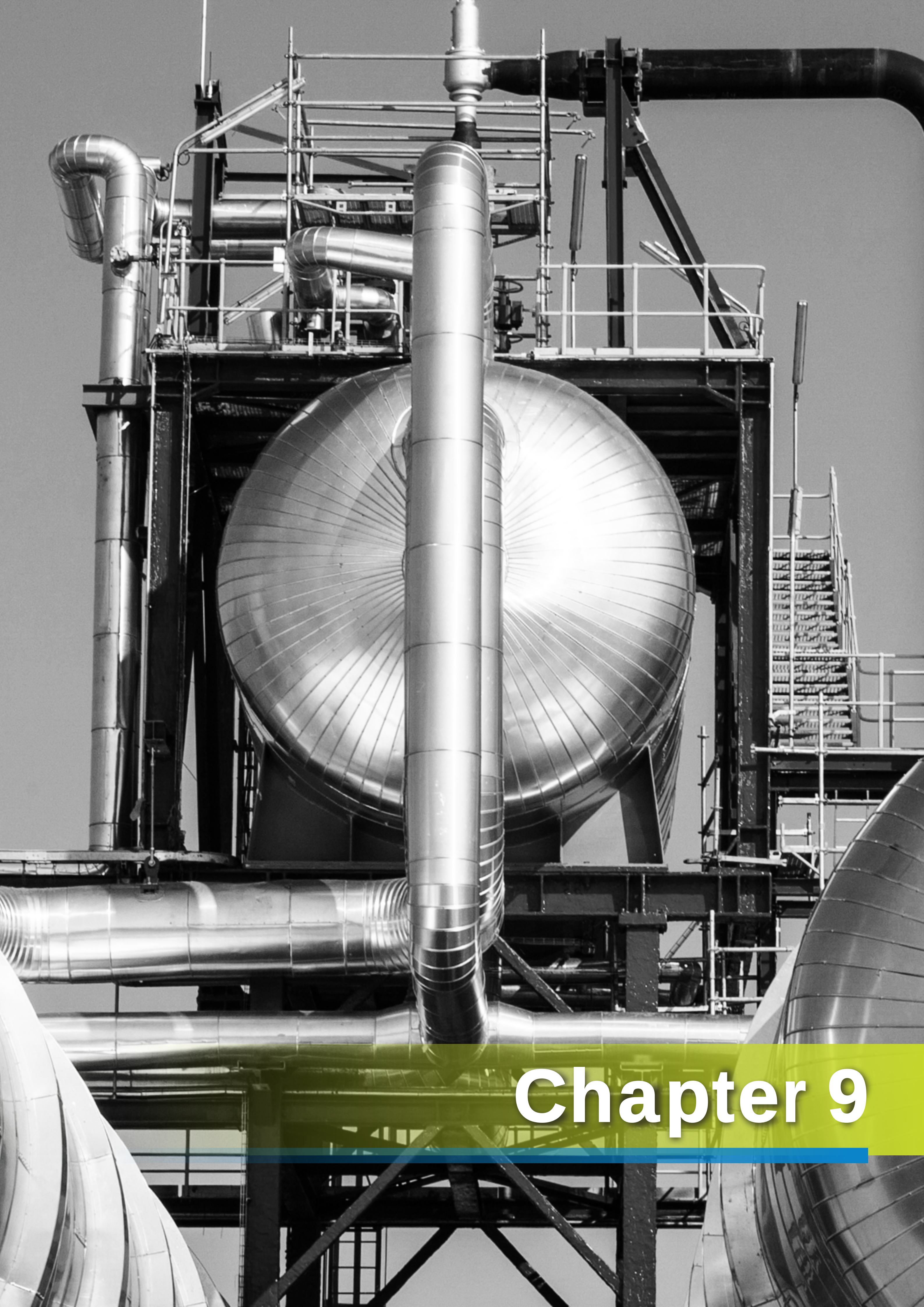

Chapter 9

Chapter 9

Conclusion

Internationally, the RE industry has seen significant movement during the preceding two years. The volume of Wind and Solar installations hit a new record in 2016 and RE has – at least on a LCOE basis – clearly achieved the long-awaited goal of grid competitiveness. More than that, in many countries it now undercuts every other source of new generating capacity, sometimes by very considerable margins. 2016 also saw unsubsidised price records, with further equipment cost cuts anticipated.

