WWF

TECHNICAL REPORT

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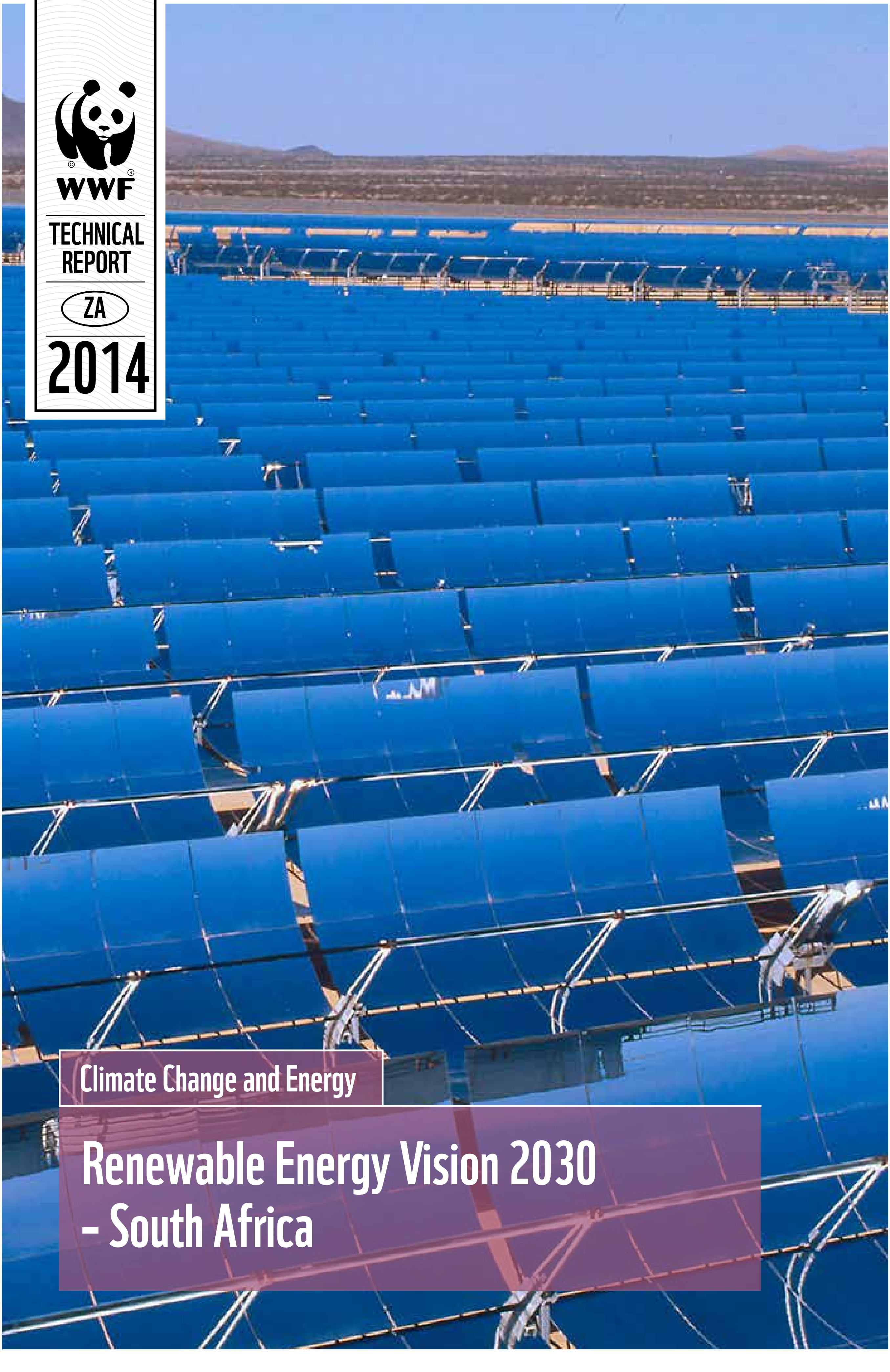
2014



Climate Change and Energy

Renewable Energy Vision 2030 – South Africa

ABOUT WWF

WWF is one of the world's largest and most experienced independent conservation organisation, with over 5 million supporters and a global network active in more than 100 countries.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

SUSTAINABLE SOLUTIONS

Consulting for Sustainable Solutions offers a menu of complementary strategy and research services focused on sustainable business and finance. Developed with real-world experience and insight, these services are delivered with an instinct for opportunity and keen awareness of potential pitfalls in implementation. CSS focuses specifically on challenges linked to renewable energy, energy efficiency and sustainable built environment in SA.

CONSULTING FOR
SUSTAINABLE SOLUTIONS

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Any errors contained in the document remain the responsibility of the author.

Designed by Apula
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LIST OF ABBREVIATIONS

CAGR	Compound Annual Growth Rate
CCGT	Combined Cycle Gas Turbine
CSP	Concentrated Solar Power
DOE	Department of Energy
ECA	Export Credit Assistance
EPC	Engineering Procurement and Construction
EPCM	Engineering Procurement and Construction Management
GDP	Gross Domestic Product
IPP	Independent Power Producer
IRP	Integrated Resource Plan for Electricity
JIBAR	Johannesburg Interbank Agreed Rate
LCOE	Levelised Cost of Electricity
LNG	Liquefied Natural Gas
KW	Kilowatt
O&M	Operating and Maintenance
MW	Megawatt
MYPD	Multi Year Price Determination
NERSA	National Energy Regulator of South Africa
NDP	National Development Plan
OCGT	Open cycle gas turbine
PPA	Power purchase agreement
PV	Photovoltaic
RE	Renewable energy
REDZ	Renewable Energy Development Zones
ROE	Return on equity
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SGP	Strategic Grid Plan
TW	Terrawatt
WACC	Weighted average cost of capital
WWF	World Wild Fund for Nature

INTRODUCTION

BACKGROUND

Government plans for meeting South Africa's growing electricity demand needs are outlined in the Integrated Resource Plan for Electricity (IRP) of 2010. The plan contains long-term electricity demand projections, and details of how demand should be met in terms of generation source, capacity, timing and cost.

In late 2013, a draft update of the IRP was published for public comment. This outlined the optimal energy mix in a variety of scenarios linked to economic growth, the energy intensity of the economy, and various other factors and events.

In the Base Case scenario, premised on average economic growth exceeding 5% per annum and full implementation of the National Development Plan (NDP), there is a gradual ramp-up of renewable energy capacity to 9% of South Africa's total electricity supply capacity by 2030 (DOE 2013). Even in this optimistic scenario, generation from new coal-fired and nuclear plants will dwarf the share of electricity produced from renewable sources.

Further, should economic growth continue to be hover around current levels of 2-3% due to weak international demand, RE will only account for 6% of the country's electricity supply by 2030[1]. Continued reliance on coal-fired power for more than two-thirds of South Africa's electricity requirements suggests that there will be on-going competition between the energy and agricultural sectors for scarce arable land and water resources, threatening the delicate balance in the food-energy-water nexus.

WWF PLAN OF ACTION

The WWF calls for a more ambitious plan, suggesting that the IRP should provide for an 11-19% share of electricity capacity by 2030, depending on the country's growth rate over the next fifteen years. The basis for this proposal is outlined in detail in this report, and relies on a scenario-based approach to energy planning similar to that used by the Department of Energy (DOE).

For the purposes of this document, renewable sources comprise solar photovoltaic power (solar PV) and concentrated solar power (CSP), as well as wind-generated energy. Hydro-electric power is excluded due to concerns over the environmental impact of large hydro-electric power plants. Also excluded are sources such as landfill gas and biogas, given the relatively small role they play in Government's plans to procure electricity from RE sources.

Table 1: Contribution of RE to South Africa's energy mix in 2030

	High-demand scenario		Low-demand scenario	
Source	**Capacity (MW / % share)**	**Generation (TWh / % share)**	**Capacity (MW / % share)**	**Generation (TWh / % share)**
Draft IRP2010 Update	17 430 / 21%	38 / 9%	9 960 / 15%	19 / 6%
WWF Vision 2030	35 018 / 37%	78 / 19%	17 518 / 24%	39 / 11%

Source: DOE (2013); own calculations.
Notes: For present purposes, RE comprises solar PV and CSP as well as wind-generated power. 'High demand' corresponds to the Base Case scenario in the IRP Update, while 'low demand' corresponds to the Weathering the Storm scenario

[1] Weathering the Storm scenario

In the WWF's vision of the future, growing RE capacity comes at the expense of new coal-fired and nuclear capacity, with intermittency and dispatchability issues being countered by thermal and energy storage capacity, as well as by flexible gas-turbine generation. In addition to the obvious environmental benefits of this scenario, it will enable South Africa to add flexibility to energy supply capacity on an on-demand basis. In an environment of significant uncertainty regarding future electricity demand, the WWF considers this to be the most sensible approach.

The annual capital requirement associated with this goal is estimated to be R40-R80 billion in current Rand terms, depending on the rate of economic growth and the associated growth in electricity demand. In light of significant investor appetite for South African RE assets to date, the WWF believes that pools of private capital, notably from local retirement funds that manage approximately R3 trillion in savings[2], will support this requirement.

A growing demand from international institutional investors for high-quality infrastructure assets such as renewable energy plants further informs the organisation's expectations. Longer-term investments with relatively stable, predictable yields and low market correlations are perceived as valuable components of retirement fund portfolios, which have long-term obligations towards their members.

From a developer perspective, retirement funds may become increasingly attractive as cost-effective, supplementary providers of debt financing. This is especially true as banks are likely to raise pricing on project debt as a result of new regulations. Further, their appetite for extending further debt will depend largely on the degree of secondary market interest in the purchasing debt that they originate.

When it comes to financing for empowerment equity takes, this is already in short supply for RE projects, which presents another avenue of opportunity for retirement funds. In particular, financing the shares of black owned partners is expensive and scarce. A subsequent paper explores the participation of retirement funds in RE financing in more detail.

[2] This estimate is based on an interview with Wilma Mokupo, Financial Services Board

UTILITY-SCALE RENEWABLE ENERGY IN SOUTH AFRICA: PAST, PRESENT AND FUTURE

PAST EXPERIENCE

Despite being critiqued for its heavy reliance on coal-fired power in the past, South Africa has recently developed what is arguably one of the most successful IPP-driven renewable energy programmes globally. It has hosted the fastest-growing clean energy market over the past five years, and is now one of the world's most attractive RE investment destinations (Pew 2014).

Further, RE is strategically viewed as an avenue through which the South African Government can respond to the challenge of climate change, improve energy security by diversifying sources of energy supply, and propel green growth through localisation and empowerment (DME 2003). The importance of developing the RE sector is further underscored by its inclusion as an integrated strategic project in the National Infrastructure Plan. This is overseen by the Presidential Infrastructure Coordinating Committee, and is aimed at catalysing development and growth in South Africa[3].

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), introduced in 2011, has by all accounts been very successful in quickly and efficiently delivering clean energy to the grid. Over six rounds of this programme, Government aims to develop private sector RE projects with a production capacity of 6 725 megawatts (MW) using a competitive bidding process. A total of 3 916 MW was allocated through the first three rounds.

During the first half of 2014, the Department of Energy opened a CSP-only bid window of 200 MW, and a fourth bid window of 1 105 MW covering PV, wind and other technologies. Favourable developments with respect to the RE price trajectory have been central to this development. Increasingly competitive bidding rounds have led to substantial price reductions, and current contracting of RE at internationally comparable tariffs supports the technology's potential as an affordable future source of electricity supply.

PRICING PARITY

In three short years, wind and solar PV have reached pricing parity with supply from new coal-fired power stations from a levelised cost of electricity (LCOE) perspective. LCOE represents the cost per kilowatt hour of constructing and operating a power plant over a specified lifecycle, taking into account factors including cost of capital and the anticipated plant load factor. In the case of the REIPPPP, it is reflected by the bid tariff, which recovers plant cost over a 20 year power purchase agreement (PPA) period.

In bidding window 3 of August 2013, the average tariffs bid for wind and solar PV were R0,66/kWh and R0.88/kWh respectively, well below the recent estimates of R1.05/kWh for supply from the coal-fired Medupi and Kusile power stations (Papapetrou 2014). In 2013, the average levelised cost of electricity supplied to the grid was R0.82/kWh (Donnelly 2014), so wind-generated power has already achieved pricing parity with the grid.

CSP, while still expensive in relative terms, costs less than the alternative peaking supply option,

[3] SIP (Strategic Integrated Project) 8 refers to green energy supporting the South African economy.

namely diesel-powered open-cycle gas turbines. Bid at an average of R1.46/kWh in REIPPP Round 3, a two-tiered tariff structure would enable CSP to be supplied into the grid during peak hours at R3.94/kWh[4], which is cheaper than the alternative peaking supply option from gas turbines[5].

In a constrained energy supply environment, renewables now present a savings opportunity. This is a radical departure from conventional thinking, which positions renewables as a more expensive source of power. Generation by mid-merit coal and diesel power plants, the latter currently running in excess of a 20% load factor, is significantly more expensive.

At the Wind Energy Summit South Africa, held earlier this year (2014), National Treasury indicated that had the 4 GW[6] of RE procured under the REIPPPP already been connected by 1 January 2013[7], South Africa would have saved a staggering R11 billion in avoidable fuel costs through the displacement of these particularly expensive fossil fuel energy sources.

FACTORS ASSOCIATED WITH REIPPPP TARIFF REDUCTIONS

Future expectations of the REIPPPP process and, more specifically, the utility-scale renewables price trajectory must be grounded in an understanding of the factors that have driven economics over the course of the programme's history. In particular, REIPPPP tariff reductions have been associated with various developments:

- The introduction of a competitive bidding process;
- Rising levels of REIPPPP competition, partly due to a weak global economy and fewer opportunities elsewhere;
- A gradual reduction in accepted leveraged equity returns;
- Alternative approaches to financing; and
- A global market shakeout in solar PV.

To elaborate, a competitive bidding process has been implemented and initial price caps recently removed. This process replaces the earlier REFIT (renewable energy feed-in tariff) concept, which proposed that electricity be procured at predetermined prices.

In Rounds 1 and 2 of this process, the existence of price caps served as reference points for the price of procuring RE. This, together with limited competition, resulted in Round 1 tariffs being bid very close to these caps. Round 2, however, saw significantly lower tariffs due to more active competition. By Round 3, when the price caps for solar PV and wind were removed and the contracts were hotly contested, price competition was fierce.

