Concentrated Solar Power
A strategic industrial development opportunity for South Africa
CONTENTS

Acknowledgements 4
List of figures and tables 4
Acronyms 5
Executive summary 6

Business case: Why should South Africa invest in CSP industrial development? 9
Status quo: The South African manufacturing sector 9
Green growth opportunity: innovation and frontier technology development 12
Concentrating solar technology: flexible, dispatchable energy source and more 14
High-level assessment of South Africa’s suitability to pursue a procurement-driven CSP industrial strategy 18
Market opportunity 22
Potential economic benefit 24
Fiscal expenditure 25
Job creation 26
Wage income 27
GDP 28
Exports and trade balance 28

Lessons learnt in CSP procurement under the REIPPPP 30
Approach to CSP procurement to date 30
Evolution of REIPPPP localisation requirement 31
Localisation experience 33

A roadmap for the future: Procurement-driven industrial strategy linked to international partnerships 37
Procurement-driven industrial policy: A conceptual framework 37
Practical implications for CSP 41
Risks 43
Recommended Procurement Framework 43
Other industrial and innovation policy enablers 44
Climate and foreign policy: Potential for international partnerships 46
Industrial and technological innovation partnership 46
Financial partnership 46

Page 2 | Concentrated solar power: A strategic industrial development opportunity for South Africa
<table>
<thead>
<tr>
<th>Conclusion</th>
<th>49</th>
</tr>
</thead>
<tbody>
<tr>
<td>References</td>
<td>50</td>
</tr>
<tr>
<td>Appendix</td>
<td>53</td>
</tr>
<tr>
<td>Economic impact assessment: Methodology and assumptions</td>
<td>53</td>
</tr>
<tr>
<td>Assumptions</td>
<td>53</td>
</tr>
<tr>
<td>Scenarios</td>
<td>54</td>
</tr>
<tr>
<td>Background and Methodology</td>
<td>54</td>
</tr>
<tr>
<td>Local content evolution: Scenario B</td>
<td>54</td>
</tr>
<tr>
<td>Procurement led industrial strategy for RE: International case studies</td>
<td>55</td>
</tr>
<tr>
<td>Globally deployed RE procurement models</td>
<td>55</td>
</tr>
<tr>
<td>International case studies</td>
<td>58</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

The authors are grateful to WWF-SA for leading and funding this study as well as the expert contributions of Saliem Fakir, Louise Scholtz and Manisha Gulati.

Additionally, the expert technical input of Paul Gauche at the University of Stellenbosch has been immensely valuable in informing the direction and findings in this study.

All remaining errors remain the responsibility of the authors.

LIST OF FIGURES AND TABLES

List of Figures

Figure 1 R&D Indicators for BRICS countries, 2010.
Figure 2 Patents at the US Patent and Trademark Office, BRICS countries.
Figure 3 Royalty and licence fee receipts, BRICS (average in current USD million).
Figure 4 Breakdown of anticipated reduction in US CSP tower LCOE from 2013 ($0.165/kWh) to 2020 ($0.086/kWh).
Figure 5 Capital cost breakdown for tower CSP plant with storage, based on a total system cost of $7 040/kW (2012).
Figure 6 Forecast CSP capacities: 2030-2050, IEA roadmap.
Figure 7 Estimated tariffs for CSP with storage, 2015–2030.
Figure 8 Impact of CSP imports and exports on South Africa trade balance, USDm.
Figure 9 Procurement strategy evolution required for a frontier technology.
Figure 10 Procurement approach to achieve industrialisation objectives.
Figure 11 Planning process to identify industrialisation objectives.

List of Tables

Table 1 Potential South African suppliers of CSP goods and services.
Table 2 Estimated annual employment impact by scenario.
Table 3 Estimated annual wage income impact by scenario.
Table 4 REIPPPP local content requirements, Bid Windows 1-3.
Table 5 Investment in technological innovation.
Table 6 Share of local content: Projection of South Africa’s ability to supply goods and services into utility scale CSP tower plants, 2015-2030.
ACRONYMS

CCGT  Combined Cycle Gas Turbine
CSP  Concentrated Solar Power
CST  Concentrating Solar Technology
EIA  Environmental Impact Assessment
EPC  Engineering, Procurement and Construction
EPCM  Engineering, Procurement and Construction Management
GDP  Gross Domestic Product
FDI  Foreign Direct Investment
FTE  Full Time Equivalent
IFI  International Financial Institution
JV  Joint Venture
LCOE  Levelised Cost of Electricity
LNG  Liquefied Natural Gas
OCGT  Open Cycle Gas Turbine
OEM  Original Equipment Manufacturers
PT  Parabolic Trough
PV  Solar Photo Voltaic
R&D  Research and Development
RE  Renewable Energy
REIPPPP  Renewable Energy Independent Power Producer Programme
SOE  State Owned Enterprise
The adoption of an environmentally sustainable development paradigm would enable South Africa to develop new industries and achieve green growth. Domestically, a steady loss of competitiveness in the manufacturing sector has demonstrated the importance of approaching industrial development differently. China and Brazil, nations which face similar developmental challenges to South Africa, are already growing their renewable energy (RE) industries by successfully leveraging their technological innovation and manufacturing capabilities to produce competitive RE exports such as solar photovoltaic (PV) panels and biofuels. As the ability to innovate and produce advanced technologies continues to constitute a crucial driver of industrial competitiveness and as Asian countries overwhelmingly dominate global low and medium skills-intensive goods production, South Africa is left with little choice but to learn to compete more effectively in technology- and knowledge-intensive industries.

**Frontier technologies with growing global demand hold the greatest potential for industrial development within this paradigm.** Technological innovation drives economic growth by boosting international trade, enabling exports and through the development of proprietary intellectual property that earns royalty income through foreign licensing arrangements. It also results in economic spillovers by boosting industrial productivity, through operation at higher efficiency or the production of higher quality goods. Consequently, increased production capability enables design and manufacturing companies to enter new markets through product proximities resulting in further industrial expansion. In this way, economic growth, job creation and the fiscal revenue base can be grown more effectively than through targeting mature, commoditised manufacturing.

**South Africa has the manufacturing and technological innovation capability to become a competitive manufacturer of frontier green technology** – a strength that few developing countries possess. The country belongs to a group of nine emerging economies which account for more than three quarters of all green patents granted by the USA to developing countries (World Bank 2012). Up until the 1990s, South Africa was an innovation leader among emerging economies. Pockets of industrial excellence provide evidence of strong intermediate manufacturing capability. South Africa is a regional hub and a significant exporter in the automotive industry: an industrial platform that can be leveraged to create capability in similar technologies and components.

**Concentrating solar technology (CST) offers South Africa an important frontier technology development opportunity,** enabled by access to solar resources among the best in the world as a platform for testing new technologies and reducing the cost gap (versus traditional baseload electricity sources). In particular, central receiver technology – or power tower, as it is also known – has been identified globally as embodying the greatest potential for utility scale concentrating solar power (CSP) cost breakthroughs. Thermal energy storage enables CSP to operate flexibly as a source of peak, mid-merit and – in future – potentially baseload
Concentrated solar power: A strategic industrial development opportunity for South Africa

power. This ability to readily dispatch power cannot be matched by any other RE source at present, implying an important role for CSP as a balancing electricity generation source in the RE-powered energy mix of the future. There is also a range of alternative applications of CST, including solar-assisted power generation, industrial heating, cooling and desalination.

Experts anticipate that 70-85% of the capital cost of a utility scale CSP tower plant can be produced domestically over the long-term. Local technology pioneers have developed and patented innovative control systems to drive heliostat mirrors, enabling immediate cost reductions and different heliostat field configurations. Coupled with this, local suppliers, including electromechanical equipment, steel and glass companies, are well positioned to supply most of the components into a typical tower plant solar field. Since the solar field is the focus of much research and the source of the bulk of expected reduction in CSP costs over coming years, South Africa is already well placed to become a technology design and manufacturing leader in this arena.

Direct economic benefits of successful CST industrial development and CSP procurement are substantial, including increased value added in the manufacturing and services sectors, increased employment and the development of skills along the spectrum from artisanal to advanced science and engineering. It is estimated that over 13,000 manufacturing and construction jobs could be created by the mid-2020s, accounting for additional annual wage income of R1bn. GDP will also be positively impacted due to multiplier effects.

To realise the opportunity, a coordinated policy approach is required, centring on an appropriately designed, large-scale CSP fleet procurement programme building on the lessons learnt from early procurement under the Renewable Energy Independent Power Producer Programme (REIPPPP). The REIPPPP, used to procure the bulk of utility CSP plants to date, has proven useful for testing various CSP technologies and learning about the OEM landscape. However, the programme will not drive the development of an export competitive CSP component manufacturing sector in future. A new approach, in which the public and private sectors partner in longer term, larger scale fleet procurement using a strategic sourcing approach is necessary in the next phase of development. This will commence once appropriate learning has taken place over the next 2-3 years, enabling a clearer assessment of the operation of various technologies, the capabilities and relative strengths of global CSP technology leaders, and the potential and challenges associated with developing domestic capabilities in the future design and manufacture of CSP systems and components. This sequencing follows the ‘crawl, walk, run’ logic employed by East Asian policymakers in developing export competitive industries.

Other key elements of this approach include aligned industrial and innovation policy as well as financing. Industrial policy which clearly targets foreign direct investment (FDI) and export competitiveness is necessary to draw in global technology leaders and drive a spirit of competitiveness among their local partners. Support for innovation through adequate R&D funding, the development of central specialised innovation hubs and the commercialisation of early stage technology, is key. Current CSP leaders like Spain and Germany have invested significantly in advanced public research centres which generate commercial spinoffs and support the development of new products for existing CSP companies.
Importantly, South Africa cannot afford to go it alone. There are clear risks to building frontier industries as a result of the unpredictable demand trajectory for targeted technologies. The most significant of these is the risk of global demand evaporating completely if a superior technology was to emerge. In the case of CSP, this threat is posed by the possible development of commercially viable battery storage which could be linked to far cheaper PV-generated power. A less serious risk is that of becoming locked in to suboptimal technology; for example, incurring unnecessarily high costs due to developing a tower component manufacturing industry while elsewhere a cost breakthrough may occur in another CSP typology, for example linear Fresnel. Partnerships with developed countries, IFIs and global Original Equipment Manufacturers (OEMs) showing CSP leadership are therefore critical. National and supranational partnerships can assist with channelling CSP-related funding into South Africa, including climate funds and development aid, as well as leveraging existing R&D and knowledge capabilities. International technology transfer between leading OEMs and promising South African suppliers will assist the latter to build their capability and absorb and adapt to CSP which is vital for emerging economies as technology takers.
**BUSINESS CASE:**

**WHY SHOULD SOUTH AFRICA INVEST IN CSP INDUSTRIAL DEVELOPMENT?**

---

**Status quo: The South African manufacturing sector**

South Africa’s manufacturing sector has become a source of concern to policymakers. While other local economic sectors have recovered since the financial crisis and global recession of 2008-2009, growth in manufacturing output has slowed due to weak demand for local goods and its share of GDP has consequently fallen over the period. This is part of a longer term battle with competitiveness in the sector: South Africa’s share of world manufactured exports has dropped from 0.33% in 1995 to 0.29% in 2013 (Makgetla 2014:14). While growth in manufacturing output has remained positive over the last five years, albeit very modestly so, the same cannot be said for its ability to create jobs. Manufacturing is the only sector to have continued shedding jobs since the third quarter of 2010, with its contribution to total employment dropping from 14% in 2008 to 12% in 2012 (Makgetla 2014:7-8).

