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INTERNATIONAL SUPPORT FOR DOMESTIC CLIMATE POLICIES

Concentrated Solar Power in South Africa

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Abstract:

This paper examines the case for accelerated deployment of Concentrated Solar Power (CSP) technology in the South African electricity sector. It discusses the climate and development co-benefits of going beyond the current targets set by the government for renewable energy contribution. A review of some of the policy mechanisms and enabling activities that need to be defined and developed to encourage investment in CSP is carried out. The use of a tender process, complemented with support from other policy instruments such as feed-in tariffs is proposed as an effective way of meeting an effective CSP target. The paper also highlights the advantages of international support and commitment to large-scale CSP deployment. These include the sharing of knowledge and the incremental improvements inherent in the process of learning-by-doing.

1. Introduction

South Africa has traditionally been a highly carbon intensive economy. In 2004, cheap and abundantly available coal resources constituted 70% of its primary energy sources (Winkler & Marquard, 2007). More than 90% of South Africa's electricity generation is dependent on coal. Therefore the power sector is an area with great mitigation potential. Diversification into renewable energy technologies (RET) will assist with carbon abatement. Added to this it will add variety to the power mix, thereby increasing the security of South Africa's power supply and decreasing its vulnerability to fluctuating primary fuel costs (Banks & Schäffler, 2006).

South Africa has vast solar resources, yet the penetration of technologies such as concentrated solar power (CSP) is negligible (DEAT, 2008). This paper discusses policy frameworks that could be employed to encourage investment in CSP technology in South Africa. It then proposes policy instruments to support the entry of the private sector into the CSP generating industry.

The analysis builds on a study led by the Department of Environmental Affairs and Tourism (DEAT) and carried out by the Energy Research Centre of Cape Town University. The Long Term Mitigation Scenarios (LTMS) report (SBT, 2007) explored the consequences of various economy-wide policy interventions that could be employed in South Africa to mitigate greenhouse gases. It emphasised the importance of prescribing a destination target and taking immediate action to develop and embark on a road map to reach this target. It was recommended that industry started making strategic technology choices to avoid being locked into a carbon-intense development trajectory. In particular three areas were outlined as being essential components of a successful transition to a low carbon society (SBT, 2007):

- Technology: strategic development and deployment must be enabled
- Investment: adequate financial support must be provided
- Policy: "legally-enforced" signals must be sent to the market

The motivation in these three areas needs to be aligned to ensure that circumstances converge to make South Africa an attractive climate for investment in low carbon technologies.

There are various positive climate policy impacts of accelerated, large-scale deployment of CSP in South Africa for example minimising emissions and providing a substitute for coal-fired generation. Added to these, there are also development co-benefits such as stimulation of an indigenous industry in solar technology and ensuring integrity of the power system whilst minimising the negative impacts of coal generation on health and the environment. Global markets also stand to benefit from the cost reductions and incremental learning inherent in decreasing the concentration of an industry and increasing the installed capacity of a technology. With this in mind the potential for international collaboration to facilitate adoption of CSP technology in South Africa is explored.

2. Background

Energy Situation I: Dependence on Coal

As a result of a history of cheap electricity, South Africa's industry of extraction and primary level processing has not had the incentive to pursue incremental energy efficiency in its processes. Consequently, the economy is highly energy intensive. This scenario, coupled with the dominance of coal in the energy mix, means that South Africa has one of the highest per capita GHG emissions in the world (DME, 2003; UNIDO, 2003). The South African electricity generation sector contributed to about 45% of GHG emissions in 2003, therefore it is an area with significant carbon emissions mitigation potential (Winkler & Marquard, 2007; SBT, 2007).

More than 90% of South Africa's electricity generation is dependent on coal. The electricity sector is dominated by the vertically integrated, state utility, Eskom, which generates 94% of the country's electricity, and estimates that a further 60% of planned capacity expansion will be coal technologies (Eskom, 2007). The significant dependence of the generation sector on coal means that it is vulnerable to volatile primary fuel prices (Eskom, 2008b). In the past Eskom has used low-grade coal that has been cheaply available through long-term purchasing contracts with its captive collieries. However as the capacity of these collieries decreases Eskom will need to source new coal suppliers, which will increase transport costs. Added to this as the global demand for coal increases, collieries will be encouraged to export and the price of coal for local consumers will increase.

Further, if the bulk of new-build is coal-fired power stations, Eskom is in danger of locking itself into a carbon-intensive technology trajectory that could have expensive repercussions in the future as emissions become increasingly restricted. Most of the coal-fired power stations are situated in the north of the country, close to the coalfields in order to minimise transport costs. An implication of this concentration of generators in the north is that power centres in the south of the country are more vulnerable to grid failures. This indicates the need to diversify the generating technology towards non-location specific technologies in order to strengthen the integrity of the grid. The government has indicated its intention to explore various alternative methods of electricity generation, in particular the conversion of solar energy to usable energy (DME, 2007).

Energy Situation II: Urgent Need for Investment

In the 1980's, South Africa had excess power capacity, which led to the mothballing of coal power stations (Steyn, 2006). However currently, the South African electricity generation sector is suffering from under-investment. In 2007, the capacity margin fell to below 10% whereas in 2002 there was a reserve capacity of over 25% (Eskom, 2008b). Reports state that unplanned outages between November 2007 and January 2008 cost the South African economy an estimated ZAR50 billion (US$4.5 billion) (NERSA, 2008b). The consequence of this crisis is that Eskom is urgently focussing on building base-load, coal-fired power stations or peaking Open-Cycle Gas Turbines. Renewable energy technologies are competing for scarce funds with projects that are less capital-intensive and are considered to be of immediate and greater national importance. Eskom's financial and human capacity is stretched to the limits.

In the 2007 'Energy Security Mater plan' developed by the Department of Minerals and Energy (DME), it was stated that 30% of new build was expected to be carried out by the private sector. Eskom, as the 'sole-buyer' of electricity, was mandated to source 5000MW of electricity from the private sector (Eskom, 2008c). However private participation has been obstructed by policy uncertainty and low electricity tariffs that do not adequately reflect the cost of supply. Added to this, under the current market structure, Eskom will continue to have complete control over transmission facilities, which could mean that independent power producers are impeded by complicated grid access procedures and codes.

Energy Situation III: Alternative Resources

South Africa is a country rich in renewable energy resources. Some resource assessments indicate that renewable energy could provide for 15% of the electrical demand by 2020 (Banks & Schäffler, 2006; Winkler, 2003).

South Africa's Environmental Ambition

South Africa acceded to the Kyoto protocol on 31 July 2002. In 2008 South Africa issued a declaration on climate change that re-emphasised its intent to align itself to the objectives of the United Nations Framework Convention on Climate Change (UNFCCC) and accelerate its transition to a low carbon economy (SA, 2008).

South Africa is endeavouring to implement effective renewable energy policies that would not only have the benefits of carbon abatement, but would also be aligned to the country's development goals of securing supply through diversity and managing energy-related environmental and health impacts (DME, 1998).

