Renewable energy gathers steam in South Africa

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ABSTRACT

South Africa's Renewable Energy Independent Power Producers Procurement Programme (the REI4P) is an extensive initiative to install 17.8 GW of electricity generation capacity from renewables – wind, solar, biomass, biogas and hydropower – over the period 2012–2030. Although at the outset the REI4P seemed an expensive option, designed only to deflect criticism of South Africa's high carbon footprint and excessive dependence on coal-based electricity generation, the escalating costs of the latter, the rapidly falling costs of photovoltaic and wind power, and the increasingly competitive bidding process of the REI4P have changed this prospect. At the conclusion of round three, the weighted cost of energy has reached a 23% discount to the cost of new coal-based generation and a 28% discount to global renewable energy prices. The bidders' commitments to local employment creation have similarly increased from 11 to 18 jobs/MW. The programme is now well placed to deliver on a broad range of objectives, including regional development and black economic empowerment. However, maximum benefit from the REI4P will not be secured without some revision to aspects of the bidding and procurement process. More specifically, the local content provisions need to be tightened to drive higher levels of local manufacturing.

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Contents

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1. Introduction

The Renewable Energy Independent Power Producers Procurement Programme (known as the REI4P) is a large infrastructure plan designed to reduce South Africa's carbon emissions, thereby addressing concerns over its present dependence on nuclear and coal as primary energy sources [1]. At the time of its launch, the programme made little economic sense given that its weighted cost of electricity was predicted to be more than three times the cost of coal-based electricity generation. This premonition was confirmed by the results of the REI4P's round one, for which the average quoted cost was $248/MWh vs. an estimated $71/MWh for conventional coal-based power generation at the time of the bidding.[3]

Furthermore, previous localisation initiatives in South Africa, such as the Defence Industrial Participation Programme, have been poorly implemented [2,3]. Although the present policy environment appears to firmly support the principles of innovation-led growth and the Beijing Consensus [4], the country's track record in being able to use major capital expenditure projects to support domestic economic growth and manufacturing has suffered from inadequate controls and monitoring capacity. It is therefore important that initiatives such as the REI4P are continuously assessed and publicly discussed in respect of delivery vs. key objectives.

Fortunately recent developments appear to have altered the cost/benefit balance of the REI4P. Rising costs for the construction of two new coal-based power stations – Medupi and Kusile – and falling costs of power from wind and solar, suggest that REI4P could reach grid parity in 2016 and become cost neutral by 2017. Furthermore, it is possible that the programme could deliver a broad range of other benefits in addition to the obvious favourable impact on carbon release and the mitigation of climate change.

This paper provides an overview of the REI4P together with a detailed discussion of the three bidding rounds, the weighted average cost of power, and the prospects for grid parity in the short term. Global benchmarks for renewable energy initiatives are developed (Section 2) and these metrics are used as performance targets to rate the present performance of the REI4P, including its overall expected cost and intended benefits (Section 3). The prospects of the programme achieving its three key objectives of job creation, enterprise development and increased local manufacturing based on a comparison to the global norms are discussed in Section 4. Finally, the conclusions of the analysis and the implications for renewable energy policy in South Africa and elsewhere are presented in Section 5.

2. Global benchmarks for renewable energy

2.1. Cost of renewable energy

Contrary to cost profiles of most fossil fuels and particularly coal, the cost of electricity generation from renewables has fallen dramatically over the last decade and is predicted to continue this steep decline until at least 2030 [5]. The levelised cost of electricity (LCOE) from photovoltaic panels, geothermal sources and onshore wind generators is close to, or below, grid parity in many countries and essentially equal to the equivalent greenfield cost of electricity from either conventional coal or nuclear technologies (see Fig. 1).

This ranking of electricity generation technologies is a new phenomenon; even as recently as 2012, large-scale comparative
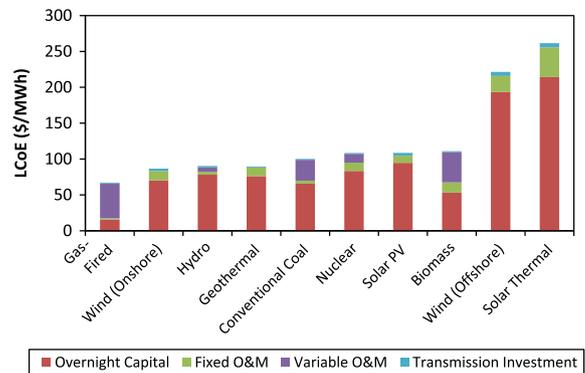
Fig. 1. Total cost of generation by technology.
Source: U.S. Energy Information Administration [46].


$$y = 41.207x^{-0.288}$$
$$R^2 = 0.95$$
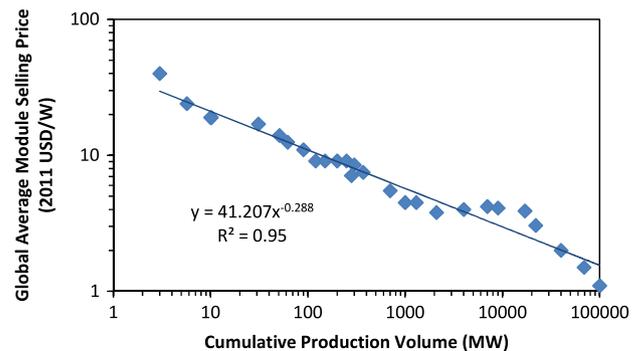
Fig. 2. PV module selling prices decrease with cumulative production.
Source: IRENA [47].

surveys have placed renewable technologies as more expensive options compared to nuclear and fossil fuels [6–8]. The LCOE from solar photovoltaic (PV) installations has decreased dramatically, with the prices of PV modules falling by 60% over the period January 2011 to December 2012 [9,10]. This sharp decrease in prices is expected to continue (see Fig. 2) and has become known in the industry as Swanson's Law, which states that the "price of solar photovoltaic modules tends to drop 20% for every doubling of cumulative shipped volume" [11].

Similarly, the LCOE of wind power is competitive even against gas-fired generation with some of the lowest-cost producers being in the range of 40–50 $/MW [9]. Installed costs of wind turbines are about $1800–$2200/kW in most countries with the exception of China where costs are 50% cheaper [9]. The equivalent cost of PV panels in India, Germany and China is reported to be about $1720, $2008 and $2160/kW respectively [8].