One of the major drivers of weakening performance in manufacturing is inadequate export competitiveness on low- and medium-skilled goods in contrast to low cost producers in the East, like China. South Africa must compete in more knowledge- and technology-intensive goods if it is to grow and sustain manufactured exports; the domestic cost base is simply too high to compete cost-effectively on many traditional, commoditised products.

Today, advanced technologies and talent-driven innovation (by which knowledge is produced) are recognised as the most important drivers of manufacturing competitiveness. While developed countries have historically led in technology development and knowledge, industrialising economies like China and Brazil have recognised that sustainable growth depends on their ability to influence design processes to support their manufacturing capabilities and to innovate.

In recent years, South Africa has neglected to adequately develop its technology-intensive industries and has consequently fallen behind in innovation and in high-technology exports. The roots can be found in both quantity of inputs and the effectiveness with which these are deployed: lower
allocation of resources to R&D overall and less effective conversion of available resources into intellectual property and associated streams of revenue. From an input perspective, South Africa currently has a lower share of researchers engaged in R&D and allocates less money to R&D activities than all of its BRICS peers but India. From an output perspective, the country is increasingly falling behind in number of patents registered and intellectual property receipts. Even India, which allocates a smaller share to R&D budget and researcher base than South Africa, is more successful in this regard. This performance by South Africa represents a substantial deterioration since the early 1990s, when the country led the BRICS group in terms of cumulative patent registrations as well as royalty and licensing fees.

**Figure 1** R&D Indicators for BRICS countries, 2010

![R&D Indicators for BRICS countries, 2010](image.png)

**Figure 2** Patents at the US Patent and Trademark Office, BRICS countries

International co-invention has been a key driver of rapidly increasing patent registration in countries like China and India over this period. This refers to nationals of different countries engaging in joint research which results in the development of intellectual property. South Africa has performed particularly poorly in this regard; its BRICS peer with the lowest number of patents, namely Brazil, still has a share of co-invented patents twice as high as South Africa (Kaplan 2014).

The technology balance of payments is suffering as a result of the absence of substantial new emerging clusters of knowledge. Royalty and license fee receipts were substantially higher for South Africa than BRICS peers in 1990, but by 2010 these had fallen to the lowest in the group and even began to decline in absolute terms.
This deterioration in outlook for technology-intensive manufacturing underpins slower output growth and a lower proportion of technology-based manufactured exports. To regain its manufacturing and export competitiveness, South Africa needs to adopt a new approach. This paper outlines an approach that identifies opportunities in renewable technologies to drive a process of sustainable green growth.

**Green growth opportunity: innovation and frontier technology development**

Green innovation, including the creation and commercialisation of frontier technologies and the diffusion and adoption of new green technologies, has become a pillar of BRICS economic growth and development. Brazil leads the world in biofuels development and export, while China has risen to dominate the global market for PV panels. Morocco hopes to establish a sufficiently large CSP base to export power to Europe.

A common vehicle used for this purpose has been public procurement-driven industrial strategy, whereby government spurs the development of a market for green products through the creation of large-scale demand, combined with appropriate industrial and innovation policy. Technology imports and transfer requirements enable local firms to adopt and adapt to cutting edge technology. This process of technology diffusion, coupled with industrial support and innovation incentives to move beyond catching up onto the global technology frontier, has supported the development of export competitiveness in various renewable energy industries. At the same time, these emerging economies have been able to develop sustainably through limiting greenhouse gas emissions, and consequently diversifying towards a more sustainable energy mix.
Technology development and commercialisation is, however, an intricate, risky and expensive process, particularly for complex products on the edge of the technology frontier. This poses both a threat and an opportunity to emerging economies. Firstly, it is very difficult for an industrial company in an emerging economy to become an OEM, capable of marketing nationally developed designs globally, given the massive technology development expenditures required and the need to establish adequate post-sale servicing and associated supply chain facilities. Secondly, if a supplier becomes purely focused on manufacturing, it will invariably end up competing on cost, with very little differentiation from other suppliers in the OEM network. However, on the positive side, there is an opportunity for a national supplier to become part of the global technology network in a global OEM supply chain through a risk share agreement and to move towards producing and engineering components of greater and greater value.

Large global OEMs of complex systems have become the key drivers of global technology development as well as of manufacturing capability in their supply chains. For example, the top 100 firms out of a survey of the global top 1400 firms account for 60 per cent of total investment in R&D (Nolan 2011). As OEMs have focused more on design and globalised their supply chains, they have developed the capability to systematically develop supply chains in a country which will add to their competitive advantage. OEM competitiveness ultimately depends on the quality of output and reliability of suppliers and the efficiency of their supply chains.

Strategic supplier partnerships with these OEMs are central to success in developing industry in emerging economies. From an industrial policy perspective, OEMs are in the business of both selecting and nurturing “winners” to become part of their global supply chains. OEMs have developed methodologies, systems and the skills required to comprehensively support a potential supplier through a technology absorption process and up a steep learning curve. Consequently, mobilising this capability in a developing country can be a powerful instrument in building component manufacturers able to produce to world-class requirements.

In the case of specific frontier technologies, there may be opportunity for emerging markets to become market leaders due to fragmentation of the supply base. There are certain frontier, or immature, technologies where system and key component design is still in a high degree of flux. In addition, the market for these technologies may be perceived as relatively marginal. In these cases, the global OEMs may focus on more mainstream technologies, creating a gap in the market for medium-sized OEMs and component designers to emerge as leaders. In these spaces, there is an additional opportunity for emerging economies to adopt a technology and manufacturing development programme in order to become a design centre of excellence in the technology. This paper examines the opportunity associated with CSP, focusing on its main role in generating clean electricity as concentrated solar power.
Concentrating solar technology: flexible, dispatchable energy source and more

The main application of concentrating solar technology in the production of solar thermal electricity with storage has gained significant traction in the last five years. Global installed capacity had risen to 3.6 GW by the end of 2013, increasing by a factor of five from just 600 MW at the end of 2009 (IEA 2014). The base of countries purchasing concentrated solar power (CSP) also expanded beyond Spain and the USA to include the UAE, Morocco, India and South Africa. The most important differentiator of CSP is the relative dispatchability flowing from its economical thermal energy storage capability, currently based on molten salt technology. This feature greatly reduces the intermittency and unpredictability of electricity supply usually associated with RE sources.

Taking into account the importance of cost in energy procurement decisions, the most immediate clean energy opportunities for CSP include acting as peakers or being integrated into hybridised plants, typically in off-grid applications. Diesel-powered open cycle gas turbine (OCGT) peaker plants generate electricity at R5-6/kWh at current fuel prices, while CSP competes quite favourably at around R4/kWh during peak periods – and without the future fuel risk attached to volatile oil pricing. South Africa, with its severely constrained electricity generation system, is currently heavily reliant on OCGTs, running these plants at load factors of 20% or higher. If CSP with storage were to supply this demand instead, the utility would save approximately R3.6 billion per annum.

In hybridised RE applications, a cheaper energy source like solar PV supplies electricity when sufficient natural resource is available to power it, while CSP with storage starts supplying when the cheaper RE source supply ends (e.g. from sunset onwards in the case of PV). Since this type of solution can approximate baseload, particularly if a fossil fuel like gas is added for when neither RE source can supply electricity, it is most suitable to off-grid applications where expensive diesel generators would be the alternative. These may include mines and remote rural areas. For example, Abengoa is building the Planta Solar Cerro Dominador plant combining 100 MW PV capacity with 110 MW CSP capacity in the Atacama Desert in northern Chile. The CSP component is a central receiver (tower) plant with 17.5 hours of molten salt storage. The hybrid plant will offer a nominal on-peak capacity factor of 94.5% (CSP Today 2014).

In the medium to long run, CSP may become a competitive mid-merit or baseload electricity source and represents a vital balancing supply source for countries aiming for 100% RE powered grids. The USA SunShot initiative is targeting the attainment of a competitive baseload unsubsidised CSP tariff of $0.06/kWh by 2020. Recently there have been promising signs of cost reduction through two main channels: the commercialisation of newer CSP technologies operating at greater efficiency, such as tower, and the achievement of economies of scale linked to larger plant sizes. Regardless of whether this cost is achieved, however, the ability of CSP with storage to counter the intermittency associated with PV and wind delivers a unique value proposition as a flexible, clean,
mid-merit alternative to combined cycle gas turbines (CCGTs). In fact, in South Africa, operation of any CCGTs built to supply mid-merit or baseload power could cost as much as R2/kWh if imported LNG were used as fuel; this is more expensive than the off-peak CSP tariffs bid in REIPPPP Bid Window 3.5.

**Dependent upon regional economics, integration with fossil fuels can prove financially attractive.** In this regard, solar technology can be used to generate electricity using the same power block, as in the case of integrated solar combined cycle plants where CSP is generated during the day and gas power overnight, maximising dispatchability. Alternatively, it can be used to augment the production of electricity by fossil fuels, resulting in increased efficiency and lower emissions. For example, concentrating solar technology can pre-heat the feed water before it enters boilers in coal-fired plants.

**Finally, CST can be deployed in industrial applications including process heating, cooling and desalination.** In South Africa, the mining, iron and steel, non-ferrous metals and non-metal minerals industries together account for 59% of the energy consumed by the industrial sector (Brent & Pretorius 2011). Parabolic trough (PT) systems are able to drive double effect absorption chillers for mining ventilation as well as provide process steam for the chemical and fuel industries. For air conditioning of commercial buildings, compact linear Fresnel systems can be mounted on roofs and drive double effect absorption chillers. Further, the ability of solar collectors to power thermal desalination plants, enables both the treatment of acid mine drainage and the provision of fresh water at mines. The extent to which these will be deployed depends on factors such as the price of carbon (e.g. via the impending carbon tax), security of grid supply and the availability of more economical alternatives.

