Assessment of the localisation, industrialisation and job creation potential of CSP infrastructure projects in South Africa – A 2030 vision for CSP

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This document was compiled by Ernst & Young and enolcon gmbh (the “Consultants”) for the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) in terms of a Letter of Engagement signed 7th December 2012 setting out our agreed scope of work, and may not have taken into account any specific requirements a third party other than GIZ may have on the subject matter discussed.

Images on front page courtesy of Novatec and Toressol
Foreword

The Southern Africa Solar Thermal and Electricity Association (SASTELA) submitted a request for support to Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) to carry out a study which provides an assessment of the localisation, industrialisation and job creation potential of Concentrated Solar Power (CSP) infrastructure projects in South Africa and to develop a suitable strategy and action plan to realise the quantified potential.

This study is complimentary to other GIZ initiatives supporting public and private sector players in the solar energy sector, which form part of a broader programme that supports the development of renewable energy in South Africa.

This study has four main objectives:

1. to verify and confirm the unique value proposition that CSP offers in terms of the potential contribution that CSP can provide in terms of dispatchable, clean energy at utility scale;
2. to assess and quantify the potential for developing and establishing a CSP component and equipment manufacturing as well as operation and maintenance industry in South Africa to respond to current CSP developments. The assessment should take into account the current state of CSP technology innovation in South Africa, in order to inform the potential for developing a local CSP industry;
3. to assess and quantify the potential socio-economic impact of a more ambitious market share for CSP in the South African renewable energy industry; and
4. to formulate an implementation strategy with a clear action plan to enable industry and government to put in place the necessary measures to ensure the quantified potential of the CSP industry is unlocked.

GIZ engaged Ernst & Young (“EY”) and enolcon (together “the Consultant”) to carry out the study.
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<th>Description</th>
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<tbody>
<tr>
<td>Bid Window 1</td>
<td>The first bid submission of the RE IPP procurement programme with submission date of 4 November 2011</td>
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<tr>
<td>Bid Window 2</td>
<td>The second bid submission of the RE IPP procurement programme with submission date of 5 March 2012</td>
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<tr>
<td>Bid Window 3</td>
<td>The third bid submission of the RE IPP procurement programme with anticipated submission date of 19 August 2013</td>
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<td>BoP</td>
<td>Balance of Plant</td>
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<td>c.</td>
<td>Circa</td>
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<td>CEO</td>
<td>Conventional Energy Options</td>
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<tr>
<td>CHP</td>
<td>Combined heat and power</td>
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<td>CPV</td>
<td>Concentrated photovoltaic</td>
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<td>CSP</td>
<td>Concentrated Solar Power</td>
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<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
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<tr>
<td>CSTDI</td>
<td>Centre for Solar Technology, Development and Innovation</td>
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<tr>
<td>DFID</td>
<td>The UK Department for International Development</td>
</tr>
<tr>
<td>DLR</td>
<td>German aerospace center</td>
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<tr>
<td>DNI</td>
<td>Direct Normal Irradiation</td>
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<tr>
<td>DoE</td>
<td>The South African Department of Energy</td>
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<tr>
<td>DST</td>
<td>The South African Department of Science and Technology</td>
</tr>
<tr>
<td>Dti</td>
<td>The South African Department of Trade and Industry</td>
</tr>
<tr>
<td>EASAC</td>
<td>European Academies Science Advisory Council</td>
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<tr>
<td>EPC</td>
<td>Engineering, Procurement, Construction</td>
</tr>
<tr>
<td>FTE</td>
<td>Full time employees</td>
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<tr>
<td>GC</td>
<td>Grid connection</td>
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<tr>
<td>GIZ</td>
<td>Deutsche Gesellschaft für Internationale Zusammenarbeit</td>
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<tr>
<td>GW</td>
<td>Gigawatt</td>
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### Abbreviations

<table>
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<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>HTF</td>
<td>Heat Transfer Fluid</td>
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<tr>
<td>IDC</td>
<td>Industrial Development Corporation</td>
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<tr>
<td>IP</td>
<td>Intellectual Property</td>
</tr>
<tr>
<td>IRENA</td>
<td>International Renewable Energy Agency</td>
</tr>
<tr>
<td>IRP 2010</td>
<td>Integrated Electricity Resource Plan for South Africa - 2010 to 2030</td>
</tr>
<tr>
<td>JV</td>
<td>Joint venture</td>
</tr>
<tr>
<td>kWh</td>
<td>Kilowatt hour</td>
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<tr>
<td>LCOE</td>
<td>Levelised costs of electricity</td>
</tr>
<tr>
<td>mt</td>
<td>Metric ton</td>
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<tr>
<td>MW</td>
<td>Megawatt</td>
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<tr>
<td>MYPD</td>
<td>Multi Year Price Determination</td>
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<tr>
<td>O&amp;M</td>
<td>Operations and maintenance</td>
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<tr>
<td>p.a.</td>
<td>Per annum</td>
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<tr>
<td>PCM</td>
<td>Phase change material</td>
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<tr>
<td>PPA</td>
<td>Power Purchase Agreement</td>
</tr>
<tr>
<td>PV</td>
<td>Photovoltaic</td>
</tr>
<tr>
<td>R or ZAR</td>
<td>South African Rand</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>RE IPP</td>
<td>Renewable Energy Independent Power Producer</td>
</tr>
<tr>
<td>SA</td>
<td>South Africa</td>
</tr>
<tr>
<td>SADC</td>
<td>Southern African Development Community</td>
</tr>
<tr>
<td>SANEDI</td>
<td>South African National Energy Development Institute</td>
</tr>
<tr>
<td>SASTELA</td>
<td>Southern Africa Solar Thermal and Electricity Association</td>
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<tr>
<td>SETA</td>
<td>Sector Education and Training Authorities</td>
</tr>
</tbody>
</table>
Abbreviations

SME  Small and medium-sized enterprises
TIA  Technology Innovation Agency
ToR  Terms of reference
U.S.  United States
VA  Value added i.e. contribution to GDP
Executive summary
Executive summary

Background to study

Introduction

This study was commissioned by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in response to a request from the Southern Africa Solar Thermal and Electricity Association (SASTELA). This study is complimentary to other GIZ initiatives supporting public and private sector role-players in the solar energy sector.

Scope of study

This study covers the following:

► Overview of the concentrated solar power (CSP) value proposition;
► Review of CSP technologies and cost reduction potential;
► Assessment of manufacturing capabilities and potential in South Africa;
► Analysis of potential socio-economic benefits of developing a local CSP components manufacturing industry; and
► Development of a potential strategy and implementation plan for the development of a local CSP components industry in South Africa.

The findings for each of the above analyses are summarised sequentially in the sections that follow:

CSP value proposition

CSP in South Africa has the following specific benefits:

► Solar resource - The direct normal irradiation (DNI) of South Africa is high, particularly in the Northern Cape region around Upington. The annual sum of DNI reaches almost 2800 kWh/m² making this region one of the most attractive for CSP in the world;
► Grid stability - CSP with thermal energy storage has an advantage over other renewable technologies due to its predictability in dispatch. It can support peak periods which is when power is most needed on the grid system. Power available during peak periods is considered to be of higher value than power outside of peak hours;

► Socio-economic benefits - with a committed pipeline of CSP projects, CSP can add valuable economic benefits through the creation of new jobs, GDP growth, international trade and energy security. As an example of job creation potential, the Department of Energy announced that developers have estimated that the first three CSP projects totalling 200MW under the RE IPP procurement programme would result in over 1,800 jobs during construction and c. 120 jobs during operations;
► Low environmental impact - A significant benefit of CSP is that it has little environmental impact - a solar only plant has almost no greenhouse gas emissions in operation and occupies a similar or smaller portion of land compared to photovoltaic; and
► Competitive life spans – CSP power stations can have life spans of up to 60 years, similar to coal and nuclear power plants.

CSP technologies and cost reduction potential

Overview of CSP technologies

There are four key global CSP technologies which are briefly summarised below with detailed information on each technology provided in Part 2 of the Report.

All four technologies operate on the same basis. DNI is captured by reflectors which concentrate it on a receiver containing a Heat Transfer Fluid (HTF). Heat collected by the HTF is transferred through heat exchangers to a water/steam cycle. The heat energy is then converted into electrical energy. The heat energy collected can be stored and released later – i.e. during peak times.

Parabolic trough

Parabolic trough plants have a more extensive track record (in terms of the number of plants commissioned) compared to other CSP technologies. They consist of several connected parallel rows of parabolic shaped mirrors.

The reflectors adjust throughout the day to track the sun via hydraulic lifting. The receiver contains HTF which is heated up to 400°C.

Solar tower

A solar tower plant consists of a tower with a receiver surrounded by a field of several hundred reflectors (heliostats). The HTF can reach higher temperatures
than a parabolic trough, resulting in higher thermal efficiency. The HTF could be molten salt with heat being transferred through heat exchangers, or alternatively steam is transferred directly to a steam turbine.

Linear Fresnel

Linear Fresnel plants consist of multiple rows of reflectors, each consisting of several slightly curved mirrors, reflecting DNI onto one or multiple absorber tubes which are located below a central receiver.

Water is used as the HTF and is converted to steam on its way through the field after which it is fed into the steam turbine.

Solar dish

This CSP technology consists of a solar dish receiver with a two axis tracking dish and a heat engine, which is the point of focus of the dish and is operated by cyclic compression and expansion of the working fluid.

The heat transfer medium inside the engine could be air, helium or hydrogen.

Large scale solar dish thermal power plants are currently not cost competitive compared to the other CSP technologies outlined above. In South Africa large scale applications and price of electricity are currently a focus, therefore the solar dish is not considered further in this report. However it is noted that solar dish may be appropriate for smaller scale projects.

Parabolic trough Solar tower

Cost reduction potential of CSP

Overall cost reduction potential

It is estimated that in the region of 28% to 40% of overall CSP investment costs could be reduced by 2020. The level of cost reduction could be due to both economies of scale as a result of increased plant capacities and due to improvements in manufacturing, (e.g. increasing the performance of the solar field or efficiency of conversion of solar irradiation to electric energy).¹ Using the Bid Window 2 tariff of R2.51, there is the potential that if overall costs could reduce by a similar proportion, tariffs could be bid in the region of R1.80/kWh (28% cost reduction scenario) to R1.50/kWh (40% cost reduction scenario) by 2020.

For each CSP technology, the solar field represents the largest proportion of the capital cost (c. 40% to 45%) and within the solar field, steel, mirrors, receivers and construction are the most significant costs.

Executive summary

A number of initiatives around the world have recently commenced aiming to reduce CSP investment costs. For example, the US DoE SunShot initiative aims to achieve a LCOE of US$0.06/kWh (approximately R0.54/kWh). This high cost reduction could only be achieved with extreme cost reductions in every part of the CSP plant, which would require significant effort in terms of R&D.

Manufacturing improvements

The main cost reduction potential of the mirrors and steel support structure are:
- Reduction of weight of the mirrors whilst maintaining stability; and
- Reduction of volume of steel demand due to advanced support structure designs and advanced mirror concepts.

The cost reduction potential for these improvement areas is estimated at between 8% and 12%.

The potential for receiver costs to reduce is estimated to be in the region of 45%, which could be due to:
- Increasing the thermal efficiency by increasing the outlet temperature. This improvement could result in an increase in efficiency of up to 13%; and
- Reducing thermal losses with advanced technologies and new design concepts of solar receivers.

Economies of scale

In addition to manufacturing improvements, cost reduction of the plant can also be achieved by leveraging economies of scale.

Engineering of the plant and project development are almost independent from the scale of the plant, therefore an increase in plant capacity will result in reduced engineering and project development costs per MW.

For mirrors and support structures, the cost will reduce when production lines are working at full capacity.

Based on the interviews with industry, significant economies of scale can be achieved in relation to the steam turbine by constructing larger CSP plants (e.g. c. 100MW up to 170MW). This could be also achieved in the solar tower by building multiple tower systems. Several studies indicate that with a turbine size of 250MW the lowest LCOE can be achieved, however financing of such large projects is currently perceived to be challenging in South Africa. Standard steam turbines used in CHP plants are already optimised and the efficiency of larger turbines is higher than small turbines. Additional cost reduction could be achieved by optimising the sizes of the solar field and the storage capacity.

The impact of economies of scale for a parabolic trough plant with different storage capacities is shown in Figure 2. Note site specific conditions are not considered in this analysis. For linear Fresnel the same qualitative cost development is expected, due to the similar setup of the solar field.

Figure 2: Cost estimation for parabolic trough plants

The economies of scale which can potentially be achieved for solar tower technology, is largely based on the number of heliostats. The specific price per

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heliostat is directly dependent on the annual production rate, therefore plants with a larger number of heliostats result in lower costs per MW. Figure 3 below shows the estimated development of the costs for heliostats based on data provided by several U.S heliostat manufacturers.

Figure 3: Potential cost reduction of heliostats based on production rate

Assessment of manufacturing capabilities and potential in South Africa

South Africa’s capabilities can currently mainly compete on basic products.

The most promising components for local manufacturing are the mirrors, the steel support structure and the support systems for thermal storage and power block.

Often specialist equipment is required to produce the specific requirements of CSP components (e.g. high reflectivity of glass, durability of support structure and longevity of products). The investment in this equipment requires a certain level of committed capacity. For example:

- Mirrors – interviews with local players indicated that an estimated 400MW to 500MW p.a. of committed CSP projects is required for a new plant to produce curved mirrors. 150MW to 200MW per annum is required to expand existing glass manufacturing capability to include flat (including moderately curved) mirrors;
- Specialist piping - an estimated 100MW - 200MW per annum of committed CSP output required; and
- Receivers – an estimated 400MW per annum of committed CSP output required.

Some international players interviewed stated that they were reluctant to build plants in South Africa due to IP concerns (as a result of previous experience in other emerging markets), lack of scale, certainty of market and high labour and raw materials costs.

Local content varies significantly depending on the type of CSP technology

Based on interviews with local industry players, the key CSP technologies for the South African market currently have varying levels of local content expectations:

- Parabolic trough – c. 40% due to the requirement for bent mirrors
- Solar tower – c. 50% - 65%
- Linear Fresnel – c. 50% - 70%+ due to relative simplicity of this technology

The local content values contracted for Window 1 of the RE IPP is 21.0% (based on 50MW solar tower and 100MW parabolic trough) and for Window 2 is 36.5% (based on 50MW parabolic trough).

Note that the local content for parabolic trough could increase up to 60% if there is sufficient scale in the CSP market in order to produce bent mirrors.

The CSP market is still immature with limited players worldwide

CSP plants consist of a number of different components, which are not specific to CSP (e.g. mirrors, power block). Companies that are already producing these components for other industry sectors typically produce these for CSP plants.

The market for some components is dominated by a few companies, for example receivers for parabolic trough (Schott, Huiyin and Siemens) and solar tower (Alstom, Abengoa, TSK) or molten salt for thermal storage (SQM).
Developers and EPC contractors often focus on one CSP technology. The current lack of consistent design, even within CSP technologies, creates a challenge for single component manufacturers, which require fairly stable production.

Labour and raw material are both weaknesses in local supply chain

South Africa is not currently considered competitive in terms of either labour or raw material costs by most of the local CSP industry players.

Of the 33 local CSP industry players interviewed in relation to costs, 75% believe that raw material is cheaper elsewhere and 19% of interviewees believe that local raw materials are over 20% more expensive than international equivalents.

All of the interviewees believe that although labour rates (unskilled and semi-skilled) may be lower in South Africa compared to Europe, local labour productivity is substantially lower than Europe. As a result of high materials and labour costs, overall costs in South Africa were cited as being between 5% and up to 300% higher than in overseas countries.

Lack of skills was not viewed by interviewees as a constraint provided there is sufficient time available for planning and training.

Depending on the timing of the roll out of CSP MW capacity allocation, a peak in demand for construction jobs may be created. This would not be as beneficial for local skills development compared to having a solid pipeline of projects which would allow labour to develop and improve their skills base.

Uncertainty of CSP MW capacity allocation considered most important obstacle to entry for manufacturers

Nearly all interviewees noted that certainty of the CSP MW capacity allocation in the RE IPP procurement programme and the IRP 2010 is important to enable supply chain players to plan their investment and market strategy.

More than half of the interviewees cited the challenge of the local market having to compete with an experienced international market.

Several local companies entering or considering entering the CSP market believe that developers would rather partner with experienced international players.
The review of the manufacturing capabilities and potential in South Africa noted a number of factors which has been incorporated in a SWOT analysis showing the country's relative position in the international CSP market (Table 1). The SWOT analysis demonstrates that South Africa’s CSP industry has the potential to become a world leader in CSP should it take the necessary steps to address the key weaknesses and threats highlighted in this study.

Table 1: SWOT analysis of South African CSP industry

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
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<tbody>
<tr>
<td>► Strong relevant industrial background (particularly in mining and petro-chemical) with transferable skills/experience/components to the CSP industry</td>
<td>► Relatively high costs of raw materials sourced locally (e.g. steel and glass prices)</td>
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<tr>
<td>► Existing local experience in developing and building large energy projects (e.g. Medupi, Kusile)</td>
<td>► High local transportation costs from port to site</td>
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<tr>
<td>► Strong and established local construction companies</td>
<td>► Local R&amp;D in CSP may be lacking compared to international companies</td>
</tr>
<tr>
<td>► Local presence of a large number of CSP players already active in the CSP market</td>
<td>► Lack of suitably qualified skilled labour and lack of training schemes</td>
</tr>
<tr>
<td>► Current production of equipment (steel, pipes, trackers) is already meeting standards required by CSP projects</td>
<td>► Unproductive labour force, resulting in an inability for South Africa to be competitive with global players in manufacturing CSP components</td>
</tr>
<tr>
<td>► Significant R&amp;D activities which can support new local technology developments</td>
<td></td>
</tr>
<tr>
<td>► The value proposition of CSP, particularly the storage potential may give it a competitive advantage over other renewable technologies. Ongoing local R&amp;D both in the academic and corporate sectors</td>
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<tr>
<th>Opportunities</th>
<th>Threats</th>
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<tr>
<td>► South Africa has one of the most favourable direct normal irradiation levels in the world</td>
<td>► South Africa fails to keep up with technological developments in international CSP market or under invests in its own R&amp;D</td>
</tr>
<tr>
<td>► Almost 90% of South Africa’s power is from coal fired sources (DoE), therefore large opportunity for renewable energy like CSP</td>
<td>► Uncertainty over the allocation of CSP under the RE IPP procurement programme</td>
</tr>
<tr>
<td>► CSP is a relatively new technology, therefore there may be potential advantages for “first movers”</td>
<td>► Low MW allocation to CSP may reduce local industry interest and reduce the potential to generate economies of scale, and compete with international players</td>
</tr>
<tr>
<td>► Hybridisation of CSP with future coal and gas projects</td>
<td>► Competition with suppliers from other countries with lower labour costs and higher labour productivity (e.g. China, India)</td>
</tr>
<tr>
<td>► Strong local content requirements (and targets) from Government</td>
<td>► Potential difficulties in obtaining finance for CSP as a relatively new technology, with financier’s potentially favouring more tried and tested renewable energy technologies (such as PV)</td>
</tr>
<tr>
<td>► Pipeline of projects being developed (South Africa IRP 2010 and RE IPP programme) with potential for increased allocations to CSP</td>
<td>► Future cost reductions in PV and other competing renewable technologies may occur at a higher rate than CSP</td>
</tr>
<tr>
<td>► Strong local content requirements (and targets) from Government</td>
<td>► Factories in Spain and other countries supply components at cost price due to lack of demand in their domestic markets.</td>
</tr>
<tr>
<td>► Significant increase of local content in CSP projects is feasible, with local manufacturing of components with higher economic added value (e.g. glass products, mirrors), which can generate significant economic benefits to South Africa</td>
<td>► High water usage, and lack of water in South Africa may reduce appetite for CSP projects (however dry cooling may mitigate this threat/risk)</td>
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Overview of socio-economic analysis

Introduction

The potential socio-economic impact of a more ambitious market share for CSP in the South African renewable energy industry was assessed and quantified. Specifically the following economic aspects were assessed:

- Labour impact – job creation in component manufacturing, construction and operations and maintenance;
- Contribution to GDP including direct and indirect impacts; and
- Foreign trade impact.

Scenarios

Each of the above impacts has been assessed against four scenarios provided by GIZ and SASTELA (“the Scenarios”) for the purposes of this study, with each scenario involving a progressively higher MW allocation to CSP:

- **Scenario A - IRP 2010 Scenario:** deployment of the 1GW of CSP in the IRP 2010 by 2020 instead of 2025;
- **Scenario B - Northern Cape Solar Corridor (NOCASCO) Scenario:** this scenario is in line with the 5 GW solar park/corridor under investigation by the DoE involving the deployment of 5GW of CSP in the Northern Cape by 2025 and 1GW for export to Southern African countries;
- **Scenario C - Increased Renewables:** this scenario assumes that the Conventional Energy Options (CEO) in the IRP 2010 are not deployed and are replaced by 60% of CSP with storage alongside other renewable technologies and gas power. The scenario looks at the deployment of 10GW of CSP by 2030, 2GW hybridisation of existing coal plants with solar steam, hence reaching 12GW of capacity by 2030; and
- **Scenario D - SADC Scenario:** as per Scenario C, plus an additional deployment of 10GW of CSP power stations across the other Southern African Development Community (SADC) countries by 2040, hence reaching 12GW of local capacity and 10GW of exported capacity by 2040.

It should be noted that as this analysis is a socio-economic macro analysis, it is fairly narrow and theoretical with a number of typical inherent limitations including:

- Full time employment ratio assumptions are considered the same for all technologies (solar tower, parabolic trough and linear Fresnel);
- Efficiency gains in labour are assumed to occur in the same proportions as efficiency gains in cost;
- GDP contribution ratios considered to be the same for all technologies (solar tower, parabolic trough and linear Fresnel);
- Impact of exports only applies to component manufacturing services (no export of construction services);
- Efficiency gains not modelled post 2017, after which time, costs are assumed to remain constant;
- Local content estimates are based on interviews conducted with local stakeholders; and
- A number of further factors have not been considered (e.g. impact on tariff, affordability, LCOE, impact on other technologies, grid impacts) as this is a limited scope assessment. These could be addressed in a follow on study as outlined in the Next Steps section.

As such the results should be interpreted with these assumptions and limitations in mind.
The feasibility of the Scenarios has not been considered, including development pipeline required in South Africa or appetite for CSP projects in other SADC countries. The Consultant was not commissioned to consider the feasibility of the Scenarios, as these scenarios are based on various planning scenarios contemplated by stakeholders. Recommendations have been provided in the Next Steps section of this report in terms of development of scenarios for recommendation in the next IRP in addition to assessment of the impact of tariff, affordability and LCOE impact.

Job creation assumptions

In seeking to determine the potential for job creation under each of the Scenarios, the following has been analysed:

- **Direct job creation** during CSP plant construction;
- **Indirect job creation** arising from demand in the supply chain (e.g. the plant maintenance and replacement of components and equipment has an indirect impact on new jobs); and
- **Induced job creation** to account for effects such as training needs for employees or consumption of goods and services on working sites.

The assumptions adopted for the indirect and induced CSP jobs are as follows:

- For every direct full-time job in South Africa: 0.9 indirect full-time jobs and 0.25 induced full-time jobs are created; and
- For every indirect full-time job in South Africa: 0.25 full-time jobs are induced.

### Table 3: Model assumptions for jobs per MW

<table>
<thead>
<tr>
<th>Parameter</th>
<th>This Study</th>
<th>IDC Study</th>
<th>RE IPPP</th>
<th>Spain 2008-2010</th>
<th>MENA study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology assumed</td>
<td>CSP</td>
<td>Various</td>
<td>Parabolic trough with storage</td>
<td>CSP with storage 70%, without storage 30%</td>
<td>CSP parabolic with storage</td>
</tr>
<tr>
<td>Component manufacturing</td>
<td>4.0</td>
<td>14.4</td>
<td>-</td>
<td>-</td>
<td>3.5</td>
</tr>
<tr>
<td>Construction &amp; assembly</td>
<td>10.0</td>
<td>21.6</td>
<td>9.13</td>
<td>17</td>
<td>8.7</td>
</tr>
<tr>
<td>Operations &amp; Maintenance</td>
<td>0.8</td>
<td>0.54</td>
<td>0.6</td>
<td>-</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: Refer to footnotes below

Note that the Spanish data is based on jobs data for CSP plants both with and without storage (c. 70% with storage, and 30% without storage based on MW proportion), but the allocation to technology is not clear. The MENA study and this study are comparable as they both assume 50MW parabolic trough with storage.

Due to this, in our study an adjustment was applied (based on known MW allocation between with and without storage) to establish the construction phase job ratio value (Table 3) for CSP with storage. This allows it to be comparable with other data in this table.

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3 IDC - Green Jobs: An estimate of the direct employment potential of a greening South African economy, 2011
4 SASTELA website: “DoE says the three projects will create 1,827 construction and 120 operations and maintenance jobs”
5 Protermo Solar; Macroeconomic impact of the solar thermal electricity industry in Spain; October 2011; Sevilla, Spain
6 World Bank, – Middle East and North Africa Region – Assessment of the Local Manufacturing Potential for Concentrated Solar Power (CSP), 2011
Executive summary

Job creation analysis

The potential direct, indirect and induced jobs created under the various scenarios are shown in Figure 4 and Figure 5.

Scenario C (Increased Renewables scenario) and Scenario D (SADC scenario) have the potential to create the most jobs with peak annual full time jobs of over 35,000 (which occurs in c. 2030).

This translates into 750,000 job years over the modelled period of 25 years, i.e. jobs p.a. multiplied by period in years.

Contribution to GDP analysis

The total cumulated contribution to GDP ("Value added" or "VA") over the 25 year lifespan of CSP plants is highest in Scenario D (as expected) amounting to c.R250 billion (US$28 billion).
Executive summary

Foreign CSP trade impact assessment analysis

Only two of the four scenarios involve exported capacity, i.e. Scenarios B and D. Scenario B does not manage to achieve a CSP trade surplus, as CSP exports do not fully compensate for CSP imports.

In Scenario D, a positive CSP trade balance is achieved from 2030 as shown in Figure 7.

Summary

Table 4 summarises the job creation, contributions to GDP and net CSP foreign trade balance under the four Scenarios.

Table 4: Summary of CSP capacity roll out under the Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total (GW)</th>
<th>Contribution to GDP</th>
<th>Full time jobs created in peak year</th>
<th>Job years</th>
<th>Net CSP foreign trade balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario A</td>
<td>1GW</td>
<td>R24bn</td>
<td>3,500</td>
<td>60,000</td>
<td>(R19bn)</td>
</tr>
<tr>
<td>Scenario B</td>
<td>6GW</td>
<td>R108bn</td>
<td>17,000</td>
<td>320,000</td>
<td>(R37bn)</td>
</tr>
<tr>
<td>Scenario C</td>
<td>12GW</td>
<td>R205bn</td>
<td>35,000</td>
<td>750,000</td>
<td>(R88bn)</td>
</tr>
<tr>
<td>Scenario D</td>
<td>22GW</td>
<td>R251bn</td>
<td>37,000</td>
<td>790,000</td>
<td>R34bn</td>
</tr>
</tbody>
</table>

Source: EY analysis

Notes to the table:
1: Full contribution to GDP (direct+indirect+induced) over full life-span of CSP plants.
2: Total full-time jobs (direct+indirect+induced) in scenario’s peak year (year with most job creation).
3: Total job.years (direct+indirect+induced) over the 25-year lifespan of the plants.
4: Due to the export of 10GW to SADC countries under Scenario D, a foreign trade surplus of R35bn is achieved under this scenario.

As stated previously, the impact of CSP with storage in the South African energy mix, the tariff to the ultimate consumer and further knock on effects are outside of the scope of this study, and the results of the scenario modelling should be considered in that light.

Note that in relation to the above paragraph, it is assumed that the competitive bidding process will help address potential knock on effects from a tariff perspective due to price being a key evaluation criterion in selecting preferred bidders under RE IPP.
**Executive summary**

**Overview of the proposed strategy and action plan**

CSP remains an emerging sector where only a small number of countries possess manufacturing capabilities. As other countries are launching large CSP plans which also leads to producing domestic products and services for CSP projects, the opportunity window for South Africa will probably remain open only for the next two to three years. Given South Africa’s strong industrial basis, a number of components required by CSP projects can already be sourced locally.

An overview of the potential for local integration for the main segments of the solar CSP value chain is presented below.

In order to realise the opportunities highlighted, several component specific roadmaps are presented in this report, focusing principally on CSP components for which short term opportunities have been identified (mounting structures, secondary components, and flat mirrors). Some components, for which local manufacturing is a long term possibility, have also been included (receivers) in order to demonstrate the variances in actions for both the short and long term opportunities.

Investments in local manufacturing capacities will be possible only if the CSP market is expected to grow significantly above current targets.

Developing a local CSP manufacturing capability will require above all a stable policy framework and a significant CSP market size. In the long run, the annual additional capacity installed should reach significantly high levels (such as 200MW to 400MW per annum) to allow for the development of local production lines, particularly in the case of technology-intensive components such as mirrors and receivers.

The current targets (corresponding to Scenario A) are considered by CSP industry representatives to be too low to allow for the development of manufacturing plants dedicated to supplying components for building a CSP plant. In the case of more ambitious growth scenarios for the CSP market (Scenarios B, C, and D) an adoption of international production standards and techniques in existing industries will be necessary. Under these scenarios, policy actions should strongly support innovation and the development of intellectual property in the field of CSP components to profit from first mover advantages and to develop technologies specifically tailored for South Africa’s conditions. In later stages, a strong export orientation should be motivated to benefit from the proximity to other emerging CSP markets in Africa or in more distant locations. Thus a production of a wide range of CSP components could be achieved.

High growth scenarios for CSP will enable South Africa to accelerate the increase of local content share in CSP projects.

A national strategy for industrial development in the CSP sector should be well coordinated with the energy policy, in particular in order to adjust the local content target setting. As highlighted in Figure 9, high local content levels (80% and above) could be achieved for CSP in the long term (2025) if the scale of CSP roll out is sufficiently high. Stakeholders interviewed in the course of this study have
pointed out that high local content levels are achievable for CSP in South Africa but they will lead (at least in the short term) to an increase in the cost of components used in projects and therefore increase the LCOE of CSP plants (although this cannot be deducted from an analysis of projects awarded under Bid Windows 1 and 2). This report concludes that this will probably be the case under Scenario A, for which the market deployment is not significant enough to generate scale effects in local manufacturing facilities. However, in Scenarios B, C and D, the larger annual roll out of additional CSP capacities will enable new investments in industrial manufacturing plants and in automation of production processes, which in turn could contribute to lowering the prices of CSP components in the domestic market.

A broad range of supporting initiatives will be required to support the emergence of a local CSP industry

Financial support will be required for the technical adjustment of production facilities (including the related feasibility assessment), for applied R&D and for training of the local workforce in some cases. As a wide range of financing instruments targeted at industrial development are already in place, the short term priorities should focus on:

- Promoting the use of existing financing instruments to support the installation of new manufacturing plants as well as the extension or upgrade of existing plants: Manufacturing Investment Programme, Foreign Investment Grant, Support Programme for Industrial Innovation, 12i Tax Incentive and Manufacturing Competitiveness Enhancement Programme.
- Bundling existing incentives as sector specific programmes: e.g. strategic program dedicated to mirrors to upgrade existing glass production lines and assess the required changes for supporting company start-ups and technology transfer.

In the long run, industrial development along the CSP value chain will require continuous efforts aimed at the creation of an attractive framework for foreign investments: e.g. facilitating application procedures for financial incentives and facilitating patenting for innovations in the solar sector etc.

The requirement for additional support measures will depend on market needs, and may include providing concessional loans to industrial development projects or support to cover the risks related to the use (or performance) of local components. Financing facilities could also be provided to facilitate knowledge transfer (e.g. via purchase of licenses).

Education and training programmes will be important in developing the CSP supply sector. Universities should be encouraged to teach CSP technology based courses particularly to engineers and other technical graduates. Low skilled workers could receive training through construction companies or apprentice schemes. Partnering of research institutes and construction companies with projects being constructed in South Africa will also contribute to the skills transfer to local workers.

Other initiatives will also be needed to support the development of a robust CSP value chain in South Africa, such as:

- Disseminating information on opportunities in the solar CSP market, quality standards and quality requirements, partnership opportunities, either with local...
Executive summary

or international firms, and support programmes and incentive schemes from the Government, in particular for upgrading industrial processes; and

- Establishing a technology or business cluster to foster international cooperation and enhance the innovative capacity of industrial sectors, to benefit both local innovating SMEs and foreign technology developers interested in setting up joint ventures.

In the medium to long term, a marketing strategy will need to be set up in order to promote South Africa’s CSP industry players and to increase export opportunities. This approach could take the form of support activities to export CSP components to nearby countries or to other markets in the Southern hemisphere (Chile, for example), or to Europe, and to support outreach and promotion activities:

- Developing a targeted strategy for foreign direct investment, and
- Implementing promotion activities dedicated to supporting the export of South African industries and services.