LCOE values tend to be highly site specific and as a consequence a direct comparison between the various technologies is complex, and even misleading. For instance, the cost can depend heavily on firstly the quality of the resource (average wind strength or solar insolation) and secondly on local financing costs.

With respect to the quality of the resource, the LCOE of wind power scales proportionally in response to wind quality, and this quality varies greatly across South Africa (see Fig. 3). Solar power is similar; a concentrating solar power plant in the best locations of South Africa – more than 2400 kWh/m^2 – will generate at least 20% more power for the same capital investment than locations with a solar resource similar to where the plants in Spain are operational – 2000 kWh/m^2 (see Fig. 4).

In terms of local financing costs, the LCOE from wind power, for example, is about 60% higher for an increase in the cost of capital from 5.5% to 14.5% [9]. Most renewable energy technologies (RETs), with the exception of biomass, are by implication capital
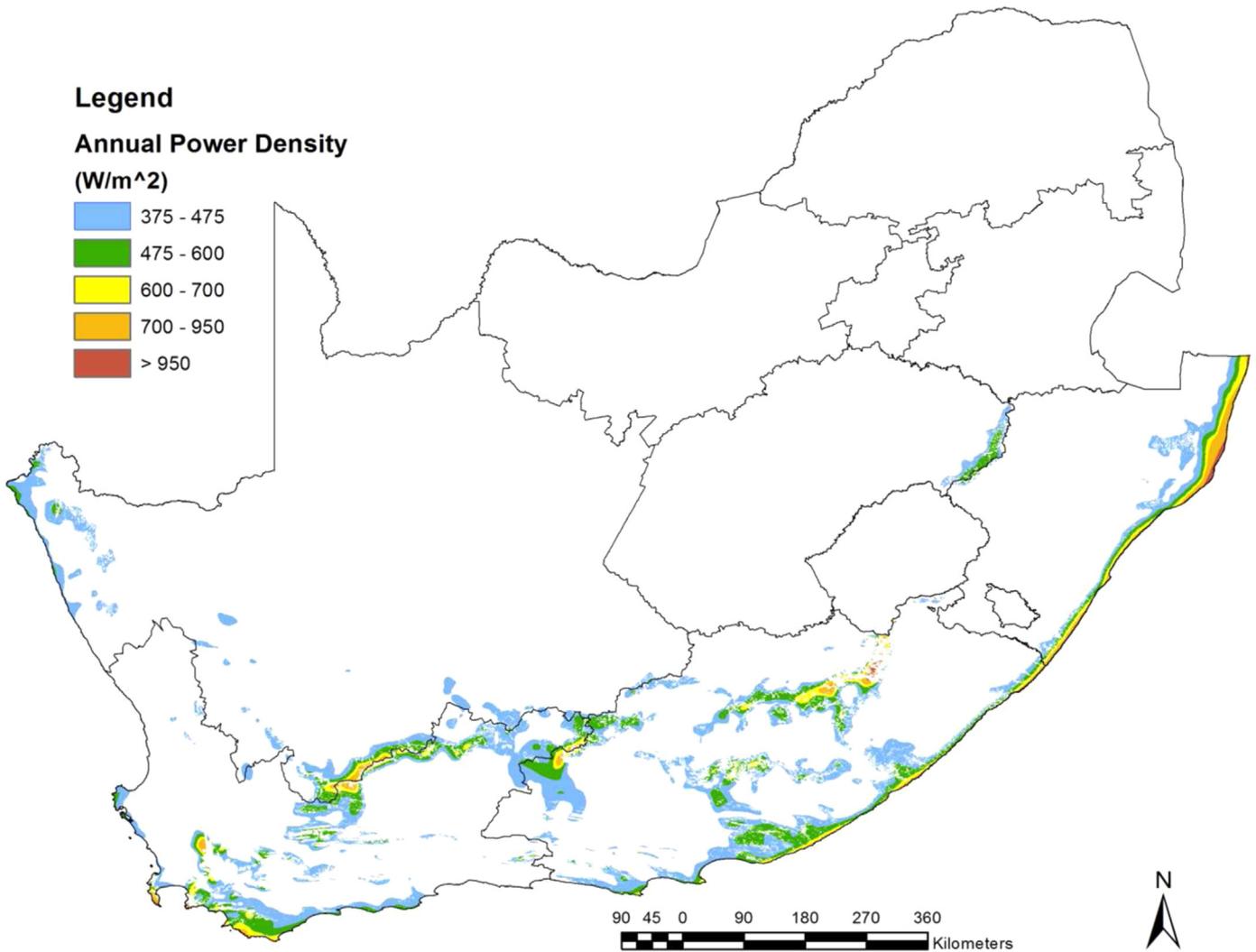
Fig. 3. Best wind resource quality areas in South Africa.

intensive (see Fig. 5), since the raw material is essential without cost, and as a consequence financing charges can significantly influence investment decisions. Developers of renewable energy projects require stable procurement contracts at guaranteed prices and off-take structures within low cost capital structures in order to submit competitive proposals.

It is noted that the LCOE values in Fig. 5 are proportional to the total costs; the actual costs are shown in Fig. 6. Wind and solar thermal are the most expensive, and gas-fired power stations and onshore wind are the least expensive.

2.2. Learning curves to predict renewable prices

Learning curves have been employed as a generalised methodology to predict the future cost of products or services based on the historical trajectories. The assumption of the predictions is that for new technologies or products prices fall over time as a consequence of several factors including increased competition, innovation, 'learning by doing' and 'economies of scale'. This fall in price is modelled by the Pearl curve as follows [12,13]:

$$y = \frac{L}{1 + ae^{-bi}}$$

where y is the present 'technology performance', L is the expected limit of performance, and i is the cumulative investment (usually

R&D) or time, and a and b are the coefficients that determine the shape of the S curve.