**The tariff at which CSP can be procured hinges fundamentally on three factors: quality of solar resource, system efficiency and storage.** CSP systems utilise direct normal irradiance (DNI). High DNI is measured in hot and dry areas with predictably clear skies and low aerosol optical depths. These areas are typically found in subtropical latitudes from 15-40 degrees north or south. The best resources for CSP energy generation are thus found in North and Southern Africa, the Middle East, Peru, Chile, Australia and parts of India (north-west), the USA (south-west) and China (west) (IEA 2014:11). South Africa, and particularly the Northern Cape, falls within the band of ideal CSP areas, with high solar radiation supporting the attainment of very competitive tariffs.

System efficiency is determined by optical efficiency in the solar field and conversion of the resulting heat to steam which powers the turbine. In this respect, the currently dominant CSP technology, namely PT, is limited in its ability to achieve further breakthroughs due to a cap on the operating temperature of the heat transfer fluid (usually synthetic oil) of around 390 degrees Celsius. This limitation is especially important for dry cooled applications, such as those required in South Africa, which result in high auxiliary energy consumption. Tower plants, by contrast, can operate close to 600 degrees Celsius, using either direct steam generation (i.e. steam is the only heat transfer fluid) or indirect steam generation in which steam and molten salt are circulated.

Finally, incorporation of a large thermal energy storage capability can bring the tariff down by increasing the capacity factor at relatively modest capital cost in high temperature systems. Tower can support a much higher storage capability than
trough due to the larger temperature difference between hot and cold molten storage tanks: hot storage operates at 565 degrees versus PT at 390 degrees, compared with cold storage dropping to a minimum of 290 degrees.

**Tower technology is expected to be the utility scale CSP technology of the future, delivering the largest cost breakthroughs and outpacing PT in new orders. From an innovation perspective, the most highly anticipated breakthroughs are in design changes in the solar field.** Heliostats comprise 35-40% of the capital cost of tower plants with storage, while receivers account for 10% (Black & Veatch 2012). A few of the key design improvements relevant to local tower projects include the following, several of which have been developed in South Africa:

- Smaller heliostats to be produced in greater volume incur lower transportation costs and are subject to less wind-loading, e.g. Helio100 system, BrightSource and eSolar;
- Innovative control systems lowering associated costs e.g. Helio100 system;
- Independent mirror driver electrical systems which reduce auxiliary power requirement and thus lower overall cost through feeding more power into the grid, e.g. BrightSource PV-powered system;
- The reduction of the steel support requirement in solar field which can lower material costs (Ernst & Young & Enolcon 2013);
- In the receiver, increasing thermal efficiency by increasing outlet temperature and reducing thermal losses may reduce cost by up to 45% (Ernst & Young & Enolcon 2013).

A detailed list of anticipated tower technology innovations can be found in Kolb et al (2011).

**A second channel for cost reduction is increased plant size.** Substantial economies of scale are said to be achievable at a plant capacity of 130-170 MW. The key driver for this optimisation is the fixed cost associated with turbine size. The smallest turbines currently available to CSP developers have capacities of approximately 130 MW. The solar field size can be increased at relatively low cost to optimise the use of these turbines. The larger the power block, the greater the thermodynamic economies of scale will be. Considering that the power block accounts for an estimated 14% of the capital cost associated with a tower plant with storage, this can make a meaningful difference to overall cost. CSP experts argue that tower plants have no theoretical capacity limit; size is constrained only by atmospheric attenuation, available crane height and local regulations.

**The third channel is standardisation as the technology matures,** resulting in a decline in development, financing, build and operating costs as well as enabling cheaper manufacturing costs through greater volumes. It is understood that CSP projects currently attract a technology risk premium of 60-100 bps in commercial project debt pricing\(^3\): a significant handicap over a 20 year PPA. Tower developers active in South Africa comment that it is currently very difficult to raise bank debt on competitive terms, particularly for large-scale plants (100 MW and larger), given the early stage of development of the technology, which creates a clear need for development financing if this technology is to be locally supported.

As a result of these factors, the LCOE generated by tower CSP is expected to drop by 50% between 2013 and 2020. Kolb et al (2011) project that a non-subsidised LCOE

---

\(^3\) Interviews with local investment bankers
of $0.086/kWh is possible in the USA by 2020\(^4\), which aligns with the USA SunShot objective of achieving $0.06/kWh LCOE by the same year. The size of the reduction also aligns with expectations of OEMs present in South Africa, who expect that CSP will become 40-50\% cheaper in South Africa over the next 5 to 10 years. As is reflected below, heliostats are the components anticipated to deliver the greatest cost reduction.

### Figure 4  Breakdown of anticipated reduction in US CSP tower LCOE from 2013 ($0.165/kWh) to 2020 ($0.086/kWh)

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance of Plant Direct Cost</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Receiver Direct Cost</td>
<td>1.3</td>
<td>1</td>
</tr>
<tr>
<td>Power Plant Direct Cost</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Indirect Cost</td>
<td>3.6</td>
<td>1.9</td>
</tr>
<tr>
<td>Site Direct Cost</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Tower Direct Cost</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Heliostat Direct Cost</td>
<td>3.4</td>
<td>1.8</td>
</tr>
<tr>
<td>PV O&amp;M</td>
<td>1.4</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Source: Kolb et al (2011)

The potential demand associated with the range of CST applications outside utility scale electricity supply supports movement along the learning curve. Evolving micro tower technology can be deployed in electricity generation for commercial, industrial and mini grids, as well as solar boosting and industrial process applications\(^5\). Other relevant technologies are PT and compact linear Fresnel. The selection of CST technology will depend on the suitability of the technology to the site and applicable costs. In these cases, only the solar field is constructed (e.g. heliostats and receiver in the case of tower technology) and there is no need for a power block or storage capability when CST is used for applications other than electricity. A relatively large number of heliostats are required in both utility scale and other CST applications. Given the importance of the heliostat field in determining overall CST costs, standardisation and economies of scale associated with high volume production for a range of uses will assist in achieving competitive pricing.

---

\(^4\) This estimate is based on US region-specific DNI, development and financing costs, applicable taxes and levies and a specific storage size. It cannot be converted directly to Rands for SA comparison.

\(^5\) For example, the US-invented Wilson 24Solar Plant capacity can be as small as 300 kW and can operate in a variety of site conditions. In US pilot application, a cost of $0.07/kWh has been achieved.
High-level assessment of South Africa’s suitability to pursue a procurement-driven CSP industrial strategy

CSP leadership requires intermediate manufacturing capability and substantial investment in knowledge. Design and systems engineering activity will be central to inventing new configurations of the solar field which deliver critical cost breakthroughs. As an engineered solution, CSP remains fundamentally different to PV, which has become far cheaper through standardisation, modularisation and mass production. This technology feature may change in future, however, with the introduction of modular micro tower systems.

Current CSP leaders include Spain, Germany and the USA. Spain lays claim to the largest installed base of CSP (almost 3 GW), subsidised through a feed-in tariff which eventually fell away as a result of the associated fiscal expense. It is home to several of the largest CSP engineering companies which now market their EPC capabilities to countries including South Africa. Importantly, Spain’s manufacturing sector is relatively low tech by EU standards, with its share of R&D expenditure approximately half the EU recommendation. It has leveraged its automotive manufacturing capabilities, the early creation of a highly skilled CSP public research hub (the Platforma Solar de Almeria) with coordinated research priorities and funding, and a large-scale public CSP procurement programme to become a CSP leader.

Germany and the USA are global R&D and technology-intensive manufacturing leaders. These countries play host to several leading CSP system and component designers and manufacturers, including Bright Source Energy and SolarReserve (system and key component design), Schott (receiver tube production) and Flabeg (PT solar collector production). In Germany, the national aerospace centre, DLR, conducts advanced research into CSP, with commercial ventures spinning out of it. DLR is currently also assisting Morocco in setting up its own CSP R&D centre under the auspices of Masen, the Moroccan Agency for Solar Energy. In the USA, the SunShot initiative coordinates and allocates R&D funding to a range of companies focusing on national CSP research priorities.

As a diversified emerging economy and Africa’s manufacturing and services hub, South Africa is currently integrated into several global value chains. Its knowledge base, efficiency and the scale of its economy position South Africa uniquely on the continent with respect to global supplier capability. Centres of excellence include mining capital equipment and specialised chemicals, which are fast growing exports into Africa, and the automotive industry, in which South Africa is a regional and specialist (right-hand steering) assembly hub. Coupled to its rich minerals endowment, the presence of metals production capability (including steel) provides South Africa with a natural base from which to manufacture a range of componentry. It has also developed world-class pockets within the services sector, including the defence, construction and finance industries. Manufacturing currently accounts for 13% of GDP, while finance, real estate and business services contribute 20% (Stats SA 2014).

Existing industrial capability is key due to the implications of product proximity for development of new industries. Proximity refers to the distance between different products in the product space, which determines the ability to leverage existing capability to design and manufacture new products.
Similar products require similar industrial inputs, including skills, technology and production lines.

**The well-developed local automotive and associated materials industries serve as a platform for developing the CSP industry.** A large automotive assembly presence in South Africa, combined with long-term industrial development incentives, has attracted not just car companies, but also automotive component manufacturers. These OEMs have supported the development of several local firms into becoming competitive exporters of components, including catalytic converters, aluminium based products and leather seats. Today, the automotive industry accounts for 12% of South Africa’s exports (Kumo et al 2014). Examples of component suppliers which may be relevant to the development of a local CSP industry include ArcelorMittal and Duferco in the steel industry and PFG in the glass industry.

**The electromechanical equipment and service industry provides another key development opportunity.** For example, the Actom group – previously part of Alstom – is the largest manufacturer, solution provider, repairer and distributor of electro-mechanical equipment in Africa. It has already become a major supplier of electrical equipment, services and balance of plant to REIPPPP projects, winning contracts in excess of R1bn to date. It has five critical capabilities which will enable it to develop into a company operating along the length of the CSP value chain:

- Cooperation agreements with international design and technology leaders;
- In-house component design engineering teams;
- Engineering projects and contracts division for turnkey project delivery;
- Locally dominant and export competitive boiler manufacturing via John Thompson;
- Provision of elasticised moulding via foam injection to create heliostat facets from flat mirrors (for example, supplied by PFG).