This will be required in particular if South Africa succeeds in taking the leadership on some R&D initiatives.

Proposals for an R&D action plan

Local technology knowledge can be developed through local R&D performed in public R&D institutes or private companies, or it can be developed through knowledge transfer by partnering with international companies. Both of these routes are important ways of developing the local technology know-how.

Local R&D may result in South Africa, in the medium to long term, positioning itself as a frontrunner in selected R&D areas, such as those with a high potential and relevance for South Africa, including:

- Thermal storage systems and technology;
- Development of innovative and improved solar collector (support structure) designs;
- Development of tracking concepts;
- Adapting and integration of alternative cooling methods into CSP plants;
- Direct steam generation; and
- Hybridisation and use of CSP in other industry sectors (e.g. mining).

A coordinated R&D plan, specifically related to CSP would be beneficial to the industry and could include following key aspects:

- **Longer term framework**: R&D programme set up to ensure funding is available over the whole development phase of an innovative product to improve prospects of innovative products reaching the market.
- **Adapt research areas to local and current needs**: A framework could be set up to adapt current research topics and focus on recent R&D areas of importance. This could include the implementation of annual calls for proposals within a long term framework.
- **Support for existing technology centres**: The importance of the proposed technology centres within the R&D framework could be raised.
- **Strengthening of academic research through cooperation with industry**: Establishment and extension of international and national cooperation between industry and research institutes. This may include pilot testing on private sector sites.

The significance of such an R&D plan would strengthen with an increasing amount of installed capacity. It would be necessary to establish such an R&D plan as a minimum if the installed capacity in Scenario B is to be achieved.

The proposed short term actions required in respect of R&D are:

- Review feasibility of a long term framework for provision of public R&D funding to ensure funding is available over the whole development phase of an innovative product and feasibility of dedicated R&D funding for the CSP component focus areas. The responsibility for this could sit within National Treasury, DoE or DST.
- Establish an R&D specific industry platform to identify and achieve common goals between industry and research institutes. This could be linked to specific time frames to encourage response and inform the R&D framework. SANEDI is already providing a platform for industry in relation to R&D, therefore it is proposed that responsibility for the platform and collation of responses would be allocated to SANEDI, which could provide this to the government body responsible for the overall CSP R&D budget.
Long term visibility and size of the CSP market

Most interviewees, both in South Africa and Europe, stated they would only extend CSP manufacturing activities in South Africa if the market size increased sufficiently.

The expected CSP capacity roll out under the IRP 2010 (Scenario A) is considered by most industry players as too small and uncertain to develop local industrial activities. Several leading EPCs, developers and technology suppliers consider that deploying 5 to 10GW (corresponding roughly to Scenarios B, C and D), would be sufficient to extend manufacturing activities.

The uncertainty of CSP roll out was noted as the most important obstacle to entry for companies interested in manufacturing CSP components.

Setting clear MW allocations in the IRP 2010, at levels that will stimulate local manufacturing, is seen as a key requirement for local and international industrial companies in order to make investment decisions. Several countries have announced significant CSP plans over recent years (e.g. Algeria, Australia, India, Morocco, Saudi Arabia), and these are rapidly drawing attention from investors worldwide. Further detail is provided in Appendix D.

Local and international interviewees all stressed that, despite having a significant solar commitment, the current domestic market is not sufficient to develop outlets for manufacturing plants of certain components. A strong market uptake in the short term is crucial to develop a local industry, either by attracting foreign investors, or based on local resource. Table 5 provides an indication (based on information shared by industry leaders during this study) of the annual output required to develop a business case for manufacturing components for the CSP industry.

<table>
<thead>
<tr>
<th>CSP components</th>
<th>Annual output of a typical factory (MW/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receivers</td>
<td>c. 400 MW</td>
</tr>
<tr>
<td>Specialist Piping</td>
<td>100 – 200 MW</td>
</tr>
<tr>
<td>Flat Mirrors</td>
<td>150 - 200 MW</td>
</tr>
<tr>
<td>Curved Mirrors</td>
<td>400 – 500 MW</td>
</tr>
<tr>
<td>Tracking System</td>
<td>c. 500 MW</td>
</tr>
<tr>
<td>Specialised Pumps</td>
<td>&gt;500MW</td>
</tr>
<tr>
<td>HTF</td>
<td>&gt;500MW</td>
</tr>
</tbody>
</table>

Source: Findings from this study.

To develop South Africa’s CSP component manufacturing industry, it is essential that the above thresholds be taken into account in assessing a suitable MW roll out of CSP for South Africa over the medium to long term.

Local content potential

The analysis undertaken for this study shows that if a more ambitious CSP program (e.g. Scenarios B, C & D) were followed, South Africa has the potential to achieve its aspirational local content target of 75% as highlighted in the Green Economy Accord.
Table 6: Local content estimations theoretically achievable over time based on available information

<table>
<thead>
<tr>
<th>Technology</th>
<th>Scenario A</th>
<th>Scenario B</th>
<th>Scenario C&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timeline and Milestones</td>
<td>Initial stage 2013</td>
<td>First stage 2020</td>
<td>Second stage 2025</td>
</tr>
<tr>
<td>Cumulated installed Capacity</td>
<td>200 MW</td>
<td>1000 MW</td>
<td>6000 MW</td>
</tr>
<tr>
<td><strong>Parabolic trough with storage</strong></td>
<td>27-30 %</td>
<td>50-63 %</td>
<td>70-73 %</td>
</tr>
<tr>
<td><strong>Parabolic trough without storage</strong></td>
<td>30-32 %</td>
<td>52-65 %</td>
<td>72-74 %</td>
</tr>
<tr>
<td><em><em>Linear Fresnel</em> with storage</em>*</td>
<td>n/a**</td>
<td>50-60 %</td>
<td>75-80 %</td>
</tr>
<tr>
<td><em><em>Linear Fresnel</em> without Storage</em>*</td>
<td>30-35 %</td>
<td>50-60 %</td>
<td>70-75 %</td>
</tr>
<tr>
<td><strong>Solar tower with Storage</strong></td>
<td>25-27 %</td>
<td>52-65 %</td>
<td>70-72 %</td>
</tr>
<tr>
<td><strong>Solar tower without Storage</strong></td>
<td>27-29 %</td>
<td>54-67 %</td>
<td>70-73 %</td>
</tr>
</tbody>
</table>

* Due to the short track record of Linear Fresnel, wider ranges of estimation are required.
** Linear Fresnel with storage is not yet built on a commercial scale.
Background
Introduction and objectives of the study

Introduction

This study has been commissioned by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in conjunction with the Southern Africa Solar Thermal and Electricity Association (SASTELA). SASTELA submitted a request for support to GIZ to carry out the proposed study, which is complimentary to other GIZ initiatives supporting public and private sector role-players in the solar energy sector.

South Africa’s Integrated Resource Plan (IRP 2010) has allocated a 1,000MW of concentrated solar power (CSP) to be deployed by 2025. The introduction of the Renewable Energy Independent Power Producer (RE IPP) procurement programme has seen South Africa pursue its own competitive model to introduce renewable energy into the grid.

This study aims to assess the localisation, industrialisation and job creation potential of CSP infrastructure projects in South Africa and to develop a suitable strategy and action plan to realise the quantified potential.

Objectives

The study has four main objectives:

1. To verify and confirm the unique value proposition that CSP offers in terms of the potential contribution that CSP can provide in dispatchable, clean energy at utility scale;

2. To assess and quantify the potential for developing and establishing a CSP component and equipment manufacturing industry as well as an operations and maintenance industry in South Africa to respond to current CSP developments. The study takes into account the current state of CSP technology innovation in South Africa, in order to inform the potential for developing a local CSP industry;

3. To assess and quantify the potential socio-economic impact of a more ambitious market share for CSP in the South African renewable energy industry; and

4. To formulate an implementation strategy with a clear action plan to enable industry and government to put in place the necessary measures to ensure the quantified potential of the CSP industry is unlocked.

Socio-economic scenarios

To test the socio-economic impacts of a larger market share of CSP as required under objective 3, the following four scenarios (the “Scenarios”) provided by GIZ were analysed:

- **Scenario A - IRP 2010 Scenario:** deployment of the 1GW of CSP in the IRP 2010 by 2020 instead of 2025;

- **Scenario B - Northern Cape Solar Corridor (NOCASCO) Scenario:** this scenario is in line with the 5 GW solar park/corridor under investigation by the DoE involving the deployment of 5GW of CSP in the Northern Cape by 2025 and 1GW for export to the Southern African countries;

- **Scenario C - Increased Renewables:** this scenario assumes that the Conventional Energy Options (CEO) in the IRP 2010 are not deployed and are replaced by 60% of CSP with storage alongside other renewable technologies and gas power. The scenario looks at the deployment of 10GW of CSP by 2030, 2GW hybridisation of existing coal plants with solar steam, hence reaching 12GW of capacity by 2030; and

- **Scenario D - SADC Scenario:** as per Scenario C, plus an additional deployment of 10GW of CSP power stations across the other Southern African Development Community (SADC) countries by 2040, hence reaching 12GW of local capacity and 10GW of exported capacity by 2040.

Note that, in terms of our scope of work, a narrow analysis of the socio-economic effects for each scenario has been undertaken. The analysis does not, for example, consider the following:

- Feasibility of the Scenarios, including development pipeline required in South Africa or appetite for CSP projects in other SADC countries; or

- Impact on electricity price and knock on effects on the larger economy.

Given that the scenarios analysed in this study are based on publically available information, it would be necessary to assess the above points in conjunction with the studies already underway in relation to Scenarios B & C. Please refer to the Next Steps section of the report.
Introduction and objectives of the study

Project timing

This study comprised two phases, with the following time line:

- Phase 1: December 2012 to mid February 2013; and
- Phase 2: End February 2013 to mid April 2013.

The findings of Phase 1 were presented to stakeholders at a meeting held on 22 February 2013 and the findings for Phase 2 were presented to stakeholders on 9 April 2013.
Part 1
1.1 Review of CSP value proposition, technologies and cost reduction trends

1. CSP value proposition
2. Overview of CSP components and manufacturing processes
3. CSP cost reduction potential
4. Main CSP players
1.1 Review of CSP value proposition, technologies and cost reduction trends

CSP value proposition

Direct normal irradiation levels in the Northern Cape amongst the best in the world

Value proposition of CSP

This section describes the suitability of South Africa’s solar resource in relation to CSP and the value proposition of CSP, including:

► Solar resource quality in South Africa;
► Grid stability;
► Socio-economic benefits;
► Higher local content achievable compared to other renewable technologies;
► Reduced greenhouse gas emissions compared to other generation technologies; and
► Reduced surface area per technology compared to other renewable technologies.

Direct normal irradiation in South Africa

The direct normal irradiation (DNI) of South Africa is high (Figure 10), particularly in the Northern Cape region around Upington. The annual sum of DNI reaches almost 2800 kWh/m² making this region one of the most attractive for CSP in the world.

Table 7 provides the average DNI for comparison with key CSP countries.

Table 7: Average annual sum of DNI

<table>
<thead>
<tr>
<th>Country</th>
<th>Average annual sum of DNI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>2000 kWh/m²</td>
</tr>
<tr>
<td>Spain / Portugal</td>
<td>2200 kWh/m²</td>
</tr>
<tr>
<td>Tunisia</td>
<td>2400 kWh/m²</td>
</tr>
<tr>
<td>U.S. (Nevada)</td>
<td>2500 kWh/m²</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>2500 kWh/m²</td>
</tr>
<tr>
<td>South Africa</td>
<td>2800 kWh/m²</td>
</tr>
<tr>
<td>Chile</td>
<td>2900 kWh/m²</td>
</tr>
</tbody>
</table>

The direct normal irradiation (DNI) of South Africa is high (Figure 10), particularly in the Northern Cape region around Upington. The annual sum of DNI reaches almost 2800 kWh/m² making this region one of the most attractive for CSP in the world.

Table 7 provides the average DNI for comparison with key CSP countries.

The DNI is the most important factor which influences the design of a CSP plant. A higher DNI value results in lower costs for the electricity production, assuming the same frame conditions. Frame conditions are all factors that have a direct or indirect influence on the design of the CSP plant like the cooling method, installation costs, soil conditions, grid connections, etc.

This provides South Africa with an optimal starting point for the integration of CSP technology into its energy mix.
CSP value proposition

Influence on grid operation and system stability

CSP has several advantages in terms of the grid and system compared to other renewable energy technologies (e.g. onshore wind or PV).

► CSP plants with thermal storage systems have proven dispatchability, which can assist the grid operator to reliably match supply and demand;

► CSP plants are able to support the system stability of the transmission network by providing additional inertia (spinning reserve, steam generator). The influence of CSP on inertia is important because the steam generator of a CSP plant is small compared to the steam generator of large coal fired plants; and

► CSP plants are also able to contribute to grid requirements by providing “reactive power” which is needed to achieve local balance of the system. However, due to the typical distance of CSP plants from the energy demand centres, it has been highlighted that CSP is unlikely to make a substantial contribution to meet system operational needs for reactive power.

As the amount of intermittent renewable energy within the total South African energy pool increases, CSP plants with storage can play an essential role that will be of benefit to the system operator from a dispatchability standpoint.

Socio-economic benefits

Several studies demonstrate that CSP technology has a positive impact on socio-economic development, as a result of the increase of available energy and the job creation potential.

Interviews with local industry players during Phase 1 of this study indicate that the capability and capacities exist for some CSP components to be manufactured by existing local industries.

Jobs are created within the construction phase and the operational phase of the plant, typically a period of 25 years. The Department of Energy has announced that developers have estimated the first three CSP plants in South Africa (50MW solar tower, 100MW parabolic trough and 50MW parabolic trough) will create over 1,800 jobs in the construction phase and c.120 jobs during the operational phase.

Impact on greenhouse gas emissions

Greenhouse gas emissions are measured during the lifecycle of the project and are taken into consideration for the provision of the raw material, the manufacturing steps and the disposal of components.

Previous studies have analysed the greenhouse gas emissions of a CSP plant in Southern Europe compared to a combined cycle gas plant.

► The CSP plant’s greenhouse gas emissions were noted as 13.8g/kWh, which falls within the range of other renewable energy systems (e.g. small hydro and onshore wind);

► The greenhouse gas emissions for the gas plant are significantly higher at approx. 422g/kWh; and

► A conventional coal fired plant could have greenhouse gas emissions in the region of 978g/kWh (based on a coal fired plant in South Africa).

Impact on land and water use

The land use of CSP in terms of surface area is significantly below that of other renewable technologies, as outlined in Table 8.

Table 8: Estimated land use of different renewable energies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Land use (km²/TWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSP</td>
<td>8 - 10</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>10 - 15</td>
</tr>
<tr>
<td>Wind (onshore)</td>
<td>up to 41</td>
</tr>
</tbody>
</table>

Source: Trieb, 2005; EASAC, 2011

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9 Trieb, F. et al; Concentrating Solar Power for the Mediterranean Region (MED-CSP), April 2005, Stuttgart, Germany
10 Energy Resarch Center. (2011). Information about Climate Change in South Africa: Green house gas emissions and mitigation options
The amount of water used for a CSP wet cooling system is roughly the same as agricultural irrigation of an area corresponding to that occupied by the CSP plant in a semi-arid climate.

The amount of water a CSP system requires can be reduced by introducing dry cooling (from approximately 3.6 l/kWh to 0.3 l/kWh), however this results in a total efficiency reduction of the plant.

In comparison to a wet cooling method, dry cooling results in a reduction of the efficiency of about two to three percentage points. All thermal power plants in areas with water scarcity are confronted with this problem. Given the fact that South Africa is a water scarce country, dry cooling should be considered as the standard for CSP.

**Eskom’s point of view**

Eskom notes on its website that CSP with thermal energy storage has an advantage over other renewable technologies due to its predictability in dispatch and its potential to become cost competitive with conventional generation options. The Eskom representative interviewed during this study confirmed that the value of power available during peak periods was considered higher than that outside of peak hours.

Eskom indicated that the thermal storage capacity of CSP was assessed during studies undertaken for the IRP. CSP options with varying storage potential were assessed and as a result the optimum design storage capacity of CSP is considered to be 9 hours. This allows for sufficient energy storage to be available to be released over peak demand periods (usually between 6pm and 8pm). This also takes into account the reduced storage period over winter.

Eskom consider the following to be the strategic value of CSP to South Africa:

- **Grid stability** - Proven energy storage of the heat transfer medium forms an integral part of the plant. This means that CSP plants can generate electricity when the sun does not shine and provide power when it is most needed on the grid system, to support peaks;

- **Socio-Economic benefits** - The tower technology could be manufactured with a higher local content when compared to parabolic trough plants, thus contributing to sustainable job creation through the establishment of local manufacturing capacity;

- **Large-scale generation** - CSP plants can be built in modular format in multi-MW units. The plant can be replicated in parks in multiples of 100MWs or larger, with no fuel costs, and requiring land similar to that of conventional fossil plants with coal mines; and

- **Low environmental impact** - A significant benefit to CSP is that it has little environmental impact - a solar only plant has no emissions and has a similar land footprint compared to conventional fossil fuelled plants.

Eskom indicated that there are good potential opportunities for hybridisation of CSP with coal or gas fired power plants.

Eskom is currently conducting a feasibility study to better understand the integration of CSP into existing coal fired power plants.

The biggest current disadvantage of CSP, in Eskom's view, is its higher cost relative to other renewable technologies but it acknowledges that the wider system costs need to be taken into account in assessing the relative merits of competing renewable technology.

**Two-tiered tariff**

Currently there is only a single tariff for renewable energy generated under the RE IPP procurement programme regardless of when power is produced (i.e. on and off peak tariff is the same). The possibility of a two-tiered tariff was highlighted by Eskom at the National Planning Commission session on 13 March 2013. Broadly this tariff structure would involve a higher tariff for power provided during peak periods (when the value of power is higher) and a lower tariff during off-peak times. This would assist in making CSP with storage more comparable with other renewable technologies that produce power primarily outside of peak, by comparing the off-peak tariffs.

This proposal would thus assist in pricing the CSP value proposition in relation to storage. It will potentially allow developers to develop facilities with nine hours plus of storage as the business case to do so is strengthened by the two tier tariff structure.
There are currently four main CSP technologies

CSP technologies

There are four key global CSP technologies which we have outlined below for completeness and provided further detail in Part 2 for readers unfamiliar with the technology.

The technologies all operate have the same principle in that DNI is captured by reflectors that concentrate it on a receiver tube containing a Heat Transfer Fluid (HTF). Heat collected by the HTF is transferred through heat exchangers to a water/steam cycle.

Parabolic trough

Parabolic trough plants have a more extensive track record compared to other CSP technologies. They consist of several connected parallel rows of parabolic shaped mirrors.

The reflectors adjust throughout the day to track the sun via hydraulic lifting. The receiver contains HTF which is heated up to 400°C.

Solar tower

A solar tower plant consists of a tower with a receiver surrounded by a field of several hundred reflectors (heliostats).

The HTF (water or molten salt) used can reach higher temperatures than a parabolic trough, resulting in higher thermal efficiency. The HTF could be molten salt with heat being transferred through heat exchangers, or alternatively steam is transferred directly to a steam turbine.

Linear Fresnel

Linear Fresnel plants consist of multiple rows of reflectors, each consisting of several slightly curved mirrors, reflect DNI onto one or multiple absorber tubes which are located below a central receiver.

Water is used as the HTF and is converted to steam on its way through the field after which it is fed into the steam turbine.

Solar dish

This CSP technology consists of a solar dish receiver with a two axis tracking dish and a heat engine, which is the point of focus of the dish and is operated by cyclic compression and expansion of working fluid.

The heat transfer medium inside the engine could be air, helium or hydrogen.

Large scale solar thermal power plants are currently not cost competitive. In South Africa large scale applications and price of electricity are currently a focus, therefore the solar dish is not considered further in this report.

Figure 11: Comparison of main CSP technologies
Main components and manufacturing of CSP plant

Basic CSP components

CSP plants consist of several components, of which some components (e.g. piping, steel for support structure) can be used in different industry sectors.

The support structure is typically made of steel, although aluminum is used in order to reduce weight. There are no special requirements in relation to the quality of the steel.

Different designs of optical systems and support structure may be used, but the overall process and manufacturing steps remain the same.

Specialised CSP components

The challenge for local manufacturers is the CSP components which have specific requirements resulting in a need for investment in adapting existing facilities (e.g. production of glass with high reflectivity and/or curved glass).

CSP mirror production requires the production of “low iron” float glass to ensure a high level of reflectivity. This requires a high investment in production facilities.

Different production steps and specialist equipment is required depending on if flat glass (solar tower, linear Fresnel) or bent glass (parabolic trough) is being produced.

There are only a few players globally who have the equipment and know-how to produce glass for the CSP industry. The mirrors require high reflectivity, low tolerance and must be capable of lasting for at least 25 years, matching the typical life span of a CSP plant.

This requires significant capability to ensure the quality of mirrors and the durability of the coating is fit for purpose.

A detailed description of components and manufacturing processes is provided in Part 2 of this report.

<table>
<thead>
<tr>
<th>Table 9: Overview of CSP components</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic components</strong></td>
</tr>
<tr>
<td>Civil works (land preparation)</td>
</tr>
<tr>
<td>Assembly of solar field</td>
</tr>
<tr>
<td>Electronically equipment</td>
</tr>
<tr>
<td>Power block</td>
</tr>
<tr>
<td><strong>Solar field</strong></td>
</tr>
<tr>
<td>Float glass production</td>
</tr>
<tr>
<td>Mirror Production</td>
</tr>
<tr>
<td>Support Structure</td>
</tr>
<tr>
<td>Receiver</td>
</tr>
<tr>
<td><strong>HTF and Storage system</strong></td>
</tr>
<tr>
<td>HTF system</td>
</tr>
<tr>
<td>Connection piping</td>
</tr>
<tr>
<td>Storage system</td>
</tr>
</tbody>
</table>
1.1 Review of CSP value proposition, technologies and cost reduction trends

Overview of CSP technology and manufacturing processes

Capital costs for CSP have the potential to significantly reduce over time

CSP plant cost reduction potential

It is estimated that in the region of 28% to 40% of overall CSP investment costs could be reduced by 2020. This could be the result of both economies of scale due to increased plant capacities and improvements in manufacturing, (e.g. increasing the performance of the solar field or efficiency of conversion of solar irradiation to electric energy).12

The cost breakdown of a CSP plant will vary depending on the technology and design. Detailed cost estimations by technology are described in Appendix A.

For each CSP technology, the solar field represents the largest proportion of the capital cost (c. 40% to 45%) and within the solar field, steel, mirrors, receivers and construction are the most significant costs. The other main components of the CSP plant also represent significant shares of the capital cost, such as the thermal storage system (c. 10% to 15%) and the power block (c. 15% - 20%).

Manufacturing improvements

The main cost reduction potential of the mirrors and steel support structure are:

- Reduction of the weight of the mirrors whilst maintaining stability; and
- Reduction of the amount of steel demand due to advanced support structure designs and advanced mirror concepts.

The cost reduction potential for these improvement areas is estimated at between 8% and 12%.

The potential for the receiver costs to reduce is estimated to be in the region of 45%.13 This could be due to:

- Increasing the thermal efficiency by increasing the outlet temperature. This improvement could result in an increase of the efficiency up to 13 %; and
- Reducing thermal losses with advanced technologies and new design concepts of solar receivers.

Economies of scale

In addition to manufacturing improvements, cost reduction of the plant can also be achieved by introducing economies of scale.

The engineering of the plant and project development are almost independent from the scale of the plant, therefore an increase in plant capacity may not result in reduced overall engineering costs, but in reduced engineering costs per MW.

For mirrors and support structures, costs will reduce when production lines are working at full capacity.

Significant economies of scale can potentially be achieved in relation to the steam turbine by constructing larger CSP plants (e.g. c. 100MW to 170MW). For central tower systems this could also be achieved by building multiple tower systems. Several studies indicate that with a turbine size of 250MW the lowest LCOE can be achieved, however financing of such large projects is currently perceived to be challenging in South Africa. Standard steam turbines used in CHP plants are already optimised and the efficiency of larger turbines is higher than small turbines.

Additional cost reduction could be achieved by optimising the sizes of the solar field and the storage capacity. Whilst the increase of the storage capacity and solar field increases investment costs, the capacity factor of the CSP plant increases until the capacity limit of the steam generator is reached. Due to this limit, there is an optimal design point in terms of size and cost reduction. This will vary depending on plant configuration and site specific factors. Standard steam turbines used in CHP plants are already optimised and the efficiency of larger turbines is understood to be higher.

The impact of economies of scale for a parabolic trough plant with different storage capacities is shown in Figure 12. Note site specific conditions are not considered in this analysis. For linear Fresnel the same qualitative cost development could be expected, due to the similar setup of the solar field.

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1.1 Review of CSP value proposition, technologies and cost reduction trends

Capital costs for CSP have the potential to significantly reduce over time

The economies of scale which can be achieved for the solar tower technology are largely based on the numbers of heliostats. The specific price for one heliostat is directly dependent on the annual production rate, therefore plants which produce a larger number of heliostats result in lower costs per MW. Figure 13 shows the estimated reduction in costs for heliostats against production rate based on data provided by several U.S heliostat manufacturers.
The CSP industry is a young and dynamic market

Main players of the CSP value chain

The CSP market is a particularly dynamic and young market, with a number of players in the power generation and supply chain. We have therefore outlined below an extract of the recently most active and recognised players in the sector rather than all the industry players. The selected players are currently involved in large scale projects, have substantial experience and/or are developing relevant parts of the CSP technology.

Developer and EPC providers

EPC companies are typically large companies with experience in building and management of large infrastructure projects. Most EPC contractors have their own supply network for specialised components based on their experience with suppliers in prior projects.

<table>
<thead>
<tr>
<th>Company name*</th>
<th>Products</th>
<th>Experience / Focus</th>
<th>Local experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Cobra</td>
<td>EPC and project developer</td>
<td>Several plants in Spain, MENA, US</td>
<td>Bid Window 2 project</td>
</tr>
<tr>
<td>Abengoa Solar (Abener)</td>
<td>EPC and Project developer</td>
<td>Strong supply chain through various subsidiaries, approx. 350 MW in operation, 968 MW under construction</td>
<td>Bid Window 1 projects</td>
</tr>
<tr>
<td>Alstom</td>
<td>EPC</td>
<td>Experience in power block (over 40 years) &amp; boilers, Shareholder and strategic partnership with BrightSource</td>
<td>Conventional steam power plant experience.</td>
</tr>
<tr>
<td>MAN Ferrostaal</td>
<td>EPC and Project developer</td>
<td>Andasol 3, storage concepts BrightSource</td>
<td></td>
</tr>
<tr>
<td>Torresol (Sener)</td>
<td>Project developer</td>
<td>Gemasolar (Heliostats, Receiver, Storage)</td>
<td>Bid Window 2 project</td>
</tr>
<tr>
<td>Novatec</td>
<td>Project developer, Technology provider</td>
<td>Focus on Linear Fresnel</td>
<td></td>
</tr>
<tr>
<td>BrightSource</td>
<td>Technology provider</td>
<td>Focus on Tower systems, approx. 2.4 GW installed</td>
<td>Developing locally</td>
</tr>
<tr>
<td>Areva</td>
<td>Project developer</td>
<td>Focus on Linear Fresnel</td>
<td>Developing locally</td>
</tr>
<tr>
<td>TSK/Parsons</td>
<td>EPC</td>
<td>Active in North America and Spain</td>
<td></td>
</tr>
<tr>
<td>SolarReserve</td>
<td>Project developer and technology provider</td>
<td>Central Receiver (Solar Two), active in North America and Europe</td>
<td>Developing locally</td>
</tr>
</tbody>
</table>

* Note Siemens and ABB have stepped out of the CSP EPC business, although continue to supply component to the industry.

The project developers provide the conceptual design, basic decisions and proposals for technical specifications. This requires technical know-how, which is often focused on a specific CSP technology. International players can often provide expertise to address development of the project, the engineering, project management and financing issues.

Table 11: South African project developers

<table>
<thead>
<tr>
<th>Company name*</th>
<th>Products</th>
<th>Experience / Focus</th>
<th>Local experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emvelo</td>
<td>Project developer</td>
<td>Developing the Karoshoek Solar Valley Park (1GW)</td>
<td>Developing locally</td>
</tr>
<tr>
<td>Kathu Solar Consortium</td>
<td>Project developer</td>
<td>Developing locally the Kathu Solar Park (500 MW)</td>
<td>Developing locally</td>
</tr>
<tr>
<td>Solafrica Thermal Energy</td>
<td>Project developer</td>
<td>Developing the Bokpoort parabolic trough CSP project with ACWA Power (50MW)</td>
<td>Bid Window 2 project</td>
</tr>
<tr>
<td>Sasol</td>
<td>Project developer</td>
<td>Acting as developer for Round 3</td>
<td>Developing locally</td>
</tr>
</tbody>
</table>

Source: SASTELA

Solar field

Companies active in the supply of mirrors for the solar field are often based in the conventional glass industry. Their manufacturing focuses on glass for households or the automotive sector, rather than CSP mirrors. An emerging CSP market gives them the potential to diversify by selling their high quality mirror products (i.e., low iron glass).

The components for the support structure are also not specific for CSP, therefore local companies that are active in steel manufacturing and semi-finished parts can act as suppliers.
The CSP industry is a young and dynamic market

A few companies acting as project developers have also developed their own solar field system (e.g. Abengoa).

Table 12: Solar field

<table>
<thead>
<tr>
<th>Company name</th>
<th>Products</th>
<th>Track record</th>
</tr>
</thead>
<tbody>
<tr>
<td>BrightSource</td>
<td>Central tower technology provider</td>
<td>Technology provider including design software, heliostat and performance modelling</td>
</tr>
<tr>
<td>Flabeg</td>
<td>Mirrors (flat and bent)</td>
<td>Market leader with over 2 GW in Spain, USA, India and MENA,</td>
</tr>
<tr>
<td>Saint-Gobain</td>
<td>Mirrors (flat and bent)</td>
<td>Mirrors and ceramic receivers for solar tower</td>
</tr>
<tr>
<td>Rieglass Solar Novatec</td>
<td>Mirrors</td>
<td>Produces exclusively for Abengoa Solar</td>
</tr>
<tr>
<td>Group Sener</td>
<td>Support structure (linear Fresnel)</td>
<td>SENERtrough (e.g. Valle 1&amp;2 with 2x50 MW)</td>
</tr>
<tr>
<td>Abengoa</td>
<td>Support structure (parabolic trough, solar tower)</td>
<td>Astro trough collector, several plants in operation in Spain (e.g. PE20, Sollnova)</td>
</tr>
<tr>
<td>Schott Solar AG</td>
<td>Receiver (parabolic trough)</td>
<td>Market leader of receivers</td>
</tr>
<tr>
<td>Siemens (Solel)</td>
<td>Receiver (parabolic trough)</td>
<td>Track record of 20 years</td>
</tr>
</tbody>
</table>

Source: CSP-world.com; enolcon

HTF and thermal storage

Players active in the chemical industry typically have the capability to supply HTF and produce storage systems as these systems are based on technology and know-how used in the chemical industry.

The salt used for the molten salt storage system is predominantly imported from Chile, which is where the most abundant natural resources are.

Sener is currently the most experienced player in CSP thermal storage with up to 12 systems in operation, construction or development.

Table 13: Power Block and Grid connection

<table>
<thead>
<tr>
<th>Company name</th>
<th>Products</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siemens</td>
<td>Steam turbines &amp; GC</td>
<td>Several steam turbines for CSP delivered, market leader</td>
</tr>
<tr>
<td>MAN Turbo</td>
<td>Steam turbines</td>
<td>Steam turbines for CSP, second position in market</td>
</tr>
<tr>
<td>GE Oil&amp;Gas</td>
<td>Steam turbines</td>
<td></td>
</tr>
<tr>
<td>ABB</td>
<td>Steam turbines &amp; GC</td>
<td>These 3 companies have entered the CSP market and can leverage off significant experience in conventional power plant operation and construction</td>
</tr>
</tbody>
</table>

Alternative methods for thermal storage are currently under investigation, and include addressing cost, behaviour of the storage material, the setup of the storage system and thermal efficiency.

Power block

The power block for a CSP and the systems do not differ significantly from conventional power plant systems, therefore players active in the conventional power plant space are likely to also have the capability of supplying parts of the CSP power block.

ABB and Siemens have announced that they are no longer acting as EPC provider for CSP projects, although they continue to sell their components to the CSP market.

Production of steam turbines is a mature technology and the share of CSP is relatively small compared to the overall production, therefore no significant developments in terms of changes in the market structure are anticipated in this area.

The steam turbine market is dominated by four to five players, although there are several smaller companies that provide specialised products.
The CSP industry is a young and dynamic market

R&D

R&D is a key factor for the further development of CSP technology in order to realise the full potential of cost reductions. Several CSP developers/EPC providers have their own R&D departments (e.g. Sener and Abengoa).