For $i \ll \ln(a)/b$ or $y \ll L$ this equation is often simplified to the classic power law

$$y = Ki^c$$

which for the purposes of this analysis on PV module prices can be expressed as follows:

$$(Price)_2 = (Price)_1 \times \left(\frac{Capacity_2}{Capacity_1}\right)^c$$

where c is the power relationship and suffixes 1 and 2 refer to prices and cumulative production capacities at times 1 and 2 respectively. Often exponent c is captured as the learning rate (LR), which is the proportional reduction in price for a doubling in manufacturing capacity,[4] or:

$$LR = 1 - 2^c$$

For example, learning rates for cost of PV modules as a function of installed capacity have been calculated at 20–25% depending on

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[4] Note that this relationship only applies over the linear part of a technology S curve only.
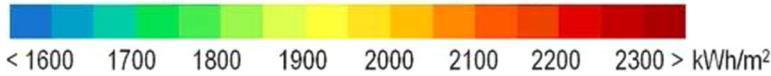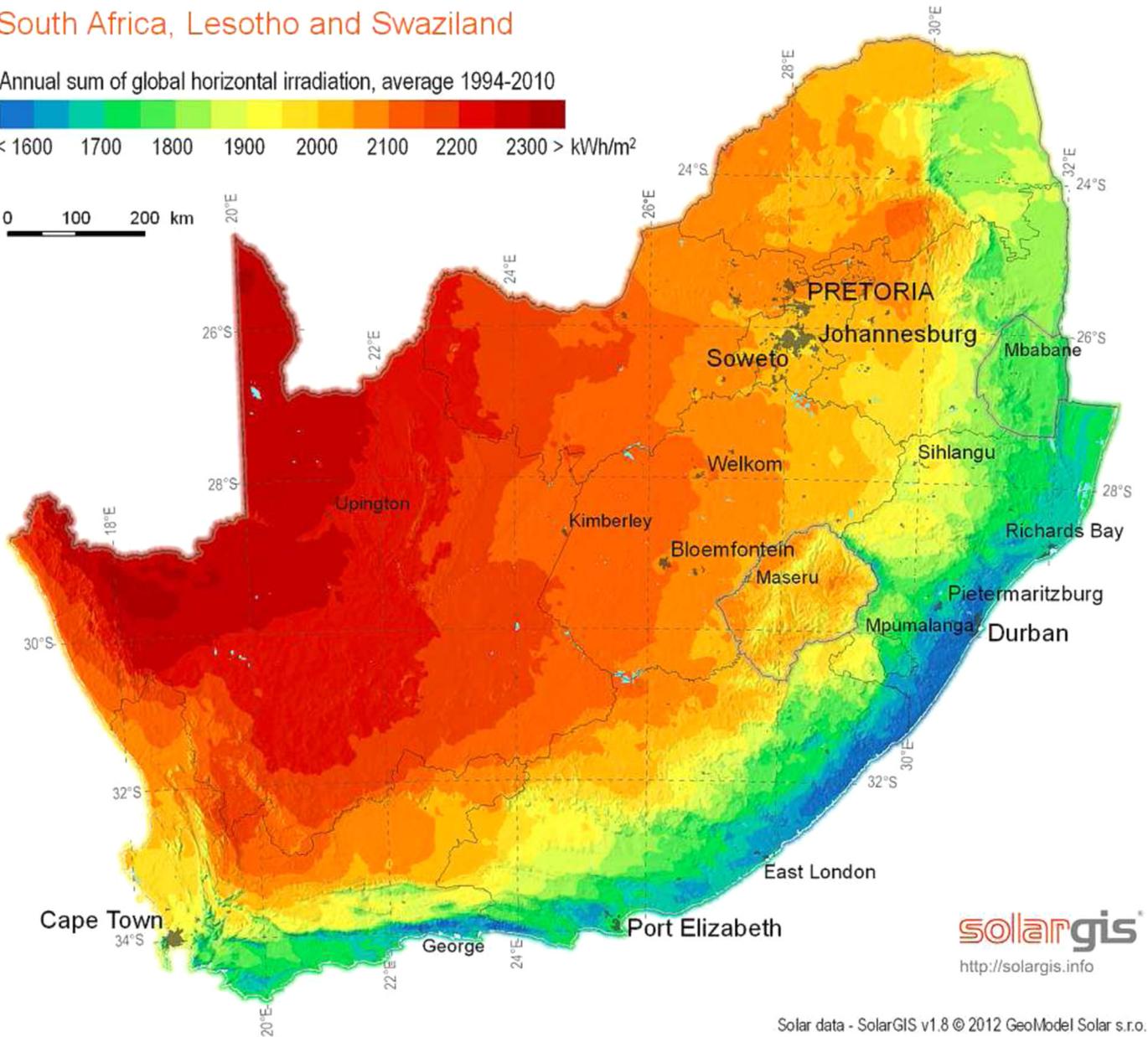
Fig. 4. Solar resource quality across South Africa.
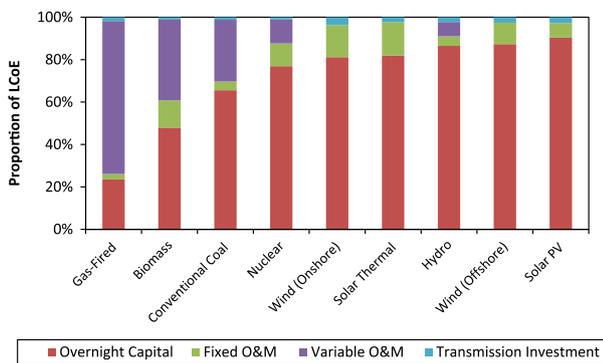
Fig. 5. Relative proportions of cost factors to total generation cost.
Source: U.S. Energy Information Administration [46].
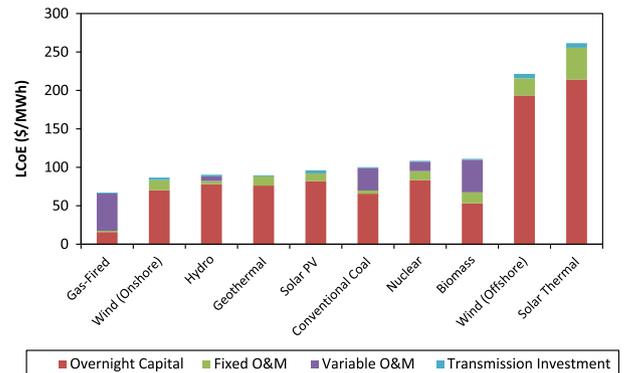
Fig. 6. Actual costs of generation.
Source: U.S. Energy Information Administration [46].

the times periods [14]. In this study, a learning rate of 18% has been calculate over the period 1979–2012, but a much higher rate of 31% over the more recent period of 2006–2013.