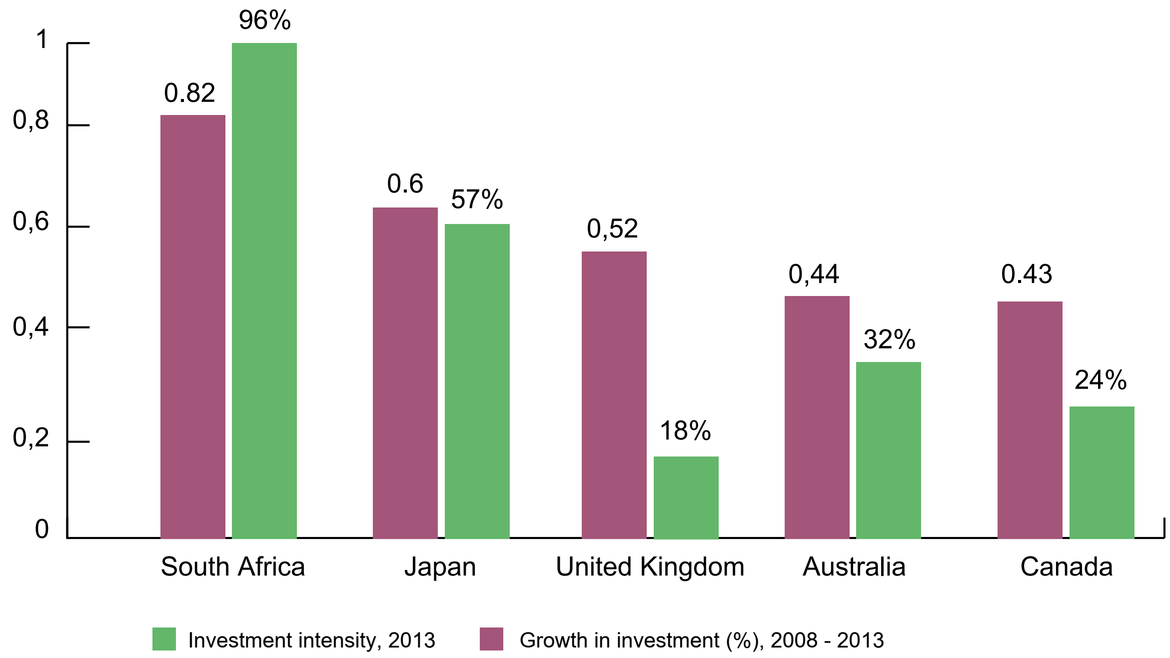
The rate of competition within the REIPPPP has increased due to a combination of declining investment in renewables elsewhere and growing confidence in both the REIPPPP and South Africa's potential as a utility-scale RE market. Global economic conditions have disadvantaged renewables in other markets, with clean energy investment dropping for a second straight year in 2013 (Pew 2014: 6).

The trend in South Africa has been markedly different, though, as the REIPPPP has supported - in quick succession - several contracting rounds for new renewables supply. A robust procurement process, extension of a 20-year sovereign guarantee on the power purchase agreement (PPA) and, especially, ideal solar power conditions, have driven the investment case for RE in South Africa.
Increasingly active competition has resulted in the REIPPPP success rate declining from highs in excess of 50% in Round 1 in 2011 to less than 20% in Round 3 in 2013 (Papapetrou 2014).

[4] 270% of the baseline tariff reported in Papapetrou (2014).
[5] This comes at a cost of approximately R5/kWh (Silinga & Gauche 2014).
[6] This figure includes the preferred bidders in Round 3, not all of whom had been contracted yet at time of comment.
[7] This is a hypothetical scenario to demonstrate the relative savings associated with increased use of renewable energy in South Africa.

These numbers do not take into account the anecdotal evidence that several Round 3 bids were not submitted for fear of proving uncompetitive.

Figure 1: South Africa leads as a clean energy investment destination



Source: *Pew (2014)*

Notes: *Investment intensity is defined as clean energy investment per dollar of GDP.*

The figure below further demonstrates how tariffs evolved relative to the price caps initially set by Government. In the first round, tariffs were set just below the price caps. Dramatic reductions took place in Round 2 as competition for awarded megawatts intensified. In Round 3, when caps were removed, prices fall even more rapidly. CSP is omitted from this analysis as tariffs are not strictly comparable across the three different rounds[8].

EQUITY FINANCING

As a result of these factors and growing confidence in the REIPPPP, equity investors are currently accepting leveraged returns well below the initially targeted 17%. A recent NERSA report (2014) reflects a range of approximately 14-25% in nominal post-tax terms, with returns falling through successive REIPPPP rounds. According to Eberhard et al (2014: 7), NERSA had initially estimated that investors would require a 17% real post-tax return on equity to spark participation in a new industry, equating to nominal returns in excess of 22%. However, as participants gained confidence in the process and institutions of the REIPPPP, the programme risk premium has fallen and, with it, required investor returns.

Further, the successful procurement programme has attracted international equity investors willing to accept lower returns than local investors, potentially in the low double digits on leveraged projects. This is consistent with the returns targeted in other middle-income economies[9]. By contrast, local equity investors typically target nominal post-tax returns above 16-18%.

[8] Developers set tariffs according to their own optimal mix between peak and off-peak supply, which are priced differently

[9] See for example comparison with Middle Eastern and North African countries in ISE (2013).

Alternative financial structures are also being employed, indicating the emergence of pricing competition.

Initially, REIPPPP projects were funded almost exclusively by project financing. Using this approach, a project is financed as a separate entity on the basis of its cash flow, with the option of limited recourse to the sponsor's balance sheet in the event of default. Senior secured debt is the instrument most generally used, typically accounting for more than two-thirds of the project financing requirement. This is supplied by the local banks at the Johannesburg Interbank Agreed Rate (JIBAR)[10] plus 270-390 basis points (Papapetrou 2014), translating into an approximate average nominal cost of debt of 11.3%[11]. A PV or wind project may have faced a cost of capital of approximately 11.1% in Round 3 on typical project finance terms[12].

In Round 3, Enel's winning bids based on corporate financing drew significant attention. Global utilities and developers, looking for global expansion opportunities in an otherwise quiet market, may finance the development of new projects off their strong balance sheets as part of their corporate strategy, potentially accepting equity returns as low as 8-10%[13] on individual deals. Taking advantage of the low cost of raising working capital in their home markets, these companies are able to take a portfolio view, developing a variety of prospects worldwide in order to diversify risk. Consequently, the cost of capital for a project funded by the likes of Enel may be 1-3 percentage points lower than one funded in the conventional project finance manner. Compounded over a period of up to 20 years, cheaper financing confers a significant cost advantage on a project, and so influences the bid tariff.

A comparison of a theoretical levelised cost of electricity (LCOE) based alternatively on project finance and corporate finance structures offers some insight. To compare the impact of different financing structure, the weighted average cost of capital (WACC) is calculated on each project[14]. A standard project finance structure in Round 3 may have faced a cost of capital of 11.1%, compared with a corporate finance deal where a 10% yield might be have been acceptable.

The impact of reducing the cost of financing by 110 basis points associated with switching the deal finance structure is a reduction in the bid tariff of approximately 7-8%, a significant advantage for deals financed off balance sheet. The impact is the highest on projects with longer construction periods or larger capital expenditure required in the early development phases, such as CSP.

This calculation has not taken into account other non-interest financing costs, which corporate finance deals may avoid. These include costs related to foreign exchange hedges and project finance fees.

Foreign exchange hedging costs may run to 2.8% or cost as much as R200 million per project in the case of CSP (Papapetrou 2014). Project debt fees typically amount to 1.75% of the facility, which covers arranging, underwriting and structuring. Other fees may include commitment fees on undrawn loans during construction, as well as coordinating bank fees in cases in which multiple banks participate. These typically amount to R20 million per deal[15]. It is therefore clear that the sponsor's project motivation and associated financing strategy will have significant implications on the competitiveness and success of a bid.

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[10] The South African money market rate, calculated as the average interest rate at which banks buy and sell money locally. It is linked to the prime lending rate.
[11] This is based on a 9 year swap rate of approximately 8%, as at May 2014.
[12] This assumes a 70/30 debt/equity split, fixed interest rate of 11.3%, corporate tax rate of 28% and a hurdle rate for return on equity of 18%. The quoted cost of capital is expressed in nominal terms.
[13] These are quoted as nominal post-tax unleveraged returns.
[14] The WACC is estimated by multiplying the share of each source of capital (debt and equity) by its cost and adding the results. The cost of debt is adjusted for corporate tax.
[15] Information reflects interviews with local bankers

approximately 7-8%, a significant advantage for deals financed off balance sheet. The impact is the highest on projects with longer construction periods or larger capital expenditure required in the early development phases, such as CSP.

PV TECHNOLOGY

PV technology is a special case, with extremely rapid price reductions over the three REIPPPP rounds. PV tariffs bid in the REIPPPP programme have exhibited the most dramatic decline, reducing by 70% across the three rounds of bidding over a period of two years[16]. There is currently a degree of scepticism in the market regarding this decline, with some commentators viewing this as an anomaly specifically due to capital equipment being offloaded at or below cost due to dumping or obsolescence.

In reality, the solar PV industry has evolved extremely rapidly over the past five years, with supply expanding faster than demand. There are several reasons for this.

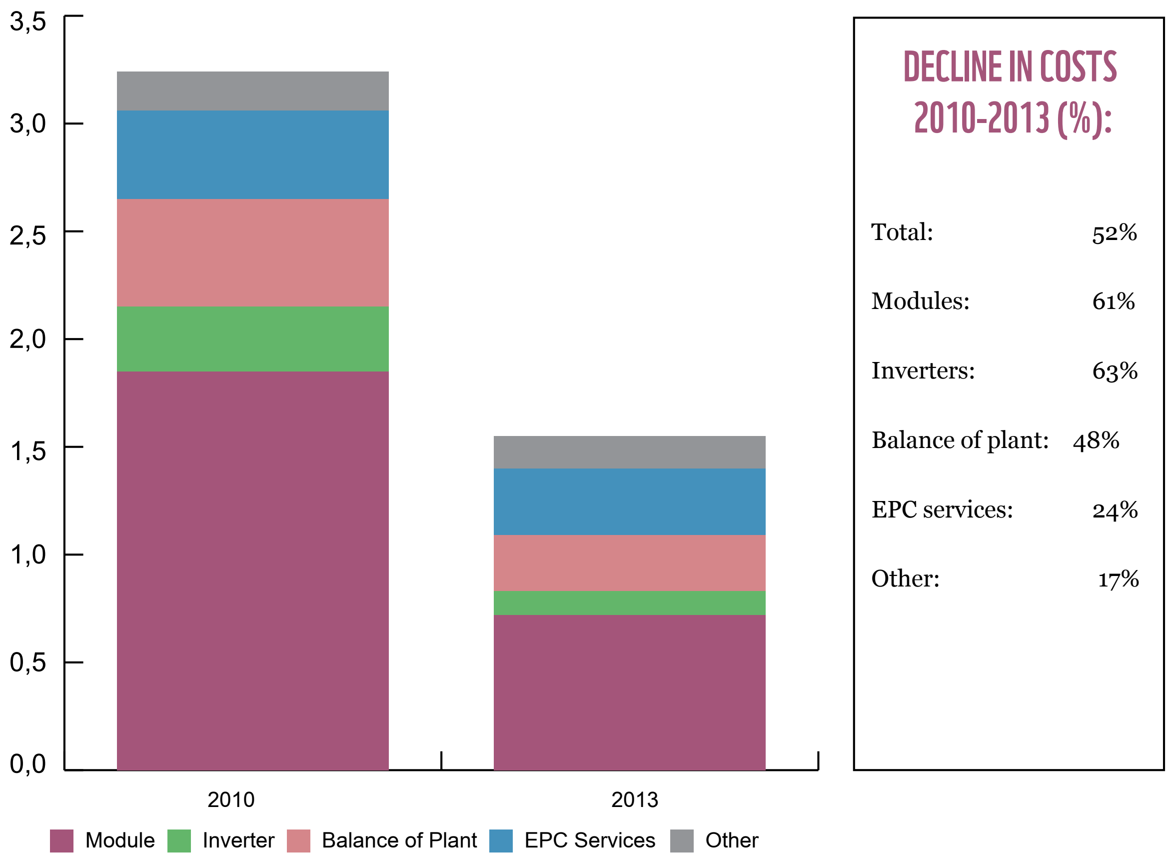
The first relates to China's entrance as a bulk, low-cost producer of solar PV modules. By 2012, module production capacity was 50 GWp (gigawatts peak), while demand had fallen to just 31 GWp as declining international feed-in tariffs and renewable subsidies took their toll (ISE 2013). In these weak conditions, Chinese exporters of solar PV crystalline silicon modules, which they there are able to produce at 30% less than the cost of the same technology in Europe and Japan, drove prices down, which resulted in dumping allegations and subsequent penalties in the USA (Candelise et al 2013).

Consequently, several established manufacturers filed for bankruptcy as factories became unable to cover production costs at rapidly falling prices. The industry is currently in a consolidation phase with various companies moving into other activities in the solar PV value chain, notably project development, which is a higher-margin activity than production.

The second reason for changes in the solar PV industry has been the fall in the prices of components across all elements of solar PV systems. Oversupply of silicon and an 80% decline in silicon prices from 2008-2013 has led to large developers being able to secure solar panels for as low as $0.76/W, resulting in a substantial impact on module prices. Similarly, pricing on inverters has fallen by almost two-thirds since 2010 (BNEF 2014: 34). The net result is an internationally applicable 52% reduction in the dollar price of solar PV systems between 2010 and 2013.

[16] Own calculations based on Papapetrou (2014)

Figure 2: The rapid decline in solar PV costs (USD) (2010-2013)



Source: BNEF (2014); own calculations.

As a result of this multitude of factors impacting tariffs bid in successive REIPPPP rounds, the South African market appears to compete quite favourably with other international markets in terms of the price of RE. It is therefore unlikely that tariffs will continue to reduce as rapidly as they have in the past.

GOVERNMENT TARGETS AND FUTURE PLANNING

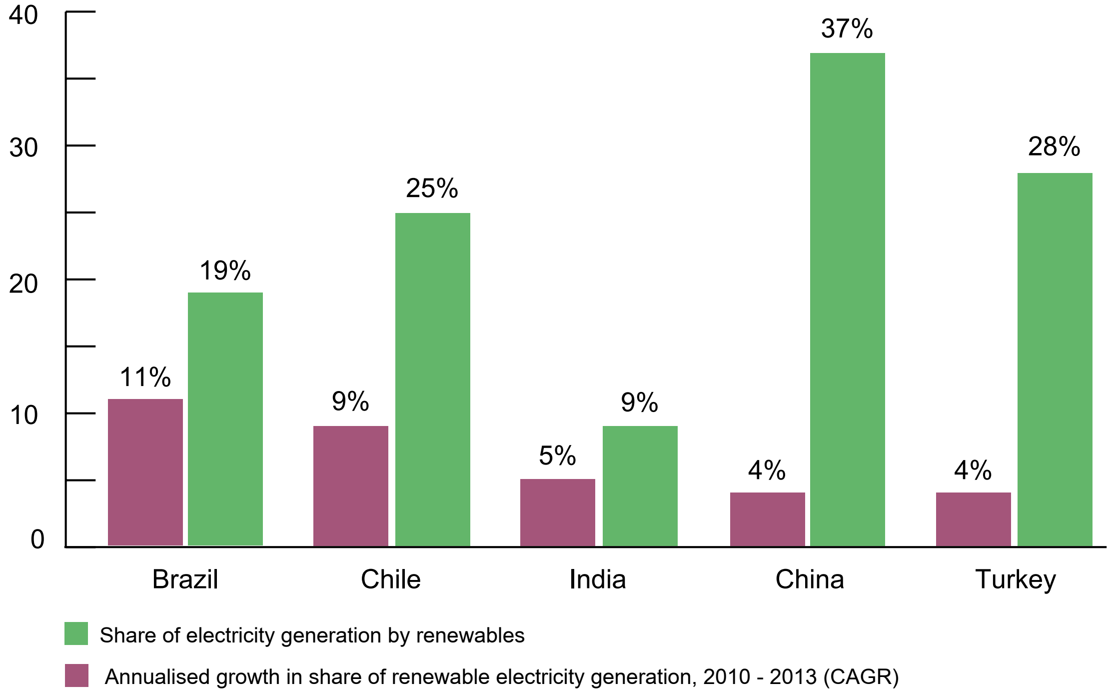
The Integrated Resource Plan for Electricity (IRP) articulates the principles and logic employed by the DOE to guide day-to-day decision-making regarding new investment in energy production capacity. Together with the Strategic Grid Plan and the Transmission Development Plan, this informs policymakers' views on decision-making and expenditure priorities in generation, transmission and distribution. All three of these documents are regularly updated to take into account changing conditions.