**With respect to tower technology specifically, it is estimated that at least 50-60% of a utility scale tower plant’s value can be produced locally in the near future.** Only the power block, storage material and non-boiler type receiver are beyond the country’s current capabilities. In the longer term, as much as 85% value may be captured locally; the receiver on indirect generation systems is the only component requiring highly specialised science and design capability which may not exist locally. It is clear that CSP tower is a technology with very high localisation potential in a country with South Africa’s industrial capability. In this respect, there is still a clear advantage over peers like Morocco who also plan to build local CSP industries.
Figure 5  Capital cost breakdown for tower CSP plant with storage, based on a total system cost of $7 040/kW (2012)

Source: Black & Veatch (2012)

Companies and industries which have already been identified as potential suppliers to the South African CSP sector cover a broad base of the tower componentry and service input requirement.

Table 1  Potential South African suppliers of CSP goods and services

<table>
<thead>
<tr>
<th>Component Manufacturing</th>
<th>Potential Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heliostats</td>
<td>Mirrors</td>
</tr>
<tr>
<td></td>
<td>Satchwell (foam injection)</td>
</tr>
<tr>
<td></td>
<td>Rigifoom (foam)</td>
</tr>
<tr>
<td></td>
<td>PFG building glass (silvering)</td>
</tr>
<tr>
<td></td>
<td>PFG building glass (glass)</td>
</tr>
<tr>
<td>Gears/Drives</td>
<td>Actom</td>
</tr>
<tr>
<td>Steel suppliers for structures</td>
<td>Macsteel, Aveng Trident, Duferco and Arcelormittal SA</td>
</tr>
<tr>
<td>Controls</td>
<td>Helio 100 (intelligence), Wirecon (wiring) and Reutech</td>
</tr>
<tr>
<td>Trackers</td>
<td>Helio 100, Reutech</td>
</tr>
<tr>
<td>Receiver</td>
<td>John Thompson, Defence industry</td>
</tr>
<tr>
<td>Tower</td>
<td>Brolaz, Macsteel, Trident, Duferco, Sectional Poles and Graffo</td>
</tr>
<tr>
<td>Storage</td>
<td>Intertherm, Steel companies and EPC (storage container only)</td>
</tr>
<tr>
<td>Power block</td>
<td>n/a</td>
</tr>
<tr>
<td>EPC services</td>
<td>Group Five, Aveng and Crowie Concessions</td>
</tr>
</tbody>
</table>

Source: Interviews with local CSP experts
Industrial development opportunities can be split into three categories: engineering services, design and production of key components, and production of basic components.

The provision of Engineering Procurement and Construction (EPC) services, while accounting for just 5-10% of CSP tower plant value, is a vital enabler of local component sourcing given its position at the top of the CSP value chain. The engineers who design the system are able to create sufficiently narrow specifications that globally only one or two suppliers are able to qualify. Where EPCs are international and promote foreign interests, this can form a non-transparent barrier to procurement from domestic suppliers. To maximise the value chain opportunity associated with CSP exports, sufficient engineering skill should be developed to enable South African companies to deliver CSP plants elsewhere in the world, using South African components.

This is a relatively specialised capability which can either be developed by engineering firms, electromechanical equipment companies such as Actom (currently focused on balance of plant turnkey delivery), or construction companies such as Group Five (responsible for the delivery of Soitec Concentrated Photo Voltaic plant in Touwsriver). While engineering jobs created will be limited, EPC may enable the creation of construction jobs if the engineering company has a competitive turnkey design and build capability.

Design and manufacturing of key components is the main industrial opportunity, capturing 40-50% plant value with co-production of intellectual property which can earn royalty and licensing fees. Immediate opportunity lies in the heliostat field, comprising almost 40% of a tower plant capital cost, and offering the largest potential for tower cost breakthroughs. Engineers at the University of Stellenbosch have developed the patented Helio 100 modular heliostat system with a breakthrough low cost autonomous control system compared with standard control technology, and an indirect saving through compatibility with fields of smaller heliostats.

Smaller heliostats can be less expensive, due to lower wind resistance requirement and easier transportation, among other factors. Heliostat field configurations containing large numbers of small heliostats support modularisation, standardisation and high volume production. This will enable a local engineering company to design and manufacture linear actuators to dynamically adjust the facets as the sun moves. Drivetrains such as slew gearboxes and linear actuators currently account for approximately 50% of the cost of a heliostat. Most of the large international gear and drive manufacturers are adapting and designing products for CSP and PV trackers. There is no reason that South Africa cannot favourably compete, given its own satellite and telescope technology development. Future design-related opportunities outside the heliostat field include the development of alternative thermal storage solutions (i.e. using materials other than molten salt) and receivers (e.g. for direct generation, using John Thompson boilers).

Manufacturing may either be enabled by the development of own designs or through cooperation with a foreign OEM, through licensing agreements or joint ventures. In design-related opportunities, South African innovators can register patents, enabling the earning of royalty and licensing fees, creating another stream of revenue in addition to component production. In cooperation with foreign OEMs, South African firms can experience learning with respect to the operation of the new technology,
laying the foundation for future design. Chinese firms have employed this model of technology transfer extremely profitably. In either case, the focus is likely to be on precision and innovative engineering, the product of which is capable of legal protection, and hence there is a degree of resilience against the threat of competition with lower cost Asian countries.

This high value adding works category should clearly be the focus of industrial policy aimed at creating export competitiveness. It also has some potential to create jobs, which will likely be mixed in terms of skill intensity. Advanced science and engineering skills are required in design, while production may involve mass assembly lines operated by semiskilled personnel.

**Finally, basic component production offers limited value add – around 10% of the value of a plant – but significant and immediate job creation potential to assist with unemployment.** Basic components include storage tanks, steel structures and some generic cabling and wiring. An earlier study (Ernst & Young & Enolcon 2013) has highlighted the suitability of South African producers to supply these components, provided that input costs, including those of raw materials, can be contained. Typical suppliers would be construction companies and their general component suppliers, for example insulation and sheet metal companies.

This works category has far less potential than the previous two to become export competitive. Nonetheless, it is important for creating a number of low to semi-skilled jobs, most notably in the region in which CSP plants are built where unemployment is typically a significant challenge (e.g. the Northern Cape and other remote rural areas). In many cases, these components are already being procured under the REIPPP’s local content commitments.

**General barriers to success identified with OEMs include a complacent supplier mindset, limited artisanal skills, and logistical infrastructure** in the Northern Cape – the area currently targeted for CSP-led industrial development. Complacent supplier mindset manifests in inflexible ways of working, uncompetitive pricing and protracted timelines. This represents a major barrier to partnership with global OEMs, reducing their expected return because of the significant investment of time and effort in nurturing export-competitive local suppliers. Limited artisanal skills encapsulate both the quantity of adequately trained workers available and their time spent on the job. Absenteeism has been identified as a productivity challenge. Logistical infrastructure refers to the rural remoteness of the solar corridor, with urban hub Upington – the possible location of a Northern Cape Special Economic Zone – far away from a port or convenient rail link to a port. All of these problems would need to be creatively overcome if South Africa were to pursue this industrial development opportunity.

**Market opportunity**

The IEA (2014) projects that CSP, powered by 980 GW installed capacity, will account for 11% of global electricity generation by 2050. Solar energy, more generally, is expected to contribute almost a third to the world’s electricity generation mix by that year: a very rapid transformation to a new energy source by any account. The largest CSP markets will be the US, Middle East and India.
Africa, at 147 GW of installed capacity, will account for 15% of global demand. While this may sound modest in comparative terms, it is important to bear in mind that the continent currently accounts for only 3% of global electricity generation (BP 2014). If the envisioned capacity was to operate at 50% load factor – a conservative assumption considering thermal energy storage developments – CSP alone would almost double current electricity generation in Africa, revolutionising the current landscape. Indeed, Africa is expected to be the second largest producer of solar thermal electricity globally due to its excellent solar resource, despite having only the fourth largest capacity (IEA 2014:22).
South Africa is well positioned to supply CSP goods and services regionally. Contributing factors include trade blocs (such as SADC), existing South African exporter trade networks (for example, such as those Actom and Group Five have established across the continent), and an understanding of African markets and business practices based on regional integration. Even if South African companies were only to capture 3 GW, or 10%, of the rest of Africa’s projected 2030 CSP capacity, this could prove very lucrative.

Potential economic benefit

To create a picture of the potential economic impact possible with a localised CSP industry in South Africa, a high-level economic impact assessment exercise was undertaken. This exercise centred on two scenarios: an internally focused one – Scenario A – in which South Africa continues with the current CSP procurement approach and local content plateaus, and a second one – Scenario B – in which South Africa uses a procurement-driven industrial strategy to build an export-competitive local component industry focused on CSP tower technology. The exercise draws largely on existing studies and research reports for specification of key modelling parameters.

Five channels for impact are evaluated:
- Fiscal expenditure;
- Job creation;
- Wage income;
- GDP growth;
- Exports and trade balance.

---

6 This is estimated at 29 GW, being the projected IEA figure of 32 GW less SA’s own installed capacity of 3 GW, as per the Integrated Resource Plan Update of 2013.
Assumptions and methodology are laid out in more detail in the appendix. All financial figures provided are in 2015 Rand.

In Scenario A, South Africa focuses only on procuring CSP for its own generation requirements at lowest possible cost. The approach laid out in the IRP Update is followed (DoE 2013b), in terms of annually procured volume and total capacity operating by 2030. 200 MW CSP is secured annually, building up to a total of 3.3 GW capacity (i.e. an additional 2.7 GW is procured), assumed on the basis of the REIPPPP or a similar price-driven auction model. There is no attempt to direct procurement spend at specific CSP technology types or suppliers, resulting in procurement of a fragmented base of PT, tower and possibly others. Local content plateaus at current levels of around 40% as a result. No meaningful manufacturing capability develops, and no products or services are exported.

In Scenario B, South Africa takes the decision to become export competitive based on directed, large-scale procurement of CSP, focusing deliberately on building a critical mass of tower plants. Annual procurement increases to 300 MW capacity, in line with the minimum feasible demand for localisation of factories as stated by most potential component manufacturers in Ernst & Young and Enolcon (2013), building up an additional 3 GW capacity to the current 600 MW using a coordinated large-scale procurement programme linked to the solar corridors (or similar). Local content escalates over the period in line with deepening industrial capability. In the mid-2020s, South Africa starts exporting tower components to the rest of Africa. It is anticipated that annual export capacity of at least 300 MW could be developed to service this requirement (IEA 2014) by the mid-2020s, if a successful procurement-led industrial policy were implemented soon. Timelines are assessed against the example in Spain.