Unsurprisingly, low-cost RE led new capacity additions throughout the world, suggesting a shift towards a RE-rich, clean energy future. In addition, low-cost RE is realising a convergence between the electricity, transport and heating/cooling sectors, and compounding and accelerating opportunities for RE application and market growth.

The rapid growth of RE internationally is still gathering pace; it is destined for a central role in future energy systems. The development of new battery storage technologies and intelligent grid infrastructure are likely to enable and support further market growth.

Low-cost RE has also given rise to decentralisation, empowering consumers to develop onsite solutions that meet their sustainability commitments/targets and power needs.

Large shares of decentralised VRE are going to force a revolution in the way power grids are designed, and the way they are regulated. Up to 40 percent VRE is already being accommodated internationally with nominal additional system costs, but thereafter power system management requires rethinking. Solving 'base-cost renewables' are increasingly the focus of global energy think tanks and industry forums.

Fortunately, South Africa can again benefit from the lessons of the international community to craft a locally relevant, cost effective solution – similar to the groundbreaking design of the REIPPPP.

Compared to the buoyancy of the global market, South Africa's renewables programme experienced a slowdown during the two-year review period, but brought with it opportunity for consolidation of the industry.

In the years since 2011, the short term has always looked very promising, with the RE industry growing explosively and market penetration increasing rapidly. While the early REIPPPP projects came at a premium, their success created a credible platform for the low prices offered in later bid rounds, thereby enabling South Africa to purchase clean energy at globally competitive rates.

Since 2015, 1,301 MW additional RE capacity was added to the grid as the construction phase for the first bid rounds winds down. Following the September announcement by the Minister of Energy, expectations are that the Round 4 projects will soon start construction, commencing the next build phase that will bring new capacity online in another two years.

Rooftop Solar PV further marks a notable area of growth outside of the REIPPPP, with recorded installations growing seven-fold since 2015.


Sustainable Power Solutions Rooftop PV installation at Lourensford Wine Estate near Somerset West

The robust policy and regulatory framework that provided the platform for the success of the REIPPPP, was strengthened by the developments of the preceding two years. The already supportive policy environment was enhanced by South Africa's ratification of the Paris Agreement, aligning the country's long-term vision with the global push. It has further been augmented from the ground up by long-term energy modeling for the IRP, demonstrating the technical feasibility and the environmental and economic value of a RE-rich energy future. While the exact magnitude will depend on current and subsequent planning iterations, it is clear that RE has a very significant long-term role in South Africa's energy future.

We have also seen an integration of the policy framework from national to municipal level, across different Government departments and across the quantitative silos of utility-scale generation and embedded generation (large and small). Presently feasible generation technologies have been advanced and EE has been further incentivised.

The 2017 Regulatory Indicators for Sustainable Energy (RISE) report, published by the World Bank[1], analysed sustainable energy policies in more than 100 countries. This global energy policy scorecard identified South Africa, among other developing countries, as an emerging leader in sustainable energy, with robust policies to support energy access, renewables and EE.

Despite this accolade, a lot of work remains to be done in order to achieve the country's targets for universal access to clean, affordable energy. Rapidly maturing RE, storage and network technologies are growing a portfolio of viable solutions to support South Africa meeting these targets. It is expected that new technologies will soon make the electrification of remote areas possible at affordable costs, creating opportunities for rural communities to thrive beyond subsistence, as they become part of an inclusive society.

Besides addressing energy challenges, these emerging energy solutions hold the potential for local economic development. Mini grids coupled with distributed generation and storage will enable communities to participate in the economy in new ways.