Several universities and research institutions specialise in CSP related R&D. These institutions have been in involved in most CSP commercial technology developments, including licensed production of components or founding of new companies (e.g. Novatec or CSP services).

The current focus of the global CSP R&D sector is on cost reduction, storage technology and efficiency improvements.

In addition to the main international players (e.g. DLR - Germany, NREL and Sandia Labs - U.S and the Fraunhofer Institute – Germany), local universities (e.g. Stellenbosch University in South Africa) and research centres (e.g. CSIR) are important in R&D in order to address specific local problems.

Local R&D is to be addressed further in Phase 2 of this study.
1.2 Review of manufacturing capabilities and potential in South Africa

1. Interview process of local industry players
2. Analysis of South African CSP capabilities and potential
3. Potential industry changes and support measures
1.2 Review of manufacturing capabilities and potential in South Africa

Over forty CSP stakeholders interviewed for the study

Interview process with CSP industry stakeholders and component manufacturers

In order to assess the current and potential CSP component capabilities of the South African market, the value chain was segmented and the key areas in terms of importance and value of the plant were identified as follows:

► Solar field (assembly, heat transfer fluid, logistics, mirrors, piping, support structures);
► Power block (cooling towers, turbines, generator, steam condenser, pumps); and
► Storage (molten salt, heat exchanger, steel for tanks).

Other industry players interviewed during Phase 1, such as CSP developers, logistics companies, engineering companies and Eskom, were interviewed to gain an understanding of their view of the CSP market including barriers to the growth of the CSP component industry.

Relevant companies for each of the above categories were obtained from:

► Companies which attended the Launch meeting on 5 December 2012;
► Companies which are members of SASTELA;
► Ernst & Young and enolcon’s knowledge of the manufacturing industries; and
► Desktop research in order to identify any gaps in the value chain.

Ernst & Young and enolcon compiled a long list of 67 companies to contact, of which over 30 companies were interviewed in Phase 1.

In Phase 2, four R&D institutes (including IDC), four project funders and the dti were interviewed.

A questionnaire was designed to cater for both CSP developers and component manufacturers. The questionnaire design was based on a similar study undertaken by Ernst & Young for the CSP market in the Middle East and North Africa. A questionnaire covered the following key areas:

► Overview of the business model and product base of the interviewee;
► Current involvement of the company in the CSP market;
► Perceived future size of the Southern African CSP market;
► Manufacturing capability;
► Investment required to produce relevant CSP components and requirements for investment approval;
► Raw material and labour costs and view of their competitiveness compared to the international market;
► Research & Development (R&D) (if applicable); and
► Ranking of barriers to entry and support mechanisms for CSP component suppliers.

Figure 14: Number of companies interviewed by area of expertise in Phase 1
Over forty CSP stakeholders interviewed for the study

Limitations of the interview process

The information gathered during the interview process was inherently limited by the following:

- Companies were reluctant to offer potentially commercially sensitive information so were unable to provide responses to certain questions – for example the proportion of local content was considered confidential for some companies;

- A number of the component manufacturers had not considered an investment in the CSP supply industry and as such were unable to provide information around number of jobs created and the level of capacity at which they would invest; and

- Certain companies that are active in the CSP supply industry could only offer indicative ranges of “ball park estimates” of MW allocation that would trigger further investment.
Localisation potential of CSP depends on the type of technology and design

Analysis of South African CSP capabilities and potential

Industry’s view of the CSP market

- Developers interviewed noted several concerns around the roll out of CSP in South Africa:
  - Timing of the RE IPP procurement programme creates a peak in demand for construction jobs, which does not necessarily promote local skills development. Newly trained labour are likely to work only on one project at a time rather than having a pipeline of projects to work on thereby and increase their skills base;
  - The supply of renewable energy (i.e. solar and wind) does not satisfy peak evening demand for power. Developers were concerned about the subsequent need to use diesel fired peaking plants at a higher cost than CSP and the potential destabilisation of the grid; and
  - CSP being located in the same area rather than a geographically diversified project landscape was noted as a potential concern due to potential variances in the DNI levels.

- Developers are currently unsure of the CSP roll-out as a result of uncertainty around the RE IPP procurement programme, i.e. timing of bidding rounds. Timing is of importance to developers in order for them to manage their development expenditure effectively.

Developers indicated that their preference for a programme to assist the CSP industry would be:

- A programme where there is a guaranteed capacity available per year and developers/suppliers are able to create a localised industry around CSP, creating various areas of excellence which would enable a large part of the value chain to be supplied locally; and
- Recognition of the potential benefits of CSP to provide base load energy.

Local content potential

To date, CSP plants have often been designed outside of South Africa, with a consequence being that certain components are best sourced overseas. The Intellectual Property (IP) associated with the design and manufacture of certain components is also located abroad.

Furthermore, designs by foreign companies are often based on the manufacturing capabilities of the international market in which it was designed. Interviewees indicated that under the current market outlook, any change to a design is potentially expensive as current designs are proven and cost effective. Changing any part of the engineering is considered risky to the system as a whole. This may be subject to change if the volume of CSP is increased and if the volume anticipated is a steady roll out.

**Linear Fresnel**

Linear Fresnel plants are viewed as having the most potential for high local content, partly due to these plants being less complex than parabolic trough, dish or central receiver technology.

An example of high local content is the small scale linear Fresnel process heat plant being commissioned at Eskom’s Rosherville plant. This plant was specifically designed to achieve a high local content in excess of 90%.

For a linear Fresnel plant with internationally designed technology, it was estimated that c. 80-90% of the capex of the heat plant can be localised.

**Tower technology**

Two interviewees noted that, in their view, localisation of approximately 60% of solar tower development can be achieved.

Approximately 30% of the total capex for tower technology consists of the mirrors, steel structure, and control (together the heliostat). All of the heliostats can be localised, but this would involve developing new capability in South Africa.

A further significant cost is the civil and site works, which the larger domestic construction companies can deliver.
Local capacity to produce bent mirrors could be achieved with increased CSP roll out

The areas which are difficult to source locally are motors, gearboxes and access to technology as R&D is done internationally in more mature markets. Software and microchips can only be localised under licensing to ensure IP is protected.

**Parabolic trough**

Abengoa and ACWA have both been awarded preferred bidder status for parabolic trough projects in the Northern Cape of 100MW and 50MW respectively under the RE IPPP programme.

It was perceived by developers that it is difficult to reach the 40% local content requirement in this technology and that higher local content could be achieved in tower and linear Fresnel projects. This is due to the requirement for bent mirrors in parabolic trough designs, which will have to be imported as South Africa does not currently have the current capability to manufacture parabolic shaped mirrors, nor the current capacity to silver bent glass.

Some parabolic trough players have indicated that they would not look at localising more than the current minimum requirement of 40% (under RE IPPP programme) as this may make their projects uncompetitive. However if there was an increased roll-out of CSP, glass companies such as PFG may set a up production lines for bent mirrors which in turn could result in increased local content of potentially up to 60%.

**Increasing localisation over time**

Construction companies are weighing up which risks to take on in relation to using local components where local manufacturers have no track record of supplying the CSP industry. Some complex areas will not be localised in the immediate future, but may be done so over time as more experience is gained. Further risks associated with using local CSP components with no track record of supplying the CSP industry may be taken in subsequent projects once the components had been proven.

For example, a power block component provider indicated that once they have proven the 40% local content in CSP they would seek to increase the local content. They have developed the know-how for local teams to perform the maintenance through enterprise development.

One developer commented that it will be expensive to localise the supply chain initially as there will be training and investment costs involved, however in the long run, and assuming a steady pipeline of CSP projects, the efficiencies of a local supply chain can be exploited and it may become less expensive than importing certain parts. For example, in India, a developer was able to localise welding of the boiler (a non specialised task). It is possible for a training school for specialist welders to be delivered by internationally experienced employees.

**Economies of scale**

The scale of CSP in terms of both plant size and total MW allocated will also have an effect on price:

- **Plant size**: Economies of scale can be achieved for larger plant sizes. For example a developer quoted an approximate 10% reduction in price for a single 200 MW turbine compared to two 100 MW turbines. Some developers indicated that project sizes of between 100 MW and 170 MW are necessary to achieve economies of scale and hence price reductions.

- **Total MW allocated**: Certainty of total CSP MW allocation and sufficient volume will allow the supply chain to commit to identifying manufacturing opportunities and developing areas of excellence. A sufficiently large capacity of CSP over time may allow cost reductions as experience is gained and economies of scale are achieved.

**Additional knowledge transfer to reduce costs may be gained from**:

- **International partnerships**: Partnerships where technology, experiences and knowledge are transferred from international companies to local companies can result in significantly reduced prices from local component manufacturers; and

- **Utilising skills from established industries**: South Africa is a heavy industry based country and cost savings are potentially available where there is a skill overlap with established industries.
1.2 Review of manufacturing capabilities and potential in South Africa

Key local industry sector current and future capabilities

South African CSP component capacities and potential

We have considered the key local industry sectors and their current and potential capabilities and capacities for supplying the CSP industry. The summary from the interviews with local companies is outlined in Table 11.

The following sections set out a summary table of companies interviewed, current local capacity and future capacity. Note that the current and future capacities included in the tables only include the capacities of the companies interviewed.

Table 11: Summary of key local industry sectors and summary from interviews

<table>
<thead>
<tr>
<th>Key local industry sector</th>
<th>Core competitive advantage*</th>
<th>Core competitive weakness</th>
<th>Current local capability</th>
<th>Future potential capability</th>
<th>Required changes to expand or establish capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>Silvering capabilities for flat glass</td>
<td>High iron content of raw materials found in SA requires additional iron extraction costs</td>
<td>Flat silvering capacity</td>
<td>May invest to manufacture flat mirrors should at least 150 - 200MW of CSP be rolled out per year for at least 5 years</td>
<td>Certainty of CSP roll out and at least 150-200MW of capacity per annum</td>
</tr>
<tr>
<td>Steel</td>
<td>Significant amount of spare capacity for steel production</td>
<td>Price of steel compared to imported steel</td>
<td>Steel capacity for over 1GW of CSP p.a.</td>
<td>Over 1GW depending on sustainable orders received</td>
<td>Sustainable orders required</td>
</tr>
<tr>
<td>Piping</td>
<td>Piping currently supplied to a number of industries in SA</td>
<td>Centre pipe/torque tube required in parabolic troughs is an unusual product in the South African market.</td>
<td>Seamless piping available for c. 100 - 200 MW p.a.</td>
<td>Possible investment in spiral plant at 100 - 200 MW committed annual pipeline</td>
<td>Certainty of CSP roll out and at least 100-200MW of capacity per annum</td>
</tr>
<tr>
<td>Pump</td>
<td>None</td>
<td>CSP pumps not currently manufactured in SA</td>
<td>None</td>
<td>Unlikely due to the technical complexity</td>
<td>Significant pipeline required</td>
</tr>
</tbody>
</table>

Tracking device | Expertise in tracking devices through supply of trackers to the mining industry | Track record of supplying CSP plants required | Current potential to supply tracking devices | Reutech may invest and produce trackers if CSP output of 500 MW p.a. over 12 years | Certainty of CSP roll out |

Receiver | None | Local R&D required | None | At least 400MW required for a new production line | Certainty of CSP roll out |

Molten salt | None | Lack of natural resources in South Africa to produce at the scale required for a CSP plant | Logistics only | Logistics only | n/a |

Construction | Well established construction industry in SA | Lack of track record therefore in the short term international management supervision may be required for solar field construction | Adequate industry capacity to undertake a number of CSP contracts | Willingness to invest in further skills development if certainty of pipeline can be provided | Certain, committed pipeline of CSP to enable investment in skills |

Power block | Experience in coal power stations | More competitive international price for majority of components | Local content for turbine, generator and housing of 50% possible 5% localisation for tanks, vessels, boilers, pumps and pipes | Fabrication could be localised with investment welding know-how | Significant pipeline required |

Heat exchangers | None | Technical expertise required which is currently largely protected by international companies | Logistics and installation | Potential capability to produce subject to sufficiently resource | Time required to establish resource | Significant pipeline required |
Local glass producers would be willing to invest if there was certainty of orders of a reasonable scale

Glass industry

Local glass companies produce glass for the building and automotive industries. Demand for locally produced glass has recently reduced due to economic slowdown affecting the building and automotive industries and an increase in the volume of competitively priced imported glass. This has resulted in significant local spare capacity for the production of low iron glass and mirrors.

It is a challenge for local companies to supply low iron glass locally at a competitive price, particularly with volatility in the exchange rate. The high iron content of raw materials found in South Africa requires additional iron extraction costs which international players may not be subject to. A further reason for the high price of supply in South Africa is the lack of demand in the local market resulting in an inability to benefit from economies of scale.

Specifically, there is no local capability to bend glass and silver bent glass to the specification required for parabolic trough CSP plants due to current lack of local demand.

PFG Building Glass is the only local company with the ability to produce low iron float glass and silver flat mirrors for the power tower and linear Fresnel applications on a commercial scale. It has some experience with the successful manufacturing of low iron glass to supply the PV and solar water heater industries.

Summary of capacities of glass companies interviewed

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five glass companies</td>
<td>• Flat silvering capacity of approximately 3 million m² p.a. (c. 265 MW)</td>
<td>May invest to manufacture flat mirrors should at least 150 - 200MW of CSP be rolled out per year for at least 5 years</td>
</tr>
<tr>
<td></td>
<td>• Flat low iron glass production of c. 2 million m² p.a. (c. 90 – 130 MW) depending on the specifications</td>
<td>International competitor may require 400-500MW per year for 5 years to invest in local</td>
</tr>
<tr>
<td></td>
<td>• May invest to manufacture flat mirrors should at least 150 - 200MW of CSP be rolled out per year for at least 5 years</td>
<td>glass and silvering factory to serve the full requirements of CSP market</td>
</tr>
</tbody>
</table>

Note: We have assumed that a 50MW plant with 7.5 hours of storage requires 570,000m² of mirrors and for simplicity that the MW relationship is scalable upwards on a linear basis.

Current local capability

There is currently no South African glass producer which is able to produce the bent glass required for parabolic trough plants. The specialist furnace and silvering line is not available locally.

For the Bid Window 1 parabolic trough project, Abengoa is sourcing bent mirrors from its subsidiary, Rioglass which has operations in Spain and the USA.

Glass is one of the more specialist logistics areas in the CSP supply chain due to the requirement of careful transportation and handling on site. There are only a handful of companies in South Africa which have the capabilities to transport glass.

Silvering capabilities locally consist of only one glass producer being able to silver flat glass only. Currently one South African company can silver flat glass in partnership with a European technology partner using proven technology, chemicals and paint for CSP applications. Samples were tested and the quality approved by the technology provider. Currently no South African company can silver bent glass.

A glass transportation company noted it has the capacity to transport c. 80-100,000 tons of glass per annum (615MW – 770MW). It can transport float glass in loads of up to 8 metres and in sizes of up to 3210 x 2250 mm.
Local glass producers would be willing to invest if there was certainty of orders of a reasonable scale

Future local capability

Glass companies estimated that it would take them c. 5 to 8 months to mobilise to produce low iron glass, including acquiring the necessary know-how and machinery. Procuring the equipment and funding the initial trial run can be a costly exercise, but sourcing the funding is not considered to be as challenging as securing orders for the product once the investment has been made. R&D is being performed in order to find improved cost effective methods of extracting iron from the raw materials and finding additional sources of high quality raw materials.

An international player raised concerns that local glass players may not have the knowledge to produce product at the required level of high specification or the necessary infrastructure. It was estimated that if they were to commence now, without an international partner, it would take 2 years for them to be in a position to supply the market. The quality required for glass for CSP is difficult to produce due to the high levels of purity (low iron content) and low tolerances demanded. Concerns were raised that the banks may not be comfortable funding a project with a new entrant local player supplying all the glass for the project. There may need to be a transition phase where the local producer would supply some of the glass with the international supplier providing the balance.

This would reduce risk with the international company capable of supplying all the glass should the local supplier fail to meet the required standards. Local glass producers would only be willing to invest if there was certainty of orders of a reasonable scale, for example if CSP allocation in the RE IPP programme was 150-200MW per year for at least 5 years.

An international company interviewed noted that they would not invest in a local glass producing plant and mirroring facility without a reliable CSP market. In order to base a new plant here, approximately 400 to 500 MW per annum of CSP roll out for a period of 5 years would be required with the glass supplier assuming 50% of the supply. Even at this level of pipeline a plant would be border line in terms of justifying the investment. In addition, most of the specialist equipment for a factory would need to be imported to ensure sufficient quality for a product which would need to last for 30 years. Overall labour costs are similar to the costs in Europe (due to lower productivity, lower skill levels of South African labour), therefore in the absence of incentives or stronger local content requirements, there is little reason why a factory would be set up in South Africa.
Steel producers currently have a significant amount of spare capacity

Steel industry

Steel is produced locally by Arcelor-Mittal and Evraz Highveld Steel and these players sell 80-90% of steel produced to the local market. The demand for steel in South Africa is expected to track the current economic trend of a slow but modest recovery in the coming years. This current lack of demand has resulted in overcapacity in the industry.14

EPC contractors typically source the majority of their steel requirements for CSP plants from local steel merchants fabricated to the required specifications.

Summary of capacities of steel companies interviewed

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three steel companies</td>
<td>• Up to 1GW p.a. for Arcelor-Mittal</td>
<td>• Up to 1GW p.a. for Arcelor-Mittal</td>
</tr>
<tr>
<td></td>
<td>• Other players have capacity dependent on sustainable demand and firm orders</td>
<td></td>
</tr>
</tbody>
</table>

Note: We have assumed that a 50MW plant with 7.5 hours of storage requires 12,000 tons of steel (80% long products) and for simplicity that the MW relationship is scalable upwards on a linear basis.

Current local capability

A wide range of steel is required for a CSP plant, such as long steel for structuring, galvanised steel and plating. Steel for both CSP RE IPP bid Window 1 projects is sourced from local steel producers.

In order to be competitive with the imported steel market, steel to CSP and PV players is being offered at a discounted price compared to steel for other uses.

Future local capacity

The steel producers are prepared to expand their facilities, depending on the amount of sustainable orders they receive. Some indicated that they would only expand if off-take agreements were signed upfront.

Steel producers currently have a significant amount of spare capacity. Plants have been mothballed during current low demand (i.e. not running close to maximum capacity), therefore even if capacity was 1GW per annum, existing facilities could still be used. A lead time of 6-12 weeks is typical, depending on the steel producer and the specification of the product. Steel producers note that they were able to meet the high orders during the 2010 Soccer World Cup and thus expect to have capacity to meet the CSP market.

One of the steel providers has not considered entering the CSP industry due to the uncertainty of future orders.

14 BMI South Africa Metals Report Q1 2013
1.2 Review of manufacturing capabilities and potential in South Africa

Seamless pipes for heliostat design available in local market for c. 100-200MW p.a.

Piping industry

Piping is supplied in South Africa mainly to the mining, logistic, petrochemical, building and construction, engineering, manufacturing, energy and power, water and automotive industries.

The piping in CSP plants consists of both low and high pressure pipes. The high performance alloy material required for the high pressure pumps can be supplied by only three companies globally.

The type of piping required for CSP projects will depend on the design of the plant and could be:

- Spiral welded pipes – used for example on parabolic trough; or
- Seamless pipes – used for some heliostat designs.

A number of local companies focus only on spiral pipes, for example for use mainly in the transportation of water. The specifications for these pipes are different to that of CSP. These companies typically secure large infrastructure contracts which tie up capacity and the products are charged at a premium as heavier tubing and additional processes are required post welding. There is currently a high demand for these products, therefore less incentive to supply the CSP market which requires bespoke piping products. The thin walled piping (centre pipe/torque tube) required in parabolic troughs is an unusual product in the South African market and requires special engineering to meet the high tolerances required in CSP designs.

Summary of capacities of piping companies interviewed

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three piping related companies</td>
<td>• Seamless piping available for c. 100 - 200 MW p.a.</td>
<td>• Investment in training would be provided depending on certainty of pipeline • Possible investment in spiral plant at 100 - 200 MW committed annual pipeline</td>
</tr>
</tbody>
</table>

Current local capability

The specific design required in CSP pipes is not the same standard as applied to the local mining industry. It is expensive to produce the low volumes of the piping required, however it was identified that there are a number of local suppliers that are able to fabricate the required steel structures consistent with the design required by an international EPC provider.

One local company imports the raw material for high pressure piping as it noted that there is not a mill in South Africa that is capable of producing the level of quality required. The piping is bent and welded locally to specification.

There are a number of manufacturing challenges in meeting the high tolerance and precision necessary for CSP plants.

It was noted that local piping prices are high as a contingency is priced in to cover for the risk of reworking pipes. In the early phases during trial runs, there were a number of reworks required due to not meeting the required high tolerances due to welding flaws and warping post galvanising.

An international player indicated that there was a local capacity constraint with galvanising tanks for the torque pipes required. The local kettle sizes allow significantly less throughput of torques due to the size constraint of the kettle, which could restrict ability to meet a CSP developer’s construction schedule. A further problem is that there are no galvanizing facilities in the Northern Cape. A potential solution proposed was that the international player provides the equipment and the local piping company provides the training.

Future local capability

In order for spiral piping to be produced, specialised mills are required to accommodate the specification for large pipes. Depending on whether existing infrastructure can be upgraded or a greenfield site used, investment in spiral mills ranges from R30 to 100 million. If about 100 - 200 MW of CSP projects are procured every year over at least the next five years, then it may be viable investing in a new spiral mill to supply the CSP industry.

A local company currently produces flexible decouplers for the automotive industry and has access to the process to produce joints and compensators necessary for the connection between receiver and piping system is similar to their current production process. Equipment that can be applied to produce...
Not considered feasible to manufacture molten salt pumps locally

prototypes locally is expected to arrive in mid 2013 and prototype production is expected to commence shortly after.

Pump industry

Large pumps are mainly used across the petrochemical, gas and mine industries. Feed water pumps are not currently produced in South Africa due in part to the importance of reliability of the pumps, which adds complexity. The feed water pumps for Medupi and Kusile are imported.

In CSP, specialised pumps that are capable of pumping high temperature and corrosive fluids are necessary. These pumps are fabricated with highly specialised materials.

Summary of capacities of pump companies interviewed

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>One company</td>
<td>• None</td>
<td>• Unlikely due to the technical complexity of the pumps</td>
</tr>
</tbody>
</table>

Current local capacities

Only one pump supplier was identified in South Africa capable of supplying pumps to handle molten salt to the CSP industry. The company is an agency representing a company located in Germany, as well as representing various other specialist pump suppliers. The local company obtains the local technical data for the international company who produce and test the pumps and are currently producing the pumps for the Bid Window 1 CSP plants.

According to the local company, there are only two companies globally which are able to produce the types of pumps required in a CSP plant.

There is very limited local involvement in the production side of the local company as the guarantees on the pumps are provided based on factory production with no further modifications. Due to this, the pumps are fully assembled prior to delivery. The local company assists with supervision of the installation and O&M, but all the pumps’ parts required for maintenance are imported.

Future local capability

The local company is unlikely to set up a factory for producing pumps as it already has two factories in Germany which deliver the pumps worldwide. The set up costs involved in producing the pumps locally and the limited volume anticipated in the South African and SADC markets do not justify the large investment required.
SA has the potential to produce tracking devices for CSP

Tracking device industry

Tracking devices allow the mirrors to track the sun during the day to achieve maximum solar reflection.

Reutech is a South African defence company that supplies tracking devices to other industries. The trackers were developed in Australia and are now produced locally by Reutech. Reutech has built up its expertise in tracking devices through supply of trackers to the mining industry where accuracy of tracking devices is essential.

Reutech approached Eskom for PV and CSP tracker opportunities; however they were not successful due to a lack of track record supplying the renewable energy industry.

Reutech has won a contract to supply CPV trackers to for a Bid Window 1 project. These trackers were qualified by an independent engineering firm.

Reutech's current design for CPV is considered competitive internationally and was chosen above other international designs.

Reutech has indicated that it has the current capability to supply tracking devices and related steel structures to the CSP industry. The tracking devices in the CSP industry are considerably larger than those used on the mines.

Reutech manufactures trackers using its local factory and local sub-contractors.

Future local capability

If orders for tracking devices were to increase in the future, Reutech would train staff in-house and increase the project management staff.

Reutech identified the most important aspect to investment decision to be certainty of orders. Reutech did not perceive investing the required amount to be problematic if they had firm orders to produce trackers required for 500MW CSP per annum.

In addition to Reutech, the University of Stellenbosch has a demonstrated tracking system through its small prototype system which is being scaled up in 2013 to “full scale” for smaller CSP plants using private funding. It is anticipated that the University will seek funding for a pilot plant in 2014.

Summary of capacities of tracking device companies interviewed

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>One company</td>
<td>• Current potential to supply tracking devices</td>
<td>• May invest and produce trackers if CSP output of 500 MW p.a.</td>
</tr>
</tbody>
</table>

Current local capacity

Reutech has not been able to qualify their trackers for use in CSP plants due to a lack of firm CSP orders. In order to produce trackers for a 50-100 MW project, Reutech would require the assistance of sub contractors for manufacturing pipes, laser cutting and galvanising.

In order for Reutech to consider investing in the piping, laser cutting and galvanising themselves, approximately 500 MW of CSP per annum over a period of 12 years would be required.
1.2 Review of manufacturing capabilities and potential in South Africa

Analysis of South African CSP capabilities and potential

Receivers cannot currently be produced locally

Receivers for line focusing systems

The receivers in CSP power plants convert concentrated solar radiation into heat that is used to produce steam to drive turbines.

There are three main suppliers in the CSP market: Schott (Germany), Huiyin (China) and Siemens (factory in Israel). Schott is the leading supplier of parabolic trough receivers with a c. 75% global market share.

Summary of capacities of receiver suppliers interviewed

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two companies</td>
<td>• None</td>
<td>• At least 400MW as this is the requirement for a new production line</td>
</tr>
</tbody>
</table>

Current local capability

There is currently no local capability for production of receivers as it is high proprietary technology. The receiver would have to be imported and the local content would include logistics and installation.

Future local capability

Although reflectors and carbon sealed tubes could potentially be localised, production of the coating on the receiver and the software control system will not likely be localised as this is proprietary knowledge.

It was indicated that at least 400MW worth of allocation of CSP may be required in order for an international company to set up a production line to manufacture receivers.
Logistics for molten salt delivery to site can be supplied locally

Molten salt industry

Molten salt is used for heat transfer in power plants. Conventional mixtures of sodium nitrates and potassium nitrates (as used in the fertiliser industry) are already proven as energy storage media in trough and tower configurations. Molten salts usually comprise 60% sodium nitrate and 40% potassium nitrate.

SQM, a Chilean based company, is the only multi-national company that has the capacity to produce both large scale potassium nitrate and sodium nitrate required for molten salt in CSP. Consequently, it is the dominant provider of salt to the CSP industry.

SQM has two main competitors, BASF (Germany) and Haifa Chemicals (Israel) which produce sodium nitrate and potassium nitrate respectively, but on a smaller scale compared to SQM. SQM is the only company to source both the raw materials for the salt.

Summary of capacities of salt suppliers interviewed

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>One company</td>
<td>• Logistics only</td>
<td>• Logistics only</td>
</tr>
</tbody>
</table>

SQM is supplying molten salt from Chile to the one of the RE IPP bid submission Window 1 CSP projects. It is estimated that the quantity of salt required for the project is 30,000 tons for the life of the plant. The finished product is shipped out in one ton bags to South Africa.

Current local capacity

The only local aspect SQM is providing is the logistical solution for delivery of the salts to site. The logistics are complex as it requires 400 tons daily of salt delivered.

Future local capability

Future local capability is limited by the lack of natural resources in South Africa to produce at the scale required for a CSP plant. Synthetically produced salt is possible but is unlikely to be cost competitive with imported salts as evidenced in the fertiliser industry which involve similar products and no synthetic products are available.
Construction industry has capability and capacity to undertake construction for CSP industry

Construction industry

There is a substantial, well established construction industry in South Africa which is able to provide the civil works required for a CSP plant. The similarities in construction between power projects being constructed in South Africa (e.g. Medupi and Kusile) and CSP are some evidence of the capability of the civil works in the industry.

The major local construction companies include Murray & Roberts, Group 5, Aveng Group, Basil Read, Crowie and WBHO. Often the construction companies have local partners or subcontractors which they use if they are unable to provide the entire service themselves.

Several construction companies view CSP as a good business opportunity and often as more valuable for them compared to alternative renewable energy technologies as CSP provides a larger amount of civils work due to the significant amount of concrete and steel structures required for a CSP plant compared to an onshore wind or solar PV plant.

Summary of capabilities of construction companies interviewed

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
</table>
| Four local companies   | · Most assembly can be localised but may require international supervision  
                         · Adequate industry capacity to undertake a number of CSP contracts  
                         · Willingness to invest in further skills development if certainty of pipeline can be provided |

Current local capabilities

Many of the construction companies capable of providing civil works to the CSP industry have a local track record of constructing large power plants for Eskom and are currently involved in wind and PV projects.

The following areas of CSP construction could be localised:

- Piping and electrics;
- BoP, civil works, engineering;
- Support structures;
- Erection of Mirrors; and
- Solar field can be assembled locally, but requires international management supervision as the plant construction relates directly to performance.

Turbines and generation sets are imported as it is not feasible to manufacture these locally.

Future local capability

One of the construction companies interviewed believes that being awarded a single CSP project per year is a good size contract to manage as this would enable it to use the same construction skills each year on subsequent projects. Two of the construction companies interviewed specifically mentioned that additional demand would be difficult for them to accommodate.

Construction companies noted that they are prepared to invest in the necessary technical skills required provided there is a certain, committed pipeline of CSP projects which will enable them to plan resources appropriately.
Experience from Medupi & Kusile power plants can be applied to CSP projects

Power block components

Medupi (4,800 MW) and Kusile power (4,800 MW) stations are currently under construction and are expected to commence commercial operations in late 2013 and 2014 respectively. There are similarities between the power block components of these power plants and the power block components required in a CSP plant.

Alstom, in conjunction with Actom and Hitachi, are providing the power block turbines and boilers for Medupi and Kusile power stations. A 50% local content for the turbine island (turbine, generator & housing) was achieved on the Medupi power station. It is possible that similar levels may be achieved on CSP projects.

Hitachi Power Africa is currently building 12 steam generators for Eskom using the design and specification provided by Hitachi Power Europe.

Siemens no longer provides turnkey EPC services, however still supplies components into the CSP industry. The majority of the components would be imported.

Summary of capacities of power block companies interviewed

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three companies</td>
<td>• Local content for turbine, generator and housing of 50% possible (5% localisation for tanks, vessels, boilers, pumps and pipes)</td>
<td>• Fabrication could be localised with investment in welding know-how (Decision to invest depends on certainty of scale)</td>
</tr>
</tbody>
</table>

Current local capacity

Local production of the gearbox and motor is not justified from an investment perspective due to the low volume and high capital investment required.

Industry’s view is that it will take years and will require multiple 100Mw projects to support a business case for investment to locally produce gearbox and motors.

A significant proportion of the power block cost would not be localised mainly as a result of a currently more competitive international price. Only 5% localisation of the following power block component cost can currently be achieved: tanks, vessels, boilers, pumps and pipes.

Hitachi does not focus on the smaller turbines required for CSP plants (50-100MW) and therefore it collaborated with DB Thermal and other local pressure part manufacturers to achieve a local content for the overall scope of supply (incl. structural steel, duct work, piping, etc.) of around 60%.

Steel for the boilers is imported as due to high specification required which can only be sourced from few international companies with the required technical know-how.

The cooling towers for Medupi and Kusile are produced by DB Thermal. SBX and GEA are also capable of producing cooling towers locally. Therefore these companies should potentially be able to produce CSP cooling towers locally.

Future local capacity

The fabrication of a CSP tower steam generator and possibly also the CSP tower receiver could be localised with imported fabrication and welding know how and tube material. Specialist equipment for the steel mills capable of supplying the required tube material would be imported from the USA, Europe or Japan.

The decision to invest would be based on economies of scale not only in the CSP industry, but also based on gas and coal power stations. In this regard, CSP may benefit from the future coal and gas projects.

As with the international glass manufacturer requiring a business rationale for locating a new factory in South Africa, a turbine provider indicated it already has four manufacturing facilities globally, therefore would require a large pipeline of projects to build an additional factory locally.
Heat exchangers currently sourced internationally due to lack of local CSP market scale

One heat exchange provider did not believe it was feasible to produce their heat exchangers in South Africa as these are currently produced at one international facility and shipped around the world.

**Future local capability**

There is not sufficient volume in the South African market to justify the investment of a new production facility in South Africa. A further important consideration is the threat to IP as one of the companies interviewed indicated that they had closed facilities in certain countries in order to protect their IP.

It was seen as a possibility to produce heat exchangers locally as this is the case for supply to Medupi and Kusile power stations, although with these plants currently ongoing, it was considered that securing resources may prove difficult.

The small proportion of the heat exchanger which could potentially be produced locally is the steam condenser.

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### Heat exchangers

The heat from a CSP plant is used to produce steam via a heat exchanger.