**Fiscal expenditure**

The anticipated cost of procuring the specified size fleets of CSP capacity ranges from R294bn to R427bn in Scenarios A and B respectively. In Scenario A, an estimated 194 TWh of solar thermal electricity is purchased, compared with 323 TWh in Scenario B. This is a function not only of greater capacity being allowed for in Scenario B, but also PPAs applying over a 30 year period rather than the current 20 year period stipulated in the REIPPPP. The useful lifetime of CSP plants is understood to be significantly longer than wind and PV plants, hence a 20 year PPA is considered suboptimal; the net result is recovery of capital cost over an inefficiently short period of time, leading to higher electricity tariffs in Scenario A. Since the current Eskom operating model involves the resale of procured RE to its customer base at regulated tariffs which apply uniformly to all electricity sources, it is anticipated that 30 year PPA structure would be more suitable. If the PPA in Scenario B were to drop to 20 years, the associated procurement cost would drop to R344bn.
Note that, by 2030, CSP with storage is projected to be competitive with cleaner mid-merit and baseload alternatives to coal at a project cost of R1/kWh in Scenario B. Such alternatives would include nuclear power and combined cycle gas turbines operating off natural gas.

**Job creation**

The estimated number of full time equivalent direct jobs created annually is 6000-13400, representing at the low end Scenario A and the upper end Scenario B with exports in support of 300 MW capacity installed elsewhere in Africa. It is anticipated that construction will be the biggest job creator initially, although such jobs will be of a temporary nature. To provide some security in employment prospects, Government would need to procure capacity regularly for the duration of the procurement programme, to enable construction-related workers to make maximum use of their skills on subsequent projects. Should South Africa develop an export-competitive CSP industry, it is clear that manufacturing could become both a larger and more durable source of employment.

---

*CSP* stands for Concentrated Solar Power.

*CCGTs* utilising natural gas are anticipated to offer electricity in the region of R0.80-R1.20/kWh, as opposed to the R2/kWh mentioned earlier in connection with LNG.
Table 2  Estimated annual employment impact by scenario

<table>
<thead>
<tr>
<th>Description</th>
<th>FTE jobs per MW p.a</th>
<th>Scenario A 200 MW SA</th>
<th>Scenario B 300 MW SA; no export</th>
<th>Scenario B with exports 300 MW SA; 300 MW exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction and Assembly</td>
<td>15.4</td>
<td>3080</td>
<td>4620</td>
<td>4620</td>
</tr>
<tr>
<td>Operations and Maintenance</td>
<td>0.4</td>
<td>80</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>14.4</td>
<td>2880</td>
<td>4320</td>
<td>8640</td>
</tr>
<tr>
<td>Total jobs</td>
<td>N/A</td>
<td>6040</td>
<td>9060</td>
<td>13380</td>
</tr>
</tbody>
</table>

Source: Own analysis based on a variety of data sources including interviews, Maia et al (2011) and Ernst & Young and Enolcon (2013).

It must be noted that these employment figures have not taken into account indirect and induced jobs. If the estimates of ratios between direct jobs, indirect and induced jobs contained in Ernst & Young and Enolcon (2013) are relatively accurate, then total annual employment could rise to 32 000 in the mid 2020s, during the tail end of South Africa’s CSP procurement programme and once export activity is taking place.

Wage income

While the construction industry may initially create more jobs, these will largely be of a semiskilled nature and thus accrue limited yields in terms of wage income. This may nevertheless prove a great source of upliftment in impoverished rural communities in areas such as the Northern Cape. Wages in the manufacturing industry are substantially higher, given the mix of skills employed. By the mid-2020s, workers in the industry could be generating close to R1bn in wage bill if manufactured exports were flourishing.

Table 3  Estimated annual wage income impact by scenario

<table>
<thead>
<tr>
<th>Description</th>
<th>Average annual wage</th>
<th>Scenario A 200 MW SA</th>
<th>Scenario B 300 MW SA; no export</th>
<th>Scenario B with exports 300 MW SA; 300 MW exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction and Assembly</td>
<td>R 26 132</td>
<td>R 80 487 279</td>
<td>R 120 730 918</td>
<td>R 120 730 918</td>
</tr>
<tr>
<td>Operations and Maintenance</td>
<td>R 26 132</td>
<td>R 2 090 579</td>
<td>R 3 135 868</td>
<td>R 3 135 868</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>R 92 968</td>
<td>R 267 749 057</td>
<td>R 401 623 585</td>
<td>R 803 247 170</td>
</tr>
<tr>
<td>Total jobs</td>
<td>R 350 326 914</td>
<td>R 525 490 371</td>
<td>R 927 113 957</td>
<td></td>
</tr>
</tbody>
</table>

Source: Own analysis based on 2013 averages for manufacturing and construction industries (Quantec), adjusted for inflation.

Note: Operations and maintenance wages are assumed to be equal to construction wages.
**GDP**

The GDP multiplier impact results from government infrastructure spend allocated to local suppliers for the provision of goods and services for the supply, installation and maintenance of CSP plants for generation of electricity within South Africa. It is estimated that GDP will increase by R50-105 billion as a result of the South African CSP procurement programme, with the lower end of the range representing Scenario A and the upper end representing Scenario B. This considers only the expenditure directed towards capital costs, and is hence conservative.

This estimate is based on estimated expenditure by IPPs on local content in the form of goods and services in the manufacturing and construction industries of R61 to R107 billion, representing Scenarios A and B respectively.

**Exports and trade balance**

During 2014, South Africa had a cumulative trade deficit of R95 billion, or approximately $8 billion at current exchange rates. Embarking on a large-scale energy procurement programme brings with it the risk of further worsening the trade balance through high volumes of imported goods and services.

In the case of Scenario A, this is a legitimate concern. If business continues as usual, no significant local component industry will develop, with local content – assumed to remain constant at 40% – continuing to be largely driven by services, owner’s costs and balance of plant. The impact on the trade balance is persistently negative, peaking close to $800m, alleviated only by global reduction in capital costs due to learning.

For Scenario B, however, the initially worse impact on the trade balance – due to a larger CSP plant build programme – rapidly disappears as local industry capability develops. By 2024, when exports begin, the impact on the trade becomes positive, reaching more than $600m by 2026.
Figure 8  Impact of CSP imports and exports on South Africa trade balance, USDm

Source: Own analysis based on Black & Veatch (2012)
LESSONS LEARNT IN CSP PROCUREMENT UNDER THE REIPPPP

Approach to CSP procurement to date

Up until now, the Department of Energy (DoE) has favoured the use of a price-driven auction-style bidding process for the bulk of CSP capacity procured. The REIPPPP is fundamentally structured as a series of independent transactions concluded between the state-appointed buyer (Eskom) and various Independent Power Producers (IPPs). The procurement strategy objective associated with the adoption of auctions is to secure the lowest cost of different forms of RE by encouraging maximum competition between different providers. Since each transaction is relatively small, the risks associated with any individual transaction are relatively small. Indeed, private sector IPPs carry all of the risk associated with the construction and operation of the relevant RE plants. By overwhelmingly focusing on the procurement of a uniform commodity (i.e. kilo-watt hours), the REIPPPP has to a significant extent achieved, this relatively simple objective.

Up to and including Bid Window 3.5, 600 MW of CSP capacity had been procured through the REIPPPP. Three quarters of this capacity is accounted for by PT technology, with tower making up the balance (50 MW Abengoa Khi plant with 2 hours of storage, under construction, and 100 MW AWCA/SolarReserve Redstone plant incorporating 12 hours of storage, awaiting financial close). BW3 baseline tariffs bid by the successful IPPs stood at approximately R1.60-1.65/kWh (fully indexed) for the allowable 12 hours of energy supplied outside of peak, with 270% of this tariff applicable in peak hours (DoE 2013a). It is understood that the Redstone project baseline tariff holds the record as the lowest ever bid by a CSP utility scale project in South Africa, in the region of R1.45/kWh.

Employing an approach more aligned with a fleet procurement strategy, a tender is under way for Eskom to source its own 100 MW CSP tower plant. The plant, for which specifications have been written by an owner’s engineer, will be procured from a technology provider, developer or EPC company on a turnkey EPC basis over the course of a two stage bidding process (technical bid followed by commercial bid, with only pre-qualified suppliers invited to bid). It will be transferred to Eskom, once up and running, on the basis of a build-own-operate-transfer agreement which will include training for Eskom staff on operations and maintenance.

Eskom’s PPP (public-private partnership) approach to CSP procurement enables strategic sourcing tied to a selected technology, deepening localisation over time, increased implementation of coordinated, supportive CSP policy, and the possibility

---

8 This includes preferred bidders announced for Bid Window 3.5.
of lower cost electricity. The Eskom procurement process is similar to the one implemented by Morocco for the Noor projects, also partially funded by the World Bank. In contrast with the REIPPPP, the procurement focus is on acquisition of a particular technology type, in this case tower. If the CSP capacity requirement were scaled up, this would create a critical mass of demand for selected technologies. Further, if this procurement capacity were appropriately phased over a long time horizon, it would support deepening industrial capability development by global OEMs. Extensive engagement with a range of OEMs provides the state agency with comprehensive information on the ability of each to procure goods and services locally, enabling the development of an ambitious but credible localisation plan. Thirdly, the allocation of risk differs, since the state agency owns and operates the plant post-construction. Implementation of supporting, coordinated policy is more likely in this scenario. Finally, lower cost CSP is made possible by a larger field of competitors, concessionary IFI (international finance institution) loans, and longer procurement time horizons.

It remains to be seen whether further commitments to CSP procurement will follow, and what shape they will take. The IRP Update, the DoE’s key document laying out expectations regarding final electricity demand and generation options for meeting these, includes a sizeable 3.3 GW allocation to CSP (DoE 2013b) by 2030, implying a further 2.8 GW investment. However, it points to the price-sensitivity of this allocation, stating that if the anticipated learning rates of 10% per annum fail to materialise, further investment (beyond Round 2) will not take place (DoE 2013b:41).

Evolution of REIPPPP localisation requirement

From inception, the REIPPPP had dual objectives: primarily to secure RE at the lowest possible price and secondly to promote local economic development (LED). The identified priority focus areas, reflected in the REIPPPP local economic scorecard, include the creation of a RE component manufacturing sector with associated jobs and the promotion of the broader agenda of broad-based black economic empowerment (BBBEE), with specific reference to communities living in the vicinity of RE plants.

The focus on LED can be traced back to the Green Economy Accord and DTI’s Industrial Policy Action Plans (IPAPs). The 2011 Green Economy Accord states that the RE sector commits to achieve a localisation level of 35% by 2016, working towards an aspirational target of 75%. In the process, 50 000 jobs are to be created by 2020 (DED 2011: 18-19). In a similar vein, the 2013-2016 IPAP (“IPAP 2”) identifies the revision of the local content requirements of the REIPPPP as a key action plan, with the desired outcome being “increased local content threshold for renewable energy projects in line with the development of a competitive local renewable energy manufacturing industry” (DED 2013:122). In this respect, then, political support for the REIPPPP was contingent not only upon standard energy procurement criteria, but also achievement against targets for the development of a new RE manufacturing sector in South Africa.