Current Development Plans

In 2003 a White Paper on Renewable Energy (WPRE) was developed. In terms of supply-side strategy, the WPRE outlined the government's objective of achieving 10,000GWh of renewable energy contribution to final energy consumption by 2013. This target included the deployment of end-use technologies such as solar-powered water heaters, which Eskom estimates could contribute 23% of the target (Eskom 2008a). In 2007, the National Energy Regulator of South Africa (NERSA) modelled three electricity demand scenarios for the years up to 2026. The medium demand forecast, based on a 4.2% average growth in demand, estimated that the total energy requirement for 2013 would be about 309 839GWh (NERSA, 2007). Therefore the target of 10 000GWh outlined in the WPRE amounts to about 3% of final demand. The government also released an Energy Efficiency Strategy in 2005 that sets a target of 12% average reduction in final energy demand by 2015.

Since the introduction of the WPRE in 2003, deployment of RET has been limited: Small-scale PV installations have been used for residential applications including rural, off-grid electrification. The Darling Wind Farm, a 5MW independent power producer was commissioned in 2008 (DME, 2005) and a program to encourage the installation of solar-powered water heaters was launched by Eskom in 2008.

It is believed that implementation of the WPRE is slow due to the high costs of technology in contrast to the low electricity tariffs and the lack of certainty in policy and institutional framework (World Bank, 2007).

The Long Term Mitigation Scenarios (LTMS) report models the impacts of existing South African renewable energy and energy efficiency policies on future emissions. As can be seen in Figure 1 the emissions level in 2050 is not far below the business as usual scenario of unrestrained growth. This indicates that current South African climate policy needs to define more ambitious targets in order to effectively reduce emissions to a level more closely aligned to that required by science[1] for GHG stabilisation (SBT, 2007).

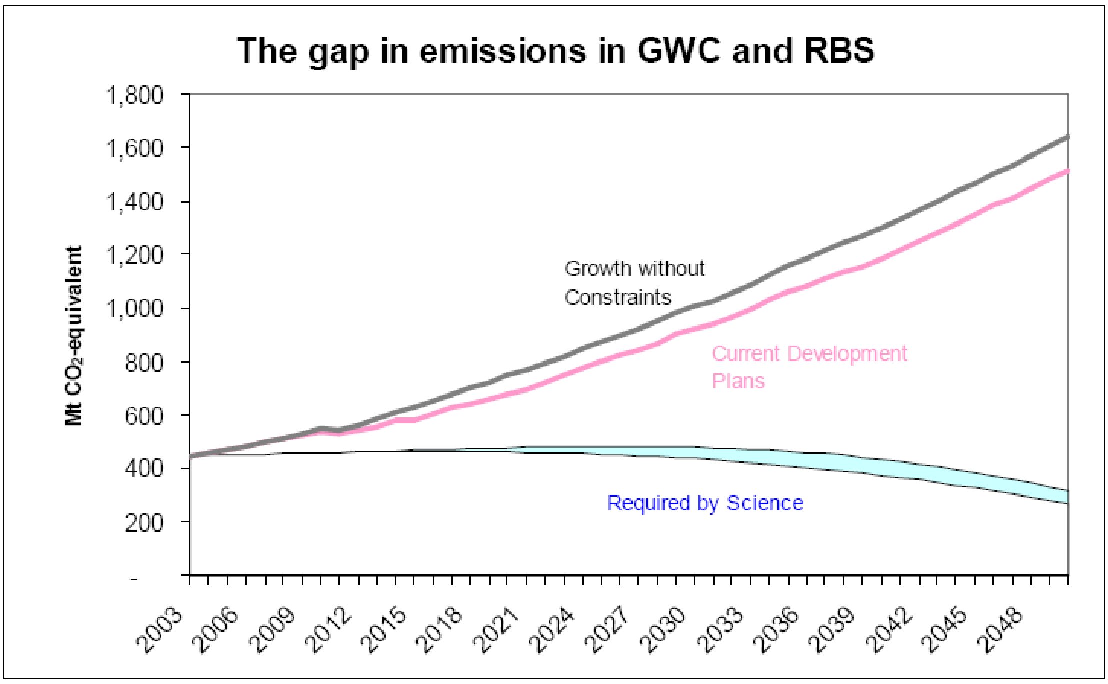

Figure 1: Mitigation impact of current climate development plans (Source: Long Term Mitigation Scenarios, SBT 2007) Note: 2008 population estimated at 48.6 million (www.statssa.gov.za).

CSP Technology

The abundance of renewable energy resources in South Africa makes it the ideal location for deploying RETs. In particular, South Africa has a vast amount of solar resources, which makes it an ideal location for the deployment of concentrated solar power (CSP) plants (UNDP, 2000). The two main technologies focussed on in this paper are 'solar trough' technology and 'power tower' technology. Solar trough technology operates by concentrating the sun's rays onto a pipe containing a heat transfer fluid (HTF), located at the centre of parabolic, linear reflectors. The station is made up of long lines of these trough-like collectors. The accumulated heat from the HTF is fed through a heat exchanger, which then generates steam to drive a turbo-generator. Solar trough has a reasonably established technology base as Solar Electricity Generating Stations (SEGS) using this technology have been operating commercially since 1984. Power tower technology is a newer technology where the suns rays

[1] The Required by Science scenario assumes that South Africa has all the technical and financial resources at its disposal to reduce emission by between 30-40% below 2003 values by 2050. This amounts to mitigation of about 1300Mt of GHG per year (SBT, 2007).

are reflected by hundreds of separate mirrors positioned around a central tower-like receiver that contains the heat transfer fluid. Power tower has the potential to reach higher thermal efficiencies, therefore in the long run it is proposed that the Levelised Electricity Costs (LEC) costs for this technology will be lower than solar trough (Sargent & Lundy, 2003).

International Experience

CSP is a low carbon generating technology that has been supported by the EU for the past 10 years (EC, 2007). A total of 418MW of demonstration plants have been built in the USA however interest in CSP development slowed after oil and energy prices began to fall in the 1980s and 90s. Recently, interest has been renewed with the increased awareness that renewable energy technologies will be a crucial component of mitigating climate change. Spain was the first country in Europe to commission an 11MW plant in 2005. Some studies indicate that a further 5800MW of CSP projects are planned globally, with a majority of the capacity planned for USA or Spain (EER, 2007).

In USA, the 1974 Solar Energy Research Act was passed to support R&D in solar specific technologies, although the peak of government RD&D budget for solar thermal-electric technologies only occurred in 1980 (IEA, 2004). The first set of commercial-scale CSP plants (SEGS) were commissioned in stages between 1984 and 1990 (FPLEnergy, 2008). Energy tax credits and favourable purchasing regulations[2] were seen as incentives for CSP deployment in USA at this time (IEA, 2004).

In Spain, a suite of government policies provided the market 'pull' for the deployment of CSP. Various regulations promoted the proactive inclusion of RE in the primary energy mix. Feed-in tariffs, priority network connections and 5-year committed off-take agreements guaranteed future revenues. Technology 'push' was developed through RD&D programs and capital grants in the form of non-refundable loans or subsidies (In particular the Aid programme for solar PV and solar thermal introduced in 2001 (IEA 2004)). In 2001, 10% tax deductions were offered for investments in renewable technologies. Investment was also supported through low-interest loans.