<table>
<thead>
<tr>
<th>Companies interviewed</th>
<th>Current local capacity</th>
<th>Future local capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two companies</td>
<td>None</td>
<td>• Potential capability to produce subject to sufficiently resource.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Barrier is protecting international IP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Steam condenser</td>
</tr>
</tbody>
</table>

**Current local capability**

The heat exchangers for Bid Window 1 CSP plants are to be sourced internationally.

The current localisation of the heat exchangers provided is logistics, installation, insulation and after sales support. The installation will be performed by a local team of 10 semi skilled workers which will be provided by the freight company.
Currently SA can compete internationally only on basic components

Competitive advantages and weaknesses of CSP value chains in South Africa

Competitive advantages

A number of component manufacturers believe that currently South Africa can compete with international products only in respect to basic products (e.g. pipes, steel, mirrors), rather than more specialised products such as turbines, curved mirrors and receivers.

There are a number of examples where experience in South Africa in other sectors (e.g. oil and gas, mining and defence industries) may specifically benefit the CSP industry:

- Alstom has 30-40 years of experience in the power industry in South Africa and uses local teams to perform maintenance on power stations. In this respect, Alstom has developed enterprise and relationships with SMEs;
- Reutech has produced tracking devices for the mining industry for a number of years. It believes trackers for concentrated solar PV are competitive internationally, with the design being offered in the USA; and
- A similar technology to dry cooling condensers used in CSP plants has been used in coal plants in South Africa for a number of years.

Weakness in CSP value chains

Labour

The majority of interviewees observed that labour in South Africa is not competitive on an international level, mainly due to the lower productivity of local workers.

Although labour rates are lower than most overseas counterparts, the overall labour cost is higher if labour productivity is taken into consideration. The overall labour cost differential quoted ranged from labour being 5% more expensive to being three times more expensive in South Africa than internationally. The latter was quoted by a player who had performed a cost exercise on both a local and international CSP plant.

Uncertainty of CSP roll out was seen as a barrier to increased productivity as the investment in the necessary skills will not be made until there is certainty of future roll out. Strikes were also noted as affecting productivity, resulting in a component manufacturer contemplating mechanising processes in response.

Interviewees indicated that low labour productivity was unlikely to change in the short term, but may in the long term if a change in labour sentiment occurs. Additional training and skills development may assist in this regard.

Even at higher levels of CSP rollout, lack of skills was not viewed as a constraint, provided there is sufficient time available for planning and training.

Cost of components

A number of interviewees noted that certain raw materials in South Africa are expensive compared to the international market as outlined in Figure 15.

One interviewee stated that in comparison to costing for a coal fired plant, capital costs per MW can be higher by as much as 50% due to higher raw material costs. A construction company discussed raw material cost with international counterparts and estimated it to be as much as 1/3 more expensive in South Africa, with the majority of this cost pressure coming from steel, cement and transport.

The raw material most noted as cheaper to import was steel. Developers are seeking to take advantage of imported steel and aluminium which are understood to still constitute towards local content (under the RE IPPP programme).

Lack of capability in certain components

South Africa currently lacks capability in being able to manufacture certain components; some examples include:

- Receivers;
- Producing bent mirrors for parabolic trough systems; and
- Tanks, vessels, boilers, pumps and certain pipes.
SA raw material prices higher than Europe

Local companies have provided price quotes to supply seamless and spiral welded pipes for a number of CSP projects, although it appears that initial local prices without the benefit of international experience could be more than 60% more expensive compared to European equivalent products.

Competiveness with the international market is further constrained due to the small size of the domestic CSP market. Components are not unique to CSP therefore CSP component manufacturing may be a relatively small part of an international manufacturer's business. Local industry may struggle to compete with large global companies such as Siemens or GE, which can change their pricing model to achieve economies of scale. Furthermore, CSP component manufacturing factories in Spain are operating well below capacity therefore may price competitively in order to cover their fixed costs.

Developers are considering whether they should buy lower priced international products or increase local content. Some developers observed that local manufacturers may add a cost premium to their product to reflect the risk they are taking by investing in new manufacturing facilities in South Africa.

Local transport costs in South Africa were noted as being particularly high. Several interviewees noted the cost of local transport often exceeded the cost of international transport on a comparable basis. Interviewees considered transport costs to be high due to a lack of reliable rail network coupled with expensive and inefficient road freight.

Uniformity of design

The interview process highlighted that the challenge with CSP is that there seems to be no consistent design even within the same subgroup of CSP. The projects awarded preferred bidder status in South Africa are all projects with a different design and there is no certainty as to which will be the future dominant technology. Furthermore, EPC providers may wish to diversify their risk and use different suppliers for different elements of the supply chain.

This lack of economies of scale makes it more challenging for single component manufacturers. Manufacturers require fairly stable, predictable production, but fragmented demand combined with significant uncertainty creates a challenging environment for manufacturers.
1.2 Review of manufacturing capabilities and potential in South Africa

Analysis of South African CSP capabilities and potential

Certainty of roll out in CSP capacity allocation in RE IPP programme most important support measure

Required industry changes

To assess the required industry changes that may be most beneficial to stimulate the CSP manufacturing industry in South Africa, a number of interviewees were asked to rank in order of importance the following barriers:

- Uncertainty of roll out in MW capacity allocated to CSP;
- The market size of SADC for CSP;
- The market size of South Africa for CSP;
- The lack of R&D support;
- The lack of local skilled labour;
- The lack of access to capital required;
- The lack of accessible information on the CSP industry;
- Inability to compete with strength of relationships of international manufacturers with developers;
- Inability to compete with experience of international manufacturers;
- Labour cost too high to compete internationally; and
- The cost of raw materials too high to compete internationally.

The responses received include 4 developers, 3 EPC/construction companies and 11 component manufacturers.

Figure 16 demonstrates the barriers to entry which were perceived as the most important. The top four are:

- Uncertainty of roll out in MW capacity allocated to CSP;
- The market size for CSP is too small;
- Inability to compete with experience of international manufacturers; and
- Raw material cost too high.

Figure 16: Barriers to entry in the CSP manufacturing industry

Source: CSP players interviewed

Note: The brackets express the number of respondents per barrier

Uncertainty of roll out of capacity allocation under the RE IPP programme

The uncertainty of the aforementioned roll out was noted as the most important obstacle to entry for manufacturers supplying CSP components.

Nearly all interviewees noted that pipeline certainty is important to enable supply chain players to plan their investment and market strategy.

Certainty of pipeline and sufficient capacity allocation under the RE IPP programme were viewed as an imperative in order to be competitive.
CSP market size currently too small in South Africa

Internationally. This will enable players in the CSP supply chain to make the necessary investment in terms of facilities and training to achieve competence and efficient production, which should result in reduced prices for CSP components. It was quoted that "given scale and long term certainty, South Africa will be competitive with the rest of the world". Sufficient capacity allocation under the RE IPP programme will allow supply chain players to achieve production economies of scale in order to offer a competitive price.

Glass, for example, was noted to be more expensive locally than internationally due to the relatively small size of the domestic market. With pipeline visibility, its price should reduce significantly.

Gradual development of the sector through phasing of CSP plants being constructed is important so skills can be developed and a peak in job creation followed by lack of job opportunities in the industry can be avoided.

Market size too small

It was noted that although the number of projects in the pipeline is significant, the CSP allocation in South Africa is small, as stated previously.

In the SADC region, demand for power in Namibia and Botswana were viewed by most as being too small. A CSP plant of at least 50MW or 100MW is required in order to make economic sense.

One interviewee noted that although a feasibility study in Namibia concluded that there is a short term justification for 150MW CSP, the initiative has not progressed.

Offshore gas in Namibia was thought to have the potential to assist the development of CSP by way of hybridisation. Some interviewees questioned the credit quality of regional power utilities, and the impact on raising finance,

Inability to compete with experience of international players

This is a barrier for local companies entering the market as developers prefer to partner with experienced, proven suppliers/manufacturers.

One of the ways to overcome this barrier is to partner with experienced international manufacturers, EPC providers or developers.

Raw material cost too high

Certain raw materials in South Africa were seen to be more expensive than internationally, with the example most observed as being steel. It was noted by one interviewee that although steel is currently more expensive, once the market is opened up, the price may fall back.

It was observed that including the cost of transport, importing glass will still be less expensive than locally manufactured products.
CSP market size currently too small in South Africa

Support mechanisms

A number of interviewees were asked to rank, in order of importance the following potential support measures of the CSP industry:

- Certainty of level of MW roll out in the RE IPP programme;
- Local content requirements in the RE IPP programme;
- Administrative support;
- Other financing mechanisms;
- Support initiatives to promote start up enterprises;
- Loans and grants for local manufacturing; and
- Tax mechanisms.

Responses were received from 4 developers, 3 EPC/construction companies and 11 component manufacturers.

Chart 3 demonstrates the support measures which were perceived as the most important. The top three being:

- Certainty of CSP roll-out (percentage);
- Local content clauses; and
- Loans and grants.

Administrative support was not considered important evidenced by the fact that some well established players are struggling in this market but have sufficient administrative support.

Support initiatives to promote start-up enterprises were not viewed as important by the majority of interviewees. It was noted that this type of support to start-up enterprises would be insignificant unless niches are identified and it may take a long time for a new product to be bankable, therefore being a new player in such an industry is challenging.

However, the provision of skills transfer and mentoring were noted as being beneficial to start up enterprises.

Tax mechanisms were seen as a ‘sweetener’ rather than a decision making support initiative.

Other financing mechanisms were mostly ranked as of medium importance. These could include use municipality buildings (e.g. for a training centre).
Local content requirements in the RE IPP programme important to SA CSP industry

Certainty of roll out

Similar to uncertainty of roll out of MW allocation to CSP in the RE IPP programme being the most important obstacle, certainty of such roll out was described as the most important support measure.

Interviewees recognised that the South African energy environment evolves and it is difficult for DoE to give such certainty, however a strong and consistent indication of capacity roll out over the medium to long term is required to encourage local focus.

Local content requirements in the RE IPP programme

Local content requirements were seen by the majority of interviewees as very important.

It was noted that a programme has to be supported by dti. The automotive industry received dti support and this has created jobs successfully. The industry would like to see a similar support programme being applied to the CSP market.

There were a number of issues discussed in terms of local content. The concept of “local local” requirement was introduced whereby more importance was sometimes placed on job creation in the immediate vicinity of a project rather than to South Africa as a whole. This could constrain the industry if applied as specialist skills would need to be utilised on many projects to develop skills and drive efficiencies.

One of the issues mentioned was that local content requirement does not necessarily compel the transfer of skills and knowledge to local companies. It is based only on number of employees rather than skills and IP.

It was highlighted during the interview process that the requirement for local content is to be weighed up against the overall cost to the consumers in terms of the electricity tariff. If there are only a limited number of local suppliers of a component, market concentration can be created which may keep price levels high. Companies will ensure that they comply with the minimum local clause requirements, but it is often more price effective to source internationally. The consumer pays for this cost of compliance through an increased electricity tariff.

Loans and grants

Loans and grants were considered by some interviewees as important. This includes interest free loans with an obligation to repay as and when the project generates the required cash flow.

A developer noted that it had invested in a CSP design to maximise local content without financial support.

Grants were not considered by the interviewees to be as important a support mechanism as loans. Interviewees felt that grants must be conditional, for example have employment requirements or specific local targets.

Further, the type of grants to be utilised would require careful consideration. For example, large government grants in particular require some caution in terms of at what stage they are awarded (e.g. providing grants during a bidding process would provide an unfair competitive advantage).
Local content requirements in the RE IPP programme important to SA CSP industry

R&D and developing a centre of excellence in South Africa

There are a number of different areas of R&D currently in progress in South Africa as set out in Table 12.

Table 12: Current local corporate CSP R&D

<table>
<thead>
<tr>
<th>Company</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sasol</td>
<td>Thermal efficiency in receivers, heliostats, thermodynamics and storage</td>
</tr>
<tr>
<td>Robor</td>
<td>Efficiency in steel structures</td>
</tr>
<tr>
<td>BBE Energy</td>
<td>Own design and build of linear Fresnel</td>
</tr>
<tr>
<td>Bergstan</td>
<td>Hydrogen from CSP</td>
</tr>
<tr>
<td>Reutech</td>
<td>More efficient and accurate trackers</td>
</tr>
</tbody>
</table>

Source: CSP interviewees

In some areas, local companies may compete (e.g. Sasol) in R&D on an international level).

In order to benefit from R&D, South Africa would need focus on new areas rather than more established areas of R&D.

Interviewees listed other areas where South Africa can develop new technology locally including:

- Area of Tribology – developing materials for boilers so it is less corrosive. For example SA has invested in R&D for mining steel where there are similar corrosive conditions to CSP industry; and
- Support for prototypes may be useful - e.g. Earth, an R&D iron exchange company which takes the salt out of water and recombines as thermal salt.

Access to existing IP is expensive and current R&D activities in South Africa are understood to not be investigating developments in the mirror market.

R&D is further discussed in the Research and Development section of this report.

R&D funding

In terms of R&D support, incubation by large companies of small companies was perceived as being potentially very helpful as this would enable opportunities to be funded.

Supporting pilot projects by assisting in transfer of know-how, provision of land for construction site and supporting funding may be a way to enable new technologies to gain a track record. Only a few market participants will be in a position to build pilot projects on balance sheet.
Local funders strongly support CSP, although funding to CSP projects may be limited

Bankability

Local banks strongly support CSP projects, although often with a preference for more established CSP technologies. Commercial banks are most comfortable with parabolic trough due to the more tried and tested nature of this technology. Solar tower technology was viewed as being challenging for the banks to fund in Bid Window 1, although it is expected that for following projects the banks will be more comfortable once tower technology has developed more of a track record. One of the banks, which has not yet lent to a CSP project, indicated that it was supporting solar tower projects.

A number of banks are looking at linear Fresnel technology, although at this stage only with a developer with a track record and only with regards to the technology without storage.

Challenges for banks include bankability and scalability. Larger plants would require a club or consortium of banks, which provides further complexities in arranging the lending facility.

In terms of bankability, banks assess the development, construction and operational track record of the developer as well as the technology track record. One of the challenges identified by one of the banks was that reference projects and the developer track record may only relate to CSP plants of a smaller size (e.g. 30MW), whereas in South Africa they may be developing a plant of 100MW. In this instance, the bank would insist on longer manufacturing warranties and performance guarantees and strong sponsor support.

Size of market

A number of banks indicated that there is cash available in the market for CSP projects, although there was a consensus amongst some of banks that there would be a limit on funding available from local banks. This was estimated to be in the region of 100-200MW of CSP projects at any given stage. Further capacity to invest could be released by banks selling their debt, which could be at commercial operations or earlier, depending on the bank’s appetite to hold debt.

One bank indicated that it is looking for equal proportions of wind, solar PV and CSP in order to maintain a diversified portfolio of renewable energy projects.

It was noted that CSP as a technology faces funding challenges following the negative press of the increase in consumer electricity tariff requested by Eskom for MYPD3 (although a lower tariff increase was granted by NERSA); therefore it could be a challenge for CSP to establish itself compared to the current average tariff for other renewable energy technologies.

Local content

Banks are generally risk adverse when it comes to local content and would stay within the level of local content required, but support any business locally if it has a track record and works with international equipment companies setting up in South Africa i.e. some form of support from a parent company would be required to guarantee that quality is achieved and components are manufactured in a responsible and sustainable way to enable banks to take a 20 year view of the project.

CSP was viewed by one of the banks as an easy technology to reach the local content requirement through for example civil works, mirrors and storage. One of the banks noted that it would be uncomfortable with local content being used for tracking software, although this was recognised as a low proportion of the total project cost. Heat exchangers were viewed by this bank as a component which is unlikely to be manufactured locally in the short term.

It was noted that even though CSP has the highest level of local content, if only 100MW per annum is being rolled out, it would appear to be difficult to establish an industry, particularly in light of the potential size of market of other countries (e.g. Saudi’s intention to establish 25GW).
SWOT analysis

The review of the manufacturing capabilities and potential in South Africa noted a number of factors which has been incorporated in a SWOT analysis showing the country’s relative position in the international CSP market (Table 13). The SWOT analysis demonstrates that South Africa’s CSP industry has the potential to become a world leader in CSP should it take the necessary steps to address the key weaknesses and threats highlighted in this study.

Table 13: SWOT analysis of South African CSP industry

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Strong relevant industrial background (particularly in mining and petro-chemical) with transferable skills/experience/components to the CSP industry</td>
<td>▶ Relatively high costs of raw materials sourced locally (e.g. steel and glass prices)</td>
</tr>
<tr>
<td>▶ Existing local experience in developing and building large energy projects (e.g. Medupi, Kusile)</td>
<td>▶ High local transportation costs from port to site</td>
</tr>
<tr>
<td>▶ Strong and established local construction companies</td>
<td>▶ Local &amp;D in CSP may be lacking compared to international companies</td>
</tr>
<tr>
<td>▶ Local presence of a large number of CSP players already active in the CSP market</td>
<td>▶ Lack of suitably qualified skilled labour and lack of training schemes</td>
</tr>
<tr>
<td>▶ Current production of equipment (steel, pipes, trackers) is already meeting standards required by CSP projects</td>
<td>▶ Unproductive labour force, resulting in an inability for South Africa to be competitive with global players in manufacturing CSP components</td>
</tr>
<tr>
<td>▶ Significant R&amp;D activities which can support new local technology developments</td>
<td></td>
</tr>
<tr>
<td>▶ The value proposition of CSP, particularly the storage potential may give it a competitive advantage over other renewable technologies. Ongoing local R&amp;D both in the academic and corporate sectors</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ South Africa has one of the most favourable direct normal irradiation levels in the world</td>
<td>▶ South Africa fails to keep up with technological developments in international CSP market or under invests in its own R&amp;D</td>
</tr>
<tr>
<td>▶ Almost 90% of South Africa’s power is from coal fired sources (DoE), therefore large opportunity for renewable energy like CSP</td>
<td>▶ Uncertainty over the allocation of CSP under the RE IPP procurement programme</td>
</tr>
<tr>
<td>▶ CSP is a relatively new technology, therefore there may be potential advantages for “first movers”</td>
<td>▶ Low MW allocation to CSP may reduce local industry interest and reduce the potential to generate economies of scale, and compete with international players</td>
</tr>
<tr>
<td>▶ Hybridisation of CSP with future coal and gas projects</td>
<td>▶ Competition with suppliers from other countries with lower labour costs and higher labour productivity (e.g. China, India)</td>
</tr>
<tr>
<td>▶ Strong local content requirements (and targets) from Government</td>
<td>▶ Potential difficulties in obtaining finance for CSP as a relatively new technology, with financier’s potentially favouring more tried and tested renewable energy technologies (such as PV)</td>
</tr>
<tr>
<td>▶ Pipeline of projects being developed (South Africa IRP 2010 and RE IPP programme) with potential for increased allocations to CSP</td>
<td>▶ Future cost reductions in PV and other competing renewable technologies may occur at a higher rate than CSP</td>
</tr>
<tr>
<td>▶ Strong local content requirements (and targets) from Government</td>
<td>▶ Factories in Spain and other countries supply components at cost price due to lack of demand in their domestic markets.</td>
</tr>
<tr>
<td>▶ Significant increase of local content in CSP projects is feasible, with local manufacturing of components with higher economic added value (e.g. glass products, mirrors), which can generate significant economic benefits to South Africa</td>
<td>▶ High water usage, and lack of water in South Africa may reduce appetite for CSP projects (however dry cooling may mitigate this threat/risk)</td>
</tr>
</tbody>
</table>
1.3 Analysis of potential social and economic benefits of developing a CSP components manufacturing industry

1. Introduction to the modelling concept
2. Direct and indirect economic impact
3. Labour impact: job creation
Key assumptions

Overview of socio-economic analysis

Introduction to the modelling concept

This section of the report assesses and quantifies the potential socio-economic impact of a more ambitious market share for CSP in the South African renewable energy industry, including:

- Labour impact: job creation in component manufacturing, construction and operations and maintenance;
- Contribution to GDP including direct and indirect impacts; and
- Foreign trade impact.

Scenarios

Each of the above impacts has been assessed against four scenarios provided by GIZ and SASTELA (“the Scenarios”), with each scenario involving a progressively higher MW allocation to CSP (Figure 18):

- **Scenario A - IRP 2010 Scenario**: deployment of the 1GW of CSP in the IRP 2010 by 2020 instead of 2025;
- **Scenario B - Northern Cape Solar Corridor (NOCASCO) Scenario**: this scenario is in line with the 5 GW solar park/corridor under investigation by the DoE involving the deployment of 5GW of CSP in the Northern Cape by 2025 and 1GW for export to the Southern African countries;
- **Scenario C - Increased Renewables**: this scenario assumes that the Conventional Energy Options (CEO) in the IRP 2010 are not deployed and are replaced by 60% of CSP with storage alongside other renewable technologies and gas power. The scenario looks at the deployment of 10GW of CSP by 2030, 2GW hybridisation of existing coal plants with solar steam, hence reaching 12GW of capacity by 2030; and
- **Scenario D - SADC Scenario**: as per Scenario C, plus an additional deployment of 10GW of CSP power stations across the other Southern African Development Community (SADC) countries by 2040, hence reaching 12GW of local capacity and 10GW of exported capacity by 2040.

We note that the Scenarios have been provided for theoretical modelling purposes only, in order to assess the potential socio-economic impacts of progressively higher allocations to CSP.

We caution that the analysis undertaken is a fairly narrow analysis with a number of assumptions and limitations and should not be used in isolation as a basis for assessing appropriate MW allocation to CSP. The analysis should be considered in conjunction with other studies that are currently underway such as the solar park/corridor study, Eskom Green scenario and the future energy mix/alternative IRP study commissioned by the National Development Plan.

There are a number of other factors that need to be taken into account including affordability, LCOE, impact on other technologies, grid impacts etc. These could be addressed in a follow on study as outlined in the Next Steps section.

The Scenarios are used to calculate and analyse the potential economic benefit, based on an expected CSP plant life span of 25 years. It is recognised that the PPAs in South Africa have a term of 20 years, but it is assumed that the plants will continue to operate for the remainder of their economic life. We note that CSP power stations can have longer life spans of up to 60 years (similar to coal and nuclear power plants).
1.3 Analysis of potential social and economic benefits of developing a CSP components manufacturing industry

Key assumptions

Key assumptions

Ratios

Our analysis uses dynamic modelling to assess the economic effects of a growing CSP market in South Africa, with the following key inputs:

► Job creation ratios (FTE jobs per MW installed or operated);
► Contribution to GDP ratios (ZAR per MW installed or operated); and
► The learning curve of local companies in developing CSP technology is modelled depending on the annual installed capacity. This defines the local share which South African companies are able to eventually capture and is estimated based on CSP stakeholder interviews conducted by Ernst & Young and enolcon's experience in the South African CSP market.

Job creation and contribution to GDP ratios are based on widely recognised international studies on socio-economic impacts of renewable energy.  

The detailed assumptions for each of the above three categories are included in Appendix B.

Job creation ratios

Table 14 summarises the key direct job creation ratios assumed for this study together with the IDC 2011 study (note this study did not have the benefit of DoE’s job data from Bid Windows 1 and 2 of the RE IPP procurement programme), data from the first three CSP projects under RE IPP procurement programme, the MENA study and jobs estimated from the Spanish CSP industry between 2008 and 2010.

Table 14: Comparison of total direct job creation ratios for CSP (direct jobs/MW)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>This Study</th>
<th>IDC Study</th>
<th>RE IPPP</th>
<th>Spain 2008-2010</th>
<th>MENA study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology assumed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Component manufacturing</td>
<td>4.0</td>
<td>14.4</td>
<td>-</td>
<td>-</td>
<td>3.5</td>
</tr>
<tr>
<td>Construction &amp; assembly</td>
<td>20.0</td>
<td>21.6</td>
<td>9.13</td>
<td>17</td>
<td>8.7</td>
</tr>
<tr>
<td>Operations &amp; Maintenance</td>
<td>0.8</td>
<td>0.54</td>
<td>0.6</td>
<td>0.9</td>
<td></td>
</tr>
</tbody>
</table>

Source: Refer to footnotes

Note that the data above is not directly comparable as different technology mixes have been employed in some cases. For example, the Spanish data is based on jobs data for CSP plants both with and without storage (c. 70% with storage based on MW proportion) but the allocation to technology is not clear. The MENA study data and this study are comparable as they both assume 50MW parabolic trough with storage.

The construction and O&M labour assumptions for this study appear to be reasonable based on the data from Spain (considering lower South African productivity) and the labour estimates for the first three CSP projects under the RE IPP procurement programme. The component manufacturing, job creation assumption is much lower than the value included in the IDC study, but is comparable with the MENA study.

Reference plant

For the purposes of the analysis a typical 50MW, parabolic trough CSP plant with between 7 to 13 hours storage has been assumed (the “Reference Plant”). This has been chosen as a reference plant due to the availability of data for this type of plant.

References:

15 Commonwealth Scientific and Industrial Research Organisation, 2011: CSP drivers and opportunities for cost-competitive electricity

European Commission, 2009: The impact of renewable energy policy on economic growth and employment in the EU

UK Department of Renewable Energy and Climate Change, 2004: UK renewable Energy Industry Gap analysis

BERR, 2008: Supply Chain Constraints on the Deployment of Renewable Electricity Technologies

16 IDC - Green Jobs: An estimate of the direct employment potential of a greening South African economy, 2011

17 SASTELA website: “DoE says the three projects will create 1,027 construction and 120 operations and maintenance jobs”

18 Protermo Solar; Macroeconomic impact of the solar thermal electricity industry in Spain; October 2011; Sevilla, Spain

19 World Bank, – Middle East and North Africa Region – Assessment of the Local Manufacturing Potential for Concentrated Solar Power (CSP), 2011
of project, as numerous projects of this size and type have been constructed, particularly in Spain.

**Bottom up approach**

A bottom-up approach is applied, with each input above being modelled for each component of the CSP value chain. This allows identification of the direct and indirect effects (job creation, GDP impact) for each CSP related service. The share of these effects captured by local companies is applied to produce the results outlined in this section.

### Table 15: CSP value chain

<table>
<thead>
<tr>
<th>CSP service</th>
<th>Value chain component</th>
<th>Reference plant jobs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component manufacturing</td>
<td>• Collect systems (glass, mirrors)</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>• Collect systems (receivers)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Power block</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Heat Transfer System and Fluid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Support Structure and electronic</td>
<td></td>
</tr>
<tr>
<td>Construction, installation and project management</td>
<td>• Project development and management (EPC)</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>• Installation</td>
<td></td>
</tr>
<tr>
<td>Operations &amp; maintenance</td>
<td>• Operations &amp; maintenance</td>
<td>40</td>
</tr>
</tbody>
</table>

*Note that over the 25-year life of the plant, component manufacturing jobs are created over one year, construction jobs are created over 2 years, and O&M jobs are needed every year over the 25 years of the CSP plant’s life.

**Basis for calculating job impact**

Our basis for calculating the job impact is the number of total jobs that are created by the Reference Plant over the 25 year life span of the plant (Table 15).

The distribution of employment across the segments of the value chain is detailed in Figure 19.

![Figure 19: Distribution of full-time job years created by a CSP parabolic 50MW reference plant over its 25-year life](image)

When taking into account the job-years created over the 25-year life of the plant:

- **Component manufacturing** accounts for about 10% of total full time employment. The share of local companies in capturing these benefits is typically smaller than in other segments of the value chain.

- **Construction and installation of the plant** account for 45% of total full time employment.

- With a share of 45%, operation and maintenance of the plants will create jobs over a longer time period, after the initial construction of the plant. As presented further, the learning curve of South African companies could allow them to rapidly position themselves in that segment and capture its benefits.

Efficiency gains are expected to reduce job creation ratios (full time employees per MW), over time in about the same proportions as cost-efficiency gains (R per MW). Based on a study conducted by CSIRO, and referred to by the IDC in the preliminary results of its feasibility study for the establishment of a local manufacturing facility of CSP modules and components in South Africa, over time efficiency gains may decrease the cost of parabolic trough CSP plants by 41%.
1.3 Analysis of potential social and economic benefits of developing a CSP components manufacturing industry

Key assumptions

Basis for calculating contribution to GDP

Our basis for calculating contribution to GDP is the added value created by the Reference Plant, which amounts to **USD151 million** (R1.34 billion) over the 25 year lifespan of the plant. The allocation of value between local and foreign companies will depend on the capacity installed throughout any given year.

In a scenario where over 150MW of capacity is installed per year (Figure 21), the learning curve of local companies is faster, and local content of the supply chain increases, particularly in mirror manufacturing.

There is currently no mirror manufacturing facility in South Africa. Based on our interviews with local glass manufacturers, 20% of the mirror’s value could be produced locally in a medium capacity scenario (50MW to 150MW of installed capacity). One interviewee stated that at a threshold level of 150MW, investment is likely to increase, allowing local manufacturing of the entire mirror.

Component manufacturing accounts for over 50% of total contribution to GDP. Despite its low job-creation potential, component manufacturing will be a key aspect of South Africa’s long-term strategy for high-skilled employment and high value-added industrial output.

Construction accounts for 36% of total contribution to GDP. This constitutes a robust foundation for both job creation and GDP contribution through CSP projects.

Post construction, the share of contribution to GDP from O&M accounts for only 11%. This segment is the least challenging to capture for local companies, as the learning curve is typically fast, with the possibility to handle nearly 100% of operations as soon as 2015, though some project management jobs will remain with foreign companies.
1.3 Analysis of potential social and economic benefits of developing a CSP components manufacturing industry

Introduction to the modelling concept

Key assumptions

Assumptions on local content
It is assumed that 100% of O&M activities will be handled locally. For component manufacturing and construction & installation, the local share may depend on the capacity installed in any given year. Figure 22 presents the variation of local content in different installation scenarios.

In a Medium Capacity Scenario, 50% of total contribution to GDP is captured by local companies, whereas in the High Capacity Scenario, this share increases to 70%.

Based on local stakeholder interviews, it is assumed that 70% local content is the maximum local share achievable.

Linking back to the four scenarios provided by the terms of reference:
- Scenario A: with about 100 MW installed each year up to 2020, roughly corresponds to the “medium capacity” scenario;
- Scenarios B, C, and D: over 150 MW of capacity is installed each year starting in 2019; all three cases correspond to a “medium capacity” scenario up to 2018, and enter the “high capacity” scenario starting in 2019.

The following table presents a summary of job creation potential for each segment of the value chain, and achievable local shares based on our analysis of local capabilities.

Table 16: Summary of job creation potential of CSP parabolic technology

<table>
<thead>
<tr>
<th>CSP service</th>
<th>Total job creation potential (50 MW reference plant)</th>
<th>Local share in medium capacity scenario (50 to 150 MW installed per year)</th>
<th>Local share in high capacity scenario (over 150 MW installed per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM: mirrors</td>
<td>25 FTE over one year</td>
<td>20%</td>
<td>100%</td>
</tr>
<tr>
<td>CM: receivers</td>
<td>27 FTE over one year</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>CM: power block</td>
<td>22 FTE over one year</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>CM: HTF and Fluid</td>
<td>54 FTE over one year</td>
<td>29%</td>
<td>44%</td>
</tr>
<tr>
<td>CM: support structure and electronic</td>
<td>72 FTE over one year</td>
<td>92%</td>
<td>92%</td>
</tr>
<tr>
<td>CIM: project management and development</td>
<td>145 FTE over two years</td>
<td>18%</td>
<td>85%</td>
</tr>
<tr>
<td>CIM: installation</td>
<td>355 FTE over two years</td>
<td>78%</td>
<td>89%</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>40 FTE every year of operation</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Figure 22: Local value-added shares in different scenarios for CSP parabolic technology

Note in the above graph, the following applies to the growth scenarios:

- Low Capacity Scenario: < 50MW installed per year;
- Medium Capacity Scenario: 50 to 150MW installed per year; and
- High Capacity Scenario: over 150MW installed per year.
Narrow socio-economic analysis applied with a number of limitations

Limitations of analysis

It should be noted that as the socio-economic analysis in the next section analysis is a macro analysis, it is fairly narrow and theoretical with a number of typical inherent limitations to such a macro socio-economic analysis. The key limitations are as follows:

- Full time employment ratio assumptions are considered the same for all technologies (solar tower, parabolic trough and linear Fresnel);
- Efficiency gains in labour modelled are assumed to be in the same proportions as efficiency gains on cost;
- GDP contribution ratios considered to be the same for all technologies (solar tower, parabolic trough and linear Fresnel);
- Impact of exports only applies to component manufacturing services (no export of construction services);
- Efficiency gains not modelled post 2017, after which time, costs are assumed to remain constant;
- Local content estimates are based on interviews conducted with local stakeholders; and

- A number of further factors have not been considered (e.g. impact on tariff, affordability, LCOE, impact on other technologies, grid impacts) as this is a limited scope assessment. These could be addressed in a follow on study as outlined in the Next Steps section.