9 The key difference is the ownership structure. In the Moroccan case, IPPs will operate the plants and sell electricity to energy agency MASEN.
10 Some CSP OEMs are reluctant to take on the risks of development, financing and operation associated with becoming part of an IPP consortium. It is understood that the pool of competitors was consequently larger in the case of the Eskom tender than for the most recent round of the REIPPPP.
11 This represents a substantial increase on the original 1 GW allocation in the 2010 IRP.
While more importance was assigned to LED than generally allowed, price remains the primary driver of contract award. Under standard government procurement legislation, 90% of the scoring of tender submissions for large, publicly awarded contracts is based upon price, with the remaining 10% determined by performance on LED criteria. In terms of the REIPPPP, a reduced allocation of 70% of the score was assigned to pricing, with the remaining 30% determined by performance on an LED scorecard. Local content and job creation components were added to a modified BBBEE scorecard, collectively accounting for half of the LED score (Eberhard et al 2014).

Share of local content accounts for just 7.5% of overall bid scoring. This is defined as ‘the value of local content spend as a percentage of total project value, adopting the SATS (South African Technical Standard) for local content’. Certain specific exclusions apply in calculation of the numerator: these have changed across bid windows, with currently excluded elements being finance charges, land, mobilisation fees, and private costs incurred in connecting to the grid. At the same time, steel – regardless of origin – is now counted as local content, to encourage cost-competitive sourcing of components manufactured from this material (Eberhard et al 2014:26-27). In accordance with the DTI’s industrial development objectives, the REIPPPP threshold share of local content has increased steadily since the first round of the REIPPPP in 2011. The target has, however, remained unchanged, at 65%.

Table 4  REIPPPP local content requirements, Bid Windows 1-3

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Bid Window 1</th>
<th>Bid Window 2</th>
<th>Bid Window 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Threshold</td>
<td>Target</td>
<td>Threshold</td>
</tr>
<tr>
<td>Solar CSP</td>
<td>35%</td>
<td>50%</td>
<td>35%</td>
</tr>
<tr>
<td>Solar PV</td>
<td>35%</td>
<td>50%</td>
<td>35%</td>
</tr>
<tr>
<td>Onshore wind</td>
<td>25%</td>
<td>45%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Source: Eberhard et al (2014)
Note: Information for Round 4 is not yet available; no award had been made at time of writing.

Stimulating the development of a new local industry through imposing local content requirements assumes that locally competitive components can be developed for integration into global supply chains. This requires an understanding of local manufacturing capabilities, an appreciation of the likely output cost implications, at least in the short to medium term when local components are initially manufactured at sub-economic scale, and a belief that eventually locally produced components, subsystems and services can be globally competitive and thus attractive alternatives to foreign OEMs (Rennkamp & Boyd 2013). It also assumes that the demand is sufficiently large to offer producers the necessary economies of scale to become internationally cost competitive.

12 Preferential Procurement Policy Framework Act
13 This is typically the BBBEE scorecard as specified in the Codes of Good Practice published under the Broad-Based Black Economic Empowerment Act of 2003.
The DTI recognised that that sufficient component manufacturer capability may not exist early on, and ‘key components’ were identified by the DTI for gradual import substitution. The DoE noted that “...gradual rollout may be necessary in order to build manufacturing capacity in South Africa” (Eberhard et al 2014:26). IPPs have been required to provide more granular information on local content since Round 2, including the identification of EPC and non-EPC components, the local content supplied for each and the associated cost. Scoring on LED criteria has, however, not changed to reflect progress made in manufacturing core components locally.

The CSP key components are as follows (Ntuli 2012):
- Solar concentrators and mounting
- Heat receiver
- Heat transfer fluid and handling system
- Electrical generation system (including generator, steam turbine and ancillary equipment)
- Condenser and cooling system
- Thermal storage system
- Distributed control system
- Pumps, motors and auxiliary steam cycle equipment
- Water treatment plant

Combined, these components represent an estimated two thirds of the capital cost of a typical CSP power plant with storage\(^\text{14}\).

**Government has changed the scoring in recent rounds to reward only IPP commitments above the threshold level in order to further promote local content.** Under this system, the bidder offering the highest commitment received full points and all other bidders were awarded proportionately according to their position on the spectrum between the highest bidder and the threshold level (Eberhard et al 2014). Anecdotes suggest that several ‘red herring’ bids which scored very highly on economic development, but at extremely unattractive prices, were submitted in order to reduce the points awarded to economic development on competitively priced bids, thereby effectively dropping the relative weighting of economic development in the final award\(^\text{15}\).

**Localisation experience**

On the face of it, the RE IPPs appear to have performed according to expectation, progressively increasing local content in line with escalating target levels across bid windows. In the cases of both PV and wind, industry localisation appears to be going according to plan. However, for CSP, achieving even the current threshold level of local content – 45% – has been challenging. One contributing factor has been the much smaller quantity of CSP capacity procured thus far: approximately one third that of PV and wind\(^\text{16}\). The critical mass required to incentivise investment in local production per CSP technology type (i.e. PT or tower) is 500 MW; even PT as the dominant CSP technology has not achieved this level.

---

\(^\text{14}\) Own calculations based on Black & Veatch (2012)
\(^\text{15}\) Interviews with key stakeholders
\(^\text{16}\) Own calculations based on Papapetrou (2014)
Despite the aggregate achievements with industrial development outcomes particularly for CSP has been disappointing. There are at least four main reasons for this.

Firstly, local content stipulations need not result in meaningful industrial development. This implies a disconnect between government expectations of industrialisation and targeted measures. A value-based definition of local content with no specified sub-component requirements need not result in local manufacturing activity, particularly at lower threshold requirements. IPPs find it easier to locally procure services and generic balance of plant components and materials (concrete, cabling, piping, etc.) than specialist core components. For key components, EPCs and developers usually have global supply agreements with specialist suppliers. Sourcing local suppliers of key components capable of providing the required level of product quality at competitive prices may be challenging, particularly at short notice and during early stages of the industry’s development. OEMs are typically required to give 20 year equipment guarantees on entire systems to IPPs which have signed 20 year PPAs: doing so for systems incorporating unproven core components may prove risky. A lengthy process of OEM supplier accreditation is required first.

Secondly, insufficient steady REIPPPP-driven demand exists to justify substantial manufacturing investment by individual OEMs or local component manufacturers. The REIPPPP market is characterised by the awarding of relatively small individual project contracts (maximum 100 MW) on an independent, transactional basis. The embedded uncertainty of demand is an especially significant deterrent for OEMs designing and manufacturing specialised technologies. Component specifications may differ substantially even within the same technology, limiting the ability of a single OEM or local component manufacturer to serve a range of successful IPPs. A relatively small population and economy (compared with other BRICS countries) and geographic remoteness from other major RE markets dampen the local investment business case. This issue is also evident for other RE components: wind and PV manufacturers with local assembly plants comment that only 2% of production is for the local market (Creamer 2014b).

Thirdly, the unpredictable capacity and timing of REIPPPP contract awards creates major challenges for production planning, with associated impact on manufacturing costs and feasibility. The first source of unpredictability is the relatively ad hoc and short-term schedule of REIPPPP rounds: little future visibility exists, with the only certainty provided by medium-term ministerial determinations which are not binding commitments. The second source is delay in the process itself. Financial close in Round 3 and the announcement of preferred bidders in Rounds 3.5 and 4 have been delayed by grid connection issues. Earlier on, capacity issues delayed award (Papapetrou 2014). These unforeseen delays threaten the viability of recently established local plants, such as the R300m DCD wind tower manufacturing plant at Coega and combined R245m solar PV facilities in Cape Town operated by module manufacturers Jinko Solar, SolaireDirect and ARTsolar (Creamer 2014b).

Fourthly, a substantial degree of regulatory uncertainty exists. There is no indication that further rounds of the REIPPPP will be pursued, despite the IRP Update plans for 17 GW RE capacity by 2030. The recent announcement of the intent to embark on a major nuclear programme has left many market participants...
wondering what role RE has to play in future utility scale energy procurement. In addition, Eskom, the single offtaker of RE, is in financial difficulty, undermining the prospects for signature of PPAs in future. By contrast, in a liberalised, decentralised energy market, some incentive would remain to supply energy to other buyers, even where national commitment waived.

Nonetheless, there is a strong case to be made that as a first phase, low risk procurement approach, the REIPPPP was appropriate and that there are a range of critical lessons that can be gleaned from the REIPPPP that can be used to inform more complex and ambitious procurements. These include:

- The programme will give insight into the actual performance of different renewable technologies in South African conditions.
- The programme will give insight into the responsiveness and sincerity of different suppliers in achieving Government’s broader developmental objectives.
- The programme will give insight into the capabilities and responsiveness of South African manufacturers to the opportunities created by the programme and, to some degree, into the likely capabilities and responsiveness to larger opportunities.

**International experience has shown that local content requirements are not always successful in catalysing RE manufacturing sector activity.**

China, with its large market, steady RE procurement and coordinated industrial policy offering financial and tax incentives, has had a very successful localisation track record in PV and wind. By contrast, Brazil initially struggled to meet its ambitious local content requirement of 60% for wind due to supplier bottlenecks and had to temporarily abandon this requirement. It took an ongoing commitment to consistent wind procurement through regular wind auctions and a credible process to achieve the sustained development of a local manufacturing base which enabled meeting the 60% target. Generally speaking, five lessons may be drawn from the experiences of countries which have pursued procurement-driven industrial strategy in RE technologies:

Firstly, credible, long-term CSP procurement commitments with phased, local content requirements are key support for the development a local manufacturing industry.

Secondly, the country needs to understand its main optimisation objective: developing a local technology supply base or obtaining energy at the lowest price. There may be a tension between the two in the short to medium term. Further, it should be understood that IPPs which provide the lowest bids today may do so for a variety of reasons unrelated to the merits of a particular CSP technology, including dumping (e.g. due to recession-driven equipment obsolescence), strategic pricing (to win the local market) or alternative financing arrangements (e.g. on balance sheet). In the case of Morocco, the main procurement priority is to test various technologies at scale, while keeping the associated tariff reasonable through risk sharing, and also developing the necessary R&D and skills to support local innovation. For Chinese wind energy, the early priority was to rapidly grow an innovative, export-competitive component manufacturing base through international partnerships. Tariffs were kept reasonable through auctions where price played a minority role. This reflects that even where local content is top priority, careful programme design must ensure a reasonable price to maintain public support.
Thirdly, international partnership is key in sharing the risks of developing new technologies and industries, both from financing and technology innovation perspectives.