Local Experience

So far CSP has not yet penetrated the South African market (DEAT, 2008). However solar power is mentioned as one of the most important technology options for the energy sector in the 'Resource document for South Africa's Climate Change Technology Needs' (2007). This indicates that South Africa is aware of the important role of solar power in its future energy mix. South Africa has vast solar resources with studies suggesting that 194 000km^2 of land in South Africa receives sufficient solar radiation to make a CSP plant viable (WPRE, 2003). A yearly direct normal irradiance (DNI) of 2 000 kWh/m^2 is often considered a minimum requirement (IEA, 2008) (The DNI is the solar ray that strikes a mirrored reflector at a perpendicular angle). It is clear that not all of this land would be suitable for building CSP, taking into account factors such as vicinity of power lines and location of built up areas. However if a mere 5% (9700km^2) was used, 242GW of CSP could be deployed[3] (see Figure

[2] In 1978 The Public Utilities Regulatory Policies Act required utilities to purchase power from qualified, small-scale private producers at the avoided cost rate. This encouraged deployment of renewable energy technologies (IEA, 2004).
[3] Using the assumption that a 100MW plant can be built on 4km^2 (Eskom, 2006). However Brightsource, the company contracted to build power tower plants in California for Pacific Gas and Electric, claim that a typical 100MW plant can be built on between 600 acres (2.4km^2) and 800 acres (3.2km^2) of land. http://www.brightsourceenergy.com/faq.htm

2). With a 25% capacity factor (EU, 2008), this translates to about 530TWh of annual electricity supply. To put this into perspective, this is more than *twice the electricity demand* of the South African population in 2007. A higher capacity factor could be possible in the future with advances in technology development (this could also be achieved through storage or integration of solar into combined cycle gas turbine plants)

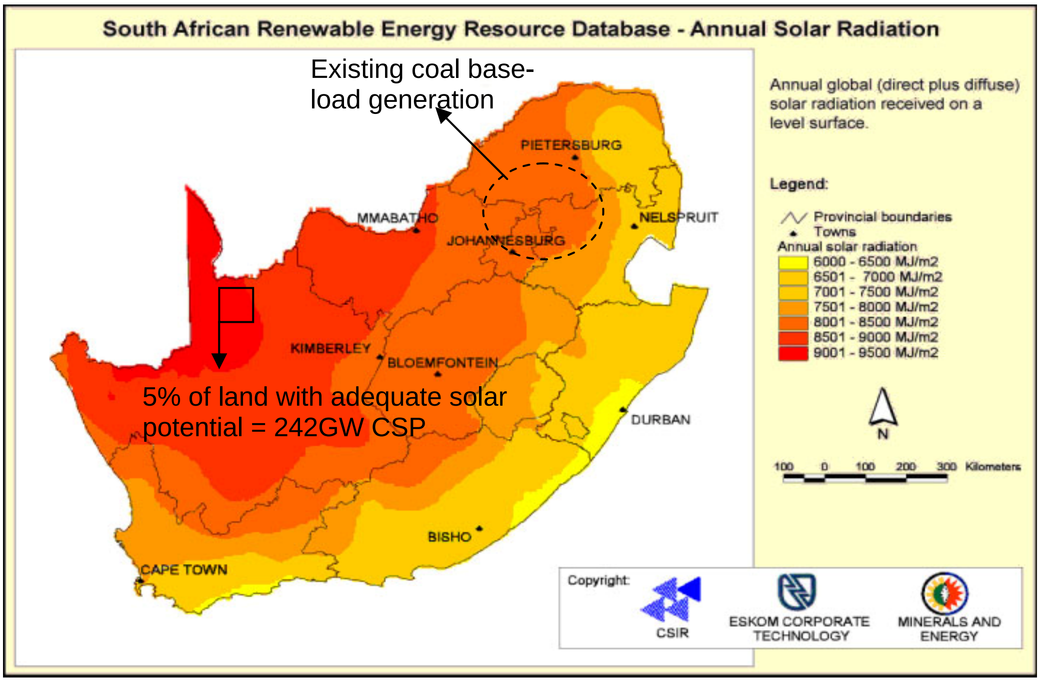

Figure 2: Solar radiation map of South Africa (Source: 2003 White Paper on Renewable Energy, DME, 2003). Note: This figure shows both direct and diffuse solar radiation – in CSP only the direct normal irradiation (DNI) is usable.

2. Description of policy

Target Level

The current development plan stated in the White Paper on Renewable Energy is that **10,000GWh** of energy from renewable sources is expected to contribute to final energy consumption by **2013** (DME 2003). Based on a 4.2% average growth in demand for a medium demand forecast (NERSA, 2007), this amounts to about 3% of final demand in 2013.

Accelerated Deployment

It has been proposed that a more ambitious target for the deployment of renewables is implemented in order to accelerate South Africa's transition to a low carbon economy (See Figure 3 adapted from Winkler, 2007; pg 68). A scenario of **15%** contribution from renewables to final electricity consumption by **2020** has been proposed by various studies (EDRC, 2003; Banks & Schäffler, 2006; Winkler 2007, Marquard et al, 2008).

The 15% contribution suggested in this study is not a prescriptive solution, but an indication of what is pragmatically achievable. However setting a generic quantity target for RET raises concerns that promising technologies with slightly higher capital costs will not be deployed as firms will choose to invest in technologies with a more attractive rate of return (Winkler, 2003). As a consequence, the benefits of cost improvements and 'learning-by-doing' resulting from accumulated capacity could be lost. Therefore defining an independent target for CSP within the total RET target, will encourage investment in this area. Capacity scenarios indicate that nominal CSP capacities between 2GW (Banks & Schäffler, 2006) and approximately 3GW (SBT, 2007) could be realised by 2020. Assuming that the average electricity demand increases at an unrestrained rate, by 2020 it will be 406TWh (NERSA, 2008). CSP contribution could then amount to between 1% and 3% of this final demand. If electricity demand follows a more energy conscious growth trajectory (for example in line with the 12% reduction in final demand called for in the 2005 Energy Efficiency Strategy), then the percentage contribution from CSP would be more.