The feasibility of the Scenarios has not been considered, including development pipeline required in South Africa or appetite for CSP projects in other SADC countries. The Consultant was not commissioned to consider the feasibility of the Scenarios, as these scenarios are based on various planning scenarios contemplated by stakeholders and policy makers. The Consultant provides recommendations in the Next Steps section of this report in terms of development of scenarios for recommendation in the next IRP revision in addition to assessment of the impact of tariff, affordability and LCOE impact.

As such the results should be interpreted with these assumptions and limitations in mind.
1.3 Analysis of potential social and economic benefits of developing a CSP components manufacturing industry

CSP could result in around R105 billion direct contribution to GDP, cumulated over the life span of projected CSP plants under the 12GW by 2040 scenario (SADC Scenario)

Analysis outputs

Contribution to GDP results

Effects on direct and indirect contribution to GDP are calculated in absolute numbers for each scenario. In addition to local manufacturing of components and construction of the plant, O&M will also significantly contribute to the economic impact of CSP plants in South Africa.

Local economic impact is calculated for each of the Scenarios by a model which integrates the growth of the local share and market size over time.

All investments in components and services by local companies and international companies producing locally are included in the local impact. The contribution to GDP for CSP plants is derived in three different ways:

- **Direct** economic effects related to construction of new power plants;
- **Indirect** effects from demand in the supply value chain and are assumed to be equivalent to 90% of direct effects; and
- **Induced** effects arising from consumption effects due to increased wealth, assumed to be equivalent to 25% of direct and indirect impacts.

Local economic effects are modelled for each of the Scenarios, as presented in Figure 23 for the peak year in terms of activity.

Estimates for contribution to GDP (value added) were calculated in USD, according to international costing benchmarks and studies which are most often stated in USD, and allowed the modelling of a reference plant.

USD also allows the illustration of the value of South Africa’s CSP project's in international markets. For conversion into the Rand, we have assumed a foreign exchange rate of ZAR/USD 8.8 (February 2013).

Contribution to GDP over the entire life-span of the installed plants (25 years) shows similar proportions between the Scenarios.

Figure 23: Value-added by local companies in the scenario’s peak year (year with highest value-added)
1.3 Analysis of potential social and economic benefits of developing a CSP components manufacturing industry

CSP could result in around R105 billion direct contribution to GDP, cumulated over the life span of projected CSP plants under the 12GW by 2040 scenario (SADC Scenario)

In Scenario D (22GW by 2040), with significant capacity installed and fast learning curves assumed, contribution to GDP over the life-span of the project amounts to USD12 billion (R105 billion), nearly two and a half times as much as Scenario B (6GW by 2025). This significant variation is mainly due to the large gaps between the scenarios in MW allocation and in the growth of the component manufacturing segment. This is the segment which has the highest potential to move South Africa up the international value chain.

Furthermore, additional induced economic impacts may be created when investment in CSP takes place in a given region. Induced impacts result from an increase of wealth and income that create increased demand for services and products. Significant induced impacts are added to calculated direct and indirect effects, but these are generally difficult to assess accurately.
1.3 Analysis of potential social and economic benefits of developing a CSP components manufacturing industry

Labour impact: job creation

Potential of over 900,000 job-years under the 12GW by 2040 scenario (SADC Scenario)

Job creation results

The results of the job creation analysis are provided in three different categories:

► **Direct job creation** during CSP plant construction;

► **Indirect job creation** arising from demand in the supply chain (e.g. the plant maintenance and replacement of components and equipment has an indirect impact on new jobs); and

► **Induced job creation** are modelled to account for effects such as training needs for employees or consumption of goods and services on working sites. New jobs in construction and O&M will have an impact on induced jobs in the region.

The assumptions adopted for the indirect and induced CSP jobs are as follows:

► For every direct full-time job in South Africa: 0.9 indirect full-time jobs and 0.25 induced full-time jobs are created; and

► For every indirect full-time job in South Africa, 0.25 full-time jobs are induced.

The difference in job creation potential between Scenarios C (12GW by 2030) and D (22GW by 2040) is minimal, since the difference between the two scenarios is only the additional exported capacity in Scenario D.

Export activities boost manufacturing services in the value chain, which improves contribution to GDP but yield little additional local labour.

Job creation in manufacturing operations appears low, with a total of about 2,100 local full-time jobs in 2030. However, manufacturing operations in that year represent 50% of total economic contribution to GDP, due to the highly skilled nature of those services. Construction and installation services will yield the most benefits for South Africa up to 2030, with 88% of local market share achieved and relatively strong labour intensity and high contribution to GDP.

Post 2030, O&M activities will continue creating a significant amount of employment, until the total installed capacity of CSP starts declining around 2045.
1.3 Analysis of potential social and economic benefits of developing a CSP components manufacturing industry

Labour impact: job creation

Potential of over 900,000 job-years under the 12GW by 2040 scenario (SADC Scenario)

Figure 28 shows the product of jobs and years employed (“job-years”) for each scenario.

The local manufacturing of CSP components can push the local manufacturing of other products and create an attractive income to the local industry if the products are sold on the global CSP market.

Induced jobs

Figure 28: Full-time employment created for local companies over the 25-year life-span of the CSP plants

In Scenarios C (12GW by 2030) and D (22GW by 2040), nearly 400,000 direct job-years can be expected, which is two and a half times the local job-creation potential of Scenario B.

Scenario B partly relies on:

- High exports, with minimal job creation potential; and
- Minimal construction and O&M activities, which are labour-intensive.

In addition to these direct and indirect impacts, CSP plants offer the opportunity for South Africa to attract more jobs for highly skilled workers. By creating a skill enhancement programme for local workers, sustainable development of the region can be reached within the next years, especially in Scenarios C and D.

The cooperation with international firms in the energy sector will open further business opportunities to South Africa, which can lead to additional economic benefits.
1.3 Analysis of potential social and economic benefits of developing a CSP components manufacturing industry

Trade deficits generated by the growth of CSP capacity are compensated by stronger positive economic impacts

Results of foreign trade impact assessment

The foreign trade impact on the South African trade balance is obtained through integrating the evolution of local share, installed capacity and exported capacity over time, and applying a discount rate of 5%.

Although O&M activities are assumed to be undertaken completely by local companies (100%), a sizeable share of manufacturing and construction services will have to be imported, as previously demonstrated in Figure 20 and Figure 21.

There is no exported capacity in Scenarios A and C. Scenarios B and D include exported facilities, which respectively cumulate to 1GW and 10GW. This exported power capacity boosts South African CSP manufacturing services, especially mirrors, heat transfer systems and fluids, and support structure and electronics that have a high share of local content. On the other hand, some imports remain necessary for manufacturing and construction services.

As shown in Figure 29, South Africa’s trade balance in Scenario B remains in deficit, as exports do not fully compensate imports.

In Scenario D, a positive trade balance is achieved starting in 2030. Post 2030, local installation of CSP capacity ceases, as well as imports. Only operations and maintenance services remain, which are delivered locally.

Export capacity, however, continues growing in Scenario D, reaching a cumulated 10 GW of exported capacity in 2040. In the period 2030-2040, South Africa can rely on its strong experience in manufacturing services, acquired between 2013 and 2030, to export CSP capacity to other SADC countries on a large scale.

These results are finally compared with the total contribution to GDP to the local economy, including direct, indirect and induced effects, over the full life-span of CSP installations. Trade deficits are balanced against stronger positive economic impacts in Scenarios A, B, and C. Trade surplus is achieved in Scenario D.
Trade deficits generated by the growth of CSP capacity are compensated by stronger positive economic impacts

CSP trade surplus represents 14% of contribution to GDP in Scenario D.

Trade deficit represents:
- 34% of total added-value in Scenario B, where 1GW of exported capacity is achieved;
- 43% of total added-value in Scenario C; and
- 81% of total added-value in Scenario A.

The results above demonstrate the role CSP exports and increasing local content plays in driving a trade surplus for South Africa from the CSP industry.
Part 2
2.1 Current support measures and their potential adaptation

1. Local content requirements
2. Considerations for the RE IPP procurement programme
3. Current financing support measures
Increasing the RE IPP procurement programme local content requirements over time

The South African Government has promoted high participation of local industry in CSP projects by introducing local content thresholds and targets in the RE IPP procurement programme. Local content requirements vary by technology and have increased with every Bid Window. The target levels are in most cases higher than requirements issued for CSP tenders in other countries (Morocco requested a 30% local content level for Ourzazate phase 1).

Table 17: Local content targets per Bid Window

<table>
<thead>
<tr>
<th>Technology</th>
<th>Bid Window 1</th>
<th>Bid Window 2</th>
<th>Bid Window 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold</td>
<td>Target</td>
<td>Threshold</td>
<td>Target</td>
</tr>
<tr>
<td>CSP without storage</td>
<td>35%</td>
<td>50%</td>
<td>35%</td>
</tr>
<tr>
<td>CSP with storage</td>
<td>25%</td>
<td>45%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Source: Request for Qualification and Proposals for New Generation Capacity under the IPP Procurement Programme, Briefing Note 8, 2 February 2012, Department of Energy

Although, local content clauses are an effective instrument to stimulate industrial integration, international experiences and feedback from local industrial companies indicate that the impact of using this lever should also be considered. The requirement for local content is to be weighed up against the overall cost to consumers in terms of the higher electricity tariff.

A high local content requirement at the early stages of market deployment is likely to raise the project costs due to the relatively high prices of raw materials and equipment in South Africa. For some components, there are only a limited number of local suppliers, which may keep price levels high.

The local interview process highlighted that companies will ensure that they comply with the minimum local content requirements, but it is often cheaper to source materials and components internationally.

A number of CSP industry players consider that the local content targets specified in the RE IPP procurement programme are technically achievable, but will generate adverse effects on the electricity tariffs bid. A decrease in local component costs due to the effect of scale will take time to materialise and therefore there are concerns regarding the additional “cost” of local content in the short to medium term.

A further issue highlighted during the local interview process was that local content requirement does not necessarily compel the transfer of skills and knowledge to local companies, as it is based only on number of employees rather than skills and IP.

It is recommended that local content levels are assessed in light of local CSP projects constructed (e.g. via monitoring of local content) and local industry development and global market prices.

Table 18 provides estimates of the local content levels which could be theoretically achievable over time, based on available information.

Table 18: Local content estimations theoretically achievable over time based on available information

<table>
<thead>
<tr>
<th>Technology</th>
<th>Scenario C&amp;D</th>
<th>Scenario B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scenario A</td>
<td>Final stage</td>
</tr>
<tr>
<td>Timelines and Milestones</td>
<td>Initial stage</td>
<td>2013</td>
</tr>
<tr>
<td>Cumulated installed Capacity</td>
<td>200 MW</td>
<td>1000 MW</td>
</tr>
<tr>
<td>Parabolic trough with storage</td>
<td>27-30 %</td>
<td>50-53 %</td>
</tr>
<tr>
<td>Parabolic trough without storage</td>
<td>30-32 %</td>
<td>52-55 %</td>
</tr>
<tr>
<td>Linear fresnel* with storage</td>
<td>n.a.**</td>
<td>50-60 %</td>
</tr>
<tr>
<td>Linear fresnel* without Storage</td>
<td>30-35 %</td>
<td>50-60 %</td>
</tr>
<tr>
<td>Solar tower with Storage</td>
<td>25-27 %</td>
<td>52-55 %</td>
</tr>
<tr>
<td>Solar tower without Storage</td>
<td>27-29 %</td>
<td>54-57 %</td>
</tr>
</tbody>
</table>

* Due to the short track record, of Linear Fresnel, wider ranges of estimation are required.
** Linear Fresnel with storage is not yet built on a commercial scale.
Theoretical local content levels achievable may increase significantly over time and at higher levels of MW roll out

This technical analysis does not take into account market factors such as higher steel prices or import restrictions and is based on the cost breakdown presented in Part 1. This calculation includes a number of assumptions:

- Initial stage (Current): Construction works, assembly of support structure and piping, minor parts of the project development are performed locally;
- First stage (2020): The support structure, flat mirrors, BoP for power block and storage, parts of the HTF system (thermal oil based systems) are performed locally;
- Second stage (2025): Bent mirrors, the complete HTF system, main parts of the project development and EPC are also performed locally; and
- Final stage (2035-2040): All parts are produced with a high local content (>90%) other than the power train (turbine and generator) and the solar salt (parabolic trough and solar tower).

Specific assumptions have also been used in the case of linear Fresnel:

- Initial stage (Current): Linear Fresnel with storage is not commercially available.
- Final stage (2035-2040): For linear Fresnel without storage, only lower local content levels achieved are limited to 75% as the remaining 25% are related to the cost share of the power block.

It is assumed that the storage system for linear Fresnel is not based on solar salt and could therefore be produced with a high local content (>90%). Based on technical complexity and the high price for solar salt, it is assumed that other storage concepts will enter the market and will be used at first in linear Fresnel systems with direct steam generation.

Table 19 provides an overview of potential cost impacts on CSP components for local content requirements depending on the MW roll out scenario. This analysis does not relate to the impacts on the Levelised Cost of Electricity (LCOE) produced by the CSP plants but focuses on impact of selected capex components. These results indicate that:

- In Scenario A, increasing local content has either a neutral or negative effect on costs, as volumes are insufficient to generate scale effects, while domestic prices for raw materials and labour push prices up.
- In Scenarios B, C and D, other than for technology intensive components such as curved mirrors and receivers, prices of components sources locally could follow a downward trend in relative terms. This is explained by higher volumes which allow for automation of manufacturing processes and other industrial improvements, scale effects and a growing network of suppliers which could in turn result in increased competition in the domestic market.
- In Scenarios C and D, increasing the scale of the market deployment allows South Africa to benefit from R&D and training efforts, which would have been carried out in the initial years.
Theoretical local content levels achievable may increase significantly over time and at higher levels of MW roll out.

Table 19: Impact of increased local content levels on costs of CSP components

<table>
<thead>
<tr>
<th>Segment / Key components</th>
<th>South African potential for cost reduction</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil works</td>
<td>Scenario A: lower labour cost versus higher training effort.</td>
<td>Scenarios B, C, D: assumes experienced workers</td>
</tr>
<tr>
<td>Mounting structures</td>
<td>Must overcome higher steel price in the first Scenarios, due to higher automation production methods in higher Scenarios, higher cost reduction potential</td>
<td></td>
</tr>
<tr>
<td>Flat mirrors</td>
<td>Requires investment in R&amp;D and training, “paid out” within the higher Scenarios</td>
<td></td>
</tr>
<tr>
<td>Curved mirrors</td>
<td>Requires high investment in R&amp;D, production lines and training, most likely paid pack in Scenarios C&amp;D</td>
<td></td>
</tr>
<tr>
<td>Receivers</td>
<td>Requires high investment in production lines and training, expensive raw materials</td>
<td></td>
</tr>
<tr>
<td>Trackers, Electrical Systems</td>
<td>Side market for existing companies</td>
<td></td>
</tr>
<tr>
<td>EPC</td>
<td>Lower risks due to local experience, EPC providers still to gain own experience in Scenario A</td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>R&amp;D required, new storage concepts could reduce the costs dramatically</td>
<td></td>
</tr>
</tbody>
</table>

- Negative impact on cost reduction, increasing costs
- No impact on cost reduction
- Positive impact on cost reduction
- Significant positive impact on cost reduction
Current support measures can be utilised to further develop the local CSP supply industry

Considerations for the RE IPP procurement programme

The RE IPP procurement programme is considered to be a world class procurement programme. In order to utilize an effective structure to develop the local CSP supply industry, the following aspects of the RE IPP procurement programme could be considered:

► Local content requirements could be further specified in order to ensure that specific areas which are considered to have a sufficiently sized and capable local market have higher thresholds (e.g. civils, balance of plant).

► Further clarity and detail around the definition of local content and monitoring and evaluation were identified by some interviewees as a useful addition to the programme.

► The dti could provide upon request a reference list of local suppliers for products and services related to the development, construction and operation of CSP projects.

► Specific local requirements targeting the services sector, where use of local engineering services could be an area of focus as international companies tend to outsource detailed engineering to India or other locations where hourly rates for engineers are lower than in South Africa.

► Gradual development of the sector through phasing of CSP plants being constructed is important so skills can be developed and a peak in job creation followed by lack of job opportunities in the industry can be avoided. This will become important only at higher levels of CSP roll out (Scenarios C and D).

Current financial support measures for industrial development

A number of financing instruments have already been set up by the dti to support the installation of new manufacturing plants and the extension or upgrade of existing plants.

The key instruments include:

► The Manufacturing Investment Programme (MIP), which is a reimbursable grant for local and foreign owned manufacturers who wish to establish a new production facility; expand an existing production facility; or upgrade an existing facility.

► The Technology and Human Resources for Industry Programme (THRIP), a partnership programme funded by the dti and managed by the National Research Foundation (NRF). THRIP supports science, engineering and technology research collaborations focused on addressing the technology needs of participating firms and encouraging the development and mobility of research personnel and students among participating organisations.

► The Foreign Investment Grant (FIG) compensates foreign investors for costs incurred in moving qualifying new machinery and equipment from abroad to South Africa.

► The Support Programme for Industrial Innovation (SPII) is a support programme of the dti, managed by the Industrial Development Corporation (IDC). The SPII is designed to promote technology development in industry in South Africa through the provision of financial assistance for the development of innovative products and/or processes. The SPII specifically is essentially focused on the product development/demonstrator phases.

► The 12i Tax Incentive is designed to support Greenfield investments (i.e. new industrial projects), as well as Brownfield investments (i.e. expansions or upgrades of existing industrial projects). The new incentive offers support for both capital investment and training.

► The Manufacturing Competitiveness Enhancement Programme (MCEP) is a recent incentive programme that was developed in order to induce firms to upgrade their production facilities, process, products and people. The MCEP combines various existing programmes with new or enhanced support.
A local facility may be built as a result of a specific CSP project, depending on the component and manufacturers.

**IDC facilitation in the CSP supply chain**

The glass facility being constructed in Upington for the Abengoa Round 1 projects is an example of industrialisation as a result of a specific project. The facility is employing international knowledge from Rioglass and using PFG to silver the mirrors locally. It is funded in part through a working capital facility provided by IDC and in part by the glass companies. The facility may be used in the future to supply other local plants with mirrors.

A similar model could be set up for other CSP components, depending on the manufacturers and CSP component.

CSP components were viewed by IDC as having a higher potential for localisation if the CSP components:

- Can be used in different CSP technologies (e.g. collectors, mirrors, piping);
- Can be used in different industries (e.g. trackers); or
- Require less of an upgrade to existing facilities (e.g. flat mirrors requires less investment than curved mirrors which would require a substantial investment).

Following IDC’s experience, it is of the view that the local manufacturer would most likely need to partner with an international player to access the technology and IP. In order for the international manufacturer to be willing to participate in such an arrangement, it would need to meet business requirements for example additional capacity.
2.2 Action plan to develop the region's potential in CSP components manufacturing

4. Identifying CSP component opportunities
5. Roadmap for the production of CSP mirrors
6. Roadmap for the production of CSP mounting structures
7. Roadmap for the production of other CSP components
Identifying key opportunities

Local industrial integration can be achieved in South Africa in specific phases of the commissioning and operation of a CSP plant in the short to medium term (3 to 5 years). A local solar industry can be developed through South African companies or through the creation of new local activities through foreign investments, in particular through joint ventures (JV). The main opportunities for local industrial integration have been presented in detail in Part 1 of this study. These findings imply that given South Africa’s strong industrial basis, a number of components required by CSP projects can already be sourced locally. An overview of the potential for local integration for the main segments of the solar CSP value chain is presented below.

This table provides an indicative ranking for the relevant segments of the CSP value chain, based on two sets of criteria:

- The first set of criteria is related to the strengths of the local industries (for each segment), in terms of experience, quality of output in comparison to solar standards, investment capacity, etc. These criteria are summed up in an aggregated qualitative assessment of the barriers facing each industry in order to penetrate the solar market.
- The second set of criteria is focused on the attractiveness of the market for each segment, in terms of domestic market perspectives, capacity to export to other markets, opportunities for partnership with international companies, and potential for job creation.

### Figure 32: Barriers to entry and market attractiveness for CSP segments

<table>
<thead>
<tr>
<th>Segment</th>
<th>Output quality vs solar requirements</th>
<th>R&amp;D potential</th>
<th>Investment requirements</th>
<th>Cost competitiveness potential</th>
<th>Barriers for penetrating solar market</th>
<th>Expected penetration on the domestic solar market</th>
<th>Export potential in nearby markets</th>
<th>Job creation potential</th>
<th>Partnership opportunities (JV)</th>
<th>Overall attractiveness of market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil works</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Mounting structures</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Flat mirrors</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Curved mirrors</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Parabolic Trough Receivers</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Secondary components</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>EPC</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Storage</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>
2.2 Action plan to develop the region’s potential in CSP components manufacturing

Identifying key CSP component opportunities

Identifying CSP market segments which offer the most relevant opportunities for South Africa

The rankings obtained by each segment in Figure 33 have been plotted in the chart below.

The key actions going forward will involve training, awareness raising for entrepreneurs, and to some extent investments in order to upgrade the quality of the products. Some, CSP specific components such as flat mirrors could also be manufactured in South Africa in the short term, depending on the scale and pace of the market development.

Group 2 – JV/technology transfer (3 – 5 years). For the CSP components in this group, the market potential is significant and the technical or investment barriers are unlikely to be addressed in the short term.

In order to develop local manufacturing activities, segments included in this group will require financial support as significant investments are needed, in addition to training and capacity building, as well as technology transfer. This group includes components where South Africa could develop a local industry if the market uptake is sufficiently strong.

Key measures to implement relate to attracting foreign investment so as to benefit from joint-ventures which will provide technology transfer and capital. Developing research programmes will also be critical for this group, especially in areas such as storage where South Africa could catch up with international R&D.

Group 3 – Long term opportunities (> 5 years). For these components, the investment required as well as the global market dynamics are unfavourable in the short to medium term. The segments covered here are usually capital intensive and require high annual MW output per year. However, this does not rule out the possibility that potential joint-ventures could also be set up for these segments.

Development opportunities for local firms are not limited to supplying industrial equipment, but may also lie in the service activities, such as:

- Project development of large-scale solar plants;
- EPC contractors: the leading EPC contractors will need to have experience in assembling similar CSP plants in order to deliver the contract and to provide comfort to developers. Local companies will be required to carry out the construction of the plant but will not have the ability to undertake such contracts in the short term. Partnerships with international EPC contractors could allow local EPC contractors to build up sufficient experience over a
2.2 Action plan to develop the region’s potential in CSP components manufacturing

Identifying key CSP component opportunities

Identifying CSP market segments which offer the most relevant opportunities for South Africa

number of projects should they be exposed to all areas of the project construction.

- O&M players: Local companies may progressively provide O&M services, although in the first few years these are likely to be local subsidiaries of international firms with experience in operating large scale solar plants. Partnerships with international players and transfer of know how during the initial projects will allow local companies to accelerate their learning curve. For example, turbines are currently not produced locally, but could be serviced in South Africa. Turbine suppliers could get incentives for local service or if local components are part of the assembly package.

Review of global market trends for manufacturing CSP components

The current CSP components manufacturing market is small due to the limited scale of the CSP market (less than 3 GW globally). The manufacturing capabilities are essentially located in a small number of countries:

- Germany, which hosts a large share of the technology suppliers (components and systems);
- The USA, which has hosted the first large-scale projects and where a number of technology developers are based;
- Spain, where a large number of projects have been implemented, approximately 2 GW of installed capacity, and where industry leaders such as Schott have installed manufacturing plants; and
- Israel, where several components have been developed by companies such as Solel/Siemens and Ormat.

Recently, a number of new locations have been identified for CSP component manufacturing, such as Italy, Portugal (where Saint-Gobain Solar has implemented a parabolic mirror factory), France and Japan, as well as emerging CSP markets such as India and China. In India local industrial development is to a large extent related to local content rules and is not targeting export markets.

These developments indicate that as an emerging industry, the CSP market holds opportunities for new entrants. It also points to the fact that carefully selecting market segments where South Africa has either differentiating factors or strong assets is key to penetrating international markets and/or competing domestically with global players.

In order to achieve this, several component specific roadmaps have been outlined and presented in the next sections. These roadmaps cover CSP components for which short term opportunities have been identified (mounting structures, secondary components, and flat mirrors) as well as some components for which local manufacturing is a long term possibility in order to demonstrate the variances in actions for the short and long term opportunities.
CSP mirrors: building a robust project pipeline to attract foreign investment and achieve full local content in the long term

Current status

As described in Part 1; companies active in the supply of mirrors for the solar field will often be based in the conventional glass industry, for example companies such as Flabeg, Saint-Gobain Solar and Rioglass. An emerging CSP market will give them the potential to diversify their market depending on their ability to produce high quality mirror products (i.e. low iron glass).

Although South Africa currently does not have the local capacity to produce solar quality flat mirrors or bent mirrors for parabolic trough, it does have a significant local glass industry which supplies the building and automotive industries. Demand for locally produced glass has recently reduced due to the economic slowdown affecting the building and automotive industries and an increase in the volume of competitively priced imported glass.

As stated previously, barriers facing the development of locally manufactured CSP mirrors include:

► Difficulty in supplying low iron glass locally at a competitive price. The high iron content of raw materials found in South Africa requires additional iron extraction costs which international players may not be subject to;

► Lack of demand in the local market which has not been able to generate economies of scale. There is no local capability to bend glass and silver bent glass to the specification required for parabolic trough CSP plants. Silvering capabilities locally consist of only one glass producer being able to silver flat glass only.

► Glass is one of the more specialist logistics areas in the CSP supply chain due to the requirement for careful transportation and handling on site. There are only a handful of companies in South Africa which have the capability to transport glass.

Roadmap for the production of CSP mirrors

Local glass producers have indicated that they would only be willing to invest if there is certainty of orders of a reasonable scale, for example if CSP allocation in the RE IPP programme was 150MW per year. One international player indicated that its threshold would be in the region of 400MW per year in order to justify investments in new manufacturing capabilities. These levels are related to the initial investment costs as most of the specialist equipment for a factory would need to be imported to ensure sufficient quality for a product which would need to last for 30 years. As labour costs are more expensive than the costs in Europe (due to lower productivity, lower skill levels of South African labour), there is little reason why a factory would be set up in South Africa unless local content requirements and specific incentives were driving the decision.

The basic conditions are promising, because the glass industry is already present in this region and raw materials are easily available. A key condition for the production of mirrors for CSP technologies is the availability of production lines for low iron glass with required reflectivity for CSP, of which there are currently no such production lines in South Africa. The economic viability of a low iron glass production activity will strongly depend on the market demand for such glass in South Africa.

As a second step, new production lines for linear or bent mirrors need to be established. This could be accomplished through joint ventures with international companies experienced in mirror production for CSP plants, or by setting up new mirror production lines of South African companies, possibly accompanied by acquiring licenses for this technology. From South Africa’s perspective, a joint venture is more favourable than direct investments of international companies since this is usually linked with a more intensive know-how transfer, which may lead to a more independent evolution of the industry. Depending on how the CSP market develops in South Africa and globally, this would also facilitate the establishment of independent CSP mirror companies in South Africa in the medium and long term.

From a technology perspective, the first step for existing glass companies in South Africa interested in adapting production lines to produce glass for CSP applications is to develop new, or enhance their present, capacities of float glass production. The glass plants for CSP applications could be set up in already operating conventional plants which only need to adapt the glass production lines. South Africa should coordinate and exploit its local advantages. For example, glass plants for CSP applications could be set up in already operating conventional plants which only need to adapt production lines.

Based on these measures, further steps can be taken in the mid-term towards producing flat and parabolic mirrors for CSP plants. Flat mirrors for solar tower plants or slightly bent mirrors for linear Fresnel are easier to produce because...
they do not require a bending process. This energy intensive and sophisticated step is only necessary for the curved mirrors of parabolic trough plants and the degree of precision here has a decisive influence on the later effectiveness of the whole plant. Upgrading conventional mirror production lines to produce such precisely bent CSP mirrors requires a considerable amount of capital. It should therefore be considered that the decision regarding which mirrors should be produced in South Africa depends on which CSP technologies are awarded PPAs and the MW allocation to CSP in this region.

In addition to the necessary capital required to set up highly automated plants for the coating and bending processes, a comprehensive transfer of know-how is required. In particular, this is the case for the bending of CSP mirrors for which only a few companies can handle the necessary precision and scale. Knowledge transfer can be achieved by acquiring licenses for CSP mirror production within a joint venture. Experienced companies can also contribute their experience in the adaptation of CSP mirrors to the special environmental conditions in coastal regions, where the mix of salt spray and sand dust in the air complicates mirror cleaning and reduces the effectiveness of CSP plants. R&D efforts in this sector might be undertaken in cooperation with international companies and research institutions but might also be realised independently by South Africa.

Assuming a very favourable market development and the strong promotion of applied research in the field of CSP in South Africa, it is thus conceivable that the country could develop its own technology for products specifically tailored to its conditions. Furthermore, future technical advances, such as reflectors made of alternative materials like polymers or aluminium as well as front-surface or thin glass mirrors could possibly be developed further and customised to the needs of South Africa in the long term. However, these are currently research topics in countries with experienced research institutes and CSP industries like Spain, the United States or Germany.

In summary, if a sufficient volume of CSP plants are constructed in South Africa in the near future, there is potential that mirrors can be sourced from domestic companies, particularly flat mirrors. In addition to the technical and knowledge barriers presented above, the risk perception from the financiers of the project will also lead to having joint-ventures (or a mix supply) in the first years.

Figure 34: Roadmap for the production of CSP mirrors

- Nation-wide clear political goals regarding industrial policy; focused support for industrial development of CSP mirror industry
- One or two large suppliers of white glass and several mirror manufacturers in South Africa produce highly precise CSP reflectors at a competitive price
- Mirrors for all types can be supplied by local manufacturing plants (plus export)
CSP mirrors: building a robust project pipeline to attract foreign investment and achieve full local content in the long term

Evolution of local content

In this study, several scenarios of South African CSP market development and cumulated capacity. As a reminder, these scenarios are presented below:

- **Scenario A - IRP 2010 Scenario**: deployment of the 1GW of CSP in the IRP 2010 by 2020 instead of 2025;
- **Scenario B - Northern Cape Solar Corridor (NOCASCO) Scenario**: this scenario is in line with the 5 GW solar park/corridor under investigation by the DoE involving the deployment of 5GW of CSP in the Northern Cape by 2025 and 1GW for export to the Southern African countries;
- **Scenario C - Increased Renewables**: this scenario assumes that the Conventional Energy Options (CEO) in the IRP 2010 are not deployed and are replaced by 60% of CSP with storage alongside other renewable technologies and gas power. The scenario looks at the deployment of 10GW of CSP by 2030, 2GW hybridisation of existing coal plants with solar steam, hence reaching 12GW of capacity by 2030; and
- **Scenario D - SADC Scenario**: as per Scenario C, plus an additional deployment of 10GW of CSP power stations across the other Southern African Development Community (SADC) countries by 2040, hence reaching 12GW of local capacity and 10GW of exported capacity by 2040.

As this analysis focuses on the development of local content by the year 2020, the evolution of cumulated CSP capacity in Scenarios B, C, and D is similar in this timeframe, as illustrated in Figure 35. In these three scenarios, an annual threshold of 200MW of installed capacity is reached, while Scenario A remains at 100MW of installed capacity per year.

The information gathered from interviews with local and international players reveals that below the annual 200MW threshold (Scenario A), local content share remains limited to 20%. However, once this threshold is reached, local content can rapidly reach 80%, with a mix of “pure” local production and joint ventures.

Figure 35 illustrates this distinction, with the evolution of local production in the different scenarios.
Mounting structures: ramp up existing national know-how within the steel industry

Current state

As described in Part 1, the majority of the steel required for CSP plants is sourced from local steel suppliers and fabricated to the required specifications.

The main local companies, with technical competencies in producing a wide range of steel include Evraz Highveld, Arcelor-Mittal as well as Cape Gate. The current decline of demand for steel in South Africa has led many steel producers to have surplus capacity.

Roadmap for the production of CSP mounting structures

Steel companies in South Africa have acquired technical competencies in producing a wide range of steel products, often responding to high quality requirements (for example from the mechanical industry, aeronautics, defence sectors, etc.). In this context, local manufacture of mounting structures for CSP plants seems achievable in the short term and the potential roadmap for the production of these elements is presented in Figure 36.

As components for the support structures are not specific to CSP, local companies which are active in steel manufacturing and semi-finished products could in the short-term supply them independently. The majority of projects submitted in the first rounds of the RE IPP procurement programme have sourced steel locally.

For parabolic trough, the designs of the steel construction and the mirrors are connected, therefore in the short term it appears necessary to acquire innovative designs for mounting structures through buying licences from foreign steelmakers. International EPCs may not wish to share the designs of their mounting structures with local suppliers if they have no previous strong relationship due to IP concerns.

Due to the current economic downturn resulting in overcapacity in the industry, existing facilities can produce sufficient volumes, regardless of the CSP market development scenario. For instance, the production capacity of one of the interviewed companies alone could meet the needs for the installation of 1GW installed capacity per annum. The foundation of a joint venture or the establishment of a local subsidiary by a foreign company appears unlikely, due to the already large local production capacity and labour-intensive (non automated) production. Joint Ventures are better suited to more automated, capital intensive sectors.