South Africa is actively exploring the new opportunities and acting to integrate appropriate solutions in national energy frameworks and initiatives. It also acknowledges the localised nature of emerging solutions, recognising that a comprehensive and sustainable solution to universal access will likely depend on a collaborative spirit, incorporating all spheres of Government and local stakeholders.

Energy is a crosscutting service that underpins the delivery of infrastructure and services to ensure the health, safety and social and economic development of local communities. The emergence of decentralised energy solutions is demanding far greater integration and governance across all spheres of Government, including municipalities[i].

Local governments, concerned with securing least-cost energy services and ensuring affordability of energy for their consumers, have proactively engaged with a range of emerging, clean energy solutions. They also present a key stakeholder with interest in the opportunities being created by RE to address energy poverty and energy inequality. The technical viability of various small- and mid-size RE solutions for a variety of applications is being tested and successfully demonstrated by municipalities in innovative pilot initiatives.

The advent and rapid adoption of SSEG, particularly rooftop Solar PV, has prompted a review of traditional municipal business models and tariff structures. Local Government stakeholders have been driving a bottom-up approach to finding appropriate solutions to the new challenges,developing

Metrowind van Stadens wind farm near Port Elizabeth

i Subject to the Constitution and the provisions of national and provincial legislation and sharing excellent resources in collaboration with SALGA, GreenCape, AMEU and the South African Cities Network, among others. The immediate next priority is having revised policies and rules that will make the enormous, associated economic, socio-economic and sustainability opportunities fully accessible to all communities.

Similar to the experience of the international community, the decentralised and variable nature of RE development in South Africa is demanding an alternative planning approach for the expansion of the national electricity grid. Network requirements are shifting from connecting a few large centralised generators supplying power into the national network, to integrating a variety of generation technologies, types and sizes that are widely dispersed and sometimes located with electricity end-users, thereby necessitating a two-way flow of power.

The process applied in transmission grid planning is taking cognisance of international and local developments and is adequately robust. It also remains flexible, so as to accommodate various technological and strategic developments. Recent studies[2] confirmed that, in the interim, the South African power system will be sufficiently flexible to handle very large amounts of Wind and Solar PV generation, especially when considering the addition of Closed Cycle Gas Turbines (CCGTs) and Open Cycle Gas Turbines (OCGTs), according to the proposed scenarios in the first draft IRP-2016 base case[3]. As smart- and mini grid learnings from various research processes and initiatives become available, and storage technologies become more mainstream in future, from a planning perspective consideration to such developments will be given and, where relevant, included in future updated network plans.

Provided plans are timeously implemented, the necessary network infrastructure should be available to facilitate the delivery of South Africa's growing power needs and economic growth.

Market developments have created an extraordinary circumstance where more RE infrastructure can be procured with less investment. RE is, therefore, becoming the elusive holy grail of sustainable development, delivering more power, costing less and benefitting/including more people in its wide economic and socio-economic benefits.

South Africa explicitly joined and multiplied the objectives of sustainable development in the procurement system for RE through the REIPPPP. However, despite the signals included in the REIPPPP design, more opportunities remain for developing a local RE manufacturing sector in the country. While small gains were made, technology imports continued to dominate the supply chain. Uncertainty in the market since 2015 severely impacted the small, emerging Green Economy associated with the fledgling renewables sector. The majority of newly established, local manufacturing facilities have either closed or are in the process of closing, representing ground lost in building a globally competitive green economy. It may never be regained.

An important expectation of the IRP 2016 is that it will provide a line of sight on development timelines and will better maintain regular procurement of RE at levels high enough to sustain investment, job creation, the expansion of local innovation and the drive to higher levels of local content and industrialisation. If successfully leveraged, developmental benefits will extend to related sub-industries, scientific research and new business opportunities.