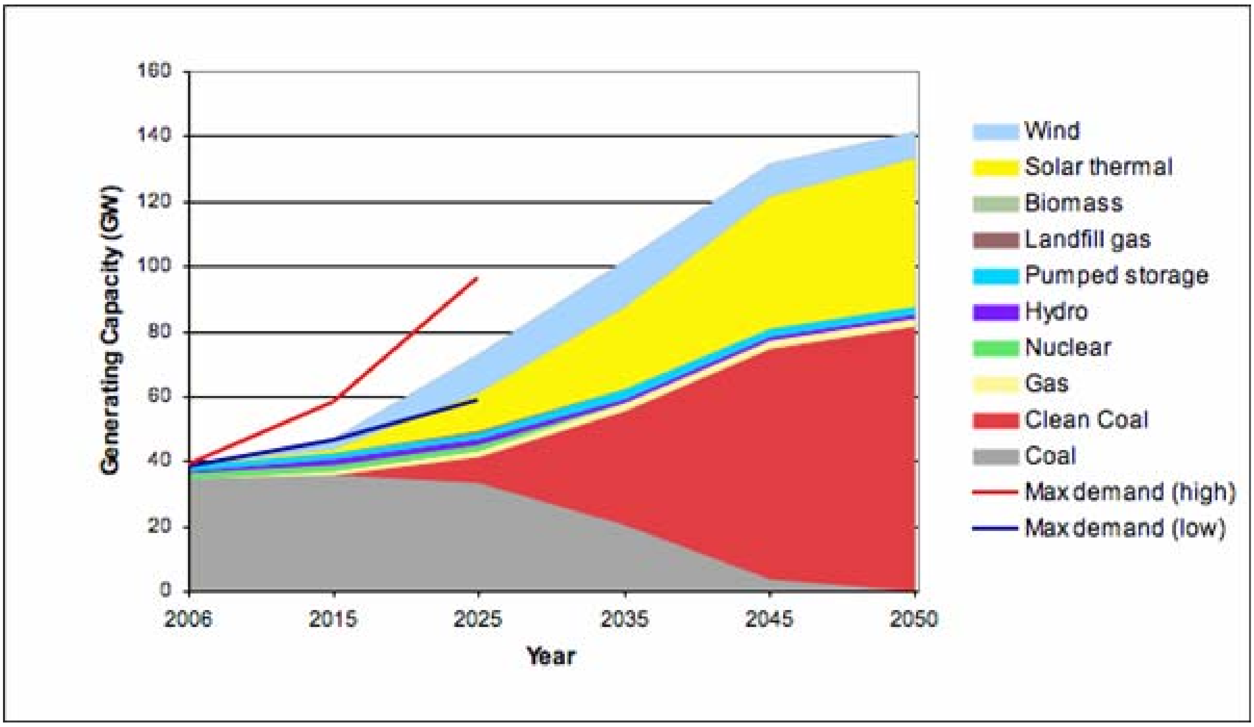

Figure 3: Accelerating deployment of renewable energy technologies (Source: Adapted from Winkler, 2007 Pg 68. Energy demand projections; (Max demand in GW) Source: Updated NIRP3 national demand forecast (NERSA, 2007).

Contributing Factors

Considering that South Africa currently has no commercial CSP plant, there are various enabling activities that need to be put into place to ensure that accelerated deployment is practically realised. It is clear that there are sufficient solar resources and need for added generating capacity in South Africa. Yet it is unclear as to whether there is enough financing, construction and material resources available to embark on an accelerated build program. The proposed lead-time for engineering, procurement and commissioning for a CSP plant is 3 years (NERSA, 2008). Enabling activities such as licensing and regulatory processes could take place in parallel with construction. However, even if the political will is present, bottlenecks resulting from environmental impact assessments, component lead times, grid access and power purchasing arrangements could act as limiting factors to reaching the ultimate target.

Suitable Policy Instruments

There are various policy instruments that have been employed to support and encourage investment in renewable technologies.

An instrument, which has been part of the strategy to encourage investment in solar technologies in the USA, is the Investment Tax Credit (ITC). The ITC is a **fiscal incentive** resulting in the reduction in an investor's tax liabilities to the value of a certain percentage (30% in the case of past ITC in USA) of the installed cost of the project (SEIA 2008). The viability of CSP projects in USA are dependent on the granting of this credit – thus uncertainty as to the extension of this support scheme reflects on the extent of deployment of the technology (Wilkins, 2008). This instrument may not be as effective in South Africa as fiscal resources are limited and are directed to social and economic programs of higher priority (DME, 2003).

In Spain long term, stable **feed-in tariffs** are believed to be the major driver for investment in CSP (Benz, 2008). At the end of 2007, some reports stated that Spain had a total of 2150MW of CSP projects registered for construction, making it an attractive location for solar industry (SolarMillenium, 2007). However it should be noted that the Royal Decree 661, which details the latest conditions of the feed-in tariffs for CSP in Spain has a target of supporting 500MW by 2010 and specifies a maximum project size 50MW (MITC, 2007).

In South Africa, feed-in tariffs would either have to be paid by Eskom, local municipalities or commercial consumers. Eskom has stated that they do not have the capacity to purchase large amounts of commercial energy at rates higher than those offered to consumers (Eskom, 2008c), and would probably have to increase the tariffs of domestic, commercial or industry consumers to raise the necessary funding. In December 2007 and again in June 2008, NERSA approved two tariff increases totalling 27.5%. NERSA projects that tariff increases between 20-25% can be expected if Eskom is allowed to recover the costs of a capital expansion program that will meet the country's growing electricity demand (NERSA, 2008c). The City of Cape Town municipality pays premium tariffs for electricity that is generated by the Darling Wind Farm. This is as a result of its self-imposed target to source 10% of its energy from renewable sources by 2020. However it is only allowed to recover these costs by selling higher priced "green electricity" to voluntary consumers (CCT, 2008). NERSA is currently working on a draft guideline for a Renewable Energy Feed-in Tariff (REFIT). It is proposed that a differentiated tariff system is used per technology set (NERSA, 2008d).

A **renewable portfolio standard** (RPS) or **obligation scheme** is a system that obliges utilities or consumers to source a certain percentage of their power from renewable energy sources. In the USA, the establishment of RPS supported investment in CSP by ensuring that suitable PPAs could be developed with utilities. For example, in Nevada, utilities must source 20% of their power from renewable energy by 2015. Further to this, 5% of the power should be sourced from solar technologies (Wilkins, 2008). This has resulted in the successful commissioning of the 64MW Nevada Solar One project in June 2007 (NREL, 20008), as well as several other planned CSP projects. The advantage of such an approach is that it provides flexibility in terms of how firms make investment and trading decisions. Obligations could be met through the trading of certificates that are allocated to operators of renewable energy plants. The disadvantage is that firms are vulnerable to uncertainty in future electricity and certificate prices (Neuhoff et al, 2008). A vehicle for the establishment of a RPS exists within the current Electricity Regulation Act of 2006. The provision exists for the Minister of the DME in consultation with the National Energy Regulator of South Africa (NERSA) to define the types of energy sources from which electricity must be generated and the percentage distribution of those sources. NERSA has proposed that Eskom Distribution is appointed as the Renewable Energy Purchasing Agency and as such would be obliged to buy electricity from any generators that are awarded licences under the future REFIT program (NERSA, 2008d). This is similar to the Public Utilities Regulatory Policies Act implemented in USA in 1978, which obliged utilities to purchase power at the avoided cost rate from qualified, small-scale private producers.

In 2007 Eskom was mandated to source 5000MW from the private sector (Eskom, 2008d). In this context, it seems feasible that a **tender** process would be an effective way of encouraging the private sector to meet the solar energy target. Bode and Groscurth (2008) mention tendering as a support scheme for power generation from renewable energies. It is described as a process whereby "A public body puts a certain amount of electricity from renewable energies to tender. The winning bidders get a guaranteed remuneration per kWh of electricity for the contracted period" (Bode & Groscurth, 2008; pg 5). The advantage of this method is that the cost of development is determined through bidding and thus the government does not limit its options by pre-setting a feed-in tariff. Investors also have a guaranteed source of revenue, which facilitates the process of securing project finance. A disadvantage is that the bidding process can be expensive and risky for market participants that have to invest in preparing project documents before the tender and it also requires sufficient institutional capacity (Winkler, 2003). Hence it is most suitable for large-scale projects, and might thus be applicable to CSP. Another disadvantage is that applicants may drive their costs down, in order to be awarded the bid. This suggests the need for some collateral to ensure winning bidders implement the project within a specified time-frame. Otherwise there is a risk of awarding a price that is not sufficient to make the project feasible or provides inadequate contingency for project cost increases.