The main issues facing the increase of local manufacturing of steel structures for CSP projects are price competitiveness and the know-how and intellectual property aspects for supplying support structures.

In terms of pricing, domestic steel faces strong competition from imported steel. Interviewees have indicated that in some cases steel for CSP or PV applications is currently offered at a discounted price compared to steel for other applications.

Additional training and skills development would also appear necessary to ensure the high quality of the mounting structures and to gain greater experience in innovating techniques.

The assembly of support structures is expected to be carried out locally using steel components manufactured in South Africa. However, some EPCs may prefer in the short term to rely on their historic suppliers in order to avoid taking any perceived risks on quality and on the timely delivery of quantities purchased. Building relationships with local suppliers will take time and will require collaborative approaches with the supply chain players. For example, training courses of limited duration could already transfer the basic knowledge on single process steps in mounting structure manufacturing. This could form part of a technical assistance programme for companies deciding to upgrade their manufacturing facilities.
2.2 Action plan to develop the region’s potential in CSP components manufacturing

Mounting structures: ramp up existing national know-how within the steel industry

Assuming an extensive expansion of CSP capacity in South Africa and strong promotion of R&D activities in this field, the local industry could in the long term develop mounting structures with technical improvements and the use of alternative materials specifically adapted to local conditions and available resources. Realising this potential will require a stable and long-term policy framework for CSP providing visibility on the market development for steel producers in order to invest in CSP. To some extent, similar products will also supply the PV and CPV markets.

If the market uptake is to be further incentivised, investment support mechanisms will be useful in order to support suppliers in upgrading their manufacturing plants, for example in the form of reimbursable technical assistance, concessional loans, etc.

In summary, there is an achievable potential for South African companies to provide and assemble complete mounting structures of high quality for all CSP technologies at a competitive price in the short and medium term. Exporting mounting structures to nearby markets might even be realisable in the long term depending on the scale of market deployment.

Evolution of local content

Based on interviews performed with steel producers present in South Africa, local content share can reach 90% in the short term, as the market is currently experiencing over capacity. However, it would remain limited to this level at best in the medium term regardless of the Scenario, provided incentive mechanisms are provided to steelmakers for expanding production capacities. The remaining 10% is likely to remain out of reach for local companies, due to the requirement to purchase licences for designs from foreign companies.
2.2 Action plan to develop the region’s potential in CSP components manufacturing

Roadmap for the production of other CSP components

Investing in other CSP components where South Africa can build comparative advantage in the mid-term

Roadmap for the production of CSP parabolic trough receiver tubes

According to the stakeholders interviewed, providing the receivers (absorber tubes) for parabolic trough technology in South Africa is theoretically feasible in the long term, but seems unlikely in the short term.

The CSP receiver tubes market is controlled by three main global suppliers with factories in Germany (Schott), Israel (Siemens) and China (Huiyin), Schott is the leading supplier with approximately 75% of the global market share. There is currently no South African production capability and no local company holds intellectual property rights in this field or has experience in producing this component. The complexity of the production processes involved makes local production unlikely. The possible development shown in the roadmap in Figure 37 is consequently limited.

In the short or medium term, setting up joint ventures with one of the three main global suppliers is the only realistic option to establish manufacturing capacities in South Africa. These could be set up with the intention to supply a regional export market in the longer term in addition to other countries in the Southern hemisphere.

Previous experience with other markets in Spain and the USA shows that two conditions are required for such production facilities to develop: a robust market deployment (several receiver tube manufacturers consider that a threshold of 400MW of installed capacity per year is required to justify a manufacturing plant) and strong Government commitment to local content rules. Without a sufficiently sized domestic or regional market, receivers will be imported as setting up a local manufacturing plant would not make economic sense.

In the medium term, several sub-components could be assembled locally. However, it is questionable whether local suppliers would be able to deal with the quality issues without prior knowledge transfer from the current market leaders. Considering the lack of experience and intellectual property in such an advanced field, it is unlikely that receiver manufacturing will develop independently in South Africa.

Therefore, a strong focus on early R&D appears to be required in order to ensure future development of local technical expertise. This will require identification of local research facilities, e.g. universities and technology clusters, and strong cooperation with international companies and experienced research facilities.

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Roadmap for the production of other CSP components

<table>
<thead>
<tr>
<th>Overall goals</th>
<th>Short term</th>
<th>Mid term</th>
<th>Long term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology development</td>
<td>Universities and other research facilities lay focus on fundamental research in CSP receiver technologies</td>
<td>New production facilities for CSP receivers are set up and necessary skills transferred</td>
<td>Local metal-working companies meet the pipe production quality required to provide receivers production facilities</td>
</tr>
<tr>
<td>Business development</td>
<td>Subsidiaries set up by foreign company (Schott, Siemens/Solel or Huiyin)</td>
<td>Transfer of intellectual property rights</td>
<td>Strong R&amp;D efforts with focus on advancements in receiver technology</td>
</tr>
<tr>
<td>Policy and market development</td>
<td>Coordinated training of employees and applied research on CSP receivers in ongoing CSP projects</td>
<td>Facilitation of foreign direct investments</td>
<td>Growing export of CSP receivers</td>
</tr>
<tr>
<td></td>
<td>Coordinated national strategies for industrial development defined</td>
<td>Long term visibility on market deployment</td>
<td>Creation of R&amp;D competencies clusters</td>
</tr>
</tbody>
</table>

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Figure 37: Roadmap for the production of receivers

- Receiver tubes for all Parabolic Trough plants in South Africa are supplied by companies with production facilities based locally. Export is possible.
- Future registration of patents in the field of CSP receiver technology.
- Nationwide clear political goals in terms of industrial & foreign investment policy.

June 2013
2.2 Action plan to develop the region’s potential in CSP components manufacturing

Investing in other CSP components where South Africa can build comparative advantage in the mid-term

Roadmap for construction, civil work and EPC services in CSP projects

Services associated with the construction of CSP plants can bring significant local value creation. South Africa can rely on a substantial, well established construction industry capable and ready to carry out CSP civil works. CSP projects share many similarities with power plant projects currently being constructed in the country (e.g. Medupi and Kusile).

The sector consists of several major construction companies (Murray & Roberts, Group 5, Aveng Group, Basil Read and WBHO) which often work with local partners and subcontractors. Most of these companies see CSP as a valuable business opportunity that may require more civil works than any other renewable energy sectors due to the need for a large amount of concrete and steel structures. Although some assembly work might require international supervision, most construction companies are confident in their ability to undertake CSP works with local resources (piping and electrics, civil works, engineering, assembling the solar fields if proper supervision is ensured by foreign partners). Companies also expressed their interest to invest in further skills development provided that long term visibility is ensured.

Figure 38 introduces a roadmap for the field of EPC. In the short-term, local companies will carry out assembly and logistics under supervision of experienced international EPC (Engineering, Procurement, and Construction) contractors. Once they have access to local players, international EPC contractors may be able to help them in becoming more competitive on price, hence driving local prices down.

After a period of international supervision, operational support and training, local service providers should gain expertise and may be in a position to master the entire value chain for future CSP projects, including EPC services. A considerable amount of work can typically be done locally, with over 90% of the workforce expected to be local workers, and less than 10% supervisors, who are likely to be foreign specialists. These supervisors could identify talented individuals and train these workers to become the new supervisors and trainers. Training could also take place in locations where construction companies already have a base (e.g. in Upington). Construction companies could push their local contractors to take advantage of a national subsidy by training youths in semi-skilled work and thereby reducing the contractor’s labour costs.

Roadmap for the production of piping components in CSP projects

As described in Part 1, there are minor components of CSP plants which might easily be supplied by local South African companies because the country has already developed production facilities and technological know-how in these fields. An example of such secondary components is piping installation.

There is no large technology step expected in these “secondary industries” as it is assumed that only smaller adjustments to production lines and technical skills are necessary to supply CSP components. Production upgrades might however be necessary to supply larger volumes if the market grew strongly or for export.
2.2 Action plan to develop the region’s potential in CSP components manufacturing

**Investing in other CSP components where South Africa can build comparative advantage in the mid-term**

Piping is supplied in South Africa mainly to the mining, logistic, petrochemical, building and construction, engineering, manufacturing, energy and power, water and automotive industries.

The piping in CSP plants consists of both low and high pressure pipes. The high performance alloy material required for the high pressure pumps can be supplied by only three companies globally.

The type of piping required for CSP projects will depend on the design of the plant and could be spiral welded pipes (used for example on parabolic trough) or seamless pipes.

Most local companies focus only on spiral pipes (e.g. transportation of water). The specifications for these pipes are different to that of CSP. In addition, there is currently a high demand for these products, therefore less of an incentive to supply the CSP market. The thin walled piping (centre pipe/torque tube) required in parabolic troughs is an unusual product in the South African market and requires special engineering to meet the low tolerances required in CSP designs.

It was nevertheless identified that there are a number of local suppliers that are able to fabricate the required steel structures consistent with the standards required by an international EPC provider. However, an international player indicated that there was a local capacity constraint with galvanising tanks for the length of torque pipes required. A further problem is that there are no galvanising facilities in the Northern Cape where CSP projects are located. A potential solution proposed was that the international player provides the equipment and the local piping company provides the training.

### Roadmap for the production of other CSP components

<table>
<thead>
<tr>
<th>Overall goals</th>
<th>Short term</th>
<th>Mid term</th>
<th>Long term</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology development</strong></td>
<td>Local companies reserve production capacities for the supply of piping for CSP plants</td>
<td>Piping for all CSP plants in South Africa is supplied by local companies</td>
<td>Secondary components are provided for CSP projects outside of South Africa</td>
</tr>
<tr>
<td><strong>Policy and market development</strong></td>
<td>Market development of CSP allows to invest in a new spiral mill to supply the CSP industry and upgrade infrastructure</td>
<td>Companies enhance their production capacities for the supply of a growing number of CSP projects</td>
<td>Favourable investment climate (financing schemes, etc.) for industrial development</td>
</tr>
<tr>
<td><strong>Long term visibility on market deployment</strong></td>
<td>Coordinated national strategies for industrial development defined</td>
<td>Availability of training centers/programmes and well trained workforce</td>
<td>Various existing South African companies develop specialized divisions for CSP piping</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Focused support for industrial development of CSP secondary industries including specific funding of small-scale and medium enterprises</td>
</tr>
</tbody>
</table>

Figure 39: Roadmap for piping
2.3 Research and development

1. R&D current activities– international and local
2. Potential support measures for R&D
Research and development

Background

Research & Development (R&D) is a crucial aspect for technological progress which may enable the local CSP industry to compete on an international basis.

Local technology knowledge can be developed through local R&D performed in public R&D institutes or private companies, or it can be developed through knowledge transfer by partnering with international companies. Both of these routes are important ways of developing the local technology know-how.

Local R&D may result in South Africa, in the medium to long term, positioning itself as a frontrunner in selected R&D areas, whereas partnering with international players enables transfer of knowledge in the shorter term (e.g. over a handful of projects).

The focus of R&D activities of companies active in the CSP industry in recent years has mainly been in relation to:

- New plant concepts;
- Technological development of the solar field; and
- Improvement of plant design processes and component manufacturing processes.

Technology research institutes in the United States, Germany and Spain have been involved in most commercial technology developments. This technology transfer from institutes to the industry typically occurs through the following steps:

- Founding of new companies from institutes’ staff (e.g., Novatec Biosol, Concentrix Solar or PSE from Fraunhofer ISE, CSP services from the DLR);
- Industry recruits employees from institutes to build up a high-skilled labour force of engineers and project developers (there are several examples from R&D institutes to the majority of CSP companies);
- Licensed production of components (e.g., tower technology by DLR commercialized by Kraftanlagen München);
- Development of materials/components for the industry (e.g., absorber coating of Schott developed by Fraunhofer ISE); and
- Testing of components for the industry (e.g., testing of the Eurotrough collector on Plataforma Solar de Almería by CIEMAT and DLR, receiver testing of Novatec by Fraunhofer ISE).

The market growth in these mature markets has increased the demand for well trained staff (who are often trained in the leading research institutes) to construct, operate, and maintain CSP power plants.

Table 20 lists the key international research institutes which conduct CSP related research. Typically, these institutes cover other industries and the wider renewable energy sector in addition to specific CSP R&D.

Table 20 Key international R&D institutes conducting CSP R&D

<table>
<thead>
<tr>
<th>Institute</th>
<th>Country</th>
<th>Source of funding</th>
<th>Research area</th>
<th>Key factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>German aerospace center (DLR)</td>
<td>Germany</td>
<td>Public and private funded</td>
<td>Wide range of research (e.g., aerospace, transport, etc)</td>
<td>- Early focus on CSP technology (end of ‘90s)</td>
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<td></td>
<td></td>
<td></td>
<td>Focus on energy, particularly renewable energy</td>
<td>- Wide range of applications and test facilities</td>
</tr>
<tr>
<td>National Renewable Energy Laboratory (NREL)</td>
<td>United States</td>
<td>Public</td>
<td>Focus on renewable energies</td>
<td>- Cooperation with other research institutes</td>
</tr>
<tr>
<td>Frauenhofer society</td>
<td>Germany</td>
<td>Public (~30%) and private (~70%) funded</td>
<td>Divided in several nearly independent institutes. several institutes are focused on solar energy and CSP</td>
<td>- Technology transfer with partners from the industry</td>
</tr>
<tr>
<td>Tekniker</td>
<td>Spain</td>
<td>Private non-profit organization</td>
<td>Research centres of manufacturing technologies and automation within different research areas. One area focuses on renewable energies</td>
<td>- Innovative (basic) research resulting in patents and licenses</td>
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<td></td>
<td>- Cooperative research</td>
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<td>- Close to industrial needs</td>
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<td>- Development in the loop with industrial partners</td>
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<td></td>
<td>- Technology transfer from and to the industry</td>
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<td>- Support for the industrial sector by generating and applying technology</td>
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<td></td>
<td>- Transfer of experience from other industrial sectors</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Huge national network with industrial partners</td>
</tr>
</tbody>
</table>
Research and development

Local R&D institutes

Table 21 outlines the main local CSP institutes which are involved in conducting CSP R&D or could be involved in funding CSP R&D.

Table 21: Main current and potential CSP R&D players in South Africa

<table>
<thead>
<tr>
<th>Institute</th>
<th>CSP R&amp;D role</th>
<th>Current CSP focused research</th>
<th>Current funding</th>
<th>Future funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>SANEDI</td>
<td>Funder of CSP R&amp;D</td>
<td>Coordination and collaboration of CSP R&amp;D</td>
<td>Public</td>
<td>Public</td>
</tr>
<tr>
<td>University of Stellenbosch</td>
<td>Conducting CSP R&amp;D</td>
<td>Predominantly solar tower technology but also linear fresnel and parabolic dish</td>
<td>Public and private</td>
<td>Public and private</td>
</tr>
<tr>
<td>CSIR</td>
<td>Conducting CSP R&amp;D</td>
<td>Solar tower and the application of synergies with other industries</td>
<td>Public (~30%) and private (~70%)</td>
<td></td>
</tr>
<tr>
<td>TIA</td>
<td>Potential funder of later stage CSP development</td>
<td>Innovation and development agency for the Department of Science and Technology providing funding for proven R&amp;D</td>
<td>Public</td>
<td>Private</td>
</tr>
<tr>
<td>Private sector</td>
<td>Conducting CSP R&amp;D</td>
<td>Various R&amp;D including trackers, molten salt</td>
<td>Private</td>
<td>Private</td>
</tr>
</tbody>
</table>

CSIR is a Government agency, reporting to the Department of Science and Technology (DST). CSIR is the only multi-disciplinary, multi-sector government science council and the largest multi-disciplinary R&D organisation in Africa, with ca. 2400 staff, of which 1550 are in the Science, Engineering and Technology (SET) base. The CSIR mandate states: "The objects of the CSIR are, through directed and particularly multidisciplinary research and technological innovation, to foster, in the national interest and in the fields which in its opinion should receive preference, industrial and scientific development, either by itself or in cooperation with principals from private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic of South Africa".

University of Stellenbosch is one of the larger South African universities. In 2008, it was awarded the responsibility to act as the national hub of a Postgraduate Programme in Renewable and Sustainable Energy (RSE) Studies by South African National Energy Research Institute (SANERI) and the Centre for Renewable and Sustainable Energy Studies (CRSES) was set up.

The overall objective of this initiative is to develop and enhance national capacity in renewable and sustainable energy in support of accelerated and shared economic growth. This will be achieved by building human resource capacity, creating and disseminating knowledge, and by stimulating innovation and enterprise in the field of renewable and sustainable energy. Subsequently, SANERI (reporting to both DST and DoE) became the South African National Energy Development Institute (SANEDI), the R&D arm of the DoE. Although a relationship with SANEDI still exists, CRSES reports directly to DST.

SANEDI recently established the Renewable Energy Centre of Research and Development (RECORD) to co-ordinate renewable energy research in South Africa, facilitate renewable energy research collaboration, contribute to renewable energy skills development, support renewable energy business development, renewable energy awareness creation, and standards development and technology evaluation.

Funding of CSP R&D

CSIR, for its entire field of operations, receives 30% of its funding from Government, with the remaining 70% being raised privately through collaboration with the private sector. Solar funding has historically been internally funded within CSIR, predominantly due to the speculative nature of the CSP industry, which makes it more challenging to secure funding from the private sector.

The University of Stellenbosch is funded through DST-NRF (human capital development support), Sasol (senior researcher and specific projects) and Eskom (research chair). Approximately 95% of the funding for the next two years is expected to be provided by these three sources. The grants received allow the University to determine in which areas the funding is spent. Funding received to date is likely to be sufficient until a pilot project and R&D facility are built at which point additional funding will be required.

SANEDI receives funding from the Department of Energy which is allocated across all portfolios. This funds the day to day operations of SANEDI, but funding from other sources is required for specific R&D initiatives.

DST commissioned the CSIR to run a multi-stakeholder process to develop a strategy for a Solar Energy Centre of Competence in 2009, and four documents were delivered to DST in 2010, including a baseline study, a technology roadmap, a feasibility study and a business proposition. This set of documents is being used
Research and development

in a combined DST and DoE process, the Solar Energy Technology Roadmap (SETRM), which is planned to be completed by end 2013.

The DST has a mandate to fund solar research, but DST funding for solar research is considered unlikely prior to the completion of the SETRM.

CSP R&D by component

This section seeks to identify which areas South Africa could focus on to become competitive with the international R&D CSP players by outlining the key R&D areas by CSP component both internationally and on a local level.

Solar field

A number of international R&D efforts on solar field technology are in progress (Table 22). Most of these consist of relatively mature technology where only minor improvements are expected to be made by experienced R&D players.

Local R&D in relation to the solar field includes the development of heliostats by both the University of Stellenbosch and CSIR. The University of Stellenbosch has looked at the target-aligned concept.

There are some specific areas within the solar field that have higher R&D potential, including new concentrator concepts (e.g. non-glass based mirrors) and tracking systems.

Drivers and tracking systems play a significant role in order to raise the accuracy of the reflector system. Research activities in relation to drivers and trackers in the U.S are ongoing. As the solar tower becomes a more popular choice of CSP technology, tracking is likely to become a more important R&D focus area as it could provide substantial cost reduction potential.

The University of Stellenbosch has a demonstrated tracking system through its small prototype system which it is scaling up to “full scale” for smaller CSP plants with private funding from Sasol in 2013 ahead of seeking funding for a pilot plant in 2014.

Storage

Storage has high R&D potential as relatively limited R&D has been conducted to date, with the only commercially available proven storage being molten salt. Table 23 provides an overview of the current international R&D storage system activities.

Given the immaturity of R&D in the CSP storage system, this provides a significant opportunity for South Africa to compete with the international R&D players, particularly in relation to advanced material and improve efficiency.
Storage system R&D\textsuperscript{20} is mainly focused on the improvement of the operational behaviour and the connection between plant and storage to achieve higher efficiencies.

Thermal storage is not only related to CSP and there are several other applications within the energy market (e.g. industrial applications or conventional power plants) where these systems can be used\textsuperscript{21}, providing additional markets for developers of thermal storage systems.

Table 23 International R&D-activities Storage System

<table>
<thead>
<tr>
<th>Technology</th>
<th>Development status</th>
<th>Drivers</th>
<th>Example</th>
<th>SA potential (required skill)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage systems</td>
<td>Technology</td>
<td>Improvements to the current molten salt systems (efficiency and operational concepts),</td>
<td>Sener: One tank system (Thermocline), implementation of first pilot plant</td>
<td>High (process engineering)</td>
</tr>
<tr>
<td></td>
<td>development</td>
<td>Three Tank systems: Basic research and first development of technology, especially for systems with direct steam generation</td>
<td>DLR: Technology development on PCM, basic research on thermo-chemical systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>STORASOL: Pilot plant for rock based storage system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 23 International R&D-activities Storage System

Storage material -pilot systems

- Increase of storage density: Basic research on phase change material (PCM) and thermo-chemical systems
- Cost reduction: pilot systems with cheap materials

- DLR: Technology development on PCM, basic research on thermo-chemical systems
- STORASOL: Pilot plant for rock based storage system

- High (process, chemical and mechanical engineering)

for developers of thermal storage systems.

Local R&D in relation to storage is ongoing, including a number of alternatives to molten salt such as packed bed and sodium potassium. Packed bed has the potential to store heat of up to 600 degrees Celsius and includes substances such as rock or ceramics packed together with hot air being channeled through the packed substances.

Packed bed is a focus area for the University of Stellenbosch, which is exploring the storage of exhaust heat at about 600 degrees Celsius from a gas turbine topping cycle at atmospheric pressure in a rock bed, for re-use in a steam turbine bottoming cycle. CSIR is exploring pressurised packed bed storage to store high temperature (800 - 1000 degree Celsius) for use in a gas turbine topping cycle. The research rig has been taken to 1000 degree Celsius several times without incident.

The University of Stellenbosch is also conducting research on sodium potassium storage; however this is less of a focus area due to the dangerous and volatile nature of sodium potassium.

HTF

Table 24 R&D-activities HTF system

<table>
<thead>
<tr>
<th>Technology</th>
<th>Development status</th>
<th>Drivers</th>
<th>Example</th>
<th>Required skills</th>
<th>SA potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature ranges</td>
<td>Mature technology</td>
<td>Efficiency: Higher temperature ranges, thermal stability of thermal oil, Lower temperature ranges for molten salt systems</td>
<td>SQM / DLR: Research on salt composition to achieve lower solidification temperatures</td>
<td>Chemical and process engineering</td>
<td>Low</td>
</tr>
<tr>
<td>Direct steam generation</td>
<td>Technology</td>
<td>Ball joints, durability under high pressure, Dynamic effects of saturated steam, controllability, Efficiency: superheated steam</td>
<td>Novatec /Areva- Ausra: Superheated steam with linear Fresnel DLR: Direct steam generation in parabolic trough</td>
<td>Process, control and power plant engineering</td>
<td>Medium</td>
</tr>
</tbody>
</table>

R&D in HTF focuses on temperature ranges of the fluid or on steam generation (Table 24).

Research on increasing the upper temperature limit for HTF is currently the largest focus area. This includes the use of molten salt as HTF which offers some advantages compared to thermal oil, including:

\textsuperscript{20} Querol, 2012

\textsuperscript{21} Schicktanz, 2012
The upper temperature range is higher resulting in a higher efficiency of the whole system; and

There is no need for an additional heat exchanger to the thermal storage, resulting in lower costs for the HTF system.

The use of molten salt as an HTF does however introduce technical challenges, for example reduction of the solidification point of the salt. This incorporates a range of required R&D including material science and mechanical engineering.

**Hybridisation**

Hybridisation is the combination of a solar thermal system with a conventional power plant system. There are currently two technologies for which pilot plants have been constructed namely, Integrated Solar Combined Cycle (ISCC) and the integration into coal fired power plants. The solar hybridisation of coal and gas fired plants offers many options, such as for new power plants, as add-on to existing plants, and as coal savers or boosters.

There may be some opportunity for South African R&D in terms of integration of the solar boiler into the conventional boiler and operational concepts such as the operation of the solar thermal plant as a fuel saver.

The integration of solar thermal applications for new build coal and gas fired plants offers opportunity for a wide range of development of innovative solutions.

**Dry cooling application in CSP**

This is considered an important topic of R&D for South Africa due to the expectation that CSP plants in South Africa will require a dry cooling facility.

A reduction in the amount of water necessary for the operation of a CSP plant is one key factor for the successful development of a CSP industry. To avoid the utilisation of water in a conventional “wet cooling” plant air cooled condensers are used, although this results in a loss of efficiency. This technology is proven and mature in conventional power technology, although R&D efforts are needed to adapt this technology to the particular requirements of CSP.

**Industrial applications**

There are several areas where CSP systems can be combined with existing technology or installations, including the installation of CSP to cover heat demand required in industry. In this example, technology using waste heat from a power plant to increase the productivity of a copper mine could be incorporated using CSP as the heat source.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Development status</th>
<th>Drivers</th>
<th>Example</th>
<th>Required skills</th>
<th>SA potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISCC</td>
<td>Pilot systems</td>
<td>- Integration into existing power plants - Hybridising of solar gas turbines</td>
<td>Kuraymat (Egypt) Combined cycle with a solar field totaling an overall capacity of 140MW with 20 MW of solar. Similar projects are located in Algeria and Morocco</td>
<td>Power plant and process engineering</td>
<td>Medium</td>
</tr>
<tr>
<td>Integration into coal fired plants</td>
<td>Technology development</td>
<td>- Integration of solar thermal applications in the existing power plant pool - Different applications like operation as fuel savers or by providing additional energy</td>
<td>Liddell (Australia) 9 MW Linear Fresnel pilot plant is integrated into a coal fired plant</td>
<td>Power plant, High process and mechanical engineering</td>
<td>High</td>
</tr>
</tbody>
</table>

The University of Stellenbosch is conducting research on the industrial application of linear Fresnel. This is expected to be applied where heat is required in industry (e.g. mine shaft air conditioning through the use of chillers). The University is also performing R&D for the augmentation of coal plants using CSP.

CSIR has been performing work in thermal desalination for a client. It has also actively pursued a project in the solar melting of scrap/ingot aluminium for foundries with DLR for two years.

R&D in tracking systems is driven predominantly by the private sector and makes use of the synergies between the mining and CSP industries. Currently local technology is being implemented in a Bid Window 2 CPV project.

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22 Stuckenbrock, 2012
Technology centres

Technology may be developed through the private sector working closely with R&D institutes, for example in relation to the testing of CSP technologies (e.g., the solar tower in Jülich (Germany) and the Plataforma Solar de Almería (PSA) in Spain). Standardised testing and monitoring procedures for installed solar fields are pushed forward on an international level, mainly by research institutes (e.g. NREL and DLR).

Spain has created technology centres that facilitate the development of R&D in the country.

► Plataforma Solar de Almería (PSA): This is the largest research and test centre in the world devoted to CSP technologies (solar thermal and concentrating photovoltaic). Its budget is based on public funding (e.g. EU or national R&D programmes) and on research contracts with the industry.

► Centro Nacional de Energías Renovables (CENER): This is a technology centre specialised in applied research, development and promotion of renewable energies. Research and consulting related to CSP is done in a separate department. CENER is supported by different ministries of the Spanish government.

The work of the Spanish universities which pioneered CSP in Spain and developed the main CSP technologies forms the basis for the technology centres. The exchange between these universities, the research centres and international universities is an important factor for innovation.

Regional centres of excellence in South Africa

A regional centre of excellence model recognises where R&D is already taking place and may be funded through a combination of the public and private sector. For example, RECORD is setting up a solar centre of excellence, the Centre for Solar Technology and Development Innovation (CSTDI). This includes plans for a solar tower to be constructed at the CSIR. The solar tower will be a national multifunctional centre that will provide research facilities for academics and private companies which may include industries such as desalination, aluminium smelting, process heating, carbon capture, storage heat and solar fuels.

The gas turbine for the pilot solar power station has already been purchased. The preliminary design of 3-hour thermal storage system has been performed. The CSIR-owned land for the field was surveyed and the German Aerospace Centre (DLR) designed a field layout for this project using the CSIR 13m² target-aligned heliostat design.

Funding for the facility has not been secured and it is expected to be a combination of funding from government and the private sector.

The University of Stellenbosch has plans to set up a solar tower based on its scalable prototypes, which have been proven on a small scale on the University’s rooftop. Funding for this project is expected to come from the private sector.

A national technology centre in South Africa

The Technology and Innovation Agency (TIA) provides funding for post proof of concept to assist with the development and commercialisation of a new concept. Through collaboration with SANEDI the concept of a central CSP R&D technology centre (similar to the PSA in Spain) was considered for South Africa, which would enable components to be tested in isolation without the requirement for an entire pilot plant.

However, a national centre such as this is estimated to require significant funding and the expected timeline of completion of a new centre could be post 2020. Specific CSP R&D is therefore being incorporated into regional existing facilities.
Research and development

R&D framework

This section seeks to identify how R&D can be enhanced, for example through specific initiatives. The approach adopted is to identify the key success factors based on a successful international programme in the European Union (EU).

EU Framework Program for Research and Technological Development

A wider exploitation of renewable energy sources is a key priority for the EU. As a result, the EU has been supporting the CSP sector for more than fifteen years. This effort has enabled research in CSP technologies and allowed the EU to maintain and develop the knowledge stock (human capacity) in CSP technologies in both the public and private sector.

Support to the CSP sector is largely provided from the EU Framework Programs (FP) for Research and Technological Development. The FP bundle research-related initiatives together, which plays a crucial role in reaching the goals of growth, competitiveness and employment.

- The Fourth Framework Program (FP4, 1994-1998) and the Fifth Framework Program (FP5, 1998-2002) co-financed R&D activities related to the CSP technology with €22 million. CSP demonstration activities were funded with additional €15 million under FP5.

- The Sixth Framework Program (FP6, 2002-2006) provided a total funding of €10.7 million. The PS10 (solar tower) and the Andasol-1 (parabolic trough) were among the projects which received additional EU funding. Funding was also provided for example in the areas of direct steam generation, solar hybrid gas turbines, dish technology and solar chemistry.

- The Seventh Framework Program (FP7) will last for seven years (2007–2013) and has a total budget of over €50 billion, a substantial increase compared with the previous Framework Programs. There are currently nine ongoing R&D projects in the CSP sector with a total EU funding of €30.8 million. Further projects are in the pipeline, with expected starts in 2013, so the overall budget related to CSP will further increase.

Horizon 2020 will be the EU Framework Program for Research and Innovation and will last for seven years from 2014 until 2020. The current proposal foresees a budget increase of 40% with respect to FP7 (above €80 billion). Renewable energy technologies have the chance to receive a significant share. The key factors which make the FP successful are outlined below:

- **Long term horizon**: The main topics of the FP, the budget and the boundary conditions are set for a long period (minimum 4 years).

- **Adaptation to local needs**: The specific “calls” for projects within the main topics of the FP can be adapted to local needs or current research results.

- **Increase in funding**: Based on the development state of a technology, the required amount of funding is increased. Within the different framework programmes, this trend is clearly observed for the CSP industry.

- **Co-financing**: The FP7 is divided into several sections with different funding concepts. Besides the fully public funded basis research area, the main part (e.g. the funding for demonstration plants) of the programme is co-funded by the public (EU) and the private (industry) sector. The share of the public funding depends on the development state of the technology. If the technology has not proven its applicability, the main share must be provided by the public sector. If practicability is proven (e.g. with a prototype), the public share could be reduced. With proven bankability (e.g. with first commercial projects), the whole share of further development could be provided by the private sector.

National R&D Programme Chile

Chile has one of the most favourable DNI values of the world at a level slightly higher than the South African DNI values. The Chilean resources of salt, required for the molten salt storage systems provide the country with an excellent starting point for CSP.

In order to build the first CSP plant, the Government launched in March 2013 a project funded by a combination of funds from the Chilean government and international entities. To support the realisation of the plant, Chile’s Ministry of Energy will provide a grant of up to US$20 million. The aim of this project is to support the cooperation between a local project developer and an international company that will build the first Chilean CSP plant.
Research and development

Over US$ 350 million of financing capital is provided by the government and global organisations in order to generate the required conditions to make CSP a viable technology in Chile.

This initiative is part of a long term program (Chile’s National Energy Strategy for 2012-2030) focusing on the support of renewable energy sources.

Technology transfer is one key factor of the national programme, supported by the construction of the first CSP plant. The national programme should therefore contribute to innovation in Chile and help to create necessary local capacities.

Funding R&D- Spain

In economic terms, the R&D effort in the CSP sector over recent years reached a total amount of more than €48 million in 2010\textsuperscript{23}.

This amount represents 2.9 % of the total contribution of the CSP industry to the GDP. This contribution is slightly above the average contribution to R&D in Europe.