Fourth, relatively affordable government intervention such as PPA or loan guarantees and the establishment of dedicated specialist RE agencies can make a meaningful contribution through the provision of public goods (skills development, R&D support, etc.) and de-risking projects.

Fifth, non-economic barriers to RE must be understood and effectively dealt with, for example EIAs, permitting and grid connection.

Further detail on international case studies can be found in the Appendix.
A ROADMAP FOR THE FUTURE: PROCUREMENT-DRIVEN INDUSTRIAL STRATEGY LINKED TO INTERNATIONAL PARTNERSHIPS

Procurement-driven industrial policy: A conceptual framework

The procurement of renewable energy in an emerging economy intrinsically falls at the intersection of energy, climate and industrial policies and their respective associated objectives. What is variable is the weight given these different objectives in the procurement of renewable energy which will profoundly impact upon the procurement strategy.

Energy policy incorporates the electricity generation plan which needs to take into consideration the costs, risks, reliability and dispatchability of an electricity source like CSP. The Integrated Resource Plan projects the long-term electricity mix for South Africa based on these factors, determining the role CSP can play over a given period based on a pattern of expected electricity demand and other available electricity sources.

With respect to climate policy, RE sources used for electricity generation can contribute to South Africa’s national carbon emissions reduction commitments under international climate agreements and related internal policies and plans.

Finally, efforts to localise services and manufacturing required for plant procurement involve industrial policy. Developing the capabilities to design, manufacture, build and maintain RE plants through the procurement of a fleet to supply a share of the country’s electricity demand would be an attempt at a fundamental shift towards a green technological foundation to the economy, contributing to the development of the technological capacity of the country and resulting in significant job creation.
Large-scale procurement of technologies and associated capital equipment can be a powerful tool of industrial policy. It can create a demand platform against which suppliers can invest in plant, skills and technology to localise the relevant industrial capabilities, not just on a subsidised import substitution basis, but to drive development of the skills and approaches necessary for independent export competitiveness.

The procurement of a frontier renewable technology creates additional challenges and opportunities. A frontier technology, by definition, creates higher risks (it is relatively untested) and comes at a relatively high price (it is early in the learning curve). That said, procurement of a critical mass of a frontier technology can place a country in a position of technology leadership in the design, manufacture and construction of a plant.

The question that needs to be addressed in the context of an emerging economy is how the additional costs and risks associated with the deployment of the technology at scale can be mitigated. This will require, at minimum, an international 'climate finance' partnership to mitigate the financial risk, and an industrial and technology innovation partnership to mitigate the learning risk. Such partnerships can be structured between national universities and research institutions with their counterparts. The success of a frontier technology development process will be significantly dependent on having a coordinating mechanism in place to ensure that any skills and technology development processes are coordinated with the build and localisation process.

It is proposed here that a phased approach is implemented, using the procurement experience resulting from past REIPPPP rounds as a springboard into deeper understanding of the technology, global OEM base and local strategic supplier opportunity. This approach can be described as 'crawl, walk, run' and is diagrammatically depicted below. It draws on the approach followed by Asian countries in the development of export competitive industries, for example South Korea in the case of nuclear power.
To achieve more ambitious industrial development in respect of any RE technology, a shift away from an auction-style procurement programme as in the REIPPPP is required, with a strategic sourcing procurement model taking its place. In a nutshell, the complexity of what is being procured will have grown significantly, which will reduce the number of suppliers who would have the capability to deliver on the required value. Core to the industrialisation process is the need to provide a critical mass and duration of demand that would make investments in plant, technologies, skills and industrial learning viable. This will create additional pressure to move to a more strategic and relationship approach based on a fleet procurement, rather than a simple commodity-based transaction approach.
In the next stage of procurement, namely ‘walking’, the ambition will be to build a comprehensive industrial footprint to support the roll out of an established, proven technology or to deepen the industrial footprint of a frontier technology. The procurement preparation process will require significant upfront research into the feasibility of localising different components and the scale of demand that would make such localisation viable. The procurement will require the building of a strategic partnership/s with OEMs which have a proven capability to localise their manufacturing processes through a fleet procurement or, in the case of a frontier technology, a more tactical procurement, i.e. less units procured than a fleet procurement but greater than a single transaction approach.

In the case of well-established, tried and tested technologies, the localisation process should not create undue risk, if the ambition is reasonably set and the process is properly planned and managed by the OEM. In the case of frontier technologies, the localisation process should be more focused on deepening industrial capability in specific intermediate areas. The procurement strategy would need to confront whether it is possible to coherently enter into a partnership with the OEMs through procuring a critical mass of power from an IPP or whether a State Owned Enterprise (SOE) or some other government entity needs to buy the equipment directly. In terms of procurement complexity and maturity, this phase can be thought of as walking.
Technology transfer and the integration of local suppliers into global OEM supply chains are critical during this phase. The gradual development of industrial export competitiveness depends, in large part, on allowing local suppliers to learn from best-in-class companies operating in their industry.

Elsewhere, countries have done specific deals with renewable energy operators that require, at minimum, the localisation of the manufacturing of the key components that make up the plant:

- In Canada, the state of Ontario made a deal with Samsung Construction Company to procure a critical quantity of wind and photovoltaic energy provided that Samsung established a consortium of world class OEMs to locate key manufacturing facilities in Ontario and to develop the associated local supply chain;
- In India, the state of Kanartaka recently concluded a deal with US-based PV manufacturer SunEdison to develop 5 gigawatts of renewable energy within five years and to build $4 billion solar manufacturing facilities with an annual production capacity of 7.5 gigawatts in a joint venture with a large Indian power operator.

Practical implications for CSP

In the context of CSP as a frontier technology, and South Africa’s recent familiarity with RE as an electricity generation source, several additional factors come into play. CSP system OEMs are relatively small, as are many of the companies in their supply chain, reflecting the immature status of the technology. While on the one hand this may provide significant leverage to the buyer, on the
other, the lack of scale will mean that the OEM has had limited experience in choosing and developing new, locally based winners for their supply chain. In addition, the relative smallness of the OEM points to the relative immaturity of the technology – it is possible that a chosen CSP technology type could prove to be a long run loser.

**Given the relatively small scale of a domestic CSP fleet procurement programme in the context of general industrial demand and the limited number of multiple complex components in the plant, it is unlikely that there will be extensive green-field manufacturing investment.** Consequently, it will be critical to ensure that there are existing South African suppliers who have both the underlying capabilities required for the manufacture of relevant intermediate complexity components and an interest in going through a learning process to meet the needs of this market in order to gain a realistic assessment of what can be achieved.

In addition, it would be vital to involve a major OEM for the production of the power pack who has a committed presence in South Africa, a proven track record of picking and nurturing winners and who is already engaged with South African companies whose capabilities would be relevant for CSP. This would enable the localisation of power pack components to the greatest extent that is viable and the OEM could be leveraged to support industrialisation in a range of other intermediate capabilities as well.

When moving forward to select one or more strategic partners in a fleet procurement, it will be important to eliminate, as far as possible, the interpretational difficulties and inappropriate outcomes that have arisen under the local content and job creation requirements for the REIPPPP. These concepts should be robustly defined, clearly stated and easy to measure and monitor. Due consideration should be given to the pragmatism of these requirements; for example, manufacturing jobs may only be feasibly created many miles away from CSP plants, for logistical, market or a variety of other reasons. Consideration may also be given to the simplification or consolidation of other LED criteria like socioeconomic development, enterprise development and community ownership, which have caused confusion among developers in the past. A solution may be the replacement of these requirements by compulsory project revenue or profit contributions to a community fund administered by regional not-for-profit institutions appointed and overseen by Government.

**In the case of a fleet procurement driven industrial strategy in CSP, there are multiple benefits that would accrue to the component suppliers, the Engineering, Procurement and Construction Management company (EPCM) and the Operator.** Depending on the scale of the fleet procurement, this could be a game changer for selected companies:

- The construction of each plant will move the EPCM and its suppliers down the learning curve, making the EPCM more competitive for future builds;
- The Operator will experience significant learning effects and gain increased credibility to market additional plants;
- The component designers and suppliers will acquire extensive plant performance feedback that will add to their learning process;
- The global CSP industry will benefit as each plant acts as a demonstrator of the technology for future marketing.
In addition, the home country of the CSP OEM will also gain the benefits of a more technologically capable and competitive company, increased exports and job creation associated with work performed by the supply chain, ongoing licence fees and royalties and dividends from operations (in cases where it participates as shareholder in the IPP).

**Risks**

Nonetheless, there are intrinsic risks and costs to an emerging economy like South Africa procuring CSP power in this phase of its technological development – the nature of a frontier technology in this context is such that it presents a high risk, high reward proposition. These factors are exacerbated by the fact that making a commitment to fleet procurement of CSP which is of insufficient scale may itself lead to a failure to achieve the desired industrialisation outcomes. The risks include:

- While some forms of CSP are no longer new, none of the applicable technologies is mature. In particular, tower technology, which holds the most promise for utility scale CSP, is immature. Some of the risks associated with an immature technology include:
  - that the technology will be out-competed and become obsolete (as is likely to be the case if PV can be linked to a sustainable battery storage solution);
  - that individual plants may be beset by unforeseen construction and/or operational difficulties as there is no standardised, tested plant design;
  - that financing for the construction of CSP plants may be difficult to obtain (and expensive when it is obtained); and
  - that the anticipated learning from experience may not occur or may occur too slowly, such that the cost reduction breakthroughs that are required for competitiveness may never be achieved.

- At present, electricity generated utilising CSP is expensive relative to most other generation technologies, including more established RE technologies such as PV and wind.

- While CSP has the potential to provide baseload generation, this can only be achieved through a geographically disparate fleet of plants, in order to counter the limited predictability of solar resource availability in any one locale. As such, CSP’s potential as a provider of baseload capacity can only be realised when, and if, it becomes a mature and competitive electricity generation solution that justifies a geographically diverse range of plants.

- Pursuing the import of CSP technology will, at least in the short-term, worsen South Africa’s trade deficit.

**Recommended Procurement Framework**

Accordingly, a CSP fleet procurement programme should take into account the range of challenges resulting from the immature status of the technology and the relative youth and small size of OEMs which are selling the overarching system (and which accordingly may not have the size and financial stability to survive material setbacks). If not adequately designed, a fleet procurement of CSP could simply result in limited industrial impact, a negative trade account impact and a high electricity price paid for by relatively poor South African consumers.