Predictions as to the future of PV prices are hazardous given the dynamic nature of these markets and the recent performance, which seems to have exceeded expectations. Using data from the
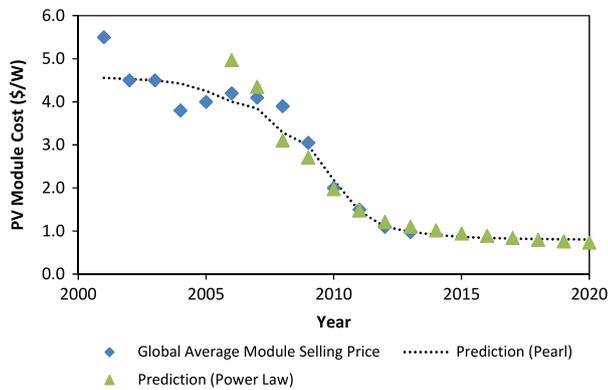
Fig. 7. Actual and predicted PV module prices from 2002 to 2020.
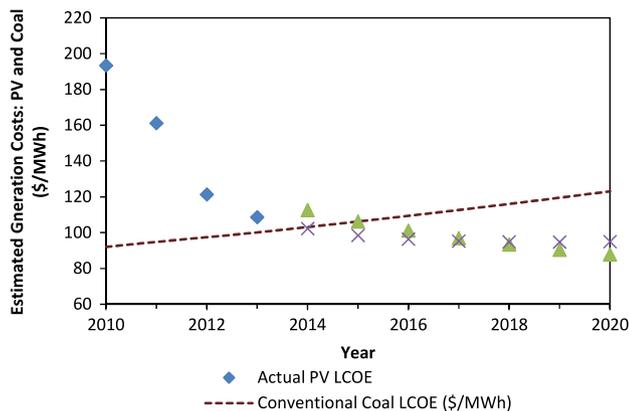
Fig. 8. Actual and predicted LCOE costs for PV power.
Source: PVinsights [48] and own calculations.

period 2002–2013, the Pearl parameters were estimated by using a least squares (sum of errors) algorithm, giving a technology limit (*L*) of about 1.25 W/$ or 0.8 $/W. A similar exercise using the learning rates estimates that PV module prices could call as low as 0.7 $/W by the end of 2020 (see Fig. 7) [15].

The conversion of PV module prices to installed overnight costs for PV facilities and finally to PV power cost depends on various assumptions such as transmission charges, operating and maintenance charges, and PV modules as a proportion of total capital costs. In this study, the capital portion of the LCOE has been calculated by using the single year cost of capital, which is about 20% per annum in South Africa. The remaining components have been calculated by assuming an inflation-linked escalation for the cost of transmission, operations and maintenance, and variable costs. These estimates have then been used to predict the future LCOE for PV, based on both the power law and learning curve estimates, and compared to the predicted cost of power from coal-based generation (see Fig. 8). This comparison confirms previous predictions, namely that the cost of PV power will fall below the cost of power from coal by the beginning of 2015, if the present learning rates on PV modules are maintained. This is an important and significant finding for the industry, and one that has not yet been fully acknowledged in national energy policies.

2.3. Employment in renewables

RETs have significant employment potential [16,17], as shown in Table 1, although these jobs have become highly localised as some countries have been more successful than others in growing sustainable sectors.

Table 1
Direct and indirect jobs in renewable energy technologies (excluding solar water heating).
Source: REN21 [17] and Wei [50].

Sub-sector	Global average (jobs/MW)	Number of direct and indirect jobs (thousands)			
		Global	China	Germany	India
Biofuels	1.9	1379	24	23	35
Solar PV	7.7	1360	300	88	112
Biomass	1.8	753	266	57	58
Wind power	1.7	753	267	118	48
Biogas	6.3	266	90	50	85
Geothermal	2.2	180		14	
Hydropower (small)	2.5	109		7	12
Solar Thermal (CSP)	2.0	53		2	
Total		**4853**	**947**	**359**	**350**

The literature data for PV-related jobs is unclear, with some sources claiming that an average of 30 jobs per peak MW installed capacity are created, spread between operations (1%), manufacturing (14%), module assembly (36%) and construction/installation (49%) [18]. Excluding installation, distribution and integration, more than 54% of the manufacturing jobs are located in module assembly [19], equivalent to about 11 jobs per peak MW. On the other hand, labour costs for this portion of the value chain account for 6% of the overall costs [20], suggesting a high ratio of employment creation to cost and consequently a potential opportunity for low-cost employment creation [19].

More conservative estimates report the PV-associated jobs at 8–10 jobs/MW. One of the sources of discrepancy may be the assumption in respect of the construction jobs. Given that less than 5% of the total jobs are in longer-term employment (such as financing, operations and maintenance, research and development), these assumptions will heavily influence the final estimate. For this analysis, a lower value of 10 jobs/MW has been adopted on the basis that in the medium term the manufacturing and construction sector will stabilise at 30% of total installed capacity (10% refurbishment and 20% expansion).

2.4. Key success factors for the renewable energy sector

Finally, in this section the key success factors for a renewable energy sector are briefly discussed. It is considered that the sustained success of a renewable energy industry, defined as its establishment and profitable operations with high levels of job creation and supply of products at competitive prices, requires attention to a range of factors within national energy markets. Although local market demand is vital, this is not the only important policy instrument; it is essential to also introduce suitable supply-side measures (such as support for R&D, training and the development of standards), and to ensure conditions for healthy competition alongside viable, clear and long-term government commitment to supporting the sector [16,21].

A summary of the key success factors for a renewable energy sector is shown in Table 2. The balance between demand-pull and R&D support as a means of accelerating technological change and the establishment of new industries is an important consideration for countries in their policy structure for renewable energy industries. Whilst the evidence indicates the importance for both to exist simultaneously, governments tend to favour demand-pull policy measures as a consequence of the more immediate market response to such stimulants. However, a case study of wind power has concluded that demand-pull has had limited success in inducing non-incremental technical change and that governments

Table 2
South Africa's compliance with the key success factors for a domestic renewable energy sector.
Source: IRENA [51] and Mulcahy [19].