The draft IRP 2010-2030 Update Report (IRP Update), released by the DOE in November 2013, therefore models the 2030 energy mix according to various scenarios. This indicates the impact of different assumptions, including economic growth outcomes, climate change mitigation policy and large-scale strategic investments. Optimisation takes place on a constrained least-cost basis (i.e. the lowest cost of meeting South Africa's energy demand requirements is sought, subject to certain policy-driven or practical thresholds and ceilings).

From the WWF's perspective, there are several critical and debatable assumptions that may result in suboptimal investment decisions in RE. These relate to energy demand, pricing and hard-coded limits on procurement of new RE capacity. As a result, even in the optimistic Base Case scenario, the share of renewables in South Africa's electricity generation capacity by 2030 is only 9%.

Given the higher base levels and substantial renewable capacity growth rates seen in comparable emerging markets, it is likely that this achievement will be relatively unimpressive in international context. Brazil and Chile have already exceeded South Africa's targeted renewables share for 2030, while China and Turkey will achieve parity within the next three years if their growth in the share of RE over the past three years continues at the same rate.

Figure 3: Renewable energy generation in comparable emerging markets



Source: *BP (2014); own calculations.*

Notes: *Based on gross electricity generation from renewable sources including wind, geothermal, solar, biomass and waste, and not accounting for cross-border electricity supply.*

DEMAND ASSUMPTIONS

Key IRP Update assumptions concerning renewable capacity relate to economic growth and associated electricity demand. These assumptions are critical to investment decision-making, as they reflect total electricity demand and required generation capacity. One could argue that policymakers will dynamically change direction in accordance with emerging evidence should these foundational assumptions turn out to be incorrect. However, this will not prevent substantial suboptimal investment in plants with long lead times, such as nuclear plants which are typically contracted 10-15 years before commissioning.

The IRP Update takes as a departure point the attainment of an average 5.4% annual gross domestic product (GDP) growth rate from 2012-2030, linked to full implementation of the National Development Plan and favourable global economic conditions. There is a further assumption that growth is increasingly driven by sectors with lower energy intensity, primarily the tertiary services sector, leading to declining energy intensity in the economy. Corresponding average annual growth in electricity demand from 2012-2030 is therefore estimated to be 2.7%, leading to an annual electricity demand of 416 TWh by 2030. Within this scenario, renewable capacity contributes 17.4 GW or 21% of the total.

However, since renewables operate at lower load factors than the majority of conventional fuel types, they account for just 9% of the total electricity generation at current assumptions. Within this scenario, 2.5 GW of new coal-fired power from the Medupi and Kusile power stations and 4.9 GW of new nuclear energy will be required.

Table 2: The role of renewable energy in the IRP Update Base Case (2030)

Technology Option	Capacity*		Generation**	
	MW	Share	TWh	Share
Coal	38 680	47,5%	288	69,2%
Combined-cycle gas turbines	3 550	4,4%	16	3,6%
Open-cycle gas turbines	7 680	9,4%	7	1,6%
Nuclear	6 660	8,2%	54	12,1%
Other (including hydro, pumped storage)	7 350	9,0%	14	4,1%
Renewable energy (excluding hydro)	17 430	21,4%	37	9,4%
Solar PV	9 770	12,0%	17	4,0%
Solar CSP	3 300	4,1%	11	2,7%
Wind	4 360	5,5%	11	2,8%
Total	**81 350**	**100%**	**416**	**100%**

*Source: * DOE (2013); ** own analysis based on load factors in DOE (2013)*

Notes: Load factors are as per IRP update assumptions; weighted averages apply for CSP and hydro. Generation from "Other" is a balancing figure.

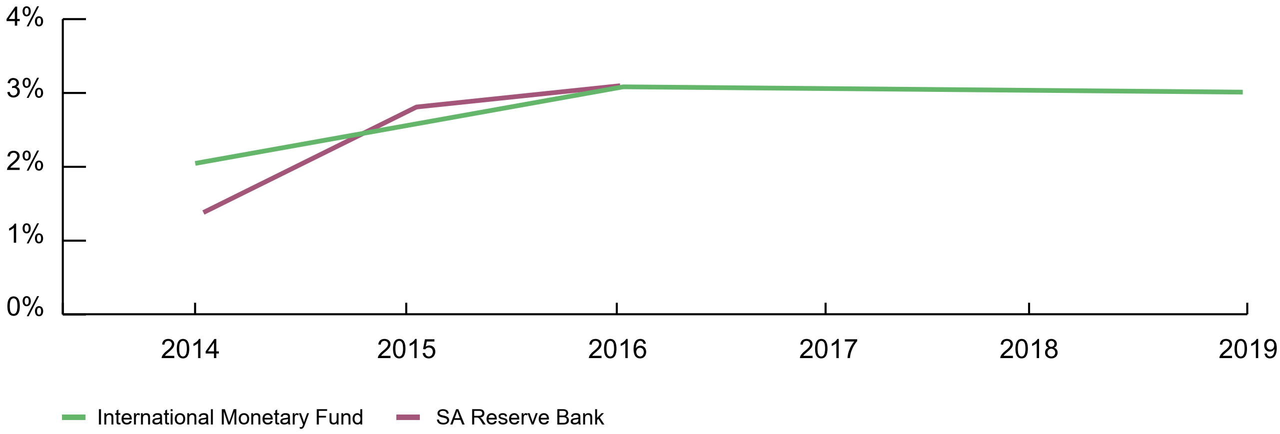
ECONOMIC ASSUMPTIONS

Neither local nor international medium-term forecasts of South Africa's GDP growth support the IRP Update's optimistic economic assumptions. The Reserve Bank's medium-term forecast paints a lacklustre picture of growth in the 1.5-3.5% range, while the IMF predicts an average of 2.9% economic growth over the five-year period 2014-2019.

This implies that the IRP Update's Weathering the Storm (WTS) scenario is the more realistic one. Lower growth seems ever more likely in light of the recent release of data showing that economic growth turned negative in the first quarter of 2014, partially as a result of ongoing labour strikes in the minerals sector.

Underpinning slow growth is weak manufacturing activity, the mainstay of South Africa's economy. This suggests that growth in linked services industries such as transportation and finance will also continue to be weak. Rigid labour markets, a weak skills base and, of course, energy supply shortages continue to place constraints on productive capacity. This suggests limits on the extent to which South Africa will attract international investment or take advantage of a recovery in global growth, even if the NDP is fully implemented.

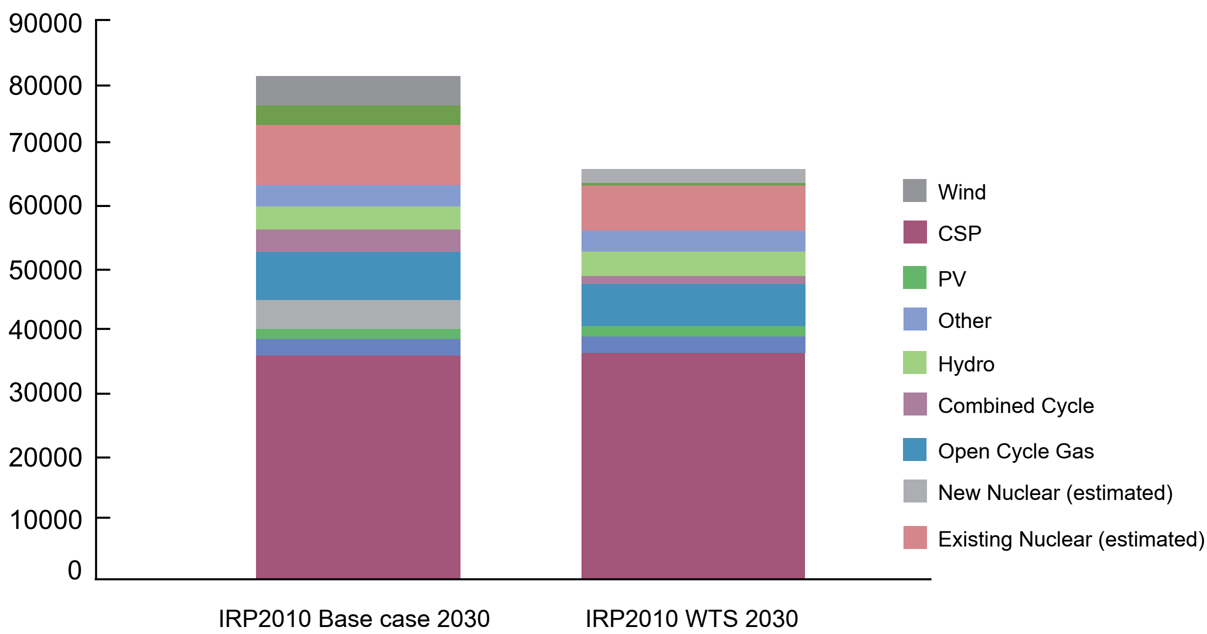
Figure 4: Medium term SA economic growth[17] forecasts (%)



Sources: IMF (2014); SARB (2014)

In the IRP Update WTS scenario, the 2030 renewable fraction falls to just 6% of the total demand of 345 TWh, supplied through a 10 GW share of the total 66 GW of generation capacity. This represents the most constrained energy demand growth outlook amongst the variety considered in this document. In this scenario no further nuclear or CSP capacity is added.

Figure 5: Comparison of IRP Update Base Case and Weathering the Storm scenarios by installed capacity (MW)



Source: DOE (2013); own calculations

Whilst low growth does appear likely, it is equally likely that the correlation with energy demand is underestimated in the IRP Update projections. Suppressed demand exists as a result of grid supply constraints (Creamer 2014a), which have manifested in Eskom's buyback programme and Integrated Demand Management initiatives. Recent dramatic increases in the electricity price have also dampened demand. However, once additional supply capacity comes online and artificial constraints on electricity consumption are removed, it is expected that electricity demand will bounce back.

[17] This refers to growth in the Gross Domestic Product

A local engineering company, GIBB, estimates that electricity demand is already growing at 3% annually, a rate that is on par with the economic growth rate (i.e. up to double the IRP Update assumption[18]). Consequently, the company believes that 40 GW of additional generation capacity will be required within the next 20 years (Gebhardt 2013).

If this is the case, South Africa would likely require the generation capacity associated with the high-growth Base Case IRP Update scenario, even if it experienced sluggish economic growth. From this discussion, it is clear that a great deal of uncertainty exists regarding real electricity demand in the coming 20 years. The optimal response is to plan flexibly, using power sources that can be procured in modest increments and brought on-line quickly and as required. RE plants fit this brief due to their modular nature and the fact that they can be speedily constructed as needed.

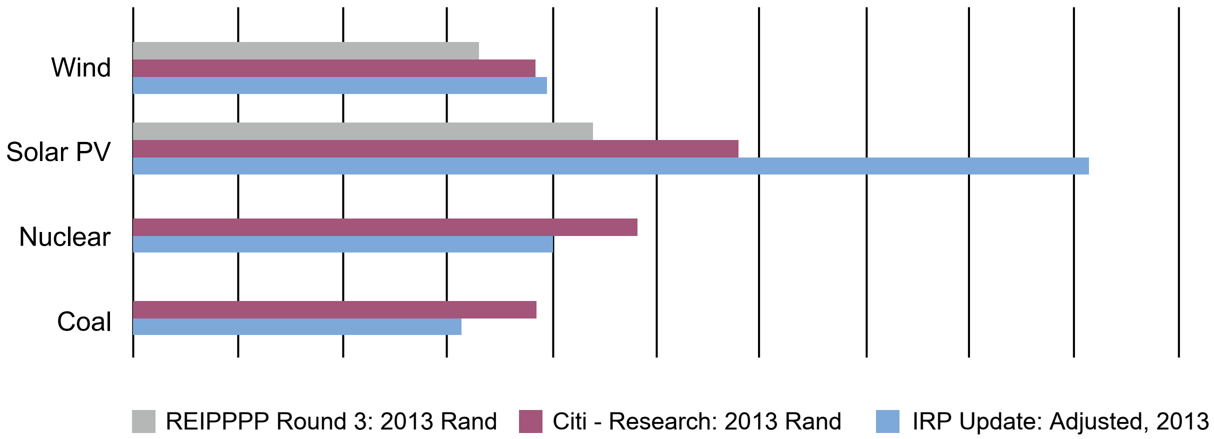
RELATIVE COSTS

The relative cost of the various electricity sources is another critical deciding factor, determining which energy mix will deliver on demand. All technologies in the figure below are evaluated on the basis of the LCOE to ensure direct comparison. From this it is evident that the LCOEs for coal and nuclear in the IRP Update are low relative to recent independent international estimates, which are approximately 20-25% higher (Citi Research 2013).

While the IRP Update estimate for coal may be accurate for old coal-fired plants, it will not apply to the Medupi and Kusile power plants, which will generate much more expensive power and comprise 20-25% of the coal-fired plant mix by 2030. Further, the carbon tax mooted by Government will have a greater impact on coal-fired power than any other energy source, given its carbon intensity. The nuclear power LCOE is understated to an even greater degree in the IRP Update, although much uncertainty regarding actual costs is acknowledged.

By contrast, RE levelised costs - even at the 2012 value of the Rand - are higher than the tariffs that were bid in 2013, erring on the high side. In particular, the LCOE calculation for solar PV seems too conservative by some margin. The net result of this mix of LCOE calculations is a decision-making lens biased towards coal and nuclear in determining the optimal energy mix for South Africa. In reality, solar PV and wind already compete favourably with the more traditional alternatives of new coal and nuclear from an LCOE perspective.

Figure 6: Price of electricity[19], (R/kWh)



Sources: DOE 2013; Citi Research (2013); Papapetrou (2014); Own analysis

[18] The electricity intensity of different economic growth pathways differs, dependent upon restructuring of industry.

[19] This is reflected either as a theoretical LCOE (Citi Research and IRP Update) or as actual tariffs bid (REIPPP).

Notes: IRP Update 2012 LCOEs are converted to 2013 Rand, adjusting for exchange rate effects using the average 2013 ZAR/USD exchange rate and the 2012 inflation rate published by the South African Reserve Bank. Share of imports is deemed to be 60% for coal, nuclear and wind, and 50% for solar. The IRP Update estimate of LCOE for solar PV is based on an outdated overnight capital cost of R29 000/kW. It will likely drop in the final version to R20 000/kW (correspondence: Keith Bowen, Eskom). Citi LCOE estimates are approximate and refer to baseline estimates except for solar. Citi solar LCOE relates to areas of high insolation (1500kWh/kWp). Most of South Africa would fall within this band.

Furthermore in the IRP Update the contribution of renewables is limited by hard-coded caps placed on the growth of capacity in solar PV and wind technology without justification from a technical feasibility perspective.