The South African Electricity Regulation Act of 2006 could provide legislative support for a tender process. There exists provision for the Minister of the DME to make regulations regarding the participation of the private sector in new generation activities. The DME was involved in a tender process for the construction of two open-cycle gas turbine power stations. The bid was awarded after a delay to a US power consortium, AES, in 2007 (Olivier, 2007). However discussions were then terminated in March 2008 as a result of changes to the project parameters and risk profile. Despite the obstacles experienced in this tender process, the DME is confident that there is interest from other bidders and that the project will continue after some delay (Van der Merwe, 2008).

Although a **tender** process is proposed as an effective tool for stimulating investment in the solar industry, it is acknowledged that a suite of instruments could give a more tailored solution for the South African context. It may be necessary to offer additional support for initial CSP projects that are acting as prototypes in order to build up capacity in the local industry. Once there is momentum in the local industry, the bidding process could become more streamlined

Beyond policy instruments, Winkler (2003) highlights the importance of "enabling activities" including funding channels and robust infrastructure that needs to be put in place to support policy instruments. The benefits of a solar policy need to be clearly understood in order to garner support from the various stakeholders whose cooperation is essential for the successful adoption of an accelerated deployment program.

3. Benefits

An accelerated CSP program will contribute to the reduction of emissions from the electricity sector. Figure 4 illustrates the abatement potential of three scenarios in the year 2020.[4] The first option is the Business as Usual (BAU) 'reference case' presented in the Third National Integrated Resource Plan (NIRP3) (NERSA, 2008), which does **not** include the implementation of RETs. The second option is the target suggested by the White Paper on Renewable Energy of 10 000GWh by 2013[5]. Finally a progressive policy option of 15% RET contribution to final energy consumption is illustrated.

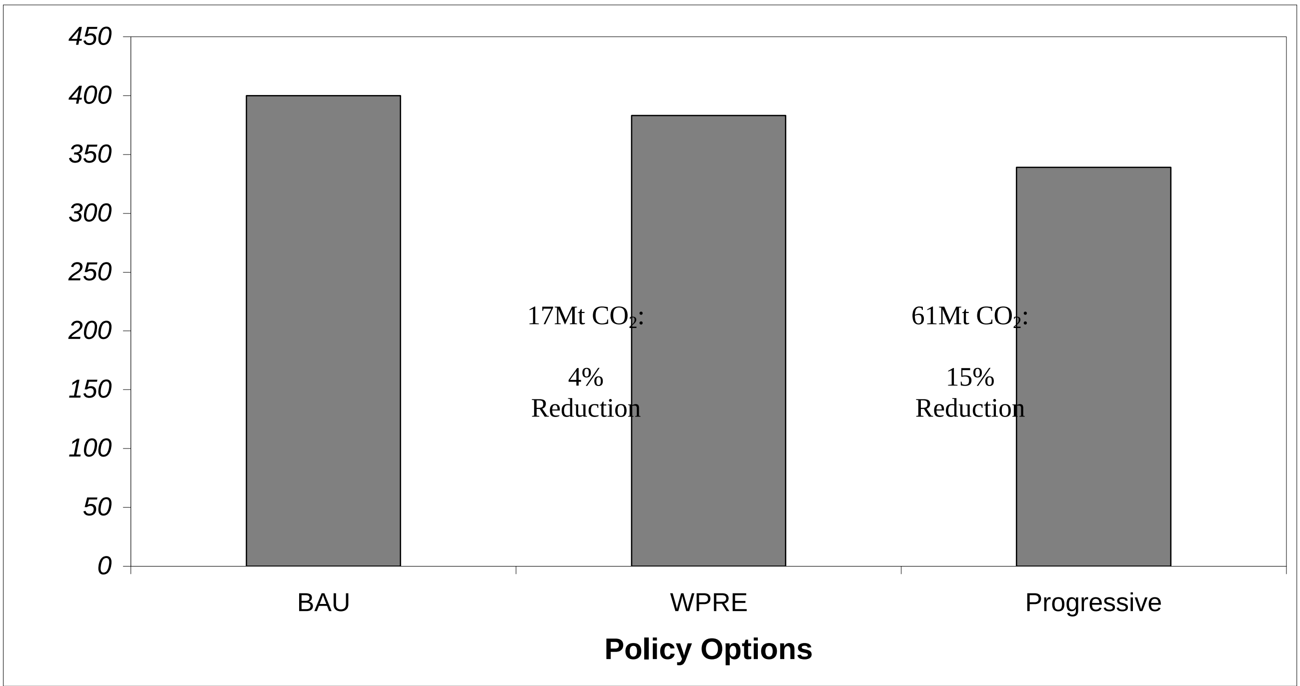

Figure 4: Carbon Abatement Potential of Policy Options in year 2020. Note: BAU – Business as Usual, WPRE – Target laid out in the White Paper on Renewable Energy (10, 000GWh RE contribution by 2013).

Figure 4 is illustrative of the potential difference in emissions. It does not take into account that clean coal technologies that could further reduce emissions in the reference case scenario as it is expected that investment in this technology will take place in conjunction with investment in RET. It also does not show the impact of the Energy Efficiency Strategy of the Republic of South Africa, which outlines a goal of average 12% reduction in final energy demand by 2015.

The benefits of encouraging investment in CSP in South Africa are not restricted to the carbon mitigation potential:

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[4] Based on Eskom's current emissions rate of about 1ton CO_2/MWh. (Emissions for 2008: 224Mt, electricity sold: 224 366GWh (Eskom, 2008)). Projected CO2 emissions for 2020 are about 400Mt per annum based on predicted electricity demand in 2020 (NERSA 2007).

[5] When the WPRE was established in 2003 it was expected that 1000GWh of RET would need to be deployed per year to reach the target. This has not occurred, however in an ideal case where the target is met and 1000GWh continue to be added per year, there would be a total of 17 000GWh of RET contribution to final energy demand by 2020.

- CSP plants are quick to construct and as such they could contribute towards assuaging the current South African power crisis. Although the capacities of CSP plants are smaller than conventional coal plants and thus their initial contribution would be small, there is significant potential for base load generation. Therefore an accelerated program would effectively direct South Africa down a more sustainable technology route.

- Avoidance of fossil-fuel dependent technology has the long-term benefits of relieving South Africa of volatile primary fuel costs and potentially expensive future carbon compensatory measures.

- It has also been suggested (Banks & Schäffler, 2006), that progressive RET deployment (above the current targets set by the government) is likely to be the most cost effective option for increasing diversity in the primary energy mix. It will be necessary to focus on solar technologies in order for South Africa to be able to achieve high renewable energy contribution targets ((Banks & Schäffler, 2006, pg 33).