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\textsuperscript{23} Protermo, 2011
Potential R&D support measures – R&D institutes view

R&D institutes noted that further funding assistance to support CSP R&D would require:

► Energy research policy with identification of a common goal (i.e. the solution to a current problem that Government is facing);
► Clear guidelines as to what needs to be achieved to obtain funding and funding paid out on achievement of those goals;
► Decision makers to understand CSP is an important technology as SA could potentially become a leader in R&D due to the infancy of the technology; and
► Appropriate Government funding to be allocated to CSP in order to realise its value (e.g. an R&D institute observed that funds allocated to CSP are approximately 1% of the funding allocated to nuclear).

R&D institutes believe that the following support measures would be useful to ensure continued funding for CSP R&D:

► **Certainty of MW roll-out**: Uncertainty of CSP MW roll out makes it difficult to secure R&D funding.
► **Certainty of funding** will drive research as researchers are able to plan more effectively.
► **New sources of funding**: This could include for example collaboration with international development agencies can further unlock funding.

The importance of collaboration was highlighted during the interview process as it was noted that research is currently segmented - national collaboration would help focus CSP R&D on one goal.

Due to the uncertain nature of CSP, collaboration with the private sector in existing markets is useful in assisting the development of CSP technology (e.g. the launch customer of the heliostat field for a research institute is expected to be an aluminium smelter).

![Figure 41: Private sector view of potential R&D support measures](image)

**Potential R&D support measures – private sector view**

The interview process included the private sector’s view of support measures for commercial R&D. Interviewees were asked to rank in order of importance the following potential support measures:

► **Improved dialogue and cooperation with local universities to develop the interest of the academic sector into CSP and spark vocations among future engineers**;
► **Support of scientific research in cooperation with CSP plants or component factories to improve processes, analyse modern technologies and develop know-how**;
Research and development

- Common training for staff in components factories and exchange of experiences; and
- Initiation of innovation networks between companies with CSP-related production and manufacturing.

The responses received include 3 developers, 4 EPC/construction companies and 9 component manufacturers (Figure 41).

Improved dialogue and cooperation with local universities

This was noted as an important factor not just in the CSP industry but also the broader renewable energy industry. There are limited local universities which offer renewable energy specific courses, which would be one way to promote skills development and increase productivity in the sector.

Several interviewees highlighted that there is an opportunity for South Africa to become a global leader in certain aspects of CSP R&D due to the infancy of the industry and various different levels of maturity of CSP R&D.

Improvement of communication between universities and collaboration of universities’ research was viewed by interviewees as having the potential to produce more focused research relevant to the local CSP industry, particularly if this were to include common goals.

Support of scientific research

Some interviewees considered R&D in South Africa to be split into two silos, namely R&D institutes and industry. It was perceived by these interviewees that R&D institutes would perform R&D to proven design but then would not commercialise the R&D. Support of scientific research by the private industry could help realise the commercial aspect of CSP R&D. A platform whereby the industry can voice their specific required research would assist R&D in identifying and achieving common goals for the industry.

Innovation networks

A number of interviewees stated that innovation networks between experienced CSP players and local companies enable knowledge transfer of existing R&D. Research institutions are currently working with international counterparts whereby the design of pilot plants are shared amongst the R&D institutes and an international counterpart, which contributes prior design experience.

Innovation networks between R&D institutes and local mature industries have the ability to unlock efficiencies within the CSP industry by using lessons learned in mature industries (e.g. the automotive industry).

Some interviewees viewed networks as useful but not practical as a result of different components with varying technology considerations in the CSP industry.

Common training

Common training was viewed as the least important support measure mainly due to concerns regarding protecting IP, however interviewees noted that common training would be useful between local and international companies where collaborations have already been formed and IP can be shared.

Other

Other important aspects of R&D were noted as mentorship and assistance with funding. It was noted by one interviewee that further monetary support for local R&D is required so that universities can build out prototypes. Private companies may not be willing to request funding for prototypes if they have to surrender a share in their venture.
R&D action plan

An R&D action plan would help focus the R&D activities in the CSP sector. In order to achieve a competitive advantage for South Africa in the CSP sector, the focus areas should include those which are relatively immature in developed markets and those with a high potential and relevance for South Africa, such as:

- Thermal storage systems and technology;
- Development of innovative and improved solar collector (support structure) designs;
- Development of tracking concepts;
- Adapting and integration of alternative cooling methods into CSP plants;
- Direct steam generation; and
- Hybridisation and use of CSP in other industry sectors (e.g. mining).

The key points of a coordinated R&D plan could incorporate:

- **Long horizon framework**: R&D programme set up to ensure funding is available over the whole development phase of an innovative product to ensure secure and predictable conditions to invest in R&D and that innovative products become commercialised.

- **Adapt research areas to local and current needs**: A framework could be set up to adapt current research topics and focus on recent R&D areas of importance. This could include the implementation of annual calls for proposals within a long term framework. A platform for the private sector to input their requirements for R&D could assist to inform the relevance of R&D areas for industry.

- **Support for existing technology centres**: Technology centres play a significant role in R&D and in taking new academic findings towards commercial operation. The importance of the technology centres within the R&D framework could be raised. The coordination of the activities of the different centres and the integration of new market entrants (e.g. spin offs, existing companies with extended portfolio) in the existing centres would require support.

- **Strengthening of academic research through cooperation with industry**: Establishment and extension of international and national cooperation between industry and research institutes. This may include testing of innovations on private sector sites.

In order to save administrative costs, it is recommended that the R&D plan for CSP is integrated into existing renewable energy. This also underlines the position of CSP within the renewable energy technology mix: It is an equally important technology as for example wind or PV in order to ensure a balanced and sustainable energy mix for South Africa.

The significance of an R&D plan or framework would strengthen with an increasing amount of installed capacity. For example, it would be necessary to establish such an R&D plan at a minimum if the installed capacity in Scenario B is to be achieved.

Figure 42 outlines a summary roadmap for the R&D sector.
Research and development

The proposed short term actions required in respect of R&D are:

► Review feasibility of a long term framework for provision of public R&D funding to ensure funding is available over the whole development phase of an innovative product and feasibility of a dedicated R&D funding for the CSP component focus areas. The responsibility for this could sit within National Treasury, DoE or DST.

► Establish R&D specific industry platform to identify and achieve common goals between industry and research institutes. This could be linked to specific time frames to encourage response and inform the R&D framework. SANEDI is already providing a platform for industry in relation to R&D, therefore it is proposed that responsibility for the platform and collation of responses would be allocated to SANEDI, which could provide this to the government body responsible for the overall CSP R&D budget.
2.4 Recommendations to enhance South African CSP manufacturing capabilities

1. Conclusions
2. Recommendations and next steps
2.4 Recommendations to enhance South African CSP manufacturing capabilities

Conclusions

South Africa is well positioned to take advantage of the benefits of CSP over other power generation technologies:

► **Resource availability** - The direct normal irradiation (DNI) of South Africa is high, particularly in the Northern Cape region around Upington. The annual sum of DNI reaches almost 2800 kWh/m² making this region one of the most attractive for CSP in the world.

► **Grid stability** - CSP with thermal energy storage has an advantage over other renewable technologies due to its predictability in dispatch. It can support peak periods which is when power is most needed on the grid system. Power available during peak periods is considered to be of higher value than power outside of peak hours.

► **Low environmental impact** - A significant benefit of CSP is that it has little environmental impact - a solar only plant has almost no greenhouse gas emissions in operation and occupies a similar or smaller portion of land compared to photovoltaic.

► **Socio-economic benefits** - with a committed pipeline of CSP projects, CSP can add valuable economic benefits through the creation of new jobs, GDP growth, international trade and energy security.

Current local industry could be competitive in several CSP market segments:

South Africa has a strong industrial sector which can actively contribute to the emergence of a local CSP supply chain. This is particularly the case for components which are not specific to CSP technologies (steel support structure, civil works, various piping and electrical components, etc.), but may also apply to CSP specific items such as flat mirrors, which will shortly be assembled and silvered locally for CSP Round 1 projects.

Specific components are required to meet solar CSP quality standards (e.g. high reflectivity of glass, durability of support structure and longevity of products), therefore supplying a growing CSP market locally will require additional investments in order to upgrade or extend manufacturing capabilities.

The investment of this equipment requires a certain level of committed capacity. For mirrors, interviewees estimated 400MW p.a. of committed CSP projects would be required for a new plant to produce curved mirrors, but 150MW to 200MW per annum could be sufficient to justify the expansion of existing glass manufacturing capability to include flat (moderately curved) mirrors.

<table>
<thead>
<tr>
<th>Component</th>
<th>% of capex*</th>
<th>Technical considerations</th>
<th>Current local capability</th>
<th>Future potential capability</th>
<th>Focus area for South Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirrors</td>
<td>12-22%</td>
<td>High reflectivity required</td>
<td>Flat silvering capacity</td>
<td>Low iron glass production potential subject to trial run.</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Efficiency highly dependent on the focus of bent mirrors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support structure - steel and piping</td>
<td>38%-43%</td>
<td>Durability for a period of 25 years</td>
<td>Steel capacity for over 1GW of CSP p.a.</td>
<td>Spiral welded piping subject to investment of facility</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Seamless piping</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Construction capability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receiver</td>
<td>11% - 25%</td>
<td>High specialised product, R&amp;D necessary</td>
<td>None</td>
<td>Reflectors and carbon sealed tubes could potentially be localised</td>
<td>Medium/Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power block</td>
<td>15% -37%</td>
<td>Pipes, small pumps and cabling possible.</td>
<td>Transformers, valves, pumps and pressure vessels could be obtained locally but more costly</td>
<td>Fabrication could be localised with investment welding know-how</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam generator requires huge effort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drives</td>
<td>1% - 6%</td>
<td>High accuracy required</td>
<td></td>
<td></td>
<td>Low</td>
</tr>
</tbody>
</table>

Source: enolcon

*Note that the range includes all main CSP technology types, but will vary between technologies
Conclusions

CSP has the potential for significant cost reduction

Given the relatively early stage of CSP compared to other renewable energy technologies (such as PV or wind), CSP's cost reduction potential remains significant. It is estimated that in the region of 28% to 40% of overall CSP investment costs could be reduced by 2020. The level of cost reduction could be due to both economies of scale as a result of increased plant capacities and due to improvements in manufacturing (e.g. increasing the performance of the solar field or efficiency of conversion of solar irradiation to electric energy).\(^\text{24}\) If we use the current CSP benchmark tariff of R2.51/kWh set by the Bid Window 2 CSP project, this means CSP tariffs in 2020 in rand terms could be between R1.80/kWh (28% reduction) and R1.50/kWh (40% reduction). Such reduction in tariffs if achieved will bring CSP close to grid parity with coal and other conventional energy sources. To achieve this potential reduction in tariffs the market needs certainty on the long term MW allocation for CSP.

Depending on the scenarios for the roll out of CSP plants, additional job creation could reach significant levels

This study has assessed the potential socio-economic impacts of a number of scenarios with increasing CSP MW allocation. The analysis reveals that it is possible to generate a number of jobs in the South African CSP industry across component manufacturing, construction and operations and maintenance of CSP plants. Scenario A (corresponding to the expected CSP roll out under IRP 2010), full-time jobs created in peak years would reach 5,200, but would be as high as over 50,000 full time jobs under Scenario D. The impact on cumulated GDP is substantial varying between c. R20 billion and R250 billion across all Scenarios.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total (GW)</th>
<th>Contribution to GDP (^\text{1})</th>
<th>Full time jobs created in peak year (^\text{2})</th>
<th>Job years (^\text{3})</th>
<th>Net CSP foreign trade balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario A</td>
<td>1GW</td>
<td>R24bn</td>
<td>5,200</td>
<td>70,000</td>
<td>(R19bn)</td>
</tr>
<tr>
<td>Scenario B</td>
<td>6GW</td>
<td>R108bn</td>
<td>24,500</td>
<td>380,000</td>
<td>(R37bn)</td>
</tr>
<tr>
<td>Scenario C</td>
<td>12GW</td>
<td>R205bn</td>
<td>49,000</td>
<td>900,000</td>
<td>(R88bn)</td>
</tr>
<tr>
<td>Scenario D</td>
<td>22GW</td>
<td>R251bn</td>
<td>51,000</td>
<td>930,000</td>
<td>R34bn (^4)</td>
</tr>
</tbody>
</table>

Source: EY Analysis

Investment in local manufacturing capacity will only be possible if the CSP market is expected to grow significantly above the current MW allocation

Developing a local CSP manufacturing capability will require a stable policy framework and a significant CSP market size underpinning it. To allow for the development of local production lines the annual installed capacity should reach sufficiently high levels capacity, as shown in Table 28 over at least a five year period. This is particularly the case in relation to technology intensive components such as mirrors and receivers.

The current CSP MW allocation (corresponding to Scenario A) is considered by CSP industry representatives as being too low to allow for the development of manufacturing plants to supply CSP components. In this Scenario, support should focus on enhancing the manufacturing of components and basic services for which the market barriers are relatively small and no large investments are required (e.g. mounting structure, civil works and assembly). It should be noted that the associated impacted of job creation will remain limited in this Scenario.

For more ambitious CSP roll out scenarios (Scenarios B, C, and D) an adaptation of international production standards and techniques in existing industries will be required to ensure the supply of suitable CSP components produced locally (e.g. mirrors, piping, cables/electronic equipment tracking systems, and a wide range of related services).

\(^{24}\) IRENA, 2012

1: Full contribution to GDP (direct+indirect+induced) over full life-span of CSP plants.
2: Total full-time jobs (direct+indirect+induced) in scenario’s peak year (with most job creation).
3: Total job years (direct+indirect+induced) over the 25-year lifespan of the plants.
Conclusions

In order to benefit from the associated economic growth and job creation in this market deployment scenario, a well defined strategy with clear objectives for industrial ramp-up should lead to identifying strategic components and services. Policy actions should strongly support innovations and the development of intellectual property rights in the field of CSP components in order to benefit from first mover advantages and to develop technologies specifically tailored for South Africa’s conditions. In the longer term, a strong export orientation should be considered in order to benefit from the proximity to other emerging CSP markets in Africa or in more distant locations.

High growth scenarios for CSP will enable South Africa to accelerate the increase of the local content share in CSP projects

A national strategy for industrial development in the CSP sector should be well coordinated with the energy policy, particularly in order to assist in reviewing and setting of the local content targets. As highlighted in Figure 43, high local content levels (80% and above) could be achieved for CSP (parabolic trough with storage) in the long term (2025) if the scale of implementation of CSP roll out is sufficiently high. This analysis also indicates that reaching such levels will only be feasible in Scenarios B, C and D.

These scenarios will allow South Africa to reach higher local industrial integration more rapidly as the annual roll out of additional CSP capacity will be higher than in Scenario A. It is expected that the same qualitative behaviour would be shown for the other technologies.

Figure 43: Expected increase in local content shares

Stakeholders interviewed in the course of this study highlighted that high local content levels are achievable for CSP in South Africa but they believe it will lead to an increased cost of components (at least in the short to medium term), thereby increasing the LCOE of CSP plants. This report concludes that increasing local content will probably lead to higher costs under Scenario A, as the market deployment is not sufficient to benefit from scale effects in local manufacturing facilities.

In Scenarios B, C and D, the increased annual roll out of CSP capacity could enable new investments in industrial manufacturing plants and in automation of production processes, which in turn could contribute to lowering the price of CSP components in the domestic market.

A broad range of initiatives will be required to support the emergence of a local CSP industry

CSP remains an emerging sector where only a small number of countries possess manufacturing capabilities. South Africa holds both a strong industrial background and R&D capability, which could be utilised to position it well in the
global CSP market. Other countries are launching large CSP roll out plans which are aiming to producing domestic products and services for CSP projects, therefore the window of opportunity for South Africa may only remain open for the next two to three years. In order for South Africa to take advantage of this opportunity, a targeted industrial and R&D strategy should be developed in the short term.

The industrial strategy could be based on a phased approach for main components, as presented in this report by way of component specific roadmaps. It should also involve clearly defined and broadly communicated targets for the market diffusion of CSP, substantial R&D efforts (for example targeted on storage) and a dedicated financing facility for industrial development of CSP industry sectors.

A local CSP supply industry could benefit from a review of the RE IPP procurement programme in terms of MW allocation for CSP in the context of tariff (based on South Africa’s overall power portfolio mix) affordability and job creation potential considering its value proposition of storage. Regular reviews of local content targets in light of feedback from current local projects, industry development and international markets should also be undertaken.

Financial support may be required for:

▶ Technical adjustment of production facilities (including feasibility assessment)
▶ Applied R&D; and
▶ Training of the local workforce (depending on the CSP component).

National instruments which have been set up to support technology or industrial growth (Manufacturing Investment Programme, Manufacturing Competitiveness Enhancement Programme, etc.) will be important in this respect. In particular, the most critical steps in the upgrade of production facilities for CSP components have been identified as:

▶ The implementation of automated processes for the production of precisely manufactured mounting structures;
▶ The supply of high quality float glass; and
▶ The adaption of techniques for coating and bending of parabolic CSP mirrors.

The requirement for additional support measures will depend on market needs, and may include providing concessional loans to industrial development projects or support to cover the risks related to the use (or performance) of local components. Financing facilities could also be provided to facilitate knowledge transfer (e.g. via purchase of licences).

Education and training programmes will be important in developing the CSP supply sector. Universities should be encouraged to teach CSP technology based courses particularly to engineers and other technical graduates. Low skilled workers could receive training through construction companies or apprentice schemes. Partnering of research institutes and construction companies with projects being constructed in South Africa will also contribute to the skills transfer to local workers.

To ensure regional and international quality requirements and to strengthen the competitiveness of future South African CSP industries, implementation of internationally aligned quality assurance standards for CSP components should be considered in the medium to long term.
This section sets out to provide recommendations to address the barriers to develop South Africa’s potential in CSP component manufacturing. These are general recommendations applicable at a national level, in order to create a more favourable framework for industrial innovation and are not CSP component specific. Achieving the objectives set out in this strategy will require focusing on clearly identified priorities and defining intermediate steps, as outlined in the component-specific roadmaps.

The interview process highlighted that the two key barriers facing the development of a CSP manufacturing industry in South Africa are ensuring:

- Long term visibility of the anticipated roll out of CSP capacity; and
- A sufficiently sized capacity of CSP allocated.

Further recommendations focus on addressing the other key barriers outlined in Part 1, such as the inability to compete with the experience of international players:

- Complete South Africa’s financing support instruments for industrial development;
- Create a robust eco-system of suppliers in the CSP value chain; and
- Promote the South African solar CSP expertise on international markets

Long term visibility and size of the CSP market

Most interviewees, both in South Africa and Europe, stated they would only extend CSP manufacturing activities in South Africa if the market size increased sufficiently.

The expected CSP capacity roll out under the IRP 2010 (Scenario A) is considered by most industry players as too small and uncertain to develop local industrial activities. Several leading EPCs, developers or technology suppliers consider that deploying 5 to 10GW (corresponding roughly to Scenarios B, C and D), would be sufficient to extend manufacturing activities.

The uncertainty of CSP roll out was noted as the most important obstacle to entry for manufacturers supplying CSP components.

Setting clear MW allocations at levels that will stimulate local manufacturing is seen as a key requirement for local and international industrial companies in order to make investment decisions. Several countries have announced significant CSP plans over recent years (e.g. Algeria, Australia, India, Morocco, Saudi Arabia), and these are rapidly drawing attention from investors worldwide. Further detail is provided in Appendix D.

Local and international interviewees all stressed that, despite having a significant solar commitment, the current domestic market is not sufficient to develop outlets for manufacturing plants of certain components. A strong market uptake in the short term is crucial to develop a local industry, either by attracting foreign investors, or based on local resource. Table 28 provides an indication (based on information shared by industry leaders during this study) of the annual output required for a plant manufacturing components for the CSP industry.

<table>
<thead>
<tr>
<th>CSP components</th>
<th>Annual output of a typical factory (MW/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receivers</td>
<td>c. 400 MW</td>
</tr>
<tr>
<td>Specialist Piping</td>
<td>100 - 200 MW</td>
</tr>
<tr>
<td>Flat Mirrors</td>
<td>150 - 200 MW</td>
</tr>
<tr>
<td>Curved Mirrors</td>
<td>400 - 500 MW</td>
</tr>
<tr>
<td>Tracking System</td>
<td>c. 500 MW</td>
</tr>
<tr>
<td>Specialised Pumps</td>
<td>&gt;500MW</td>
</tr>
<tr>
<td>HTF</td>
<td>&gt;500MW</td>
</tr>
</tbody>
</table>

Source: Findings from this study.

To develop South Africa’s CSP component manufacturing industry, it is essential that the above thresholds be taken into account in assessing a suitable MW roll out of CSP for South Africa over the medium to long term.

Short term recommendations

The following are recommended as immediate actions required developing the local CSP manufacturing industry:

- DoE reviews the MW allocation for CSP in the context of tariff affordability (based on South Africa’s overall power portfolio mix), job creation potential and the CSP value proposition.
Local content levels are reviewed in light of feedback from projects awarded under the Bid Windows 1 and 2 (e.g. via monitoring of local content) and local industry development and global market prices.

These two recommendations are to be prioritised as without long term visibility of a CSP market large enough to create industrialisation (Scenarios B, C and D), all other support measures are unlikely to have a significant impact.

Complete South Africa’s financing support instruments for industrial development

The analysis in this study indicated that both current and future players in the CSP sector are very diverse with some large industrial corporations (e.g. steel, construction, power and glass sectors) progressively becoming involved in this sector, in addition to a number of potential entrants in the value chain representing small and medium companies.

These companies do not always have the investment capacity to finance upgrades in their production process, either to meet higher quality standards or to expand their production lines to produce larger quantities. Meeting the requirements of large solar projects in both quality and quantity can therefore be a strong challenge, if no specific financing mechanism is set up.

The short and medium term recommendations for financing support instruments are summarised in Figure 44.

Short term recommendations

There are a number of existing financing mechanisms set up by the dti to support the installation of new manufacturing plants and the extension or upgrade of existing plants.

As these mechanisms are already in place, their use should be prioritised in the short term. The mechanisms are promoted on the dti website, although some local manufacturers which are new entrants to the CSP sector may not be aware of their applicability to CSP. Facilitating access to these financing facilities could include a single-desk or fast-track procedure for industrial investments specifically related to the CSP value chain and which could be promoted in a similar manner via SASTELA, SANEDI as well as the dti. As the IDC is responsible for industrial development, the single-desk or fast track procedure could be co-ordinated by it. This could be a dti/National Treasury initiative managed by the IDC on similar lines as the Jobs Fund currently being managed by the DBSA.

“Bundling” a number of existing incentives as sector specific programmes would be a useful way to support the roll out of industrial roadmaps for key sectors and promote greater visibility for the sector. It could assist those seeking support for various steps (research, demonstration, industrial production) of product development to consider the most appropriate financing facility.

Medium term recommendations

In the medium term, depending on the rate of the CSP market development, further complementary initiatives to support the establishment of manufacturing facilities could also be developed, which could include:

- Facilitating application procedures.
- Enhancing the protection of intellectual property rights.
- Facilitating patenting for innovations in the CSP sector.

Figure 44: Short and medium term recommendations to complete South Africa’s financing support instruments for industrial development
Interviewees observed that additional funding sources would be beneficial. This could include:

► Concessional loans for local manufacturing facilities and for extension of production lines (if not already provided for under the MIP and the MCEP).
► Performance guarantee mechanisms aiming at supporting the attractiveness of products manufactured locally. Such schemes are implemented for various environmental technologies in Europe.
► Risk sharing mechanisms or guarantee instruments for CSP projects (could be publicly backed or provided by insurance company) could also play a role if made eligible to projects with a high share of local content. This could at a minimum encourage lenders to rely on locally sourced components, and in the best case lower the cost of financing the project.

As discussed earlier in this report, funding from IDC using a similar model as the glass facility being constructed in Upington for the Abengoa Bid Window 1 projects could be considered for other CSP components, depending on the manufacturers and CSP component.

Creating a robust eco-system of suppliers in the CSP value chain

The broad industrial basis which exists in South Africa has all the competencies required to enable the emergence of a strong network of suppliers for CSP projects.

Supporting the employment and emergence of local EPC contractors, through JV with international players is an important factor in the localisation of the CSP supply chain. Local EPC contractors may make more extensive use of local suppliers and subcontractors since they have better access to local supplier networks. These service providers might not yet possess comprehensive experience in CSP or energy projects in general, but building international partnerships would strongly foster the development of local CSP know-how.

As the CSP sector increases, education and training becomes an important factor in ensuring that sufficient local labour is available to meet the sector’s needs.

Several interviewees pointed out a lack of qualified human resources available, particularly well trained and highly skilled workers (this mostly applies to the solar field, as professionals interviewed consider that there is no shortage of skilled employees with experience in conventional power plants). Such workers are even more difficult to hire in remote areas where solar plants are developed, therefore training of a sufficient number of professionals to manufacture, install and operate solar systems may be challenging depending on the size of the CSP market.

The short and medium term recommendations are summarised in Figure 45.

**Short term recommendations**

Providing further support to the emergence of a local CSP supply chain can complement existing professional organizations (e.g. SASTELA) by supporting the establishment of a network of companies focusing on the sector. This could take the form either of an informal network (sharing common information and resources) or of a formalised business cluster. This initiative should in particular further enable players to disseminate information on the following:

► Quality standards and quality requirements;
► Partnership opportunities, either with local or international firms; and
► Support programmes and incentive schemes from the Government, in particular for upgrading industrial processes.

This network will play a key role in raising awareness on CSP opportunities, providing visibility to local suppliers and facilitating partnerships with international developers or technology providers.

To address the potential lack of qualified labour available, adapted training programmes, focusing on skills acquisition for workers and technical staff could be developed. Practical training could be offered by private companies in cooperation with universities, research institutes or other CSP experts to provide in-depth knowledge and practical experience of the technology.

Universities could be encouraged to teach CSP technology based courses to educate engineers and other highly skilled workers. This should focus on matching training facilities to business needs, for example international players note that the skill sets which are lacking in South Africa relate more to the solar field part than to the traditional power block.

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26 As an example, ACWA Power is a new entrant in the CSP sector and has managed to conduct successful CSP bids in different locations, by partnering with experienced engineering companies.
2.4 Recommendations to enhance South African CSP manufacturing capabilities

Recommendations

It will be important to ensure that current initiatives, such as the proposed development of a renewable energy sector specific training centre at Cape Peninsula University of Technology (CPUT) to develop broad spectrum skills, match training to business needs. A specific focus on parts of the CSP technology value chain would assist in the development of the required skills for industry.

Medium term recommendations

In the longer term, the possibility of forming a technology or business cluster could be assessed. Such clusters and innovation platforms can foster international cooperation and enhance the innovative capacity of industrial sectors.

This would help small and medium-sized firms in particular to overcome innovation barriers and access the latest technology advancements. In order to facilitate technology transfer, the establishment of a single access point (shared information platform, specific guide or “one-stop shop”) would benefit both local innovating SMEs, and foreign technology developers interested in setting up JVs.

Promoting the South African solar CSP expertise on international markets

As CSP is still an emerging technology in terms of capacity installed (less than 3GW worldwide), the industrial landscape provides the opportunity for South Africa to be a first mover. This could be:

► As an industrial hub on a regional basis;
► In specific segments where it can rely on existing industrial assets (e.g. trackers, mirrors); or
► In relation to R&D efforts (e.g. storage).

Developing industrial capacities rapidly is critical as other emerging markets such as India and China are developing products (e.g. receivers in China) dedicated to the global CSP market.

CSP manufacturing industries in these countries are unlikely to focus exclusively on export opportunities in the short term. For example, in India, a strong home market demand, fostered by measures such as tax and investment incentives and local content requirements is driving the development of industrial facilities. On this basis, it cannot be excluded that markets for CSP technology will arise in China and India, and that there may be intentions to seize the opportunity of exporting CSP components to South Africa, thereby competing with local suppliers.

The short and medium term recommendations are summarised in Figure 46.
2.4 Recommendations to enhance South African CSP manufacturing capabilities

**Recommendations**

**Short term**
- Leadership in targeted R&D activities, combined with a focus on strong local integration
- Support activities to export industrial CSP components to nearby countries or to countries in the Southern hemisphere (Chile, for example), or to Europe (e.g. PV modules are currently exported to Europe, with transport costs lower compared to shipping from China)
- Development of outreach and promotion activities:
  - Articulating South Africa's value proposition for solar
  - Developing a targeted strategy for foreign direct investment
  - Promotion activities dedicated to support the export of South African industries and services

**Medium term**

Figure 46: Short and medium term recommendations to promote South Africa CSP industry on international markets

**Short term recommendations**

It is important that South Africa develops technologies or products which are differentiated and adapted to local conditions (storage, dry-cooling techniques, hybridisation, etc.). This could include a focus on strong regional integration and removal of trade barriers with its neighbours in order to seize early opportunities to export to the SADC region.

Specific R&D related recommendations are set out in the R&D section of this report.

**Medium term recommendations**

The local CSP industry could also strengthen its competitive position in global markets. South Africa's geographical position makes it a potential basis to manufacture components which could be exported to countries in the Southern hemisphere (e.g. Chile) or to Europe. Some examples exist of PV modules being manufactured in South Africa and exported to Europe (transport costs being significantly lower than if shipped from China to Europe).

To promote the competencies of the local solar industry domestically and internationally, a specific, focused approach could be launched for outreach and promotion activities. During these activities, it would be crucial to articulate South Africa's value proposition for CSP, experience in attracting foreign investment, availability of land and workforce, free trade areas and attractive business environment.

These activities could include:

- Developing a targeted strategy for foreign direct investment, by defining promotional and communication tools, organising road shows in specific locations. These initiatives could benefit from the Export Marketing and Investment Assistance (EMIA) programme managed by the dti.
- The dti represents South Africa in international energy conferences, however further promotion could be developed by organizing a specific event or by strengthening the existing renewable energy events with a focus on the CSP supply industry.

**Key priority actions**

A summary of the priority actions is provided in Table 29. Although the actions have been given a priority ranking, a number of these could be addressed in parallel as different stakeholder could take responsibility for different areas.

Table 29: Summary of short term priority actions

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Area</th>
<th>Key implementation initiative</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>DoE</td>
<td>RE IPP procurement programme</td>
<td>Review of MW allocation for CSP with storage in the context of affordability of peak power and job creation potential and considering its value proposition  Consider a two tier tariff with a premium being paid for energy at peak time</td>
<td>1</td>
</tr>
<tr>
<td>DoE</td>
<td>RE IPP procurement programme</td>
<td>Review of impact on tariff price of increasing local content requirements and assess associated long term socio-economic benefits</td>
<td>1</td>
</tr>
<tr>
<td>DTI</td>
<td>CSP framework</td>
<td>Confirm CSP component focus areas (e.g. mounting structures, piping, flat mirrors)</td>
<td>2</td>
</tr>
<tr>
<td>National Treasury</td>
<td>R&amp;D</td>
<td>Review feasibility of a long term R&amp;D funding profile and dedicated R&amp;D funding for the CSP component focus areas</td>
<td>2</td>
</tr>
<tr>
<td>SANEDI</td>
<td>R&amp;D</td>
<td>Establish R&amp;D specific industry platform to identify and achieve common goals between industry and research institutes</td>
<td>2</td>
</tr>
<tr>
<td>SASTELA</td>
<td>Marketing</td>
<td>Focus on international outreach and promotion, including international cooperation structures</td>
<td>2</td>
</tr>
<tr>
<td>Industry</td>
<td>Education and training</td>
<td>Establish CSP specific practical training programmes for workers currently trained in coal fired power plants (e.g. welders from Kusile and Medupi)</td>
<td>2</td>
</tr>
</tbody>
</table>
Next steps

In order to achieve the short term priority actions, a number of further studies may be required to support and direct initiatives, as follows:

- This study assesses the socio-economic impact of 4 scenarios as provided to the Consultant in its Terms of Reference. A further study would be required to assess the alternative scenarios for the review of the IRP 2010. As the IRP will run its own scenarios, the input provided by this study should be sufficient for the DoE to come up with alternative scenarios when it starts the review of the IRP 2010. The study should be shared with the National Development Plan Commission as it will help contribute to the Alternate IRP study that has been commissioned by the Commission.

- Further analysis on the optimal local content levels based on a comparative assessment of the effects on LCOE and resulting economic impacts. This study assesses the local content level theoretically possible, but does not consider the effect on tariff. This analysis should be based on the actual localisation results achieved in the implementation of the Window 1 and Window 2 projects (and subsequent projects) under RE IPP.

- This study outlines that part of the CSP value proposition is the added value to the grid and system operator of supplying energy during peak times. In order to fully assess the value of this to the grid, further analysis should be undertaken. This study should probably be commissioned by the System operator with the support of SASTELA.

- The study does not assess the impact on affordability and impact to the overall power portfolio of an increased MW allocation to CSP to inform the next IRP. This will be assessed as part of the IRP review process, should the MW allocation to CSP increase. The industry would like to see this review process commencing this year (2013) and concluded by 2014.