Annual additions to wind capacity are limited to 1 600 MW and solar PV to 1 000 MW. The justification for the wind limit is based on observed historical wind construction rates in a reference country, namely Spain. However, several large economies, including Italy, Germany and Japan, added more than this capacity during 2012. The cap on solar PV is imposed somewhat arbitrarily to "limit the major switch to this technology" resulting from assumed learning rates (DOE 2013: 19). In reality, rapidly declining solar PV prices have supported the technology, recently overtaking wind as the fastest growing clean energy source globally[20]. It is understood that the DOE is currently starting to experiment with removing these constraints[21].

Gas is, however, viewed as an alternative to RE and a potential game-changer. In the IRP Update's Big Gas scenario, large scale exploitation of shale gas resources in the Karoo and the gas fields of Mozambique results in a rapid switch to a gas-dominated energy mix, with renewables playing a much smaller role than in the Base Case[22].

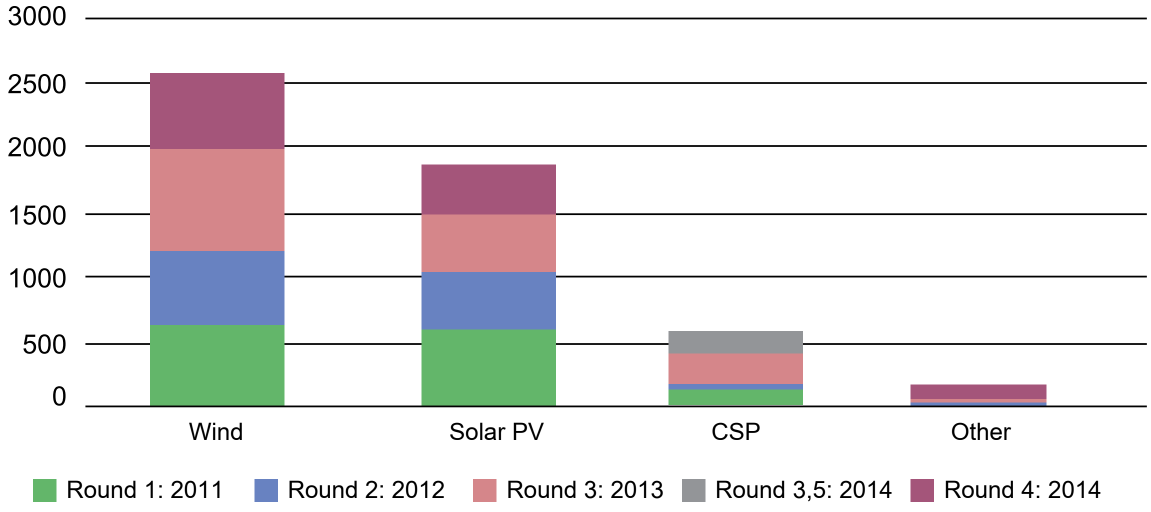
Critical assumptions include availability of gas and water, which is unpredictable in the case of shale; timing of access to these regional gas resources, which will probably only occur in 2025; and a substantial reduction in the gas price to R50/GJ in 2035[23]. As with renewables, there are significant new transmission requirements associated with gas, as generation may not take place at a load centre. Furthermore, substantial pipeline and gas terminal storage costs may be incurred. These will tend to push up the relative price of gas, even if regional sources can be competitively procured at source.

THE FUTURE OF UTILITY-SCALE RE

Despite its promising beginnings via the REIPPPP, the future of utility-scale RE in South Africa is uncertain. Assuming a 100% award rate for the most recently published requests for proposals, this leaves just 1.7 GW of the original ministerial determination available. The IRP Update recommends that 2.2 GW capacity be added annually: 1 000 MW each of solar PV and wind, and 200 MW of CSP. By this measure, commitments to procure further capacity are in place for less than a year from now. This creates significant doubt regarding the prospects for future development of the market for utility-scale renewables in South Africa, specifically with regard to modes of procurement.

[20] New solar PV capacity jumped by 29% (40 GW) in 2013, and is currently forecast to be the leader in terms of new investment and capacity in clean energy (Pew 2014: 31).
[21] Correspondence with Keith Bowen, Eskom
[22] Renewables account for just 6.4 GW capacity in this scenario.
[23] Prices are given in 2012 Rand value.

Figure 7: REIPPPP allocations to date (MW)



Source: *Papapetrou (2014); Creamer (2014b)*

Notes: *A the time of writing, Round 3 preferred bidders are contracting with the DOE. Awards have not yet been made on Rounds 3.5 and 4.*

Unpredictability, added to concerns over potentially escalating local content requirements in the REIPPPP is resulting in developers and investors exploring other avenues such as embedded and off-grid generation and utility-scale generation in other African markets. Both may be viewed positively as alternative routes to increasing RE capacity in the region.

However, REIPPPP uncertainty does not support further investment in local production capability, especially given the fact that embedded and off-grid generation currently faces its own set of significant regulatory and policy hurdles. Adverse impacts are likely to be greatest for the CSP industry, which is globally relatively small, immature and constrained by variability in technology design.

More predictable annual demand, as well as a track record of low-risk construction and operations, would be required to build substantial local CSP manufacturing capability as a viable baseload alternative to nuclear and gas. Lack of clarity regarding the type, size and location of new energy plants also creates challenges for grid planning as transmission upgrades have longer horizons than RE plant construction, so must precede these in planning.

WWF 2030 RENEWABLE ENERGY VISION

RE IN THE ENERGY MIX

The WWF believes that renewable energy should play a more significant role in South Africa's future energy mix.

Although both IRP Update scenarios examined here fall within the annual electricity sector emissions limits set by the DOE in the 2010 IRP[24], the country's energy mix will remain fundamentally driven by coal, an unsustainable energy source. The IRP Update acknowledges that the DOE emissions target for the electricity sector does not align with the limits set by the Department of Environmental Affairs in its 'peak, plateau and decline' planning (DOE 2013: 26). This work proposes that emissions peak in 2025, then plateau for some time and start declining thereafter. In line with this logic, electricity sector emissions should peak at 247[25] million tonnes of emissions in 2025; emissions only from existing coal fired power stations, including Medupi and Kusile, are likely to exceed this figure in 2030. Continued reliance on coal is consequently not compatible with a climate-resilient future.

From a policy-making perspective, RE is an excellent source of flexible supply within the context of uncertain energy demand, given the short lead times required and the modest, economically viable plant size. RE is also uniquely positioned with respect to operating costs, given that no fuel is required. In the case of gas, for example, uncertainty regarding the future price at which gas can be secured is a significant deterrent to increasing plant capacity. Similarly, Eskom's declining cheap coal supply form Mpumalanga will drive up the price of coal-fired electricity in the medium to long term (DOE 2013: 18; Davie 2010).

In addition - and critically from the WWF's viewpoint - a broad RE base will support a resilient South African future in which the food-energy-water nexus remains balanced, and able to support the needs of a developing society and economy. The encroachment by coal on scarce arable land and water resources, as well as the greenhouse gas emissions it is responsible for, will result in South Africa paying a far higher price than what is captured in the IRP Update's estimated coal levelised cost of electricity.

GUIDING PRINCIPLES

The WWF's departure point is the development of a sustainable energy mix that does not carry undue risks for the environment or for society.

Economic factors are more easily measured than environmental and social factors, and so often form the basis for decision-making. However, the reality of climate change and its influence on rainfall, agriculture and livelihoods, as well as the impact of coal usage on land and water, are examples of how externalities associated with economic activity can eventually place constraints on economic growth and development. Similarly, the externalities associated with social risks such as catastrophic nuclear disaster are often not adequately priced for and taken into account.

Accordingly, the construction of further coal-fired or nuclear power stations is not supported in the WWF 2030 vision.

[24] 275 million tonnes carbon emissions

[25] This is based on the 550 million ton carbon limit for the economy as as whole. A 45% share is accounted for by the electricity sector, according to the DOE (2013).

THE RISKS ASSOCIATED WITH COAL-FIRED POWER

The environmental risks associated with coal usage are clear: both fluidised-bed combustion and pulverised coal emit close to 1 tonne of CO^2 for every megawatt of electricity generated, and they are highly water-intensive technologies (see Table 1 in the Appendix).

Less well known is the economic risk associated with coal usage in South Africa.

An Eskom coal supply gap is currently developing, with demand for an additional 60 million tonnes of coal per annum at risk of not being met despite the country's abundant coal reserves (Creamer 2013a). Production in the Central Basin area[26], where the majority of older coal-fired power plants are located, is expected to peak in the next few years (Eberhard 2011). Eskom is already competing with export markets such as India for the limited coal supply from this area, and its pulverised coal-powered stations are running off steadily deteriorating steam coal grades as a result.

While lower coal grades might be affordable, their indirect costs are significant. An estimated 1 GW of Eskom generation capacity is being lost daily due to reliance on suboptimal coal fuel (Davie 2010). The utility is also relying increasingly on short- and medium-term coal contracts to plug emerging supply gaps. These already account for a quarter of supply, driving up the average price paid for coal (Eberhard 2011).

Coal-fired power plants in other regions are not exempt from fuel procurement challenges. Kusile in the Waterberg does not yet have a bulk fuel supply agreement in place. A disagreement with Anglo American about procurement requirements linked to the New Largo colliery has not yet been resolved, leading to fears that the plant may not have the fuel it requires when it is ready to start operating in 2016. (McKay 2014).

An apparent solution to this problem would be the development of new coalfields. However, factors such as a declining global coal price, ongoing threats of international carbon regulation and taxes, and local labour unrest deter mining majors from developing new coalfields in South Africa. There are also specific regional concerns. For example, in the coal-rich Waterberg area, water availability is limited, geology is complex, and there is insufficient rail infrastructure in the region to ensure access to other mines and markets.

THE RISKS ASSOCIATED WITH NUCLEAR POWER

While nuclear power represents a cleaner alternative to fossil fuel generation, it is a highly risky technology from both an economic and social perspective. In the first instance, significant capital cost uncertainty exists, which is acknowledged in the IRP Update (2013: 13). As a reference point, Britain's new Hinkley Point nuclear plant will generate electricity at a cost of approximately R1.75/kWh in today's terms, compared with an estimate of just R0.70/kWh in the IRP Update[27] (DOE 2013; Atherton 2014).

Build timelines are also uncertain. Hinkley Point, for instance, is expected to take nine years to construct, but it could take much longer. If the protracted construction delays on the Medupi and Kusile power plants are anything to go by, construction timelines in South Africa will likely be substantially longer, driving up the cost exponentially as a result of interest charges during construction.

[26] This comprises the Witbank, Ermelo and Highveld coalfields.

[27] GBP0.0925/kWh, 2012 value

Similarly, it is difficult to fully account for the social risks associated with clean-up operations or nuclear disasters. The lack of effective nuclear waste management solutions has led to thousands of tonnes of radioactive waste being stored outside of safe geological repositories all around the world. Countries such as Germany are attempting to price these externalities by taxing production of nuclear power heavily (by approximately EUR15/MWh) in order to phase out nuclear (Citi Research 2013). Further, nuclear is an inflexible power source that does not have the ability to ramp up or down quickly as part of a dynamic energy mix.

WATER USAGE

Water intensity is a challenging issue not only for fossil fuels such as coal, but also for certain RE technologies such as CSP. The regions in South Africa with the highest solar radiation are generally arid, and the suitability of water-intensive energy sources may thus be questioned. As a result, the WWF suggests that CSP development plans provide for incentives to implement dry cooling systems. Table 1 in the Appendix provides further information in this regard. Dry-cooled CSP systems do offer enhanced efficiencies, and the WWF encourages the application of these in South Africa.

ANALYTIC METHODOLOGY

Since utility-scale renewables are procured by power purchase agreements, the most relevant metric for our purposes is levelised cost or LCOE, which represents the break-even cost of producing energy from a given source over its useful lifetime in current Rand value.

Tariffs bid in recent REIPPPP rounds give us important information relating to the true price of procuring RE generation in South Africa.

In order to create an independent set of estimates of the price tag of South Africa's utility-scale RE aspirations, the WWF has interrogated each of the IRP Update assumptions on critical parameters, seeking the views of a range of industry experts, financiers and developers to ensure robust and credible results. The organisation has also used the most recently published, credible and independent estimates of capital cost – critical in rapidly changing RE technology markets – and accounted for increases in import costs associated with Rand depreciation. The IRP Update does not take currency effects into account.

To assess the capital requirement associated with scaling up renewables in South Africa, the LCOE for each of the three technologies is calculated for the period 2014-2030. The basis for calculation is the simple LCOE calculation as used by the National Renewable Energy Laboratory (NREL), namely:

Simple LCOE = {(overnight capital cost * capital recovery factor + fixed O&M cost)/(8760 * capacity factor)} + (fuel cost * heat rate) + variable O&M cost

In this instance, O&M stands for operating and maintenance costs. The fuel cost is necessarily zero throughout. There has, however, been one adjustment to the basic formula: overnight capital cost has been substituted with adjusted capital cost (i.e. overnight capital cost combined with interest during construction, capitalised and accrued).

Capitalising interest during the construction period has emerged as a standard practice in project finance transactions during discussions with developers and financiers, and mirrors the approach followed in the IRP Update document. In addition, overnight capital costs take account of the varying local and imported shares of cost in order to account for the effect of Rand depreciation on the imported share.

The WWF's assumptions are as follows, in line with the average share of local content in Round 3 of the REIPPPP as laid out in Eberhard et al (2014)[28].

Table 3: Local content modelling assumptions

Technology	Assumed share of local content in total capital cost, 2014	Local content, Round 3 - REIPPPP (Eberhard et al 2014)
Solar PV	55%	53.8%
Solar CSP	45%	44.3%
Wind	45%	46.9%

Source: *Eberhard et al (2014); own analysis*

Using an interest rate i and duration of payback in years n, the capital recovery factor is calculated as follows:

Capital Recovery Factor = {i(1 + i)^n} / {[(1 + i)^n]-1}

All fixed and variable operating and maintenance costs are taken directly from the IRP Update. Other parameters are discussed below. All financial estimates are presented in 2014 Rand value.

LEVELISED COSTS OF ELECTRICITY

While the LCOE is a composite of a variety of factors, the following are particularly important for RE:

- Capital cost;
- Learning rate;
- Capacity factor; and
- Discount factor (the cost of money and inflation).

In South Africa, local economic development is a specific requirement under the REIPPPP, and 30% of bidder scoring is determined by performance on a local economic development scorecard. In addition to the standard variables affecting LCOEs, this is also discussed as a factor influencing RE tariffs bid in South Africa.

CAPITAL COSTS

Capital cost is a complex term, influenced by a variety of factors. As an economic concept, it may be defined to include project developer's costs, such as bid development, environmental impact assessments, permitting, grid connection and so on; the supply and installation of mechanical, civil and electrical equipment; and other costs such as indirect project costs, contingencies etc.

Project developer's costs are unique to the project and, to a large extent, are determined by the rules and regulations stipulated by the host country and the procurement process.

Developer's costs are seen as being relatively high in South Africa[29], given the extensive set of process requirements stipulated by the REIPPPP, and the host of permits that need to be obtained for rezoning, transportation and so on. Developers suggest that development costs are in the order

[28] This would likely include operating costs, which are expected to have a higher local share than capital equipment given the nascent and limited local renewable plant manufacturing capability.
[29] Source: interviews with various REIPPPP developers.

of R5-10 million per bid (Creamer 2014c). It is understood that extensive requirements were initially put into place in order to ensure that projects would be of a high quality and would demonstrate operational and financial success once awarded.