- As long as there is sufficient land, (Eskom estimates that a 100MW plant will need $4km^2$ of land (Eskom, 2006) although other estimates are lower) water and solar radiation, CSP is not location specific (unlike coal fired power stations that are restricted by the transport costs of coal). Although the Northern Cape appears to have the greatest potential for CSP,

- Figure 2 illustrates that other provinces also have significant solar radiation. Therefore planning distributed plants would help to strengthen the integrity of the grid in the southern parts of the country. Obviously the trade-off between long-distance transmission losses versus the extent of solar radiation in certain areas will need to be calculated. Lower solar radiation levels will also affect the load factor of the plant – an important variable that should be taken into consideration when calculating the Internal Rate of Return (IRR) of a project.

- A proactive approach to CSP deployment could provide scope for international partnership in CSP demonstration projects. The process of early deployment of RETs before they are completely cost competitive, allows industry to become familiar with a technology and paves the way for future competitive markets (Neuhoff, 2006). If collaboration takes place between many countries, the economic efficiency of RD&D can be improved as resource strengths and prime testing locations can be strategically chosen.

- The technology for CSP is mainly manufactured from conventional material such as steel, concrete and glass, and most of the components are modular and well-known technologies that could potentially be absorbed and adapted by local industry (IEA, 2008; SolarPACES, 2008).

There are further indirect benefits of implementing support schemes for solar technology: it would confirm that the government is serious about moving towards a low carbon economy and thus investors and financial institutions will feel more confident about investing in the South African renewable energy sector. Finally, the successful implementation of solar targets could be used as a blueprint for similar initiatives in other developing countries.

The positive impacts resulting from progressive CSP deployment are not limited to the local context. In 2006, The World Bank carried out an assessment of the strategy for market development of CSP. In the report it was acknowledged that in order for the technology to be commercially competitive, the industry would need a greater deployment of demonstration projects - an initiative that would need to be supported by national programs (World Bank 2006). South Africa is an ideal location for the demonstration of CSP as it has significant land and solar resource and it has relatively cheap labour costs. As a result of successful deployment and 'learning-by-doing', a certain amount of knowledge and expertise will diffuse into the local industry. Nurturing a solar technology industry in South Africa would have the benefit of decreasing the concentration of the global solar sector and lowering the costs of technology.

4. Domestic drivers and barriers

In order to understand the context of the drivers and barriers that will impact the success of an accelerated solar policy it is necessary to understand the stakeholders that would be involved in the implementation and execution of the policy. It is also essential to understand who is likely to be making the investment decisions for entering the CSP market and what type of support could be utilised to encourage these emerging stakeholders.

Policy Stakeholders

The Department of Environmental Affairs and Tourism (DEAT) is instrumental in environmental affairs and climate policy development within South Africa. However it is recognised that in terms of sector specific policies, it will be necessary for government departments to collaborate to reach an effective climate policy strategy (DEAT, 2004). DEAT estimated that developing the capacity requirements in government departments for carrying out specific climate change response strategies could cost up to ZAR5 million (US$450 thousand) (DEAT, 2004). Figure 5 on the next page, is a stakeholder collaboration matrix that summarises the following discussion on some of the cooperation that will be required.

In order to develop electricity-sector specific climate policy, DEAT will need to work with the Department of Minerals and Energy (DME). The DME oversees and develops the policies that govern the energy sector (Winkler & Marquard, 2007). It will be within the mandate of the Minister of the DME to define a renewable portfolio standard under the 2006 Electricity Regulation Act. The DME will also be required to develop the regulations (in consultation with NERSA) that will define how the private sector may participate in electricity generation (i.e. a tender process). Further, historically it was the DME that hosted tenders for the provision to generate electricity.

The National Energy Regulator of South Africa (NERSA) was established as an independent body (through an amendment to the Electricity Act in 2005), to regulate South Africa's energy industries. In terms of the electricity sector, NERSA's main responsibilities are to authorise the electricity tariff system and to provide the necessary support for private sector's entrance into the electricity market. NERSA will need to collaborate with the DME over the tender process and will also be required to ensure that suitable institutional arrangements are set up with Eskom. This will require collaboration with The Department of Public Enterprises (DPE), which is the sole shareholder representative of Eskom.

The Department of Trade and Industry and the Department of Science and Technology have a significant role in the nurturing of a solar industry and in encouraging capacity and expertise in this technology.

Finally, the National Treasury will be involved in encouraging foreign investors and opening up financing channels by enabling the provision of low interest loans, or government guarantees.

	DEAT Dep. Environment and Tourism	**DME** Dep. Minerals and Energy	**Eskom**	**NERSA** National Energy Regulator of South Africa	**NT** National Treasury	**DFA** Dep. Foreign Affairs	**DTI/DST** Dep. Trade and Industry/ Dep. Science and Technology
Policy drivers - 'X' indicates an area where collaboration could occur							
Progressive climate policy	X						
RET policy to regulate electricity sector		X	X	X			
Defined structure for public participation		X		X			
Robust tender process		X	X	X			
Enabling Activities							
Re-structured electricity tariff system			X	X			
Information: Grid access, Grid codes and EIAs etc	X		X	X			
Robust PPAs			X	X			
Funding channels		X	X		X		X
Industry collaboration		X	X			X	X
International partnerships	X		X		X	X	X

Figure 5: Stakeholder Collaboration Matrix.

Executing the Policy and Mobilising Investment

There are many local and international drivers or "enabling activities" that will facilitate the execution of the proposed solar policy (See Figure 6). Many of those mentioned in the table above, are linked to institutional and legislative arrangements that need to be clarified before investors will feel confident that project risk is adequately managed.

Institutional barriers can be reduced through cooperation between NERSA and Eskom. Registration, licensing and grid connection processes as well as environmental impact assessments (EIAs) will need to be made more accessible and efficient. Difficulty in grid access was identified as a barrier to private participants entering the generation sector (World Bank, 2007). Secondly, robust power purchase agreements (PPAs) that support investment in CSP need to be developed. For example the Darling Wind Farm experienced delay in its development when it became evident that a suitable PPA could not be negotiated with Eskom (Erasmus, 2008). The importance of effective PPAs is paramount as they will provide security for investors through guaranteed revenue for a significant period or even the lifetime of the project.

Legislative barriers are evident in the current structure of the electricity market where Eskom operates as the single-buyer. Eskom exerts considerable authority and private participants may feel that there is significant risk in being dependent on Eskom's purchasing power and expansion strategies. The government has stated that the low electricity tariffs present "a weak case for full competition on a merchant basis" (DME 2007, pg55). It is generally agreed that the price of electricity in South Africa does not adequately reflect the costs of generation (DME 1998; Clarke & Drimie 2002; Eskom 2008c). The low retail price consequently does not provide an attractive climate for investment in technologies that are capital intensive. The necessary regulations and tariff structure that will balance the supply and demand of electricity over the next five years still needs to be developed by NERSA in consultation with Eskom (NERSA 2008a).

The **abundance of coal** is seen as a significant barrier to diversifying the energy mix (Eskom, 2008). In 2005, the IEA published a report on projected costs of generating electricity. The predicted LEC for a new fluidised-bed combustion plant built in South Africa in 2010 were far lower than other countries – Korea and South Africa were the only countries predicting LEC below 30USD/MWh (IEA, 2005; pg39). In the case of South Africa this is due to the extremely low projections for coal prices provided by respondents in the study. These low LEC predictions for new coal-build highlight the difficulty in encouraging new CSP-build when projected LEC for CSP in America (which has construction experience and local manufacturing expertise for CSP) are above 165USD/MWh (IEA, 2006; pg61).