Key success factor	Compliance	Comment on South Africa's compliance
Policy		
Clear and consistent government policy	Y	Policy is clearly stated in the IRP 2010–2030 and REI4P (detailed tender documents).
Transparent policy implementation	N	There is limited public information on the implementation of REI4P; some agencies are performing dual functions with clear conflict of interest.
Mix of policy instruments	Y	Specific demand side measures (competitive bidding and supply contracts) and generalised supply side incentives (R&D, human capital).
Enforcement of policies	Partly	Lack of compliance with aspects of local content and other components.
Market and funding		
Balance between stability and adaptability	N	Although investors require stability, especially in terms of price, policies should allow for degression of prices to avoid the risk of overcompensating developers; the tender allows for inflation-adjusted pricing but no degression [38].
Access to affordable capital	Partly	South Africa's cost of capital generally higher than most developed countries; moreover the industry's reliance on the Industrial Development Corporation is considered a weakness.
Public R&D funding for RET	Partly	More R&D funding will be required specifically for RETs if a stronger local industry is planned.
Industry regulations		
Regulations to support investment	Y	The programme has managed to achieve high overall coordination between government departments in establishing the necessary regulatory framework.
Local content requirements	Partly	Local content rules and requirements need tightening to ensure higher levels of localisation and job creation.
Demand-pull and supply-push	Y	Independent power producers are offered a guaranteed market for power supplied to the national grid; further incentives to switch to the most economical means of electricity generation will be required.
Industry standards	Y	Required for consistency in local content, etc. South Africa has quality standards in certain areas such as solar water heating.
Social development		
Government coordinated training in renewable energy technologies	N	Human capital development is adequate in environmental sciences but lacking in more practical training at the technology level.
Stakeholder involvement (local participation and ownership)	Partly	Local communities are mostly disappointed that there are not more local jobs; on the positive side, there is a diverse geographical spread of the IPPs.

should be wary of pursuing such policies in the absence of direct R&D support [22].

3. A programme evaluation of the REI4P

3.1. Overview of the REI4P

The REI4P is an ambitious initiative to install 17.8 GW of electrical power in South Africa from renewable sources – wind, solar, biomass, biogas and hydropower – by 2030. According to Haffajee [23], the three main policy drivers for the REI4P were a reduction in carbon in intensity – carbon dioxide emissions from 912 g/kWh to 600 g/kWh; additional generation capacity – to alleviate immediate shortage; and opportunities for economic development.

Inventories of greenhouse gas emissions in South Africa have highlighted the high emissions profile of the country although there is some disagreement as to the exact level of emission, with estimates between 470,000 and 550,000 Gg of carbon dioxide-equivalent [24]. The potential to use renewable energy as a means of reducing the carbon footprint, and simultaneously reducing the present energy shortfall, has already been noted. In particular the widespread adoption of solar water heating has been recommended [25]. However the latter has been slow to penetrate the electrical water heating market and remains at an insignificant level (1–2%) [25]; it is clear that a utility-scale intervention is required if the present deadlock is to be overcome.

A similar conclusion has been reached for other countries in the sub-Saharan region, including Kenya, Nigeria and Ghana [26,27], and a number of recommendations have been suggested in order to boost the use of renewable energy, such as policy reform,

government support, access to the national grid for independent power producers, low-cost financing, increased public awareness and education [26]. The same issues have surfaced in other developing countries including Malaysia [28], India [29] and Algeria [30]. Many different policy models and instruments for the stimulation of renewable energy generation have been adopted and reviewed in the literature such as Germany [31], Greece [32], China [33,34] and Malaysia [35]. Procurement models varying from feed-in-tariffs (FIT) to competitive tenders have been implemented with different levels of success.

Although South Africa initially considered a feed-in-tariff mechanism to support the growth of grid-connected renewable energy, the REI4P is a competitive tender or auction-based-tariff (ABT) system with clearly defined rounds of bid submission, adjudication and financial closure [36]. The adjudication process consists of two steps; the first being a screening process in which all bids are required to meet certain minimum requirements in a number of areas including environmental and technical compliance with the bid documents, and the second step being the formal evaluation of the bid against a multiple of measurement areas [37] including economic development and black economic empowerment.

Targets for local economic development were defined in the initial policy documents that formed the basis for the REI4P's implementation [38], and listed job creation; local content aimed at increasing local manufacturing; rural development, and especially the inclusion of previously disadvantaged regions in the economy; local community participation and socio-economic development; skills development and education; enterprise development through promotion of new entrants to the renewable energy industry; and participation of previously disadvantaged citizens in the industrial economy.

The potential impact of the REI4P on local job creation and economic development was not an unreasonable expectation given the experience of other countries including China and Germany, as shown in Table 1. Moreover, both objectives are of critical importance to the future of the country, given persistently high levels of unemployment (> 25%) and low rates of economic growth (about 3% p.a.) [39]. Youth unemployment in particular is a major problem; for black youth, it is estimated that the unemployment rate is 65% [39]. The issue has been highlighted in South Africa's National Development Plan 2030 (NDP 2030), which has set the following specific employment objectives [40]:

- a fall in the strict unemployment rate from 25% to 14% in 2020 to 6% by 2030;
- a rise in the labour force participation rate from 54% in 2010 to 65%; and
- 11 million additional jobs by 2030.

Whilst the achievement of the objectives of the NDP 2030 will require progress on a broad front, the potential contribution of an emerging renewable energy sector to the growth of the South African manufacturing sector and the alleviation of its employment crisis provided a necessary incentive for its government to support the REI4P. However, as in all public projects embracing multiple objectives, these incentives have had to stand alongside other objectives including the necessity of providing immediate relief to the country's present energy shortfall [41]. In the following section, the REI4P's progress against its key targets for the period 2011–2013 is described and reviewed.

3.2. Implementation of REI4P from 2011 to 2013

As of January 2014, bidding on the first three rounds has closed and the results have been announced (see Table 3). The industry anticipates that the request for proposals will be re-issued in March of each year (with round four being issued in 2014), followed by closure in August, until the year 2027 by which time the full 17.8 GW will have been allocated. At this stage only 3.92 GW has been allocated, of which about 750 MW has become operational.

The power allocations and price caps for each technology and bidding round are shown in Table 4. The latter appears to have been based on international LCOE prices and in the first two rounds, the bid prices were mostly at or close to the price cap, with the exception of onshore wind, which was bid at 78% of the cap. However, by round three all major technologies were bid at significant discounts to the price caps (see Section 3.3).

The process of bidding is expensive and complex (see Appendix A), with the cost to the developer being in the region of $2 million per bid, depending on the size of the contract, with the bulk of the fees due to legal costs and raising of the bid bond; the latter is a deposit submitted at the time of bidding, which is refundable unless the bidder defaults on the bid commitments.

A key issue is the impact of the required probability factor (P_{50} vs. P_{90}) on the final cost. In the calculation of the final bid price – selling price of power to the utility in $/MWh – it is necessary to estimate the expected capacity utilisation whose value is partly influenced by the degree of certainty required by the developer's financial partners; the higher the level of certainty, the lower the estimated capacity utilisation and hence the higher the bid price. In general, most financial institutions require the use of P_{90}, whereas a developer using in-house or balance sheet funding would use the P_{50}. The difference between the two factors relates to the degree of certainty in the capacity utilisation, with P_{90} being a higher level of certainty.