In respect of capital equipment supply and installation, South Africa is generally a price-taker in global markets. The price of each technology is a function of market conditions, market dynamics and the life stage of the technology, as newer technologies generally experience higher learning rates. Weak global conditions and the resulting decline in RE investment has already been discussed as a factor contributing towards competitive pricing.

The following section examines market dynamics and technology developments and they relate to solar and wind power. Typically high levels of competition within an industry, as well as technologies that are standardised, commoditised or can be produced at relatively low barriers to entry, tend to result in lower prices.

SOLAR PV

As already mentioned, the solar PV industry has become extremely competitive and is currently in a consolidation phase. Remaining cost-competitive manufacturers are pursuing vertical integration to capture more value as utility-scale solar project development is a higher-margin activity than manufacture, and so can cross-subsidise manufacturing at times of equipment pricing pressure. SunEdison, SunPower and First Solar are some examples of companies exploring vertical integration opportunities. This development, together with the current consolidation of the industry, should enable normal economic profits to be restored.

As a result of rapid reductions in component costs and an industry shakeout, capital costs on best-in-class utility-scale projects have now fallen to approximately R14 000/kW globally (BNEF 2014; ISE 2013; Citi Research 2013). This development is critical when calculating future projections of solar PV LCOE in South Africa. The assumption of approximately R20 000/kW (2012 Rand value) in the IRP Update is clearly too conservative. It is the WWF's position that a lower cost baseline can be structurally supported, and accordingly estimates an overnight capital cost at R13 771/kW in 2014, based on the estimate from Citi Research (2013) and adjusted for learning, inflation and foreign exchange fluctuations in the past year.

CSP is, in some respects, the polar opposite of PV. While PV technology has become commoditised and is currently being produced by many suppliers, CSP technologies are diverse and suppliers are relatively few. Parabolic trough, central receiver (tower) and linear Fresnel are some of the more common CSP plant types.

The relatively low level of take-up of these technologies on a global scale, and the consequently small supplier base, make cost benchmarking difficult for local projects. This is complicated by the fact that CSP technology is often omitted from international reports on RE capital costs, such as the International Energy Agency's World Energy Outlook. Where capital cost data is available, a further complication exists: plant costs are quoted variably, and sometimes include specific thermal storage capability, which is itself a cost driver.

Broadly speaking, the IRP Update estimates for three-hour storage plants, averaged across the two technologies included – parabolic trough and central receiver – fall within the range of international estimates.

Table 4: CSP capital costs (2012 Rand value)

Technology	Applicability (CSP without storage unless otherwise stated)	Overnight capital cost (2012 Rand/kW)
DOE (2013)	Plants with 3 hour storage, average across parabolic trough and central receiver	R39 008
IRENA (2013)	Average for developing countries	R28 700
IEA (2013	NPS Scenario: Africa	R43 050
EIA (2013)	USA	R41 535

Notes: Dollar figures are converted to Rand at the average 2012 exchange rate (www.oanda.com).

When adjusting the IRP Update figure to 2014 Rand value (correcting for inflation, Rand depreciation and learning rates), an average across technology types has been used. This includes three-hour storage capabilities amounting to a R42 046/kW overnight capital cost.

WIND

Wind is the most mature renewable technology of the three planned for roll-out in South Africa, with a global installed capacity of 307 GW (Pew 2014: 31). A broad supplier base has supported movement down the cost curve to quite competitive levels. Despite its maturity, however, cost decreases have been possible in recent years, and it is particularly interesting that there remains a large disparity between the cost of wind projects in the East and the West (IRENA 2012). This suggests that China may become as significant a cost cutting force as it already is in the PV industry. Increasing manufacturer competition and lower commodity prices for steel, copper and cement have also resulted in falling prices. This is especially notable in the fact that the cost of turbines, which comprises approximately two-thirds of the capital cost on wind power projects, experienced price reductions of approximately 35% from 2009-2013 (BNEF 2014: 38).

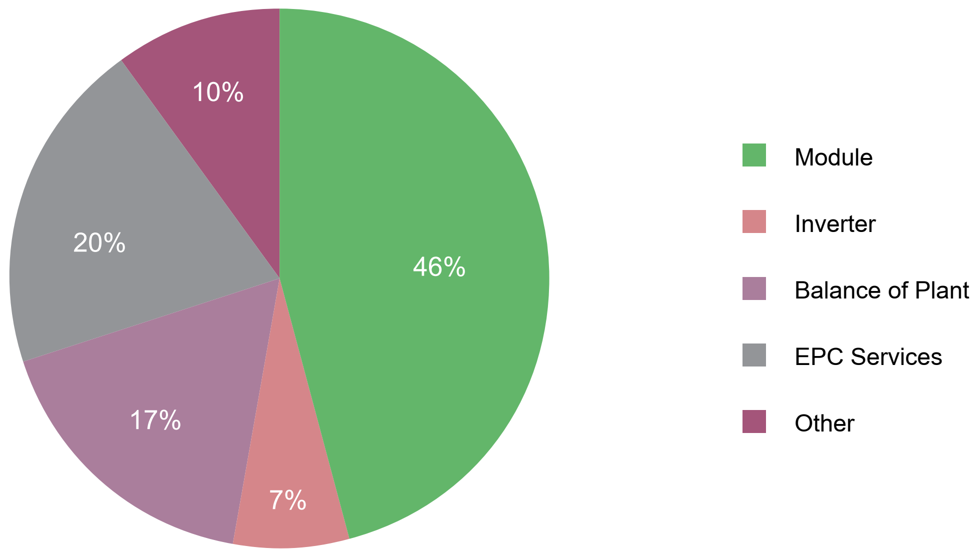
In developing this report, the WWF has given preference to the most recent independent estimates in order to accommodate the rapid changes that take place in RE technology markets. Accordingly, the Citi Research estimate (2013) has been used, and adjusted to 2014 Rand value to take into account learning, inflation and Rand depreciation. This yields a R16 642/kW overnight capital cost, slightly below the IRP Update figure adjusted to 2014 Rand value.

LEARNING RATES

SOLAR

Recent dramatic reductions in the price of solar PV and debate over the current sustainability of solar PV prices may lead to the incorrect conclusion that further learning is not possible. On the contrary, experts believe that substantial opportunities remain. Production costs for leading Chinese crystalline-silicone module manufacturers are expected to halve by 2017 to just $0.36/W (Osmundsen 2014). Since modules comprise half of the cost of an installed utility-scale solar PV system, this means that we can expect more than a 20% reduction in the total dollar cost of a system over the coming three years.

Figure 8: Capital cost breakdown for utility scale PV plants (2013)



Source: Own analysis based on BNEF (2014)

In addition, progress continues to be made in alternative module technologies, which provide potentially higher yielding alternatives to the historically preferred monoline crystalline silicon. Crystalline silicon has a theoretical maximum yield of 29%[30], with yields in the region of 20% generally more possible in practice.

Leading large manufacturers such as Panasonic, SunPower and Sharp have recently broken into the mid-twenties range, offering exciting opportunities for further cost reduction per watt (Bullis 2014). At the same time, innovation in thin film and hybrid solutions, which combines crystalline silicon and thin film principles, may deliver higher yields at lower production costs. These technologies nevertheless still need to be proven at scale by the likes of First Solar, Solar Frontier and Silevo.

Multi-junction solar cells, in which different types of solar cells are stacked upon each other, represent another option, with an efficiency of more than 40% under laboratory conditions. Soitec claims 31.8% efficiency for its concentrating PV modules using this technology, which is mounted on dual-axis trackers (Soitec 2014). Increasing use of more sophisticated mounting systems such as dual-axis trackers is also enhancing efficiency substantially as compared with fixed-tilt systems.

While solar PV and wind are relatively well established technologies, CSP presents an opportunity for more radical price reductions. In South Africa, a combination of increased plant capacities and manufacturing improvements may support possible cost reductions of 28-40% (Ernst & Young/ Enolcon 2013). Economies of scale can be realised on plants with a capacity of greater than 100 MW, with the most competitive costs being realised at 250 MW. It must be noted, however, that there are few existing CSP projects of this scale globally, so achieving this scale using project finance will be difficult[31].

Regarding manufacturing improvements, the solar field, representing 40-45% of the capital cost, yields significant learning opportunities via improvements in receiver technology and reduction of mirror weight and steel volumes. Weak supplier competition will, however, likely partly offset these technological cost-curve benefits. Already expensive CSP projects are being shelved in favour of PV in large renewable markets such as the USA, limiting the global growth of the CSP

[30] This is according to the Shockley-Queisser limit, which holds that no more than 29% of the photons that hit the cell can be converted into electricity.
[31] Technology risks are not typicall taken on on project finance deals; eligible technologies must be proven.

supplier base.
The WWF assumes a 5% solar learning rate throughout the period, but notes that disruptive innovations resulting in significant cost reductions are possible, particularly in CSP.

WIND

Modest learning rates are expected to continue for this mature industry (ISE 2013; IEA 2013). As the global economy recovers, increasing commodity prices may push up costs, but incremental innovation in wind turbines and structures, together with the development of a lower cost production base in China, are likely to offset this effect. The overnight capital cost of onshore wind power had already dropped to $1 300 (approximately R13 650 at the current exchange rate) in China back in 2010, while it cost 50% more in North America (IRENA 2012).

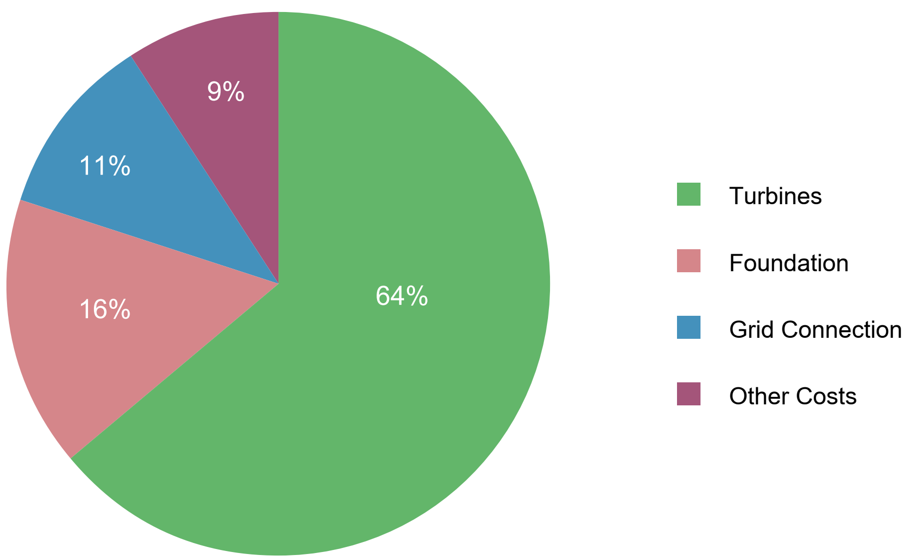
Further opportunities for cost reduction in wind turbines include the following (IRENA 2012):

- Towers, constructed mostly from steel, comprise 25% of the cost of wind turbines. The increasing distribution of manufacturers, greater competition and the use of more lightweight materials support cost reductions. Since towers can be manufactured locally, they will also be less sensitive to the weakening Rand. Cost reduction potential: 15-20% by 2030.

- Rotor blades comprise 20% of the cost of wind turbines. Ongoing improvements in reducing weight through the use of carbon fibre and other lightweight materials will support a reduction of 10-20% by 2020.

- Gearbox costs and the costs of other components may be reduced by 10-15% by 2020, owing to manufacturing efficiencies.

Figure 9: Capital cost breakdown for wind (2012)



Source: IRENA (2012)

The WWF maintains the anticipated 2012-2020 IRP Update wind learning rate of 1% per annum, but extends it to 2030. This accords with international expectations (IEA 2013; IRENA 2012).

CAPACITY FACTOR

The capacity factor describes the anticipated actual output of an RE plant to its hypothetical maximum, expressed as a percentage. In the IRP Update, load factors are referred to instead, and these are treated as equivalent in the rest of this report.

SOLAR

The IRP Update assumes a capacity factor of 19.4% for solar PV, which is conservative (DOE 2013). Giglmayr et al (2014) argue that a capacity factor of 25% can be achieved on fixed-tilt PV. Adopting the conservative IRP Update assumption in this analysis is consistent with scenarios in which PV plants are located in areas that yield satisfactory rather than optimal levels of solar radiation, yet offer immediate access to the grid.

The WWF expects grid access to become a binding constraint on plant location in the near future, particularly with respect to optimal solar zones in the Northern Cape, where grid connection capacity is quickly running out. There is, however, an upside to this capacity factor. New generation technologies may offer higher yields without sacrificing cost competitiveness. In addition, the rapid evolution of energy storage technology will boost solar PV yields.

Solar CSP capacity factors range from 31% to 47% in the IRP Update, varying with thermal storage capacity. Thermal storage currently offers up to 12 hours of capacity, with the majority of recently successful REIPPPP bidders building plants with large storage facilities in order to take advantage of the peak tariff (270% of the standard tariff).

The WWF adopts a capacity factor of 31% as it uses the capital costs of plants with three-hour thermal storage capacity for benchmarking purposes.

WIND

Selection of an appropriate capacity factor for wind-powered energy in South Africa is not a simple exercise, since it is a function of not only the rotor blade and generator, but of the local wind resource. The choice of the rotor blade and generator can be optimised according to the quality of the wind resource and the deal economics.

South Africa is considered to have an excellent wind resources in some areas, with successful REIPPPP projects currently bidding at capacity factors of 35-40% and beyond.

For example, the Jeffreys Bay wind farm is reportedly exceeding its expected capacity factor of 41% (Creamer 2014c). International experience has, however, been patchy. As the number of wind turbines increases, regional air flows change and yields drop off.

The current high yields are therefore likely to be a function of location near the best wind resources and operators are not yet having to contend with the air flow impacts of neighbouring wind farms. The WWF accordingly maintains the IRP Update assumption of 30% for the time being.

DISCOUNT RATE: THE COST OF MONEY AND INFLATION

This report has already mentioned the rapid evolution of RE financing and the associated dramatic reduction in the cost of capital for projects financed off corporate balance sheets. With price playing a decisive factor in REIPPPP project awards, it is expected that continuing pressure will be placed on the cost of capital. This will manifest in a variety of ways with regards to financing.

OVERALL DEAL STRUCTURE

Deal structure is where the most significant variability in the cost of financing is determined and, accordingly, where the largest potential for cost reduction lies. Only one third of the successful projects in Round 3, namely those where Enel was the sponsor (Eberhard et al 2014), are said to be using balance sheet financing.

Within this context, corporate-financed deals will continue to enjoy the greatest advantage and will become more popular, but may evolve into hybrid structures with a portion of the deal funded by local banks. Global utilities see benefit in taking out local bank debt to enjoy the political clout of local banking partners, especially to mitigate against risk in foreign territories. They are also likely to free up capital to pursue other opportunities as the global economy recovers.

More aggressive operating cost management structures, such as EPCM (engineering, procurement and construction management) will also be employed within the project entity. In cases such as these, an agent contractor manages individual contractors and suppliers on behalf of the principal, removing a layer of costly risk. This is a methodology that is already widely used internationally, and which may confer a 10-15% cost advantage on balance of system should sufficiently skilled contract management companies be available[32].