- This study outlines that cost of the plant can be reduced by constructing larger projects (i.e., multiple unit size of turbines). A further study would be required to assess the impact scale could have on tariff. Consideration should be given to increasing the current CSP cap from 100MW to up to 250MW to allow bidders the opportunity to generate economies of scale should it suit their technical solution and be financeable.

- Determination of CSP component focus areas. This study provides focus areas in terms of R&D potential and identification of short term opportunities depending on capacity roll out. A more detailed study to determine areas for specific players to focus on (e.g., IDC) may accelerate growth in these areas. The study into the manufacturing potential of CSP that was commissioned by the IDC could possibly be further developed with the findings from this study.

- To take the short term priority areas forward, stakeholder coordination with and input from the potential stakeholders for each short term action area would be required. The roadmaps identified should be rolled out as part of the Industrial Policy and Action Plan 2.

- This study did not benchmark the localisation potential for CSP hybridisation roll out vis-à-vis new build standalone CSP plants. A further short term action which could be explored by SANEDI, is to assess the localisation potential and viability of hybridisation in South Africa.

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27 IDC, 2013
Appendix A: Detailed technical information: CSP components, manufacturing processes and costs
Appendix A: Detailed technical information: CSP components, manufacturing processes and costs

Description of CSP technologies

Parabolic trough

This section provides a detailed technical description of manufacturing processes, cost breakdown per technology in order to inform a reader new to the market.

This section should be read in conjunction with the technical information in Part 1.

Parabolic trough

A simplified process flow diagram of a parabolic trough plant using synthetic organic fluid as heat transfer fluid (HTF) and an indirect molten salt storage system is outlined in Figure 47.

Capturing the DNI

The reflectors are readjusted over the course of the sun during the day in order to maintain the focus onto the receiver tube.

This movement is called tracking and is often realised by hydraulic lifting. The connection between the receiver tube and the collecting pipe is designed with Swivel joints to enable the movement of the reflector.

Heat transfer fluid

This flow diagram demonstrates the several parallel rows of connected collectors. The HTF flows in the tube which is heated up by the DNI (up to 400 °C in existing CSP power plants). It is equally distributed via a distribution pipe into the loops and collected in a collection pipe.

The heat collected by the hot HTF is transferred through heat exchangers to a separate water-steam-cycle.

The use of thermo oil as HTF in parabolic trough plants is currently the most common application. Applications with molten salt as HTF or application with direct steam generation are under development.

Storage system and power plant

The heat which is not required for the power plant process is transferred into a storage system, consisting of molten salt storage in current power plants.

The power plant process itself is a conventional Rankine cycle equivalent to conventional steam power plants with lower steam parameters.

Figure 47: Simplified process flow diagram of a parabolic trough plant using a synthetic organic fluid and a molten salt storage system (Siemens, 2012)

__________________________________________________________

28 German Aerospace Center
Appendix A: Detailed technical information: CSP components, manufacturing processes and costs

Description of CSP technologies

Solar tower

Central receiver plant (power tower)

Capturing the DNI

A solar power tower plant consists of a tower with a receiver surrounded by a heliostat field. The field includes several hundreds of reflectors (heliostats) distributed around the tower. The arrangement can vary depending on the receiver technology and the geographical location. The receiver is the focus of the reflectors and absorbs the solar irradiation. Figure 48 shows the principle setup of this plant.

Solar power towers can achieve temperatures up to approx. 1350°C due to the high temperature resistance of the receiver system, although reaching such high temperatures are limited by the temperature limits of the HTF.

Heat transfer fluid

The HTF for solar power tower technologies are:

- Air (pressurized or non-pressurized);
- Molten salt; or
- Direct steam generation.

Receiver

The solar tower may consist of either a non-pressurised or a pressurised receiver, depending on the type of HTF:

a) Open volumetric receiver - Figure 48a

Air is used as the HTF in a non-pressurised tower with an open volumetric receiver. The air is sent through the receiver, heated up and subsequently sent through a heat exchanger where the heat is transferred to a secondary water/steam cycle connected to a steam turbine. The water is preheated, evaporated, superheated and then sent to a steam turbine. An example of a plant with an open volumetric power tower is the solar tower in Jülich, Germany, which was one of the first solar towers to use air as an HTF.

b) Volumetric pressurised receiver - Figure 48b

This consists of a combination of a gas turbine with a steam turbine. The pressurised hot air drives the gas turbine and the heat is recovered in a recovery steam generator where the feed water is preheated, evaporated, superheated and then sent to a steam turbine. A duct burner in the air cycle is optional and can be used to increase the air temperature by burning fossil fuels (e.g. gas).

This application is similar to a combined cycle power plant with an external fired gas turbine.

Figure 48: Schematics of a non-pressurised (a) and a pressurised (b) receiver in the solar tower plant
Appendix A: Detailed technical information: CSP components, manufacturing processes and costs

Description of CSP technologies

Solar tower

Direct molten salt receiver

Solar tower plants with a direct molten salt receiver are commercially available. The heliostats reflect the radiation onto the receiver which consists of tubes of stainless steel containing molten salt. The heat is transferred into the water/steam cycle through heat exchanger (Figure 49).

Figure 49: Process flow of a tower with a molten salt receiver

The Gemasolar Thermosolar CSP plant (Figure 50) plant, in operation in Spain, has a molten salt receiver which and a 16 hour storage system (considered as the maximum storage capacity). This plant is able to operate for 24 hours on full load due to more heat being produced during the day than required. This is stored in the thermal storage system and subsequently used overnight.

Figure 50: Molten salt tower Gemasolar

Direct steam generation

A tower with direct steam generation is also commercially available (e.g., PS20 - Figure 51).

The receiver consists of tubes in which water is evaporated and the steam is sent directly to the steam turbine.

Figure 51: PS20 - tower with direct steam generation

---

29 Solarreserve
Lineal Fresnel and solar dish

**Linear Fresnel**

The main part of the linear Fresnel solar boiler comprises multiple rows of reflectors, each consisting of several slightly curved mirrors attached to a support structure. These mirrors reflect the solar irradiation onto one central (Novatec Solar GmbH) or up to ten (AREVA Solar) absorber tubes which are located below a central receiver.

Linear Fresnel uses direct steam generation technology i.e. water is used as the HTF.

The reflector angles are adjusted through a drive system in accordance with the sun’s position over the course of the day in order to maintain the focus onto the receiver.

Several solar boilers are added in length and parallel to form the linear Fresnel solar field.

The cost of linear Fresnel is lower than that of a parabolic trough plant due to the lighter solar field material and lower wind loads, therefore the support structure of the whole field can be lighter than in comparison to a parabolic trough plant.

Direct steam generation using feed water directly is currently state of the art technology. Different approaches using molten salt as HTF are currently under development.

**Solar Dish**

Each solar dish consists of a dish receiver and engine containing the heat transfer medium (e.g. air, helium or hydrogen).

The engine operates by cyclic compression and expansion of working fluid. The Stirling engine is air cooled therefore there is no requirement for water for cooling.

The typical diameter ranges from 3m to 25m, depending on the type and rated output of the unit. Current dish units have a rated electrical output in the range of 10 - 50 kWel per unit.

The key advantage of the solar dish receivers is that they can be used in small-scale decentralised applications.

Several solar dishes can be installed together to form larger scaled plants as shown in Figure 52 although in large scale solar thermal power plants they are not cost competitive.

Figure 52: Solar dish plant consisting of several dishes (SRPNET)
Overview of the main components

Figure 53 describes the main components of the CSP plant and the relevant industry sectors at each stage.

The following pages detail the manufacturing processes for the key components, including:

- Support structure manufacturing process; and
- Mirror manufacturing, including the silvering process.

The power block also represents a significant part of the CSP-plant. Both its main components (e.g. steam turbine) and smaller components (i.e. Balance of Plant) are similar to the conventional power plant business and are associated with the steel industry and the mechanical engineering.
Support structure – parabolic trough

Steel support structure

The whole value chain for the support structure is shown in Figure 54. As discussed in Part 1, the support structure is typically steel (with no specialist requirements), but could also be aluminum.

The collector itself has a total length of 12 m and an approximate total weight of 1900 kg including the mirror. The aperture area of one collector module is about 70 m². The structure itself consists of a torque box, based on four simple steel frames, two endplates and 14 cantilever arms, where the mirrors are placed (Figure 55). The different parts can be manufactured independently according to the process.

The total amount of steel required is c.1000 kg (or 15.6 kg/m² aperture area), with the torque box and the cantilever arms being the main parts.

This system has the following advantages:

► Use of only a few different semi finished parts;
► Relatively straightforward manufacturing process;
► Weight reduction of the structure; and
► Production process can be highly automated.

Other support structures (e.g. Sener trough) use a stamping process to produce the cantilever arms in order to achieve a cheap mass production with continuous quality and low weight.

The manufacturing company producing the support structure must typically be able to adopt different production steps and methods.

The accuracy and the quality of the work must be ensured over the whole production process.

30 Lufpert, 2001
Support structure – solar tower

Central Receiver Systems

The principle layout of a heliostat is shown in Figure 56. The main components for the support structure are the support pedestal and the assembly structure for the mirrors, which together represent over 80% of the required steel for the heliostat. Other raw or semi finished materials required for the manufacturing process (excluding flat mirrors) include:

- Motors, controls, cabling (e.g. steel, copper);
- Gear drives (steel and cast iron); and
- Adhesives for assembly.

Cost reduction could be achieved by:

- Maximising use of standard parts;
- On site or near site assembly; and
- Using a material saving design.

The amount of steel required depends not only on the design of the support structure but is also dependent on the mirror area. The amount of steel required for a heliostat with $148\text{m}^2$ aperture area is could be c. $27\text{kg/m}^2$.

Figure 56: Setup of a Heliostat used for a central receiver plant

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31 Kolb, 2011
Support structure – linear Fresnel

Linear Fresnel Systems

In the linear Fresnel system the curvature of the parabolic mirror is divided in several flat or slightly bent mirrors. These are placed on one level, therefore each mirror segment requires its own support structure.

The support structure (Novatex system) consists of a triangle shaped hollow structure made out of hot dip galvanized steel.

The mirrors are fitted onto these structures, resulting in a compact and light system. These structures are mounted on the support structure, together with the receiver support structure, forming the module.

![Figure 57: Setup of a linear Fresnel module](image)

One module has an aperture area of c. 510m² and an absolute specific weight of 28kg/m² aperture area, which includes the mirrors and the receiver tube.

The required amount of steel is much lower compared to other CSP technologies and less concrete for the foundations is required.

![Figure 58: Transport frames for linear-Fresnel mirrors](image)

A key advantage of linear Fresnel technology (noted by Novatec), is the use of standardised components and manufacturing techniques, therefore the manufacturing process of the mirrors and steel support structures can be highly automated. An automated serial production line was built in 2008 by Novatec in Spain.

Novatec plans to establish manufacturing factories in target market regions close to solar fields to take advantage of the logistical and transport benefits of linear Fresnel serial production. Special transport frames ensure that reflector components are delivered to the assembly site undamaged.

Minimal components and simple assembly standards are required for onsite assembly.
Mirror manufacturing process

Both CSP mirror and PV glass production require the production of low iron float glass. In comparison to glass typically produced the raw material for low iron glass contains less iron dioxide, as this substance reduces the transmittance of the glass. The production of the low iron float glass is outlined below.

Raw material becomes molten in the melting furnace after which it is poured on to a shallow bath of molten tin (Figure 59). The glass floats on the tin and spreads, forming a thin layer due to the surface tension. The thickness of the glass sheet can be influenced by the speed the glass is poured.

Figure 59: Schematic description of the float basin

Bent glass specialist equipment is required for the silvering of bent glass in parabolic trough plants.

Solar tower systems and linear Fresnel systems use flat glass; therefore the bending process is not required.

Figure 60 details the main steps of the mirror manufacturing process.

Silverying process and coating

The dominating process for silvering of mirrors is the conveyor, wet deposition method.

The annealed or fully tempered glass is thoroughly cleaned by the application of cleaners and passes through oscillating scrub brush units. After the glass is cleaned and rinsed, the surface of the glass is sensitised with a diluted solution of tin chloride. This surface treatment allows for the deposition of silver, which is deposited by spraying silver nitrate onto the sensitised surface of the glass together with other chemical configurations. This creates a uniform silver layer on the glass.

Once the silver layer has formed on the glass, methods to protect the silver layer from oxidation are utilised. A layer of copper is deposited directly onto the silver (chemically or by galvanising process).

As soon as the metal layers are attached to the glass, they are covered by a protective mirror backing paint. The mirror backing paint protects the metal layers from corrosion and from mechanical scratching. The paint can be applied either by passing the glass through a curtain of paint or by passing glass in contact with a roller paint coater. There are many mirror backing paint products available from a number of suppliers, applied as either a single or double coat. (Mirrorlink).
Mirror manufacturing process

This process can be applied to both flat and bent mirrors. The advantages of such “laminated mirrors” are improved durability of the mirror and improved due to the thinner surface mirror.

This technology is has been used for the past 60 years in the automotive sector, therefore the specific mirror design can be considered as a proven technology.

Lab tests have demonstrated that even cracked parts will still continue reflecting and concentrating solar irradiation.

A further method to create mirrors is outlined below. This has a focus on the environmental influences CSP mirrors are faced with.

One method proposed uses a thin front glass with a silvering and copper coating for the reflectivity and a thicker backing glass at the back. The two glasses are laminated with a polyvinyl butyral (PVB) film.

The whole setup is shown in Figure 62.
Potential CSP cost reduction

Influence factors on costs of a CSP plant
The cost of a CSP plant can be expressed as:
- CAPEX: Capital Expenditure, the total investment amount; or
- LCOE: Levelised Cost of Electricity.

Both CAPEX and LCOE are strongly dependent on the environmental conditions. They are influenced by:
- Site specific characteristics (e.g. the slope of the land, local infrastructure, soil conditions, cost of land);
- Costs for EPC, O&M and project development (labour costs, size of project etc.);
- Water availability for cooling (wet or dry cooling);
- Solar irradiation (DNI); and
- Size of the storage.

The comparability of different plants is therefore challenging. To the extent possible, the evaluation in this report takes the factors above into consideration.

Our analysis uses a thermal storage system with molten salt as this is the only commercial system currently available. Nearly half of the costs for this storage system are due to the amount of salt required. Other storage technologies under development use either cheaper material (e.g. rocks, sand or concrete) or material with an improved thermal efficiency (e.g. PCM and thermo-chemical systems) could reduce the costs for the thermal storage.

Summary of cost reduction potentials
The cost reduction potential for each technology is provided in Part 1 and the following sections and summarised in Table 30 (note that the cost reduction potential is always given for the specific component).

An overall reduction potential of the investment costs by 2020 of 28% to 40% is estimated based on the economies of scale in the plant size and the manufacturing industries, improvements in the performance of the solar field and a rise of the solar-to-electric efficiency\(^ {36} \).

<table>
<thead>
<tr>
<th>Table 30: Potential cost reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Receiver</td>
</tr>
<tr>
<td>Receiver</td>
</tr>
<tr>
<td>Receiver</td>
</tr>
<tr>
<td>Mirrors and support structure</td>
</tr>
<tr>
<td>Storage system</td>
</tr>
</tbody>
</table>

Source: (ATKearney, 2010), (Kolb, 2011), enolcon

Note: for potential cost reductions, the same price level for raw material as 2012 is assumed. The influences of inflation or changes in the regularity framework are also not considered.

There are several initiatives around the world which aim to reduce the costs for CSP plants. One of them is the SunShot Initiative supported by the U.S. Department of Energy, aiming for a LCOE of 6 UScent/kWh by 2020. This high cost reduction could be only achieved with extreme cost reductions in every part of the CSP plant, which requires a huge effort in terms of R&D.

For the estimation presented in this study, the cost reduction potential of each component which seems technically feasible from the current point of view, is analysed and taken into account.

\(^ {36} \) IRENA, 2012
Parabolic trough cost analysis

Parabolic trough cost break down

The cost breakdown of a parabolic trough power plant is shown below.

![Cost Breakdown Graph](image)

The solar field comprises the largest portion of cost at c. 45% and within this steel construction, mirrors and receivers are the most significant costs.

Cost reduction potential

In order to reduce the cost of a parabolic trough power plant the mirrors, steel construction and receiver are significant areas to target.

The design of the steel construction and the mirrors should be evaluated together because the support structure carries the weight of the mirrors, maintains the mirror shape and resist wind loads.

The trend is plants moving towards thin glass mirrors which require less glass; however this requires a backing plate to maintain the parabolic shape of the mirrors.

The general cost reduction potential for mirrors, support structure and receivers is outlined in Part 1.

Cost reduction may occur due to increased competition generated by new market entrants (there are currently only two producers). New companies will only invest in necessary R&D if there is a long term opportunity in the market.\(^{37}\)

Figure 63: Cost breakdown for a parabolic trough system with 50 MWe, 7.5h thermal storage and thermal oil as HTF

Figure 64: Cost breakdown of the solar field for a parabolic trough plant

\(^{37}\) ATKearney, 2010
Solar tower – cost analysis

Solar tower

The cost breakdown for a solar tower plant is presented in Figure 65. The solar field is the largest cost component, comprising 40% of the total capital cost.

The costs of the receiver system also play a significant role in the plant cost.

In contrast to the parabolic trough system, a large HTF system with sizeable pumps is not required for the solar tower. The HTF system remains in the tower and is in most cases based on molten salt, water or air.

Figure 65: Cost breakdown for a Central Receiver plant with 100 MWe, molten salt as HTF and 9h storage

The cost breakdown for the heliostat shows that mirrors and support structure together represent over 40% of the total costs of the heliostat (Figure 66).

In the receiver system, the costs are dominated by the receiver itself (over 50%) and the tower (almost 20%).

The costs for the drives are significantly higher compared to the other CSP technologies as every heliostat requires its own drives for positioning, which also requires cost for wiring and control.
Solar tower – cost analysis

Cost reduction potential

The solar collector field is the largest single capital investment in a central receiver plant. There are several possibilities for cost reduction, which is in the range of 10% for each of the heliostats:

- Highly automated manufacturing facilities for the support structure;
- Optimisation of the support structure. The challenge is to reduce the required material whilst maintaining the stiffness of the structure to resist wind loads;
- Improvements in the area of optical efficiency, which is critical to overall plant performance. Passive and active methods of keeping the reflector surface clean play a key role in reducing O&M costs of the plant; and
- Improvements in wiring and further development of the drives.

The receiver itself is a highly specific product, whose design differs significantly depending on use of HTF (salt, air or water). The approach in the design phase of the receiver is to avoid as much heat losses as possible capturing the maximum amount of solar energy on a small area as possible.

Increasing the efficiency of receivers is discussed in Part 1.

For a solar tower system with molten salt as HTF, the costs for the balance of plant (BoP) system are dominated by the salt heat exchangers. Cost reduction could be achieved by reducing the parasitic losses by optimising the plant design at an early stage.

Heliostat cost reduction due to economies of scale

Heliostats are the main component of the field that can be manufactured in mass production. Several studies show\(^39\)\(^40\) that the price for one heliostat is directly dependent on the annual production rate. An estimation of the price development is shown in Figure 67.

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\(^39\) Solar Spaces, 2010
\(^40\) Kolb, 2011

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\(^41\) Kolb, 2011

Figure 67: Estimated development of the cost for heliostats\(^41\)

This estimation is based on numbers provided by several U.S heliostat manufacturers. Several factors influence the cost curve, including a higher amount of automation and specific price for the drives, depending on the amount of drives produced.
Appendix A: Detailed technical information: CSP components, manufacturing processes and costs

Cost analysis for main CSP components, systems and CSP plants

Linear Fresnel – cost analysis

Linear Fresnel

It is particularly challenging to estimate the costs and component breakdown of a linear Fresnel plant and the share of each component, due to the lack of plants constructed.

The following assumptions were used to provide the data in Figure 68:

- The system setup is assumed to not have any thermal storage, as this is not currently commercially available for direct steam generation systems;
- Water is used as heat transfer fluid, therefore no heat exchangers are required;
- The costs for the power block are based on available data for a 100MW parabolic trough system;
- A cost for a solar field of 150 €/m² was estimated in 2009\(^{42}\). We have assumed the price for the solar field is 130 €/m², due to developments in this sector since 2009.

Figure 69 provides a cost breakdown of the solar field (based on Mertins 2009 data), which similarly to the other CSP technologies analysed, is the largest proportion of the cost of the plant.

The mirrors and support structure make up the majority of cost of the solar field as 55 %.

The amount of the costs attributable to the receiver and the absorber is comparable to the costs of the parabolic trough system.

\(^{42}\) Mertins, 2009
## Appendix B: socio-economic assumptions

### Labour creation ratios

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Assumption</th>
</tr>
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<tbody>
<tr>
<td>Component manufacturing: FTE per MW manufactured, of which:</td>
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<tr>
<td>Mirrors</td>
<td>12%</td>
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<tr>
<td>Receivers</td>
<td>14%</td>
</tr>
<tr>
<td>Power block</td>
<td>11%</td>
</tr>
<tr>
<td>HTF and fluid</td>
<td>27%</td>
</tr>
<tr>
<td>Support structure and electronic</td>
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</tr>
<tr>
<td>Construction, Installation, Project Management: FTE per MW installed, of which:</td>
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<tr>
<td>Project development and Management (EPC)</td>
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<tr>
<td>Installation</td>
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<td>Operations &amp; Maintenance: FTE per MW per year</td>
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<td>Indirect jobs: indirect FTE jobs per direct FTE job</td>
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<tr>
<td>Induced jobs : induced FTE jobs per direct FTE job</td>
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</table>

### GDP contribution ratios

<table>
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<tr>
<th>Parameter</th>
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</tr>
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<tbody>
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<td>Cost of Component manufacturing: $ per MW manufactured, of which:</td>
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<tr>
<td>Mirrors</td>
<td>$505</td>
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<tr>
<td>Receivers</td>
<td>$564</td>
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<tr>
<td>Power block</td>
<td>$453</td>
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<td>HTF and fluid</td>
<td>$1,111</td>
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<td>Support structure and electronic</td>
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<td>Construction, Installation, Project Management: FTE per MW installed, of which:</td>
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<tr>
<td>Installation</td>
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<tr>
<td>Operations &amp; Maintenance: $ per MW per year</td>
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<td>Component manufacturing</td>
<td>39%</td>
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<tr>
<td>Construction, installation, project management</td>
<td>38%</td>
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<tr>
<td>O&amp;M</td>
<td>35%</td>
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<tr>
<td>Decrease of cost for component manufacturing and installation, as a result of efficiency gains</td>
<td>41% by 2017, with a linear decrease</td>
</tr>
<tr>
<td>Discount rate</td>
<td>5%</td>
</tr>
<tr>
<td>Indirect and induced value-added</td>
<td>Identical to job creation</td>
</tr>
</tbody>
</table>

### Limitations

- Full-time employment ratios considered identical for all technologies (Tower, Parabolic, Fresnel)
- Impact of exports only applied to Component Manufacturing services (no export on construction)
- Efficiency gains in labour modelled in the same proportions as efficiency gains of cost
- Efficiency gains not modelled after 2017, after which cost are supposed to remain constant
## Local content proportions

<table>
<thead>
<tr>
<th>Value chain component</th>
<th>Detail</th>
<th>Initial local proportion</th>
<th>Local share between 50MW to 150MW p.a installed</th>
<th>Local share &gt; 150MW p.a installed</th>
<th>Local share not possible to capture</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM : Support Structure anCM electronic</td>
<td>Pumps</td>
<td>40%</td>
<td>40%</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>CM : Support Structure anCM electronic</td>
<td>Balance of System</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>CM : Support Structure anCM electronic</td>
<td>Balance of Plant</td>
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<td>100%</td>
<td>0%</td>
<td></td>
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<tr>
<td>CM : Support Structure anCM electronic</td>
<td>Steel construction</td>
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<td>90%</td>
<td>10%</td>
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<tr>
<td>CM : Receivers</td>
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<td>100%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>CM : Power Block</td>
<td>Power Block</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
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<tr>
<td>CM : Mirrors</td>
<td>Mirrors</td>
<td>20%</td>
<td>100%</td>
<td>0%</td>
<td></td>
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<td>CM : Heat Transfer System anCM FuICM</td>
<td>Heat Exchangers</td>
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<td>100%</td>
<td>0%</td>
<td></td>
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<tr>
<td>CM : Heat Transfer System anCM FuICM</td>
<td>HTF System (piping, insulation, Heat exchangers, Pumps)</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>CM : Heat Transfer System anCM FuICM</td>
<td>Salt</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM : Heat Transfer System anCM FuICM</td>
<td>Heat Transfer Fluid (HTF)</td>
<td>100%</td>
<td></td>
<td>0%</td>
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<td>Electric installations and others</td>
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<td>0%</td>
<td></td>
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<td>100%</td>
<td>0%</td>
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<td>Piping installation</td>
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<td>CIM : Installation</td>
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<td>CIM : Installation</td>
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<td>0%</td>
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<td>CIM : Installation</td>
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<td>80%</td>
<td>100%</td>
<td>0%</td>
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<td>CIM : Installation</td>
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<td>CIM : Project development and Management (EPC)</td>
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<td>10%</td>
<td>10%</td>
<td>80%</td>
<td>20%</td>
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</table>

CM = Component Manufacturing

**Limitations**

Local share estimates based on interviews conducted with local stakeholders and Enolcon assessment of industry capabilities

Only two "installation scenarios" modelled
### Appendix C: Sources of information

**Sources of information used in this study**

<table>
<thead>
<tr>
<th>Source</th>
<th>Description</th>
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<tbody>
<tr>
<td>BERR, 2008 - Supply Chain Constraints on the Deployment of Renewable Electricity Technologies</td>
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<tr>
<td>BMI South Africa Metals Report Q1 2013</td>
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<tr>
<td>Commonwealth Scientific and Industrial Research Organisation, 2011 - CSP drivers and opportunities for cost-competitive electricity</td>
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<tr>
<td>Department of Energy announced that developers have estimated that the first three CSP projects totalling 200MW would result in over 1,800 jobs during construction and c. 120 jobs during operations</td>
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<tr>
<td>EASAC. (2011). CSP: Its potential contribution to a sustainable energy future. Halle, Germany:</td>
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<tr>
<td>European Commission, 2009 - The impact of renewable energy policy on economic growth and employment in the EU</td>
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<tr>
<td>German Aerospace Center. (n.d.). More efficient solar power plants- DLR test facility for direct steam generation now operational.</td>
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<tr>
<td>IDC, 2011 - Green Jobs: An estimate of the direct employment potential of a greening South African economy</td>
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<tr>
<td>IDC – Feasibility Study to determine the viability of the establishment of a local manufacturing facility of Concentrated Solar Power modules and components in South Africa, 2013</td>
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</table>
Appendix C: Sources of information

Sources of information used in this study continued

<table>
<thead>
<tr>
<th>Source</th>
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<tbody>
<tr>
<td>Protermo Solar; Macroeconomic impact of the solar thermal electricity industry in Spain; October 2011; Sevilla, Spain</td>
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<tr>
<td>Querol, P. et al.; Single Tank thermal storage prototype; SolarPaces 2012; Marrakesh, Marocco</td>
</tr>
<tr>
<td>Renac. (2011). Global Players in CSP.</td>
</tr>
<tr>
<td>Schicktanz, P. et al.; Electricity to be stored in a HTES system and be added to the combustion air of a conventional power plant; IRES 2012. Berlin</td>
</tr>
<tr>
<td>Stuckenbrock, P. et al.; Solar combined heat and power supply for a copper mine to increase the copper production efficiency; SolarPaces 2012; Marrakesh, Marrocco</td>
</tr>
<tr>
<td>Trieb, F. et al; Concentrating Solar Power for the Mediterranean Region (MED-CSP), April 2005, Stuttgart, Germany</td>
</tr>
<tr>
<td>UK Department of Renewable Energy and Climate Change, 2004, UK renewable Energy Industry Gap analysis</td>
</tr>
<tr>
<td>World Bank – Middle East and North Africa Region – Assessment of the Local Manufacturing Potential for Concentrated Solar Power (CSP), 2011</td>
</tr>
</tbody>
</table>
Appendix D: International case studies

Industrial R&D in Spain

The focus of the R&D activities of Spanish companies within the last years was mainly on

► New plant concepts;
► Technological development of the solar field; and
► Improvement of plant design processes and component manufacturing processes.

In economic terms, the R&D effort raised through the last years (see figure below) to a total amount of more than € 48 m in 2010\(^{43}\).

\[\text{This amount represents 2.9 % of the total contribution of the CSP industry to the GDP. This contribution is slightly above the average contribution to R&D in Europe}^{43}.\]

Technology centres

One characteristic for the CSP industry in Spain is its strong network of technology centres, many of them founded long before the commercial breakthrough of CSP in 2006. All stages of the value chain participate on the technological innovations developed at these centres, resulting in a high contribution to industrialization.

► Plataforma Solar de Almería (PSA): The largest research and test centre in the world devoted to concentrating solar technologies (solar thermal and concentrating photovoltaic). In 2010 the PSA had an R&D research team of 123 people, in addition to an important number of visiting researchers and trainees. The budget is based on public funding (e.g. EU or national R&D programs) and on research contracts with the industry.

► Centro Nacional de Energías Renovables (CENER): Technology centre specialized in applied research, development and promotion of renewable energies. Research and consulting related to CSP is done in an own department. CENER is supported by different ministries of the Spanish government.

► Universities: The work of the Spanish universities which pioneered CSP in Spain and developed main technologies forms the basis for the technology centres. The exchange between the national universities, the research centres and international universities is an important key factor for innovations.

National R&D-Program Chile

Chile has one of the best DNI values of the world, even slightly higher than the South African values. Additionally the Chilean resources of salt, necessary for the molten salt storage systems, give the country an excellent starting point for CSP.

In order to build the first CSP plant, the government launched in March 2013 a project funded by a combination of funds from the Chilean government and international entities. To support the realization of the plant, Chile’s Ministry of Energy, will provide a grant of up to US$20 million. The aim of this project is to support the cooperation between a local project developer and an international company that will build the first Chilean CSP plant.

\[^{43}\] Protermo Solar, 2011
Additionally over US$ 350 million of financing capital is provided by the government and global organizations, in order to generate the conditions necessary to make CSP a viable technology in Chile.

This initiative is part of a long term program (Chile’s National Energy Strategy for 2012-2030) focusing on the support of renewable energy sources.

Technology transfer is one key factor of the national program, supported by the construction of the first CSP plant. The national program should therefore contribute to innovation in Chile and help to create necessary local capacities.

CSP development plans – examples from the MENA region

► Morocco disclosed in late 2009 its national solar plan, which aims at implementing 2 GW of solar by 2020. In September 2012, the Moroccan authorities announced the award of phase 1 of the Ouarzazate project (160 MW, parabolic trough), at a price below initial expectations (€ 0.14 per kWh). The winning consortium (ACWA Power with Acciona, TSK and SENER) has announced its intention to reach out to the local industrial suppliers and to go beyond the local content target (30%) set for this tender. The Moroccan Government has launched in January 2013 the tendering process for the second phase of the Ouarzazate project, which will be shared between parabolic trough (200 MW) and tower technology (100 MW).

► Saudi Arabia has recently announced plans to deploy over 25 GW of solar CSP by 2032 (and approximately 10 GW over the next 10 years). The Government expects to take advantage of cheap energy prices locally to develop glass and mirror manufacturing capacities matching solar quality requirements.
Local content policies: the case of the wind industry in China and India

Several countries, e.g. China, have successfully used local content requirements to upgrade the local manufacturing of renewable energy components. In 2005, the Chinese National Development and Reform Commission (NDRC) stipulated that new wind farms have to meet a 70% local content requirement on value added. Previously, local content requirements were gradually increased from 20% (introduced by the Ride the Wind Program in 1996). This led to a rise in domestic demand and to international wind equipment companies establishing manufacturing facilities in China, increasing the wind industrial FDIs and the value chain. One disadvantage is that the domestic wind turbine technology is still immature, requiring intensive maintenance and lowering load hours. This needs to be kept in mind for applications in South Africa to avoid price increases, but overall this instrument could strongly promote regional industry participation. In China, local content clauses are removed once internationally competitive local industries have been established.

The success of the Indian wind turbine industry yields several lessons for the development of CSP in South Africa:

- The development of strong learning networks, intensive collaboration with established companies (from Denmark, Germany and The Netherlands for the wind industry), extensive research and development activities in cooperation with international companies allowed for comprehensive knowledge transfer and a growing expertise in the technological field.
- The development of domestic testing and certification programs to reach international standards and the acquisition of licenses contributes to the market competitiveness of the products.
- The strategic use of advantages due to location in India, such as low labour cost and good access to capital and local networks.

The creation of several subsidiaries allowed Suzlon, India’s leading wind power solutions provider, to achieve maximum in-house production of components. Thus costs can be lowered, the intellectual property is protected and competitive advantages are increased.
## Appendix E: List of interviewees

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<tr>
<th>Area of focus</th>
<th>Sub area of focus</th>
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<td>CSP Developers</td>
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<td>Support structure/mirrors</td>
<td>Skyfuel</td>
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June 2013