Developments in the sector demand new skills, opening new fields of study and employment. With the expansion of RE comes the opportunity for 'green jobs' – generally speaking, well-paying employment in an environmentally beneficial industry. Based on international experience, the inclusion of renewables in the future energy mix is expected to contribute significant employment opportunities. The anticipated number of jobs is likely to be commensurate with the targeted size of the sector.

The importance of retaining and developing skills and innovation, in the interest of growing the evolving power sector and the associated Green Economy, is duly recognised. Research, development and innovation related to clean energy and sustainability has grabbed the attention of leading research and academic institutions in the country. Emerging innovations in the sector are promptly building on the country's proud history of scientific discovery and innovation.

Since 2010, South Africa has realised incredible benefits from the RE sector. Beyond diversifying the supply and nature of South Africa's electrical energy production, RE development has been actively employed to drive economic growth and improve the livelihoods and income generation potential of relatively poorer communities through socio-economic and enterprise development interventions.

In the most recent two years, further progress has been made in some areas while others have turned their focus towards consolidation and refinement. This 2017 State of Renewable Energy in South Africa report has also highlighted the growing opportunity for low-cost RE to fuel economic growth, create new employment opportunities, enhance human welfare, and contribute to a climate-safe future. Modeling for the 2016 IRP demonstrates the value contribution of RE to South Africa's energy portfolio, diversifying the energy mix at lowest cost, contributing towards job creation, conserving water and reducing GHG emissions. The RE revolution holds the promise of a greener and more prosperous energy future for South Africa.

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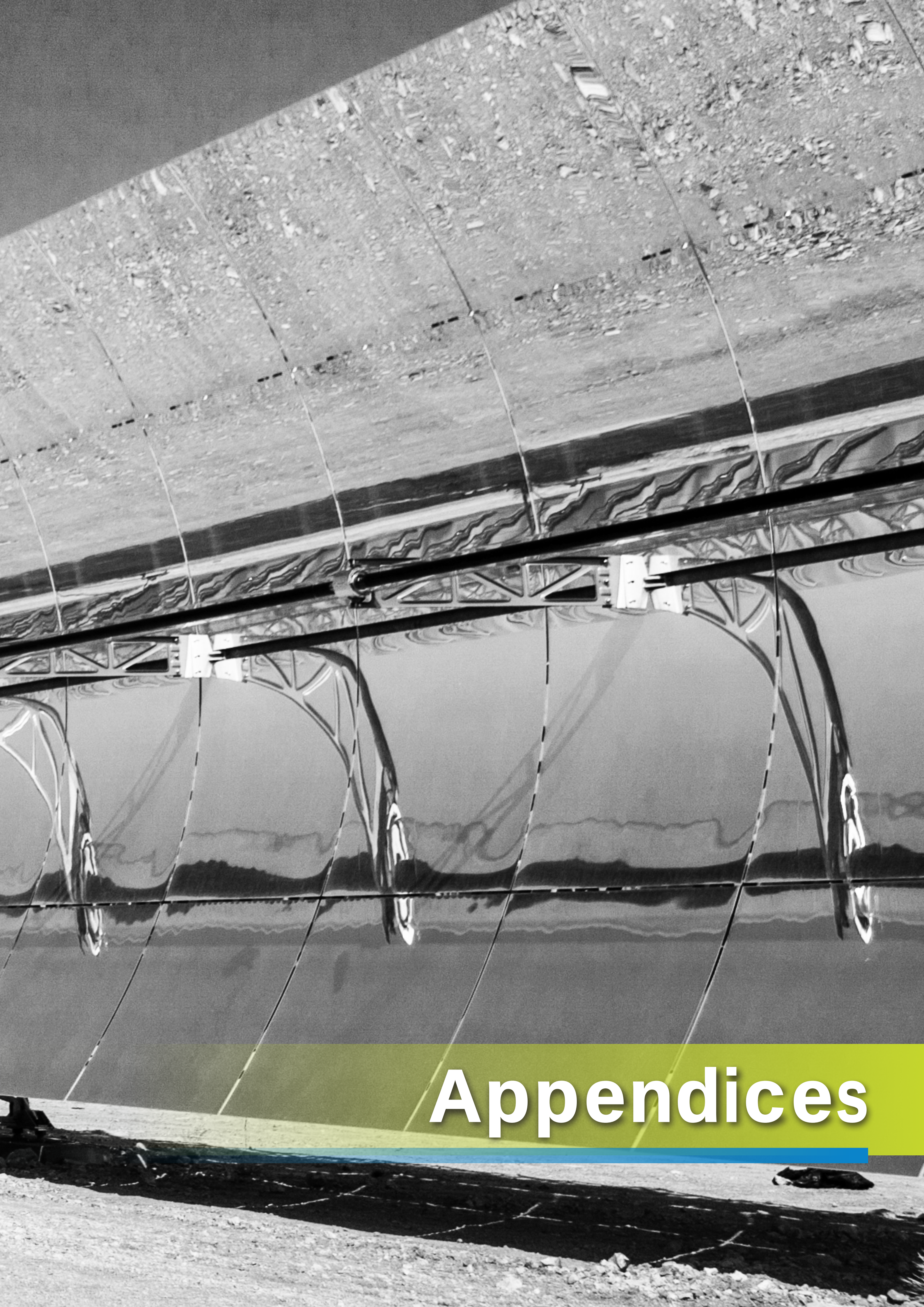