Local Drivers	International Drivers
• Strict climate policy • Sustainable electricity tariff system • Smooth grid access and licensing arrangements • Robust power purchase agreements • Building of local technical capacity • Availability of funding channels • Industry collaboration • Increased cost and scarcity of coal	• Global consensus on climate policy • Strong carbon price signal • Flow of optimal technology • Fluidity of trade channels • Availability of funding channels • Country collaboration • Increased cost and scarcity of primary fuel

Figure 6: Local and international drivers for successful solar policy.

Capacity barriers can be seen in two contexts. At the one end of the spectrum there is a lack of resources in government departments and technical sectors. At the other end, there is appears to be too much capacity of expertise in entrenched coal technologies. The dependence on abundant, low cost coal is seen as a barrier to increasing diversity in the power mix (Eskom, 2007).

Developing effective policy is essential for reducing uncertainty and for confirming the government's stance on the adoption of CSP. A suitable road map will be required not only to develop the policy and but also to ensure that it is executed. There may be scope for international cooperation and experience-sharing in this regard.

5. International cooperation

It is important for CSP to be deployed on a large-scale in order for the benefits of economies of scale and incremental learning to be reaped. International cooperation could assist with strategic deployment or the removal of barriers (Grubb, 2004). By establishing an international coalition for CSP deployment, countries will signal to industry that there is a market for CSP technology and that they are committed to reaching mitigation targets.

It is proposed that international assistance should take a partnership approach. In the South African resource report for the Technology Needs Assessment, the government's position is outlined: It is suggested that technology transfer would be most successful if it took place over a long-term collaborative time-frame that allowed meaningful adoption of the technology (Pg 76, SA resource for TNA). Winkler (2008) suggests that countries should be instrumental in developing their own Sustainable Development Policies and Measures (SD-PAMs) that identify climate policies that have the greatest synergy with development objectives. International assistance could then be mobilised to reinforce these domestic strategies.

In terms of facilitating CSP deployment in South Africa, it is envisioned that a combined top-down, bottom-up approach will provide the most effective results. Top-down policies will signal governments' commitments as well as adding authority to the process. Bottom-up support will ensure that the capacity is available to deploy CSP technology and that a sense of project ownership is cultivated amongst stakeholders.

Capacity Building Development (Knowledge Sharing)

Institutional Capacity

Initially it will be important for South Africa to develop the drivers that will encourage the adoption of a solar target. This will require the restructuring and refining of various existing policies and the development of new legislation. It will be critical that this process is carried out in a transparent and unambiguous way. Research shows (DEAT, 2004) that South Africa may not have the institutional capacity across the relevant government departments to dedicate resources to climate specific policies. Therefore the government departments may benefit from bilateral partnerships that encourage knowledge sharing at the national and municipal level. This will assist in developing a robust policy framework in which the transition to a low carbon economy can be encouraged. The Renewable Energy Market Transformation project is a capacity-building initiative launched in 2007 and supported by the Global Environmental Facility (GEF), the South African Government and the private sector. Although the project is still in an early stage of operation, it "aims to help the government implement the White Paper on Renewable Energy" by removing policy and legislative barriers (World Bank 2007, pg 4). This project provides co-financing for local capacity building projects. It is proposed that a more 'hands-on' approach of knowledge sharing rather than purely financial transfers could be a more effective way of building institutional capacity.

Sector Capacity

Hoekman et al (2005) suggest that technology transfer is facilitated by a strong, local foundation of technical skill and human capital and the ability to apply technologies to local industry processes. Initially it is assumed that existing technology, which is somewhat aggregated, will be used in CSP demonstrating plants in South Africa. However it is envisioned that the level of local content will rise as technology diffuses into industry. In 2000 the GEF co-funded a CSP evaluation program with Eskom. 14 technologies were assessed and factors such as the possibility of sourcing some components from local industry and the water requirements of the different technologies were considered in the study. Eskom concluded that power tower technology would be the most suitable choice for current South African conditions (SolarPACES, 2008). The evaluation program also assisted Eskom with identifying the most favourable locations for the deployment of CSP. Eskom joined SolarPACES and this facilitated the transfer of knowledge between other project leaders of existing GEF projects (GEF, 2001).

Grubb (2004) suggests that international collaboration can take the form of domestic 'market engagement'. This includes support systems such as co-financing and the testing of technology on a large scale to enable the sharing of risk. Initial support for demonstration or prototype projects will assist in setting up momentum in the local industry and making the technology more commercially viable. Smaller, local firms could benefit from the establishment of an information network with experienced CSP project developers. This will assist them in making optimal technology choices for the local context.

Incremental Funding

Cost of Technology

The technology for CSP already exists in a commercial capacity however it is more expensive than conventional generation technologies, mainly because the industry is in the nascent stages of development. This is a challenge in developing countries that typically have a high demand for capital and have to pay a significant risk premium for accessing capital in international markets.

In South Africa the obstacle presented by capital-intensive CSP technologies is aggravated by the availability of cheap coal and the fact that the negative externalities of using fossil fuels as an energy source are not yet integrated into the cost of service in South Africa. It is expected that as the cumulative capacity of CSP increases, the LECs will decrease (Banks & Schäffler, 2006; World Bank, 2006). However as Figure 7 on the next page indicates, with the current electricity tariffs in South Africa, even with the support of carbon credits, there is still a significant shortfall between the LECs of CSP and potential revenue from electricity sales (Van Heerden 2008).

Therefore in order to promote the diffusion of new technologies, a support scheme will be necessary to encourage investors or the government to pursue a tender process that may result in an incremental outlay above that required to invest in new coal power generation. As can be seen in Figure 7, the LEC for new clean coal technologies are less capital intensive than CSP (IEA,2005; Manual, 2008), however the LEC costs for these are dependent on fuel costs as well. If the cost of coal continues to rise the costs of generation will become comparable.