The critical enabler in cases such as these will be bank appetite for this type of contract because, until now, EPCM has generally been perceived as too risky in renewable project deals. An increase in the cost of financing could easily offset the benefits of slightly lower capital cost. Global utilities, with bulk supplier agreements and strong balance sheets to provide banks with appropriate assurance, will be best placed to implement these measures.

Finally, projects using conventional project finance structures will become more heavily geared. An 80/20 debt-to-equity split is replacing the conventional 70/30 norm as developers increase their reliance on cheaper sources of capital to bring down the total cost of capital.

COST OF DEBT

There is modest opportunity for improving pricing on debt, typically on a case-by-case basis. Bank project financing margins will, however, come under further pressure.

There has been an estimated drop in interest rates of 100 basis points since Round 1, as banks have been pressured to sharpen their pencils. It is not clear whether a further reduction is possible, since syndicated debt buyers such as asset managers reportedly do not currently show much appetite below JIBAR plus 300 basis points. Furthermore, the effect of Basel III - discussed later - will be to raise pricing.

Credit enhancement such as export credit assistance (ECA) may be used to lower the cost of bank debt. ECA is a trade promotion measure whereby the Government of the exporter host country

[32] Based on interviews with local developers and experts.

insures or guarantees the supply of goods and services against payment defaults by the buyer or borrower. This reduces the credit risk - and therefore the pricing - on large transactions. In this case, the cost associated with arranging ECA will be weighed against the benefit in terms of lower debt pricing. By way of example, some mainstream wind projects have benefitted from export credit assistance provided by the Danish export credit agency EKF.

Developers will also explore lending from other primary market participants willing to provide liquidity at competitive rates.

For example, Vantage GreenX Fund Advisors plan to raise CPI-linked debt from institutional investors with the purpose of participating in project finance deals as a joint lead arranger with commercial banks. Swap rates have increased substantially since the US Federal Reserve announced the tapering off of quantitative easing in early 2013 and, with this, also the cost of JIBAR-linked debt. Inflation rates have, however, remained quite stable. For this reason, CPI-linked debt may currently offer an attractive alternative to senior bank debt priced off JIBAR.

In particular, the combination of a front-ended equity returns profile with a back-ended debt repayment profile, where payments are linked to the same index as revenues (CPI), should favour more competitive bids (Campbell 2014). Similarly, removing the impact of a fixed interest rate (through interest rate swaps and hedges) at the start of a rate hike cycle may enable better pricing. This approach remains to be tested, though, as it is very new in the South African context. From a banking perspective, greater complexity in structuring and deal management would result in higher arranging and breakage fees.

COST OF EQUITY

There is still some potential left to improve pricing on equity, notably through attracting additional international investor flow. In Round 3, foreign shareholding in wind and solar PV projects was just over 50%, with up to 60% allowed for under the REIPPPPP provisions. CSP presents a sizeable opportunity, with just 30% equity in Round 3 being accounted for by foreign entities (Papapetrou 2014).

There will also be a clear bias towards international investors willing to accept lower returns than local investors. Current lack of opportunity elsewhere and generally lower threshold targeted returns will create a natural fit for foreign investors interested in participating in South Africa's REIPPPP process.

For example, ISE (2013: 11) suggests that large utility-scale PV and onshore wind plants in MENA countries attract a leveraged return on equity of around 9-10% in nominal Euro terms. South Africa has a similar sovereign risk rating to the average for these countries, so threshold investor ROEs should converge[33]. The greatest benefits will go to investors willing to take Rand risk, and hence enter into projects without taking on foreign exchange hedges on their equity positions.

For modelling purposes, the WWF has used a nominal WACC of 10.4% on the basis of a project finance structure with a debt-to-equity ratio of 75:25. Debt is serviced at a pre-tax interest rate of 11%[34], then adjusted for corporate tax at 28%. Equity pays a nominal post-tax return of 18%, erring on the side of caution. As the global economy recovers, investors may become more demanding in terms of hurdle rates of return. Despite being formulated to reflect the cost associated with project financing, this WACC is also compatible with corporate financing approaches at currently reported levels of ROE. Finally, a real discount rate of 4.9% is obtained once inflationary expectations are

[33] Standard & Poor's current rating for South African sovereign debt is BBB, corresponding to the average for MENA countries (Cullinan 2014).
[34] Based on 9 year swap at 8% at time of writing in May 2014, with a 300 basis point margin.

taken into account.

Regarding prices, the WWF assumes that inflation will continue to run at the average of 5.5% p.a. that it has run at over the past decade (2004-2013). Similarly, we assume that the Rand will continue to depreciate against major currencies including the US dollar by 5% p.a. on average, affecting the imported components of capital cost only.

LOCAL ECONOMIC DEVELOPMENT

The REIPPPP sets out various local economic development requirements with stipulated minimum threshold and aspirational targeted levels, which each bidder must comply with. Following a similar logic to the Broad-Based Black Economic Empowerment Codes, this requirement comprises the following components which make up a scorecard:

- Ownership by black people and local communities;
- Job creation;
- Local content;
- Management control;
- Preferential procurement;
- Enterprise development; and
- Socioeconomic development.

Final award is based on a combined evaluation in which price determines 70% of the ranking and performance on the local economic development scorecard the remaining 30%. This gives non-price criteria a much heavier weighting than they would normally enjoy under Government's preferential procurement policy.

Current localisation requirements are estimated to directly add 5-10% to baseline REIPPPP prices[35]. To date, there has been no rigorous attempt to quantify the cost associated with meeting these requirements, which will vary amongst developers according to the target levels they have committed to. Job creation, local content and preferential procurement accounted for the bulk of possible points on the scorecard in REIPPPP Round 3. Consequently, a requirement to source goods and services locally is considered to be the central driver of project costs associated with local economic development.

LOCAL CONTENT

The definition of local content is quite broad, being the value of sales less the costs associated with imports. Through successive rounds, this definition has, however, become subject to more detailed definition, with an expanding list of exclusions and increased targeting in terms of key components identified by the Department of Trade and Industry for local manufacturing.

Use of varying accounting methods, such as importing equipment at low transfer prices before marking up locally, may have resulted in projects achieving high local content scores. Mulcahy (2012: 26) shows that Mulilo exceeded the 35% local content requirement imposed on the De Aar solar PV project without buying panels, inverters or structures locally.

Amongst IPPs which are actively pursuing local manufacturing activity in response to Round 3

[35] Interviews with developers and experts. In order to estimate the combined financial impact of these requirements, it is instructive to compare local tariffs with prices in comparable countries. ISE (2013) calculates that in regions with similar solar resources, utility scale PV should have cost as little as R0.75/kWh in 2013 (EUR0.059/kWh), approximately 15% less than the average tariff bid in Round 3. Once local currency effects are accounted for, this translates into a 10% price difference.

changes in local content requirements, potential will differ by technology. Modular solar PV offers broad opportunities across the value chain, while wind turbine structures are generally imported, and only generic components such as towers can be manufactured locally in an economical way. In Round 3, solar PV bidders committed to 54% local content, as compared with 47% for wind. Five local PV panel manufacturing facilities and one for the production of wind towers have been set up so far (Eberhard et al 2014).

CORPORATE SOCIAL INVESTMENT

The scorecard also contains 'pure' corporate social responsibility requirements, including the donation of at least 1% of revenue to qualifying socioeconomic development causes and a minimum shareholding by local communities of at least 2.5%.

INDIRECT COSTS

In addition, there may be indirect costs resulting from lower final component quality and installation works. To date, cases such as these have been resolved quite effectively, although it should be noted that the industry is still very new and more experience is required in order to make a full assessment.

Compromised plant quality would potentially impact on the profitability and viability of contracted REIPPPP projects by resulting in lower realised energy generation potential from reduced plant availability or efficiency. Further, the cost of using an EPC or similar model may rise in future, as international equipment manufacturers become reluctant to provide long-term guarantees on plant equipment that incorporates a substantial local component manufactured beyond the boundaries of their standard facilities and quality control measures.

Inclusion of a local economic development component in the REIPPPP is nevertheless considered appropriate, and will help to insulate projects from a weakening local currency. In light of the sensitive local socio-political landscape and ongoing national need to build a competitive manufacturing base, experts agree with the inclusion of a localisation requirement.

From a practical perspective, deepening local content can reduce the degree of imported inflation, supporting affordable access to electricity for all South Africans. However, caution is raised regarding further increases in minimum thresholds for local content requirements, which have progressively been lifted over the past three rounds of the REIPPPP, as the additional costs may erode the business case for constructing new RE plants in South Africa. The current target of 65% local content (Round 3; Eberhard et al 2014) cannot be met without making significant changes to utility-scale RE policy. Significant further domestic and foreign direct investment into manufacturing capacity is required to enable achievement of this target, for which more certain domestic revenue opportunity in respect of sales to Eskom (REIPPPP) and private customers (embedded generation) is required.

Given the opacity of this cost, as well as a high degree of variability across projects and technologies, the WWF has omitted it from its projections. Rather, we have selected relatively conservative estimates of capital costs and capacity factors, which together capture the residual costs of localisation, both direct and indirect.

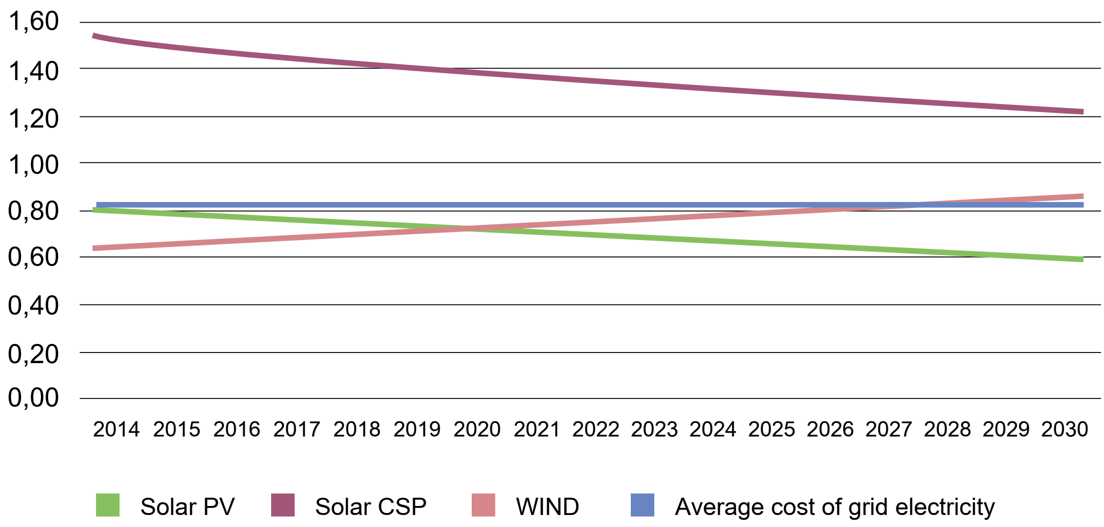
PROJECTED LCOE TRAJECTORY

The WWF's modelling indicates that both types of solar energy generation will continue to enjoy substantial reductions in price over the next 16 years. By 2020 solar PV is set to overtake wind as the most affordable source of RE. The underlying driver causing the levelised cost of wind to climb rather than to fall is the weakening Rand, as a significant negative exchange rate impacts more than it offsets the low learning rate.

It nevertheless appears that both wind and solar PV represent more financially attractive alternatives to new coal and nuclear throughout the period, even at the higher cost of capital associated with private financing[36]. The efficiency of IPP provision of electricity at a fixed cost over a 20-year period provides a significant fiscal advantage compared with the cost overruns experienced in publicly procured power plants, notably Medupi and Kusile.

When it comes to CSP, it should be noted that the average REIPPPP tariff bid is only partially useful as an LCOE benchmark. Firstly, developers bid a tariff based on their own unique optimisation of electricity supply across off-peak and peak periods[37]. The average REIPPPP CSP tariff bid data at our disposal also does not distinguish between plants with varying storage capabilities.

Figure 10: Projected LCOE trajectory over 2014-2030 (2014 Rand value)



Source: Own modelling and analysis

CAPACITY

In terms of growth rates, the WWF Vision 2030 works off the IRP Update assumptions for the total electricity demand requirement for 2030, with distinct renewable investment pathways called for in the corresponding low demand (Weathering the Storm) scenario and high demand (Base Case) scenario. Megawatts are added to the grid in the amount called for in the IRP Update, namely 2 200 MW annually (1 000 MW each for PV and wind, 200 MW for CSP).

However, we propose that the total of 1 200 MW in solar power be procured flexibly in terms of the mix of PV and CSP. This should take place in accordance with requirements for dispatchability (offered through energy or thermal storage); take into account spare connection capacity on the

[36] The South African Government is currently able to raise long term funding (15-20 years) at 8-9% nominal interest rate through the bond market.
[37] Based on interviews with local developers and experts.

grid; and consider quality of solar resource at available sites[38]. Higher aspirations may not be realistic given grid constraints, which are discussed later in this report.

In the WWF's low-demand scenario, RE comprises 17 518 MW of capacity by 2030, accounting for 11% of total electricity delivered to the grid. In the high-growth scenario, renewables account for 35 018 MW of capacity, and would contribute 18% of required electricity to the grid if all plants were online by then. Local experts believe that these numbers are achievable from a grid perspective, as long as flexible balancing power supply is available and plants are reasonably well distributed across the grid.

Table 5: WWF Vision: Renewable energy contribution to the grid (2030)

Energy Technology	High-demand scenario		Low-demand scenario	
	Capacity (MW)	Generation (TWh)	Capacity (MW)	Generation (TWh)
Renewable energy	35 018	77.8	17 518	39.0
Solar	18 884	35.4	9 334	17.5
Wind	16 134	42.4	8 184	21.5
Other energy sources	56 670	329.2	56 360	319.0
Hydro	3 690	15.8	3 690	15.8
Existing coal	36 230	269.8	36 230	269.8
Existing nuclear	1 860	15.0	1 860	15.0
Open cycle gas	7 680	6.7	6 720	5.9
Combined cycle gas	3 550	15.5	1 420	6.2
Pumped storage	2 900	6.4	2 900	6.4
Other	760	0	3 540	0
Total	**91 688**	**407.0**	**73 878**	**358.0**

Source: Own modelling and analysis
Notes: Small discrepancies may arise due to rounding

It is important to note from this table that there is a shortfall in generation of 9 TWh in the high-demand scenario if the IRP Update assumptions on the balance of the energy mix are maintained. In all likelihood, this gap will close with increasing storage capability on solar energy[39]. Conversely, excess generation of 15 TWh exists in the low-demand scenario, enabling Eskom to start retiring old, highly polluting coal-fired power stations.

In general international terms, these penetration rates appear to be feasible. Recent theoretical modelling shows that global renewable penetration rates of close to 30% can be supported without major grid disruption (Taneja et al 2013). From a technology perspective, wind penetration rates of 20% can be supported without incurring major grid integration costs, while solar can supply 7.5-10% of peak electricity demand (Citi Research 2013). This serves as a guide for what is cost-effective and feasible in the medium term.

It is instructive to note that several other countries have set renewable energy penetration rate levels higher than 19%. The EU-27 is targeting a level of 20.6% by 2020, with several individual countries aspiring to levels exceeding 30% by 2030. These include Germany, Portugal and Greece. Other middle-income countries such as Mexico, Morocco and Turkey are targeting a 30-50% renewable share of electricity generation by 2030 (Ren21 2013: 106). The obvious grid-related challenges are addressed in the next section.