Appendices

Appendix A

Overview of relevant policies and Government role players

Considering the comprehensive impact of electricity infrastructure development, RE activities are steered by, and impact on, a broad spectrum of national objectives and spheres of Government. Although energy development is primarily the domain of the DoE, sustainable development is a shared responsibility across all facets of Government. For this reason, a comprehensive enabling platform is essential for the RE industry to operate, grow, and contribute positively to the South African economy and the global environment.

A selection of the most pertinent regulations, supportive policy papers and plans from other Government departments and agencies that delineate the energy development and investment environment in South Africa, is provided below. Together these provide the current and proposed or upcoming 'rules of engagement' for investors and developers, on which to base their investment decisions.

Lead authority:	Relevant focus/contribution:
The people of South Africa: The Constitution of the Republic of South Africa, Act 108 of 1996	Provides the basis for the rule of law in a Constitutional Democracy with a separation of powers and the protection of human rights. Contains the rules governing the acceptance of international conventions into binding South African law.
National Planning Commission	Responsible for national planning, national priorities and directing the course of national development.
Most pertinent policies and regulations	
National Development Plan (NDP)	The National Planning Commission was appointed in 2010 by the President to develop a long-term national development plan. Understandably, a key focus of the NDP is the country's ability to return to a state of continued and uninterrupted electricity supply. This is to be achieved by increasing the electricity generation reserve margin from 1 percent (2014) to 19 percent in 2019, which will require the development of 10 GW of additional electricity capacity by 2019 against the 2010 baseline of 44 GW. Five of the 10 GW are to be sourced from RE, with an additional 2 GW to be operational by 2020.