The impact of this requirement is illustrated by considering a solar PV plant, which has been designed at a nameplate peak capacity of 100 MW, installed at $1/W. The actual peak capacity delivered to the grid – through a local substation – will be somewhat less than this figure due to on-site power requirements and losses in the collection and inversion of the generated power. Assuming a 5% loss, the rated capacity of the plant, as stated in the bid documents, will be 95 MW. The capacity utilisation of single-axis tracking PV panels will be about 30% on average, also referred to the P_{50} value. As a consequence, the expected energy output of the plant will be 95 total hours per year.

However, if much of the capital required for the project must be funded though bank loans, these institutions stipulate the use of the P_{90} value, which would be the normal value of 30% less

Table 4
Summary of REI4P technology-based power targets.

Technology	Power allocations (MW)			Price caps ($/MWh)		
	One	Two	Three	One	Two	Three
Solar PV	631.5	417.0	401.3	285	174	140
Onshore wind	634.0	562.6	653.6	115	115	110
Small hydro	0.0	14.3	120.7	103	103	106
CSP	150.0	50.0	200.0	345	285	165
Biomass	0.0	0.0	60.0	107	110	140
Biogas	0.0	0.0	12.5	90	90	90
Landfill gas	0.0	0.0	25.0	84	90	94
Total	**1415.5**	**1043.9**	**1473.1**			
Weighted average				**215**	**147**	**127**

Table 5
Impact of P_{90} vs. P_{50} on bid price.

Item	Units	P50	P90
Total finance charges	$ mill/year	27	
Operating hours	h/year	8322	7889
Average capacity	%	29%	27%
Power output	MWh	249,660	236,678
Bid price	$/MWh	108	114

Table 3
Summary of REI4P bidding results.
Source: Eberhard [52] and own data.

Round	Bid closing date	Planned purchase (MW)	Bids received		Bids preferred		Value ($ mill)	Weighted average capital cost ($/MW)
			No	MW	No	MW		
One	04-Nov-11	1416	53	2128	28	1416	46,026	32.52
Two	05-Mar-12	1044	79	3255	19	1044	28,059	26.88
Three	19-Aug-13	1456	93	6023	17	1456	33,810	23.22
Total		3915	225	11,406	64	3915	144,723	

1.3 standard deviations of the expected variance in solar power for the selected site. Assuming a standard deviation of 4% [42], this requirement reduces the capacity factor by a further 10%. In other words, the capacity factor is now 27%, adding a further 5–6% onto the bid price (see Table 5).

It is noted that the calculations in Table 5 include single year capital, fixed, variable and transmission costs, and assume a required return on investment of 20% per year, equivalent to an actual return on investment of about 17%, based on the local currency (South African Rands). It has been reported that the real returns to equity in round one were close to 17%, but these were reduced in round two to 13% as a consequence of higher levels of competition in the bidding process [37]. In the same table, the operating hours have been calculated assuming 347 days of sunshine for the P50 value and 329 days for P90; the latter value has been estimated based on 95% resource availability less 1.3 standard deviations (4%) due to the higher specification for P90.

3.3. Costs of renewable energy from REI4P

Bid prices for the procurement of renewable energy from the various submissions are shown in Table 6, from which it is apparent that

- the weighted average cost of electrical power from RETs has declined progressively since the launch of the programme from 211 to 84 $/MWh;
- the differential between the price cap and the average purchase price has widened from 2% below the price cap to 34% (on a weighted average basis); and

Table 6
REI4P bid prices relative to USA LCOE.
Source: U.S. Energy Information Administration [46]; U.S. Energy Information Administration [53]; and own data.

Technology	Average cost ($/MWh)			Estimated cost from USA LCOE ($/MWh)		
	One	Two	Three	One (2011)	Two (2013)	Three (2014)
Solar PV	276	165	88	211	144	114
Wind	114	90	66	97	87	86
Small hydro	N/A	90	N/A	86	90	90
CSP	345	262	146	312	262	250
Other (Bio)	N/A	111	104	111	111	113
Weighted cost	**211**	**128**	**84**	**171**	**118**	**118**

- the REI4P purchase price has declined relative to the weighted average LCOE from its initial value of 124% of the LCOE to 72% (in other words, the local price is now more, not less, competitive than the USA cost).

The steep decline in REI4P bid prices is shown in Fig. 9. Many reasons have been stated for the steep decline, although unofficial. For example, original equipment manufacturers having access to stock not taken up in other parts of the world.

There has been some controversy about the cost of REI4P to Eskom – the national utility and, in this case, the client for the REI4P energy, with Eskom claiming that the actual cost would be $198/MWh and the National Energy Regulator of South Africa (NERSA) ruling in 2013/14 that only a portion of these costs would be allowed. In this study, the procurement costs have been further revised to allow for entry of the rounds two and three bidders, on the assumption of the bid prices as either published or estimated and a 2-year implementation period.