[38] In a distributed or embedded generation scenario, off-takers may be commercial, industrial and other customers located close to the plant. In this line of reasoning, solar PV plants may be located in major metropolitan areas rather than in areas of optimal solar resource such as the rural Northern Cape.

[39] The mechanism for this is a higher capacity factor which will enable plants to deliver more electrity per megawatt than they currently do.

In summary, the location of plants close to load requirements, storage capability (thermal and/ or energy), and the use of either pumped storage or gas as a balancing energy supply will be critical enablers of the desired mix.

To more definitively answer the question of whether the South African grid can support penetration rates in this range, a systems modelling exercise needs to be undertaken. Spatial-temporal analysis, which takes into account synchronous solar and wind patterns at each geographic location, is a particularly promising methodology for this line of enquiry. It should be noted, however that this methodology is very new, and that there are very few conclusive answers on the true bounds of RE from a grid perspective. In the interim, the world is learning by doing.

CAPITAL REQUIREMENTS

In the low-growth scenario, the national price of achieving 17.5 GW of renewable energy via IPP PPAs is estimated at R474 billion over the period 2014-2030 (2014 Rand value). This rises to R1.084 trillion in the high-growth scenario, in which 35 GW of capacity is built[40]. Each annual round of purchasing 2 200 MW of RE capacity would cost approximately R77 billion in 2014 Rand value terms, following the suggested mix in the IRP update[41]. In relative economic terms, this equates to 2% of GDP per annum or approximately one quarter of Government's planned annual investment in infrastructure over the medium term. It is well within the developing country norm for infrastructure expenditure to be 2-4% of GDP (Economist 2014).

In the low economic growth scenario, which is arguably the more realistic one, the average annual new liability over the period is approximately R40 billion. This would be the actual expenditure if the pace of new capacity acquisition slowed to half of the recommended 2 200 MW capacity. The figure also represents a realistic, affordable alternative in the event that fiscal constraints become binding.

Typically, infrastructure spend is more beneficial than other government expenditure due to the infrastructure multiplier effect. This refers to the beneficial impact of infrastructure on economic growth in both the short term, resulting from expansion in aggregate demand, as well as in the longer term (six to eight years) due to enhanced productive capacity in the economy.

A recent USA study on highway expenditure revealed the infrastructure multiplier to be a factor of two on average, and greater during economic downturns (Leduc & Wilson 2013). This means that one dollar spent on infrastructure raises GDP by two dollars. If the same were to hold true, as similar analysis suggests it would (Kumo 2012, Ngandu et al 2010), this indicates that the construction of renewable energy plants could be a valuable economic growth driver at a time when fears of recession abound.

Of equal importance, building new energy infrastructure would relieve one of the key constraints on economic growth in South Africa. The cost of unserved energy is estimated at a staggering R75/kWh in the IRP Update (2012 Rand value), with a current estimated supply capacity shortfall of 4-5 GW (Creamer 2014a).

[40] While capacity doubles, cost increases by slightly more than double due to the expected rise in the wind energy price in Rand in later years.

[41] 1 000 MW of PV and wind each, 200 MW CSP

ADDRESSING THE CONSTRAINTS TO SCALING UP

Whilst the WWF believes that achieving double the IRP Update aspirations in terms of utility-scale renewable penetration rates is possible, and indeed desirable, there are significant challenges that will need to be met in order to achieve this outcome. Broadly speaking, these originate in three sources: Government policy and planning, including liability management; enabling upgrades to the national grid; and solving financing challenges.

ESKOM AS THE SINGLE OFFTAKER

Eskom is currently the only major player in utility-scale RE power purchase agreements. This raises an important challenge, namely that of the willingness of private financiers to take a risk on Eskom. To date, PPA guarantees supplied by National Treasury have substantially mitigated this risk.

Eskom itself is viewed as a shaky credit prospect. Fitch stated earlier this year (2014) that pure Eskom debt would be B rated, indicating a lack of confidence in the utility's ability to service debt, and relegating it to the junk bond category (Crowley 2014). Sovereign guarantees, provided by the National Treasury on all REIPPPP contracts to date, are thus a critically important element of the programme. Without them, a revenue stream based on a PPA signed with Eskom would be viewed as much more risky, resulting in a higher cost of capital on RE projects or, worse yet, an unwillingness to advance any further financing.

There is, of course, a natural limit to which Government guarantees will be issued in favour of Eskom, as the Government aims to limit debt to below a debt-to-GDP ratio of 50%. In its broader sense, debt is defined as comprising net debt, provisions and contingent liabilities. Governance must maintain levels below the 60% limit, which has been agreed to by the SADC member states[42].

It is concerning to note that, in the current financial year, this ratio stands at 56.9%. Further, upward pressure will be placed on this number by net loan debt, which is expected to grow more quickly than the economy over the medium term and, in turn, will place pressure on fiscal sustainability (National Treasury 2014b).

At the last reported figure of R229 billion, existing guarantees comprise less than 10% of the country's R2.16 trillion total public liability (National Treasury 2014b). However, the guarantees provided under the umbrella of the REIPPPPP programme have not yet been recorded, as these will reflect for the first time in the Budget Review published in 2015. By our calculations, each annual round of RE procurement would add approximately 1.25-2.50 percentage points to this ratio, amortising slowly over the 20-year PPA period. Given the current proximity to a debt ceiling, Government liabilities associated with the REIPPPP programme may well become a binding constraint within the current medium-term budget period (2014/5-2016/7).

A secondary issue relates to the relationship between Government and Eskom. Existing guarantees to Eskom total R350 billion, with a net exposure of R122 billion in 2013/14 (National Treasury 2014b). These guarantees are linked to the new coal-fired plant construction programme. The magnitude of this exposure is far greater than any other to major state-owned entities (SOEs) (see National Treasury 2014b: 75).

[42] Correspondence with Ms Avril Halstead, National Treasury.

At this stage, National Treasury views REIPPPP guarantees separately from guarantees for Eskom's other liabilities[43], so the fact that the single-buyer office is housed within Eskom does not appear to matter. This may change in future. Regardless of which public entity is the recipient of guarantees, rapid fiscal consolidation would be required in order to accommodate the envisioned growth in RE capacity. This currently does not seem likely.

POLICY COORDINATION AND CERTAINTY

RE policy and contracting is currently handled by a range of Government departments and entities. Core players include the departments of Trade and Industry, Energy, Environmental Affairs and Public Enterprises, as well as Eskom and the National Energy Regulator. Other entities are critical to implementation, notably local and provincial Governments, which handle rezoning applications and permitting.

Within this context, developers express a need for a more cohesive, consistent and streamlined set of Government requirements. Frustration is expressed with the multiplicity of goals, paperwork requirements and implementation roadblocks, including difficulties with rezoning applications in which small portions of agricultural land are affected[44].

More fundamentally, the lack of certainty regarding the future market for privately produced RE in South Africa is undermining the business case for local investment in such infrastructure as factories. In particular, concern over an escalating localisation requirement in the context of an unpredictable future power-purchasing environment is driving developers to look elsewhere for investment opportunities. It is hoped that the Presidential Infrastructure Coordinating Committee will become more active in resolving some of these issues.

Greater certainty about the future of utility-scale renewable energy is also required to underpin further investment in manufacturing capacity. Developers of the Jeffreys Bay wind farm, Mainstream and Globeleq, recently suggested that a Government commitment to procuring at least 2 000 MW of RE per annum is required to keep investors interested (Creamer 2014f). However, the DOE has stated in the Round 4 documentation that it "cannot confirm at this stage how the remaining MW will be allocated nor whether there will be a further determination made for Renewable Energy" (Papapetrou 2014). By contrast, the President recently made commitments to a large 9 000 MW nuclear build programme, Coal 3 procurement and shale gas capability in the State of the Nation address (Paton 2014). The future of renewable energy clearly hangs in the balance.

UPGRADING TRANSMISSION AND DISTRIBUTION INFRASTRUCTURE

Electricity evacuation requirements, substation capacity and grid planning present challenges related to the integration of RE into the South African grid. While there seem to be creative solutions to each of these issues, careful balancing of the tension between optimal renewable resource areas offering maximum yield potential and the costs of upgrading the existing network will be required. Critically, planning for further rounds of the REIPPPP programme will need to take into account the mismatch between renewable plant construction and transmission upgrade time horizons, which are 2-3 years versus 7-10 years respectively. This is an issue that will become ever more pressing as existing spare capacity on the grid is taken up by plants under development.

[43] Correspondence with Avril Halstead, National Treasury.

[44] Approvals for subdivision of agricultural land under Act 70 of 1970 are known for being particularly challenging.

It is important to bear in mind that the South African electricity grid was originally constructed to evacuate power from coal-rich areas in Mpumalanga to the major metropolitan areas, most of which are located in relative proximity to coal-fired plants. Wind and solar plants will be located far from these areas, with solar primarily in the Western and Northern Cape provinces and wind in coastal areas. In contrast to coal deposits, which are relatively intensively concentrated from a geographical perspective, the best solar and wind resources are dispersed across large areas of South Africa. These areas are located some distance away from where the greatest electricity requirement is, namely the province of Gauteng. This implies a potentially substantial infrastructure conversion requirement in terms of deep connections to RE plants.

In addition to new transmission lines, substations are required to control voltage, convert high-voltage power to low-voltage power for distribution, and to protect the stability of the grid network. RE developers usually make shallow connections to the grid, connecting to substations via distribution lines of 132 kV before being transmitted to the area of load demand. Given that most of the best renewable resources are located in the wider Cape area, encompassing the Western, Northern and Eastern Cape provinces, it is clear from Eskom's recent study (2013) that the existing connection infrastructure would need to be substantially upgraded to accommodate the bulk of power plants here, particularly if a connection of 35 GW is aspired to by 2030.

Table 6: Large-area integration stability limits, 2016

Region	Stability limits, GW
Cape (Western, Northern, Eastern)	15
KwaZulu Natal	17
Limpopo and North West	10

Source: Eskom (2013); author's emphasis

The task of upgrading transmission and distribution infrastructure currently falls to Eskom, which is beset by budgeting and planning challenges. The utility is grappling with a R225 billion revenue shortfall (Creamer 2014e), the need to refurbish or replace ageing transmission infrastructure, and uncertainty with respect to which sites will carry RE plants in future. In Round 3 alone, 500 requests for cost estimates were lodged with Eskom, each with its own requirements for extension of the existing transmission and distribution network (Papapetrou 2014). In order to deal with this uncertainty, scenario planning has been undertaken under the umbrella of the Strategic Grid Plan (SGP) which, which together with the Transmission Development Plan and IRP Update, forms the basis for energy capacity and supply planning. Broadly speaking, the SGP's objective is the identification of the grid infrastructure that will be required under a variety of electricity supply and demand outcomes. The version currently under development includes a 'green scenario' dominated by renewables, with solar CSP effectively replacing nuclear investment.

A clear requirement is articulated for new high-voltage lines between the Northern Cape and Gauteng, infrastructure which will cost at least R3-4 million/km per line. Two of these lines will be required, as will new substation infrastructure. Whether or not Eskom will receive the funding required for these developments depends on future rounds of the multi-year price determination process (MYPD), through which the regulator makes budget decisions. In the last round, planned expenditure was substantially cut.

While addressing core infrastructure upgrades, Government will likely take a geographic view on new plant development in order to contain further costs and limit the extent to which there is a mismatch between new generation and spare grid connection capacity. Renewable Energy Development Zones (REDZ) are mooted as the solution; areas designated as being suitable for RE generation on the basis of the Solar and Wind Atlases, amongst others[45]. However, extensive consultation with the IPP and scientific communities would be required if spatial limits were to be set on further utility-scale RE development. Furthermore, the Solar and Wind Atlases would need to be accurate due to the need to take temporal characteristics into account, which is difficult. Assessing these characteristics incorrectly could be highly detrimental to the industry.

Market-friendly solutions would incentivise the construction of new plants in areas where the grid has spare capacity, and encourage generation closer to load demand. Paul Gauche and his colleagues at the University of Stellenbosch demonstrate that building CSP plants along the high-capacity line between Cape Town and Johannesburg can be a grid-friendly option. While direct normal irradiation levels may be lower than in the Northern Cape, they average 2 600 kWh/m2 on an annual basis, which is a very good resource by international standards (Van Niekerk & Gauche 2013).

A more general solution to the problem would be a policy dispensation that enables embedded generation, allowing localised 'utilities' to supply electricity to nearby customers. Permitting the sale of electricity back to the grid at a known tariff would allow for the sale of any excess generation. Solar PV is viewed as particularly suitable for this purpose given its modular nature, its ability to generate electricity efficiently under a variety of solar conditions, and South Africa's claim to being one of the best solar energy regimes in the world (Eberhard 2014: 6).

Some believe that the ISMO (Independent System Market Operator) bill is critical to success. This will remove transmission and distribution from Eskom's control and provide for a level playing field for all power producers. This bill may encourage price competition amongst power producers, including Eskom, and promote more efficient and cost-effective transmission capability. Debated for several years, no apparent progress has, however, been made on this front. Even if the bill were to be passed, many questions would need to be answered regarding the ability of the new entity to raise the substantial capital required to bankroll necessary upgrades, especially in light of Government limits on the issuance of further guarantees.

[45] Interview with Kevin Leask, Eskom

THE NEED FOR DISPATCHABLE AND RELIABLE GENERATION

Intermittent power sources such as wind and PV pose challenges to grid system operator planning as well as to maintaining the stability and quality of the transmission network. Intermittency refers to the variability and partial predictability of generation resources.

Predictability, which refers to the ability to plan for the availability of a generation resource, is lower in the case of RE since it is dependent on weather patterns. Similarly, variability resulting from dynamic changes in availability of generation resources and the size of electricity demand, is higher in the case of renewables.

System operators, tasked with maintaining reliability and matching generation with load, consequently require flexible power supply to balance the intermittency of RE generation. Similarly, the transmission and distribution network is impacted through variations in the frequency at which electricity from intermittent power sources is transmitted. Energy balancing is extremely complex, and the challenge is amplified in South Africa, which has highly concentrated demand peaks in the early morning and early evening, when solar generation is minimal. If RE is to become a baseload technology, storage solutions will be a critical enabler as renewable penetration rates increase.

Dispatchability issues, on the other hand, can be minimised through the deployment of thermal and energy storage technology linked to renewable power plants. CSP, with accompanying thermal storage of up to 12 hours in current commercial technology, is currently best suited amongst the various sources of RE to meet the dispatchability challenge. It is, however, relatively expensive and is not widely used internationally. Energy storage for PV is developing quickly and is already commercially viable on more expensive grids in Europe. Local solar developers and experts expect it to be cost competitive in South Africa for purposes of supplying peak electricity demand in approximately five years' time, baseload in 10 years' time.

Flexible, relatively clean generation options, such as pumped storage and gas turbines, offer a grid balancing solution. Pumped storage facilities, such as the Ingula and Drakensberg schemes, and OCGT plants, such as the Western Cape's Ankerlig and Gourikwa plants, provide alternative solutions to the balancing problem. However, diesel is an extremely expensive fuel source for gas turbines[46] and Eskom is consequently investigating the possibility of running its OCGT plants off gas, either LNG (in which case substantial terminal storage is required) or piped natural gas from Mozambique (Creamer 2014d).