Lead authority:	Relevant focus/contribution:
Department of Energy energy Department: Energy REPUBLIC OF SOUTH AFRICA	Custodian of policy and planning for the energy sector, focusing on energy security through diversifying the country's energy mix to include RE sources.
Most pertinent policies and regulations	
National Energy Act (Act No. 34 of 2008)	The Act aims to strengthen energy planning in order *"to ensure that diverse energy resources are available, in sustainable quantities and at affordable prices, to the South African economy"* and more specifically to *"provide for energy planning, increased generation and consumption of renewable energies…"*.
Electricity Regulation Act (Act No. 4 of 2006), Second Amendment (2011)	The Act gives power to the Minister of Energy to determine new generation capacity and to approve the generation and procurement thereof. A license for generation capacity is subject to Ministerial approval. This establishes an enabling environment for IPPs to enter the market, the bid programme rules and guidelines as well as procurement of new generation capacity.
Amendment to the Electricity Regulations on new generation capacity (18 August 2015)	The amendment provides an extended definition of new generation facilities to include existing generation facilities not previously supplying electricity to the national grid and/or an extension or renewal of existing supply agreements from existing generation facilities for an additional period.
Biofuels Industrial Strategy, 2007	The Strategy approved the financial support (subsidies) for a national biofuels programme with a short-term strategy of 2 percent penetration level of biofuels in the national liquid fuel supply by 2013. The regulations to enable this programme are not yet in place, hence there has been no progress in its implementation.
Biofuels Mandatory Blending Regulations, 2012	Pertinent for the implementation of the Biofuels Industrial Strategy of 2007 was the promulgation of the Mandatory Blending Regulations for the blending of biofuels with petrol and diesel. The Regulations came into effect on 1 October 2015. The Regulations provide for all licensed petroleum manufacturers to purchase locally produced biofuels from licensed biofuels manufacturers.
Petroleum Products Act (Act No. 120 of 1997)	The Act prohibits the manufacturing of petroleum products, including biofuels, without a manufacturing license.
Petroleum Products Amendment Act (Act No. 58 of 2004	The Act authorises the Minister of Minerals and Energy to require licensed liquid fuel wholesalers and producers to supply and sell petroleum products made from 'vegetable matter,' i.e. 'blending' of conventional liquid fuel with biofuel. This is an important legislative vehicle for the development of biofuels in the country.

Lead authority:	Relevant focus/contribution:
National Energy Regulator of South Africa (NERSA)	Regulation of the energy sector in the context of national policy and planning; licensing of new energy infrastructure; regulation of electricity and hydrocarbons infrastructure tariffs.

Lead authority:	Relevant focus/contribution:
Department of Environmental Affairs (DEA)	Ensuring sustainable development and environmental integrity; environmental authorisations in terms of the National Environmental Management Act (NEMA).
Most pertinent policies and regulations	
Environmental Impact Assessment (EIA) 2010, under the National Environmental Management Act (NEMA) (Act 107 of 1998) and amendment Act (Act 62 of 2008)	The EIA process forms the framework for environmental authorisations. An EIA is required for RE generation projects which are[i]: > 10 MW; the facility is > 1 hectare; transmission power > 33kV; and the construction of masts. Ordinarily applications are made to the provincial authority, but as projects under the IPP are treated as 'Strategically Important Development' (SID) applications, these can be sent directly to the Department of Environmental Affairs. Depending on the nature of the RE project the following additional licenses or authorisations may be required: • Waste management and atmospheric emissions license is required for high impact projects; • Biodiversity authorisation where endangered fauna and flora are impacted; • Water license when taking, storing, diverting, reducing stream flow and altering banks; • Civil Aviation Authority authorisation when impeding an existing flight path; • If storing a hazardous material, such as oil; • Land use planning and sub-division requires the legal authority to do so; • Considering the impact on buildings or sites with heritage status.
Draft National Greenhouse Gas Emission Reporting Regulations ("the Draft GHG Regulations") to be made in terms of the National Environmental Management: Air Quality Act 39 of 2004.	In order to move to a low carbon economy, policy tools like a carbon tax may be used. To enable such policy tools, it is necessary to know what is being emitted by whom. The Draft GHG Regulations would regulate who must report on what and by using what methodology[1].