A comparison of the NERSA ruling on the average allowable Eskom tariffs (labelled as the 'Eskom Average Price'), the Eskom/NERSA REI4P application costs, the estimated costs for REI4P energy from this study and the cost of Eskom power from new coal-based power stations (namely Medupi and Kusile and labelled as 'Eskom New Cost') is shown in Fig. 10. Although the present REI4P cost is more than three times the average allowable Eskom tariff, and probably at least double the eventual cost of power from the two new coal-based power stations of Medupi and
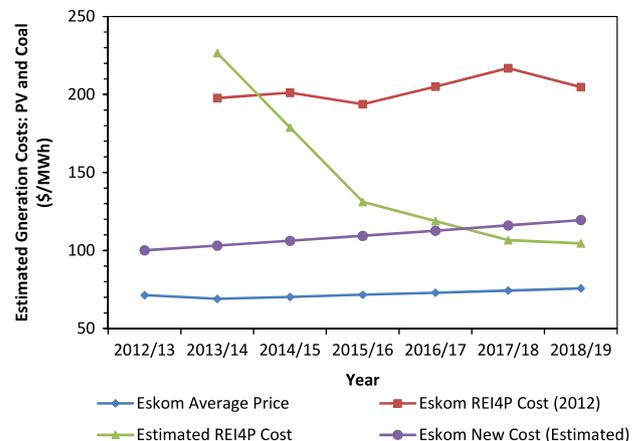
**Fig. 10.** Cost projections for conventional coal vs. REI4P.
Source: Price information has been obtained from own data; NERSA [49]; and U.S. Energy Information Administration [46].
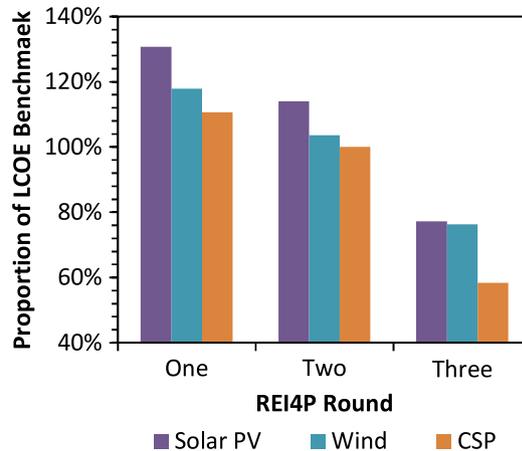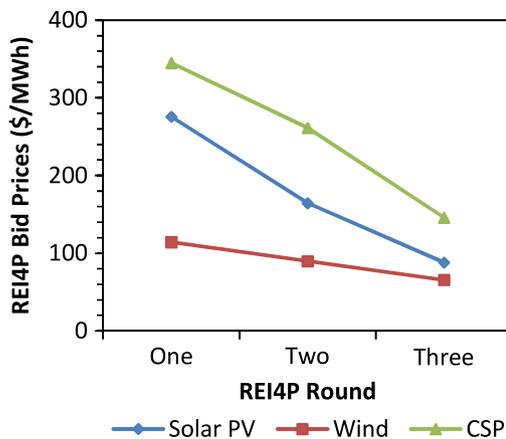
Fig. 9. REI4P bid prices more competitive in the recent rounds.

Kusile, the future comparison are highly favourable, with the REI4P cost being lower than the coal-based equivalent by 2016 (see Fig. 10).

It is possible to calculate the additional cost from the REI4P to the South African consumer using the information shown in Fig. 10 (the difference between Eskom New Cost and the Estimated REI4P Cost) and an estimated power output. The additional cost is computed at $31/MWh, which is equivalent to a premium of 3.5% on the 2014 allowable tariff. Over the period 2013–2030, it is also estimated that the first two rounds of REI4P will increase electricity purchase by about $19 million and $3 million respectively but round three will result in a saving of $5 million relative to the cost of power from a new coal-based generator (see Table 7). In other words, although rounds one and two have resulted in higher costs, the subsequent rounds will reduce the cost of power for South African consumers, especially if the future bidding rounds focus on the more cost-effective technologies only.

3.4. Employment and manufacturing

REI4P adopted local content as a measure of the manufacturing spin-offs from the independent power producers, where according to SATS 1286:2011 [43] the local content of a product is the tender price less the value of imported content, expressed as a percentage (provided that local manufacture does take place) as follows:

$$LC = (1 - (x/y)) \times 100$$

where

x is the imported content in Rand
y is the bid price in Rand excluding value added tax (VAT)

Prices referred to in the determination of x must be converted to South African Rand by using the exchange rate published by the South African Reserve Bank (SARB) at 12:00 on the date of advertisement of the bid. The REI4P bid documents specified both minimum (45%) and target (65%) local content levels, with points being awarded in the adjudication process according to the specified level within the actual bid.

In support of this local content requirement, a number of policy instruments are available in South Africa to reduce the risk of inward investments including a tax rebate and favourable financing rates from the Industrial Development Corporation [19]. Nevertheless, the response of the bidders to the localisation policies has been disappointing in the early stages of the REI4P. According to Mulcahy [19], of the 27 PV projects in the first two rounds, only 4 projects are using locally manufactured panels, equivalent to less than 5% of the overall PV power. Altogether about 300 jobs have been created or about 3 jobs per MW vs. the international norm of 10 jobs per MW (see Section 2.3), and the local contents have been reported at 25% and 41% for rounds one and two respectively. Moreover, there has

Table 7
The estimated price premium of electricity through REI4P.

Technology	Capacity utilisation (%)	Generated electricity (MWh/year)			Premium ($ mill/year)
		One	**Two**	**Three**	
Solar PV	30	827,518	546,437	570,024	163
Wind	30	830,794	737,169	1,031,285	−48
Small Hydro	90	0	56,334	0	−1
CSP	25	163,800	54,600	218,400	56
Other (Bio)	80	0	0	118,810	−1
Average cost		**1,822,111**	**1,394,540**	**1,938,518**	**169**

Table 8
Job creation commitments in the REI4P.
Source: Haffajee [23].

Technology	Global benchmark (jobs/MW)	REI4P (operation jobs/MW)			Total jobs (operation and construction)
		Round one	**Round two**	**Round three**	
Solar PV	7.7	9.7	9.1	17.3	24,209
Onshore wind	1.7	3.9	4.0	10.8	19,414
CSP	2.0	9.2	23.6	8.7	10,423
Average (operation)		7.0	6.9	12.5	
Average (operation and construction)		11.3	11.9	18.0	

been some intentional manipulation of the local content whereby bidders have been able to claim high local content without having to purchase any of the major components (inverters, panels or support structures) from local manufacturers [19].

The disappointing response to the local content targets in the first two rounds has been partly rectified in round three, for which a local content of 47% has been reported [44]. Furthermore, the number of jobs per MW (operation and construction) has increased by 60% from 11 to 18 (see Table 8), which is more than double the global average and well above the benchmark levels. It is noted, however, that the figures in Table 8 represent bid commitments as opposed to actual jobs created; it is not known at this stage whether these obligations have been fulfilled or whether there will be significant shortfalls. Certainly the data from Mulcahy [19] seem to suggest that the bidders mostly fail to reach their stated targets.

4. Discussion

Round one of the REI4P was certainly a slow start. Limited competition between the bidders, exemplified by a bid success rate of 53%, resulted in high prices relative to the price caps and international benchmarks (98% and 124% respectively). In the subsequent two rounds, competition had been more active and the bid success rate had fallen to 18%. Moreover, the preferred bid prices have fallen dramatically to 72% of the international LCOE benchmark and 66% of the price cap. These prices are highly competitive, not only in comparison to international prices, but also with respect to local coal-based electricity generation. It is estimated that by the time the round three projects are being implemented the weighted price of electricity from these investments will be 77% of the equivalent cost from new coal-based power stations.