A promising addition to the range of balancing fleet options is mid-merit CCGT. With ramp rates of 8% per minute, natural gas-fired turbines provide the greatest degree of generation flexibility amongst thermal generation plants, and combined-cycle technology is evolving quickly as a solution to the intermittency of renewable generation (MIT 2011). In the IRP Update, CCGT is calculated to be more cost competitive than coal at load factors of up to 46%[47].

As mentioned earlier, there are many unknowns with respect to gas utilisation, and the key uncertainty is the volume of natural gas that can be procured cheaply in the region. At present, LNG would be imported at highly variable prices, which can reach up to $17/MMBtu, exposing Eskom to significant fuel price expenses and uncertainty. Building LNG storage terminals would add further cost. Should regional natural gas become more readily available, experts estimate that a cost of $10/MMBtu is achievable in the medium term, offering a levelised cost as low as R0.80/kWh in current terms (Donnelly 2014).

[46] Open cycle gas turbines running off diesel operate at an LCOEof approximately R5/kWh (Silinga & Gauche 2014).

[47] Levelised cost of CCGT is calculated at R0,86/kWh in 2012 in the IRP Update.

In the case where balancing of the grid needs to be optimised, with the use of base-load or technology options that have higher capacity factors the suitability of gas needs to be looked at closely. At this point in time WWF is of the view that it is more likely that gas imports would have to be considered as a cleaner option to offset the carbon and other externality costs associated with base-load supply from coal.

INCREASING PARTICIPATION AND INNOVATION IN DEAL FINANCE

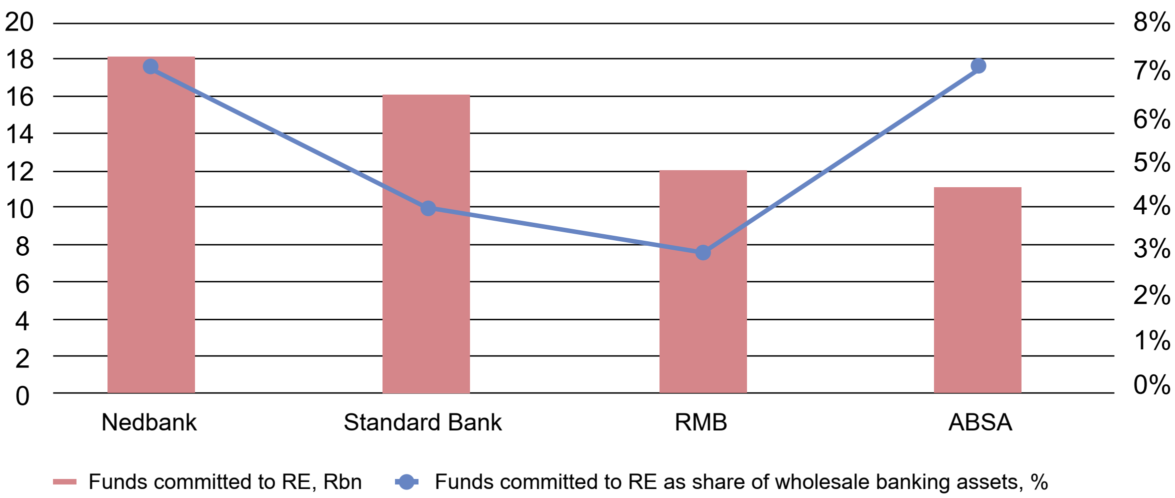
None of the stakeholders can take it for granted that local banks will continue to enthusiastically participate in RE project finance. At last count, R57 billion in debt had been granted to successful projects by South Africa's commercial banks (Eberhard et al 2014). Scaling up to the WWF vision of 19% renewable energy by 2030 would be associated with a further R400 billion debt extension after Round 4, equating to R40 billion per annum[48]. Two factors will affect banks' ability to continue to meet this requirement: prudential portfolio limits and the implementation of Basel III.

In order to manage exposure to geographic, industry and client risks, banks put prudential limits in place on categories of debt holdings. The size of the limit depends on the individual bank's view of the levels of risk on a particular type of transaction, as well as on the contribution of the asset to its broader portfolio.

To date, local banks have taken different views when it comes to RE financing. Nedbank, the largest bank by participation and representing about R18 billion in REIPPPP-related project debt, has chosen to hold its own exposure to date. Standard Bank and RMB, on the other hand, have chosen to distribute their debt through selling it off (debt syndication).

Attractive debt pricing will be key to enticing institutional investors and secondary debt buyers. There is currently little reported appetite for pre-construction or construction-phase debt at margins below 300 basis points above JIBAR. Even the banks that have chosen to hold the bulk of their debt to maturity are likely to be approaching prudential limits at this stage, and will seek buyers of syndicated debt or debt capital market instruments in the secondary market once construction has been completed. This market remains largely untested, though, which is a risk factor for banks. It may be of specific concern to Nedbank and ABSA, which appear to have the highest renewables concentration in their wholesale banking portfolios[49].

Figure 12: Local commercial banks' last reported exposure to renewable energy (2013)



Sources: FirstRand (2013); Standard Bank (2014); Nedbank (2014); ABSA (2014); Creamer 2013(b).

[48] Project cost associated with the WWF vision is anticipated to amount to R540bn, of which 75% may come from debt.

[49] Some of this debt may since have been syndicated to third parties.

If local bank appetite were to wane, one might assume that IPPs would simply turn to foreign banks for the provision of debt financing. However, the mismatch between the value of the currency in which revenue is raised for debt service, the Rand, and the value of the currency in which funding is raised would indicate that international banks would be taking a significant risk in relation to South Africa's volatile emerging market currency. Hedging this foreign exchange exposure, particularly for the long tenors associated with project debt, would push costs up and so reduce economic feasibility.

RESTRICTIONS ON PROJECT DEBT FINANCING

The Basel III regulations, due for implementation in 2016, will penalise bank holdings of RE project debt due to the classification of RE debt as an illiquid asset. Additional liquid asset requirements and reliance on international loans and debt capital markets will result in increasing term liquidity premia, causing funding curves to steepen. As a result, RE finance will be penalised for its long tenor and illiquidity. A premium of 1-2 percentage points may be applicable, linked to the impact on banks' net stable funding and liquidity ratios. It is likely that some banks have already started to price this in ahead of full implementation over the 2016-2018 period.

Other instruments with long horizons, such as the foreign exchange hedges, which would also be employed, will also become more expensive. The net result of this development will be an increasing demand for alternative sources of debt, especially debt with longer horizons matching the 20-year PPA duration.

EMPOWERMENT FUNDING

The other debt financing requirement, to fund empowerment equity stakes, is relatively expensive and already in short supply. Whether black economic empowerment business partners or community trusts, empowerment entities often have their equity stakes debt-financed, placing 10% in cash and leveraging the remaining 90%. Currently the IDC and DBSA are providing most of this financing through either preference shares or standard loans. Debt is currently priced at 6-9% above JIBAR, equating to a range of 14-17% at the time of writing, and is typically repaid through project dividends. Slightly more generous terms typically apply to community trusts, for example financing a greater share of their stake or lowering the pricing on debt.

From a shareholder perspective, it seems the large industrial empowerment companies are not participating much as empowerment partners on RE deals since they view returns as unattractive compared other opportunities, leaving small- to medium-sized players to take up stakes. Several of these companies struggle to put up the required minimum of 10% cash.

Secondly, increasingly tight project profit margins can indirectly limit financing opportunities through intrinsic links to leveraged finance repayment terms. Since debt is repaid through a trickle dividend, the ROE needs to exceed the price of empowerment financing in order to form the basis for a feasible leveraged finance deal. Typically, a real after-tax internal rate of return of 12% is required for such a financial instrument to be feasible[50]. As discussed earlier, it is becoming more and more difficult to achieve such high returns. Consequently, a shortage of fully financed empowerment partners is becoming a constraint on project development.

[50] This implies a requirement for a minimum nominal after-tax ROE of 17.5%.

CONCLUSIONS AND RECOMMENDATIONS

The WWF is optimistic that South Africa can achieve a much more promising clean energy future than current plans allow for. With an excellent solar resource and several very good wind-producing pockets, the country is an ideal candidate for an RE revolution.

We have shown in this report that the levelised cost of producing RE already competes favourably with the three main alternatives, namely coal, gas and nuclear, and that a broader RE base would contribute to a more climate-resilient future and insulate South Africa from dependence on expensive and unreliable fuel sources priced in dollars. Critical from a planning perspective, RE can also provide added flexibly on an 'as needed' basis, as electricity demand grows. This is vital in a highly uncertain environment.

In support of our vision, we call for several further actions related to RE in general. Firstly, comprehensive systems analysis needs to be undertaken in order to identify in greater detail grid suitability in high renewables penetration scenarios such as those outlined in this paper. This will inform the ideal mix across wind, PV and CSP technologies on an annual basis, as well as set out additional balancing supply requirements. Broadly speaking, it is understood that balancing gas capacity should be approximately 33% additional to renewable capacity, but this needs to be explored further.

Secondly, in procuring new electricity capacity Government should create incentives that are designed to relieve some of its most significant fiscal and grid constraints. Developers should be incentivised to connect to the grid where spare capacity exists to do so. Even more importantly, generation at close proximity to load requirements should be promoted in order to minimise strain on the ageing transmission network. Support for a distributed generation sector may be achieved through reforming a currently highly centralised electricity sector, including an easy utility licensing process and third-party grid access for supply of excess electricity at a predetermined tariff. Achieving more diversified electricity markets will boost prospects for developers and equipment suppliers, and reduce risk for banks and other investors. South Africa could then truly be positioned as a green manufacturing hub to service the broader Sub-Saharan region.

Thirdly, Government needs to commit to firmer policy on renewables and, in particular, to a longer-term RE procurement plan, subject to electricity demand growth. This will lay a foundation for deeper investment by developers participating in the REIPPPP, while simultaneously supporting the continued cost competitiveness of RE in South Africa. This should be accompanied by a coherent and consistent set of developer requirements in order to create a smoother implementation process.

APPENDIX

Table 1: Water requirements for energy technologies (gal¥/MWh)

Fuel type	Cooling	Technology	Water consumption	Water withdrawal
Nuclear	Tower	Generic	581–845	800–2 600
	Once-through	Generic	100–400	25 000–60 000
	Pond	Generic	560–720	500–13 000
Coal	Tower	Generic	480–1 100	500–1 200
		Subcritical	394–664	463–678
		Supercritical	458–594	582–669
		IGCC*	318–439	358–605
		Subcritical with CCS	942	1 224–1 329
		Supercritical with CCS	846	1 098–1 148
		IGCC with CCS	522–558	479–678
	Once-through	Generic	100–317	20 000–50 000
		Subcritical	71–138	27 046 –27 113
		Supercritical	64–124	22 551–22 611
	Pond	Generic	300–700	300–24 000
		Subcritical	737–804	17 859 –17 927
		Supercritical	4–64	14 996 –15 057
PV	N/A	Utility-scale PV	0–33	
Wind	N/A	Wind turbine	0–1	
CSP€	Tower	Trough	725–1 057	
		Power tower	740–860	
		Fresnel	1 000	
	Dry	Trough	43–79	
		Power tower	26	
	Hybrid	Trough	105–345	
		Power tower	90–250	
	N/A	Stirling	4–6	
		Binary	0–270	
		EGS	300–1 778	
	Hybrid	Binary	74–368	
		EGS	813–1 999	

¥One gallon = 3.78 litres

#CCS – carbon capture and storage

*IGCC – integrated gasification combined cycle

€CSP – concentrated solar power

∫EGS – enhanced geothermal system

Source: Gulati (2014)

Table 2: Projected LCOE trajectory over 2014-2030 (2014 Rand value)

	Units	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SOLAR PV																		
LCOE	R/ kWh	0.80	0,78	0,76	0,74	0,73	0,71	0,70	0,69	0,67	0,66	0,65	0,64	0,63	0,62	0,61	0,60	0,59
Overnight capital cost	R/kW	R13771	R13390	R13029	R12686	R12359	R12049	R11755	R11475	R11210	R10957	R10717	R10490	R10273	R10068	R9872	R9687	R9511
Local capital cost	R/kW	R7609	R7229	R6867	R6524	R6198	R5888	R5594	R5314	R5048	R4796	R4556	R4328	R4112	R3906	R3711	R3525	R3349
Imported capital cost	R/kW	R6162	R6162	R6162	R6162	R6162	R6162	R6162	R6162	R6162	R6162	R6162	6162	6162	R6162	R6162	R6162	R6162
Adjusted overnight capital cost	R/kW	R14046	R13658	R13289	R12939	R12607	R12290	R11990	R11705	R11434	R11176	R10932	R10699	R10479	R10269	R10070	R9881	R9701
Capital recovery factor		0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08
Fixed O&M rate	R/ kW/a	R232	R232	R232	R232	R232	R232	R232	R232	R232	R232	R232	R232	R232	R232	R232	R232	R232
Variable O&M rate	R/ kWh	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0
SOLAR CSP																		
LCOE	R/ kWh	1,52	1,49	1,46	1,44	1,42	1,39	1,37	1,35	1,33	1,32	1,30	1,28	1,27	1,25	1,24	1,23	1,21
Overnight capital cost	R/kW	R42046	R41162	R40322	R39524	R38766	R38046	R37362	R36712	R36095	R35508	R34951	R34422	R33919	R33441	R32987	R32556	R32146
Local capital cost	R/kW	R17683	R16798	R15959	R15161	R14403	R13682	R12998	R12348	R11731	R11144	R10587	R10058	R9555	R9077	R8623	R8192	R7783
Imported capital cost	R/kW	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364	R24364
Adjusted overnight capital cost	R/kW	R43707	R42788	R41915	R41085	R40297	R39549	R38838	R38162	R37520	R36910	R36331	R35781	R35258	R34762	R34290	R33842	R33416
Capital recovery factor		0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08
Fixed O&M rate	R/ kW/a	R625	R625	R625	R625	R625	R625	R625	R625	R625	R625	R625	R625	R625	R625	R625	R625	R625
Variable O&M rate	R/ kWh	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0
WIND																		
LCOE	R/ kWh	0,65	0,66	0,67	0,68	0,69	0,70	0,71	0,72	0,73	0,75	0,76	0,78	0,79	0,81	0,82	0,84	0,86
Overnight capital cost	R/kW	R16642	R16931	R17235	R17555	R17892	R18246	R18618	R19008	R19417	R19847	R20297	R20768	R21261	R21778	R22319	R22884	R23476
Local capital cost	R/kW	R7531	R7456	R7382	R7308	R7235	R7162	R7091	R7020	R6950	R6880	R6811	R6743	R6676	R6609	R6543	R6478	R6413
Imported capital cost	R/kW	R9110	R9475	R9854	R10248	R10658	R11084	R11527	R11988	R12468	R12967	R13485	R14025	R14586	R15169	R15776	R16407	R17063
Adjusted overnight capital cost	R/kW	R17005	R17301	R17612	R17939	R18283	R18645	R19025	R19423	R19842	R20280	R20740	R21222	R21726	R22254	R22806	R23384	R23989
Capital recovery factor		0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08
Fixed O&M rate	R/ kW/a	R346	R346	R346	R346	R346	R346	R346	R346	R346	R346	R346	R346	R346	R346	R346	R346	R346
Variable O&M rate	R/ kWh	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0

Source: Own calculations

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