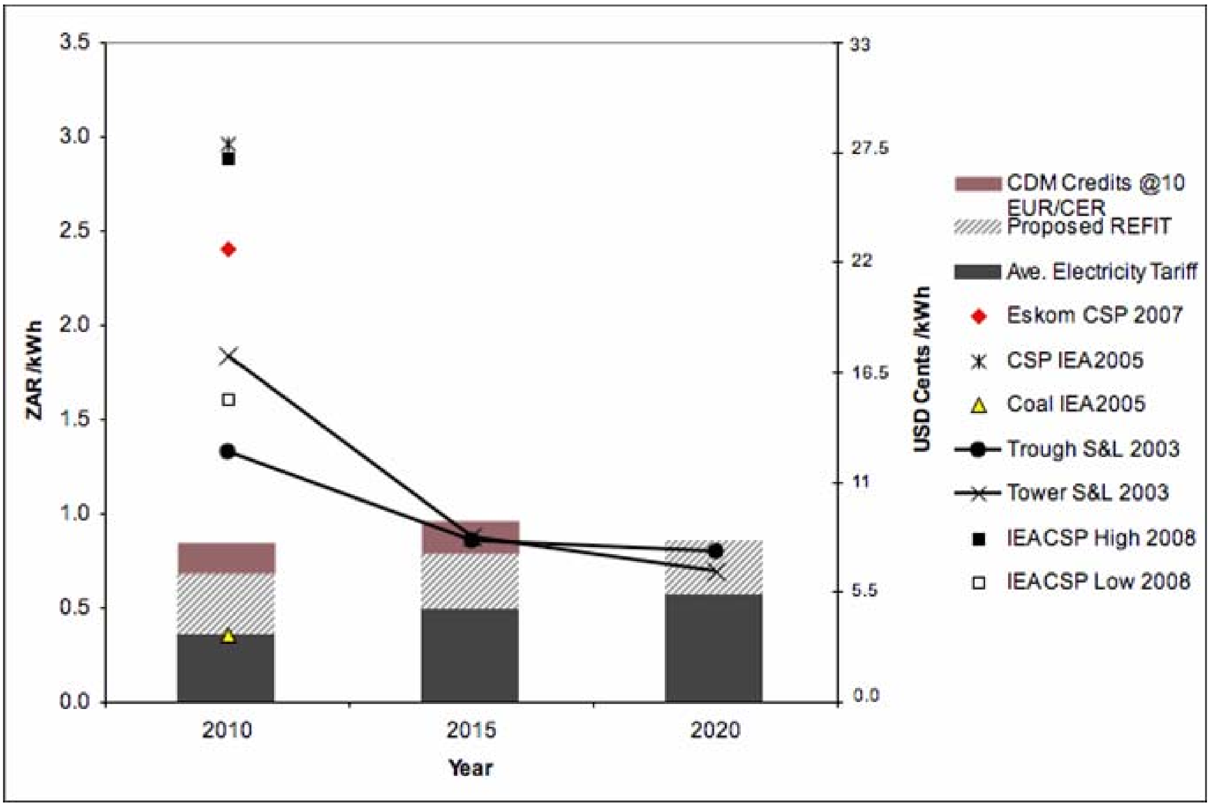

Figure 7: Shortfall between levelised electricity costs and revenues. LEC predictions: Sargent and Lundy 2003; IEA 2005 and 2008; Van Heerden, 2007). Ave electricity tariff: NERSA predicts that for the next three years, tariff increases between 20-25% will be required thereafter the price will continue to rise at the inflation rate (NERSA, 2008c). Proposed REFIT: NERSA REFIT proposal (NERSA, 2008d). CDM credits[7]: (Eskom, 2007).

As Figure 7 suggests, incremental funding will only be required for the medium term because as the cost of using coal as a fuel source increases (pushing up the LEC costs for clean coal technologies) and the LEC for CSP decreases[6], projects will begin to become competitive with conventional technologies.

The revenues suggested in the NERSA REFIT proposal (NERSA, 2008d) are illustrated in Figure 7 although the programme details are still under development. Initially CSP projects may also qualify for CDM support[7] as shown in 2010. However this CDM support is not displayed in 2015 or 2020 as the conditions for registering a CDM project is that it results in the deployment of ‘first-of-kind’ technology and that the IRR of the project under normal circumstances is less than a defined benchmark. It is projected that with increasing electricity tariffs and suitable FiT arrangements, CSP could have a viable IRR by 2015, which will preclude it from qualifying for CDM support, but may still qualify it for other forms of tradable certification schemes.

Cost of Capital

[6] The rate at which the LEC for CSP decreases depends on the global cumulative capacity. The LEC is also dependent on the local capacity to supply components and expertise.
[7] The revenue a CSP plant operating at 25% load factor would receive from carbon credits was calculated using a grid emissions factor of 1.2kg/kWh (Eskom, 2007 pg 187) and a forward selling price of €10 per ton of carbon. Exchange rate 1€ = ZAR 14.24

RET is perceived to have a high-risk profile and thus the cost of capital may be at a premium. Added to this, international financial institutions may feel that South Africa presents a risky investment climate. International support could boost South Africa's risk rating and therefore indirectly facilitate the securing of affordable project finance.

Research indicates that the South African financial sector has suitable finance packages and capacity to finance renewable energy investments, although debt of tenure longer than 7 years from the banks or 10 years from the development finance institutions will be dependent on a robust electricity off-take agreement (World Bank 2006). However experience from the Darling Wind Farm indicated that the project was not only enabled through local finance institutions (Central Energy Fund and Development Bank of South Africa) but also required the support of funding from the Danish government and a grant from the GEF (Erasmus, 2008).

Building Confidence in a Future Market

Robust government commitment is an incentive for the private sector to enter the RET market. If this commitment were augmented through international collaboration the private sector would be encouraged by the potential of an attractive market. Not only would increased support corroborate the existence of this prospective market in the medium term, but it would also indicate that CSP would be deployed on a large scale in the long term. This increased scale of market could give firms the confidence to invest in the solar technology industry. In addition, large-scale strategic deployment would induce cost reductions by allowing access to optimal components and also through the incremental improvements gained through 'learning-by-doing' (Neuhoff, 2006).

6. Conclusion

Despite South Africa's intentions to reduce its GHG emissions, studies show that under current development targets, the reduction of emissions is likely to be limited (SBT, 2007). Thus it is evident that an accelerated program for adoption of low carbon technology is required. This paper discussed the benefits of developing a more ambitious target for renewable energy contribution than the one currently outlined by the White Paper for Renewable Energy (DME, 2003). In particular it focussed on the large-scale deployment of concentrated solar power (CSP) technology.

In the current market context of Eskom being mandated as the sole-buyer of electricity, it was suggested that a robust and transparent tender process would be an effective way of encouraging the private sector to enter the solar generation market. This support mechanism would need to be complimented with other policy instruments such as the REFIT programme proposed by NERSA in order to make CSP projects financially feasible under current tariff circumstances. It is acknowledged that the development and refinement of such policies will require collaboration between, and significant capacity building within, various government departments and stakeholders.

Besides the benefits of carbon abatement that are implicit to CSP, other development co-benefits are discussed. Accelerated deployment of CSP could assist South Africa in reaching its economic development targets: The government's assurance that it is committed to meeting RET targets could act as a stimulant for local industry to enter the solar technology industry. Investing in CSP would assist with other development targets such as security and diversity of power supply and the reduction of negative health impacts associated with coal-fired electricity production.

In particular South Africa has significant solar resources and land, which makes it an ideal location for CSP demonstration plants. Through international collaboration, these resource strengths could be leveraged to facilitate strategic deployment of CSP.

There are various obstacles that need to be overcome in order to ensure that South Africa can realistically meet an ambitious solar target. Various channels of international collaboration are discussed. It is evident that varying degrees of support are required in all three key areas proposed by the LTMS: policy, finance and technology (SBT, 2007). This support can manifest itself through knowledge sharing and information networks, incremental funding for projects or the facilitation of access to optimal technology. The global benefits of large-scale CSP deployment will be seen in cost reductions resulting from 'learning-by-doing' and incremental improvements in efficiency.

International commitment will augment and support South Africa's intentions to meet RET contribution targets. This will assist in mitigating risk and boosting confidence in the potential of an attractive, self-sustaining solar market in the long term.

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