This improvement in the outcomes of the REI4P bidding process is a reflection of the programme's attention to a broad range of factors that support competitive prices, including many of the key success factors identified in Section 2.4. South Africa's compliance with these factors has already been detailed in Table 2 and the generally high rate of compliance augurs well for the future of REI4P. For instance, the bidding process was clearly communicated with the extensive bid documents covering in detail many aspects including quotas in respect of technologies; price caps in R/kWh for each technology; requirements for local content, job creation and socio-economic development; cap on foreign exchange exposure; allowable inflation clauses; evaluation process and scoring template (see for example documents from the Department of Energy [38,45]). Moreover, it is apparent that the template and the evaluation process are closely aligned to the overall objectives.

Unfortunately it is not possible to establish at this point the extent to which the REI4P's objectives are being realised. Although the national Department of Energy has implemented a detailed

monitoring and evaluation process, none of this information is publicly available, making it difficult for independent researchers to assess the programme's effectiveness in several of its key area. Even in the absence of this information, other studies have noted a few early problems including

- limited competition in round one and hence the high procurement prices relative to international benchmarks [37];
- manipulation of the local content formula by importers and hence the low probability that the programme will achieve its targets with respect to job creation and manufacturing (see Section 3.4) [19];
- high transaction costs and lack of suitably qualified transaction advisors to fulfil the contractual requirements of the procurement process [37]; and
- difficulty in achieving a balance between the promotion of economic development and electricity prices, and hence the need to re-calibrate the 70:30 model, where the latter refers to the adjudication points which are allocated on the basis of 70% price and 30% socio-economic development [45].

Despite the progress in round three, the present situation is still disappointing in respect of localisation. Some companies have established manufacturing facilities, yet have failed to see any orders from the independent power producers and have or are considering closing these facilities. An alternative means of both establishing local manufacturing and job creation targets, and monitoring compliance with these targets, is required. Several possibilities exist including the use of 'jobs per MW' as the localisation indicator, or higher local content targets (these have already been increased for future rounds), or more detailed targets in certain specific areas including PV module assembly, wind turbine support towers and blades, and other components.

5. Conclusions and policy implications

South Africa's REI4P has been a successful initiative in several respects, including the diversification of the power generation sector from a single to 64 power producers in the first three rounds only, a more rapid response to its energy crisis than would have otherwise been possible, and the procurement of electricity at competitive prices, even relative to the present grid prices, with the exception of the first bidding round which was characterised by a general lack of competition and high prices. Indeed, the predictions of this study have shown that the REI4P cost of electricity will reach parity with the cost of new coal-based generation by 2016 and thereafter will be lower than the LCOE of either coal or nuclear power. This is an important and highly significant result, and suggests that the continued inclusion of non-economic options in South Africa's energy policy, such as coal-based power and nuclear technology, requires urgent revision.

In addition to the energy mix, there are several other areas in which the REI4P could be improved in order to ensure that its overall socio-economic targets can be met, and its impact can be increased. These areas include a revision of the local content requirements to increase inward investment and technology transfer for local manufacturing; additional stimulation of local research and development; and increased transparency in terms of monitoring and evaluation to ensure greater public scrutiny of the programme's benefits. The revision of the local content requirements in particular is considered to be an important requirement given evidence of its limited impact to date and some manipulation of the system by local REI4P bidders.

Finally, the high capital investment characteristic of renewable energy projects means that over time such projects will compete primarily on a cost of capital basis. Bidders with access to 'balance sheet' funding will have a significant advantage due to being able to bid using P_{50} as opposed to P_{90} factors and will dominate in the bidding process. Although the first two rounds of the REI4P have been successful at bringing new, smaller companies into the power generation sector, in the subsequent rounds it is likely that the bigger companies will be more successful. If this outcome is to be avoided the adjudication process will need to be revised in order to include additional measures that will favour small bidders, such as ring-fencing for such bidders a portion of the total allocation.

Acknowledgements

Appendix A. Steps and associated costs in the submission of a REI4P bid

See Table A1.

Table A1
Source: Department of Energy [45].

Step	Activity	Duration (years)	Description	Developer cost (R's)	Comments
One	Site selection	1–3 years	Site selection	R0.5–R1 million	Involves identification of suitable sites, collection of site specific climatic data and final site selection. Wind and CSP projects require 2 years of climatic data; PV plants can submit NASA irradiation data.
			Agreement with landowner	R50,000 to R0.25 million	Some landowners request initial options payment.
Two	Environmental Impact Assessment	1 year	Completion of required EIA	R0.5 to R1 million	A study is required for each site.
Three	Preparation of bid documents	6 months	Securing of black business and financial partners	R2.5 million	Extensive legal contracts are required at this stage requiring inputs from lender's legal adviser, the lender's technical adviser, accounting adviser, insurance agents and the 'equator principle' audit team.
Four	Bid Bond	2 months	Submission of the first bid bond	R100,000 per MW	The bid bond is a refundable deposit payable upon submission of the bid documents.
Five		6 months to 1 year		No additional funding	Time delay can cause additional interest charges if any of the development expenses have been funded with interest-bearing loans.

Table A1 (*continued*)

Step	Activity	Duration (years)	Description	Developer cost (R's)	Comments
	Award as Preferential Bidder		Adjudication of the bids by the Department of Energy and National Treasury		
Six	Financial Close	3 months	Submission of second bid bond	R100,000 per MW	This bond is required for financial close and is refundable to the developer after the signing of documents with the DOE. In reality these expenses are never incurred as they are only invoiced (not paid) at financial close.
			Preparation of financial close and power purchase agreements	R6 million	Estimate of the costs of the lender's legal adviser, the lender's technical adviser and developer's legal advisor to compile the documents for financial close.
Seven	Signature of the EPC contract	3 months	The EPC contract usually stipulates an initial payment of 10–15% of the total cost	15% of total contract	Engineering, Procurement and Construction (EPC) contractor is required to submit a performance fee with the Department of Energy (15% of total contract); may be covered by a performance bond.
Eight	Construction and commissioning	1–2 years	Construction and commissioning of the generation plant	85% of EPC contract	Project may incur delays if there are problems with international procurement or lack of clarity on scope of services/tie-ins to the national grid.
Nine	Operations	20 years	Generation and sale of power to Eskom as per the supply agreements	Revenue as per the supply agreement	Revenues are guaranteed over a 20 year period on an inflated basis (CPIX), depending on the supply agreement. The rate of return is specific to each agreement but would typically be about 18% based on the energy regulator's guidelines in respect of a 'fair rate of return'.

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