i PDG (2012) Mapping of Authorisation Processes for Renewable Energy Projects

Lead authority:	Relevant focus/contribution:
Economic Development Department (EDD)	Responsible for economic policy, economic planning and economic development; focus on employment creation and the Green Economy.
Most pertinent policies and regulations	
Infrastructure Development Act (Act 23 of 2014)	This Act is intended to provide for the facilitation and co-ordination at the highest level of public infrastructure development which is of significant economic or social importance to the Republic, through the Presidential Infrastructure Coordinating Commission (PICC). Of the 18 Strategic Infrastructure Projects (SIPs) identified in terms of this legislation, three concern energy, namely SIPs 8, 9 and 10. All would support the roll-out of renewable energy and the socio-economic aims of the REIPPPP.
New Growth Path (NGP), Economic Development Department (EDD, 2011)	The NGP is Government's "framework for economic policy and the driver of the country's jobs strategy". Job creation is prioritised by outlining strategies to enable South Africa to develop in an equitable and inclusive manner. The NGP targets 5 million new jobs by 2020. It also aims for "300,000 additional direct jobs by 2020 to green the economy, with 80,000 in manufacturing and the rest in construction, operations and maintenance of new environmentally-friendly infrastructure"[ii].
Green Economy Accord, Economic Development Department (EDD, 2011)	Supporting the NGP, the accord was signed in November 2011 and is a comprehensive social partnership designed to grow and develop the Green Economy to meet the NGP objectives. Signatories to the accord include multiple Government departments, organised labour and business. An objective realised was the development of the South African Renewable Energy Council.[iii]
Local Procurement Accord	Government, led by the EDD, and social partners signed a Local Procurement Accord on 31 October 2011, as an outcome of social dialogue on the New Growth Path. The accord was negotiated through the National Economic Development and Labour Council (NEDLAC) structures alongside the Green Economy Accord, showing the implicit and explicit aim that the Green Economy Accord and the resultant Green Economy should strengthen localisation efforts. The anticipation at the time was not that RE would be cheaper, but that it was worthwhile pursuing given the broader economic benefits that were available.
National Skills Accord (residing with the Department of Higher Education and Training, but a sister accord to the above)	The purpose of this Accord is to join the private sector, organised labour, communities and government in a strong partnership to expand skills in the country as a platform for creating five million new jobs by 2020. The ED/SED elements of the REIPPPP are examples of how the Accord is permeating successfully into renewable energy procurement in the country.

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ix Montmasson Clair, G., Moilwa, K. and Ryan, G. (2014) *Review of Regulation in Renewable Energy*. TIPS pg29

Lead authority:	Relevant focus/contribution:
Department of Trade and Industry **(the dti)** the dti Department: Trade and Industry REPUBLIC OF SOUTH AFRICA	Development of local industries and trade with particular focus on green industries and job creation; attracting foreign investment.
Most pertinent policies and regulations	
Industrial Policy Action Plan (IPAP) 6, Department of Trade and Industry (2014)	**The dti** plays a critical role in supporting the local manufacturing base, which includes renewable technology development and deployment. The IPAP is an annually updated, three-year rolling plan for industrial policy implementation; since 2011 it has specifically identified the energy sector (Solar and Wind energy; solar water heating and energy efficiency) as a priority for the country's industrial policy[iv].

Lead authority:	Relevant focus/contribution:
National Treasury (NT) national treasury Department: National Treasury REPUBLIC OF SOUTH AFRICA	Governing fiscal and procurement policies and incentives, inclusive of the mooted carbon tax.

Lead authority:	Relevant focus/contribution:
Department of Water and Sanitation water & sanitation Department: Water and Sanitation REPUBLIC OF SOUTH AFRICA	Ensuring sustainable water use for present and future generations across the economy, including energy.
Most pertinent policies and regulations	
The National Water Act 36 of 1998 and its amendments, Act 45 of 1999 and Act 27 of 2014. Of the extensive regulations, GN R.1560 of 25 July 1986 and GN R 139 of 24 February 2012 might affect hydro power, GN R267 of 24 March 2017 might affect solar thermal power generation, while GN R810 could apply to both hydro and solar thermal power plants	The purposes of the act include meeting the basic human water needs of present and future generations. The Act thus regulates water use, implicitly impacting on all existing and proposed energy developments. Beyond setting compliance standards it implicitly recognises that sustainable water use requires the energy sector to use water responsibly and sustainably.

iv Montmasson Clair, G., Moilwa, K. and Ryan, G. (2014) *Review of Regulation in Renewable Energy*. TIPS pg29

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