The procurement programme should be structured in such a way that the costs, risks and benefits of the procurement are shared between South Africa, the relevant OEM and the OEM’s home country, recognising
the mitigation impacts of procurement and the industrial benefits to the seller. It should also ensure that the ability to build, operate and maintain plants, as well as design and manufacture components for them, are localised: this should be core to the design of the programme.

**The format of the procurement programme should be a public-private partnership, in which Government is actively invested in success.** The relative benefits of this approach, as opposed to an auction-style model like the REIPPPP, are laid out in the appendix. Suggestions on appropriate contractual arrangements are also included. In essence, the proximity to suppliers (OEMs and local) as well as the practical challenges of developing new technologies and industries, should result in an outcome characterised by better coordinated policy, creation of the correct institutions and frameworks, and directing of the necessary public technology development funds.

**In light of the current maturity of the renewable procurement process, it would be extremely risky to rush into the fleet procurement of a frontier technology such as CSP with ambitious industrial development – in essence, it would be running before having learnt to walk.** There has been insufficient time to assess how CSP technology operates in South African conditions, the developmental attitudes and capabilities of different OEMs, as well as the attitude and capabilities of the national supplier community. In addition, the power system and associated cluster is extremely stressed, making it unlikely that a CSP fleet procurement programme would get sufficient policy and administrative attention as well as political commitment to ensure its success.

Consequently, it is recommended as an interim step that:
- Cabinet provides a clear mandate to a Department to lead a process of exploration;
- A preliminary market sounding takes place to assess what OEM interest there would be in a partnership approach and what value the OEMs believe could be delivered on the back of such an approach;
- A thorough assessment, in consultation with key OEMs, is done of the South African supplier community in terms of capability and attitude;
- Bilateral discussions commence with potential partner countries regarding a climate finance structure for a CSP fleet procurement as well as how technology development partnerships could be structured;
- Should the above steps prove promising, an existing institution is mandated (e.g. Eskom, CSIR) or a new institution established to focus on assessing the feasibility of localising CSP and to determine, in greater detail, how this would be structured. Part of this brief should include the definition of what institutional mechanisms would be required to coordinate the procurement with a technology and manufacturing localisation programme as well as a plan to house and develop such institutional capabilities.

**Other industrial and innovation policy enablers**

In addition to committing to a well-designed, large-scale public procurement programme to drive sufficient local demand to develop a local industry, South Africa will need to put several other policy measures in place if it is to succeed in green innovation generally and CSP industrial development specifically.
Technology transfer and skills development are of prime importance in strengthening entrepreneurship and industrial ability to absorb imported technology and develop it further. Learning is crucial to emerging market technology catch-up as a springboard to future leadership. Countries like China and India successfully develop science and engineering skills while requiring business partnerships with multinationals to enable this learning. Initiatives such as the Renewable Energy Centre of Excellence (RECE), which will focus primarily on creating an artisanal skills base for construction and operation RE projects in the Northern Cape, are complementary to but do not replace the need for advanced science and engineering skills. Both are important for developing the industry in South Africa.

Appropriate supply-push R&D together with supportive public financing is crucial. Where the necessary technological capabilities and governance exist, well-coordinated and adequate R&D funding – both direct and indirect – has proven to be an extremely effective channel for developing local industry. In the wind industry, a marginal million dollars of public funding allocated to R&D generated 0.82 inventions, while the same amount spent on demand-pull policies – such as feed-in tariffs – generated only 0.06 inventions (World Bank 2012). CSP leader countries have leveraged central research hubs, where scientists can jointly develop new approaches and products aligned with funded R&D focus areas as platforms for technology leadership. South Africa should consider taking the same well-coordinated and resourced approach to build critical mass in technology knowhow and funding, instead of dispersing small budgets to individual, detached, academic units and other institutions.

Similarly, developmental finance institutions such as the IDC and DBSA will have vital roles to play in the financing the commercialisation of new technologies (together, where appropriate, with IFIs with developmental mandates). It should be ensured that there is sufficient public funding and support (in the form of quasi-equity or mezzanine debt and/or government guarantees to support commercial debt provision, as has been implemented by the US Government in connection with the SunShot Initiative) along each stage of the technology development and commercialisation value chain, bearing in mind that South Africa’s debt and capital markets are oriented mostly towards technologies that have been proven commercially. This is particularly the case for project finance, which has been the structure employed on most of the REIPPPP projects. At the point at which technologies are to be implemented through plant construction, in the absence of such ongoing DFI and Government support, it is likely that obtaining the necessary financing at rates that can be borne commercially would be impossible. The extent and nature of financial support will, to some extent, be contingent on the nature of the procurement and the procuring entity (which may have a balance sheet of its own).

---

17 Examples of direct R&D funding include funding to set up and run public labs and other research institutions, grants, and soft loans. Indirect R&D support includes tax incentives.
Climate and foreign policy: Potential for international partnerships

It has been mentioned that the development of industry based on a frontier technology is risky and costly to an emerging economy like South Africa. To mitigate the risks, improve the chances of success, and help South Africa carry the costs, international assistance is required, both in industrial development and in terms of the costs associated with procurement and industrialisation.

Industrial and technological innovation partnership

Technology partnership with one or more OEM host countries is critical to the development of a competitive local CSP industry given the large variation in R&D budgets between CSP leaders and South Africa. This suggests that it would be vital to align the OEM home country’s industrial policy aims in respect of CSP with South Africa’s own industrial development aspirations. Key components should be identified for joint national research and development as part of the procurement process, or even prior to any procurement taking place.

Table 5  Investment in technological innovation

<table>
<thead>
<tr>
<th>Metric</th>
<th>Germany</th>
<th>Spain</th>
<th>US</th>
<th>South Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita (est. 2013)</td>
<td>U$ 39 500</td>
<td>U$ 30 000</td>
<td>U$ 52 800</td>
<td>U$ 11 500</td>
</tr>
<tr>
<td>% of GDP spent on R&amp;D (2010)</td>
<td>2.80</td>
<td>1.40</td>
<td>2.74</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Sources: GDP per capita, PPP (current international $): World Bank (2015)  
Researchers in R&D (per million people): World Bank (2015)

Financial partnership

Global climate finance flows are substantial at $331 billion, but there has been limited success in channelling these outside countries of origin. A globally weak economic environment has driven an imperative for public and private financiers alike to embark on domestic stimulus projects, attracting three quarters of available flows. Nonetheless, public agencies and intermediaries – accounting for 40% of global climate finance – remain committed to covering developing country risks. Virtually all of the flows from developed to developing countries come from these agencies (Buchner et al 2014).
Bilateral climate agreements between two governments, either stand alone or linked to technology partnership, provide a promising and largely untapped avenue. So far there have been relatively few deals linking the sale of renewable technologies to a bilateral climate funding arrangement that would recognise the benefits accruing to the seller while also acknowledging that emerging economies are paying a premium for renewables as part of their mitigation endeavours. Worth noting, however, is a Japanese Government “Joint Crediting Mechanism” initiative that effectively provides carbon mitigation funding with the sale of Japanese renewable technologies. This mechanism is based on the principle that the purchaser is effectively demonstrating Japanese technologies and mitigating carbon emissions so that it is appropriate for the Japanese Government to make a financial contribution recognising these externalities.

Another international cooperation format is partnerships with international financial institutions with developmental mandates, such as the World Bank/IFC. The $5 billion Clean Technology Fund, a co-funder of Eskom’s current 100 MW CSP procurement project as well as Morocco’s CSP procurement programme, is a significant player in this regard. The Fund focuses on large-scale country-led projects in RE, energy efficiency and transport, focusing on larger transactions in middle income countries. Its goal is to contribute to the demonstration, deployment and transfer of low carbon technologies which can meaningfully assist in reducing emissions. Mechanisms include driving down technology costs, stimulating private sector participation and enabling replicable transformation.
CONCLUSION

With substantial knowledge and manufacturing capabilities, South Africa is well placed to embark on industrial development opportunities tied to promising frontier technologies. CSP is ideal in many respects, given the suitability of South Africa’s solar resources, proximity in manufacturing to existing pockets of supply excellence, and offers a flexible future source of electricity.

The benefits of industrialisation will be varied. The most important of these, conceptually, is the reversal of a process of de-industrialisation that has taken place over the past two decades, tied to stagnation in technological innovation and weakening business competitiveness. More directly, it is possible to create an export-competitive industry supporting up to 32,000 jobs and generating around R1 billion p.a. in wage income by 2030, an increase in GDP in the order of R100 billion, and the ability to sustain imports of other goods as a result of substantial positive contribution to the trade balance.

To enjoy the green growth benefits that countries such as Brazil, India and China are experiencing, South Africa will need to become more externally oriented, pursuing the development of export-competitive green industries through procurement-driven industrial policy with a focus on international technology transfer and export-related incentives. This will ensure a critical mass of demand to support targeted knowledge development, the setting up of local production capability, learning from international leaders and developing domestic technology leaders.

Given the costs and risks associated with large-scale procurement and industrial development of a frontier technology, South Africa will need to develop durable international partnerships. These will be both in respect of technology co-development and financing.

Most immediately, the country should focus on learning from CSP projects procured under the REIPPPP and Eskom’s current CSP plant procurement process, in parallel with embarking on international enquiries of CSP suppliers, technology leader countries and aligned IFIs. The sequencing of policy is just as important as the policy itself. Adopting a ‘crawl, walk, run’ approach to developing export-competitive manufacturing industries has worked very well for East Asian countries; there is no reason that it should not be successfully adopted here.
REFERENCES


- Ernst & Young and Enolcon. 2013. Assessment of the localisation, industrialisation and job creation potential of CSP infrastructure projects in South Africa – A 2030 vision for CSP. Report commissioned by the GIZ (Deutsche Gesellschaft fur Internationale Zusammenarbeit GmbH), SASTELA (Southern Africa Solar Thermal and Electricity Association) and the DTi (Department of Trade and Industry). June 2013.


Economic impact assessment: Methodology and assumptions

Assumptions

Below are key assumptions in terms of the technology used and job creation:

Technology

- Capital costs are as per 2015 USD estimate from Black and Veatch (2012): 200 MW net CSP plant with 6 hour storage and dry cooling (initially PT, switching later to tower);
- A 10% learning rate applies with respect to capital cost, resulting in an average annual cost reduction of 3.3% based on global capacity doubling on average every 3 years, as per IEA Solar Thermal Energy Roadmap (IEA 2014);
- South Africa is a price taker;
- The average ZAR/USD exchange rate in 2015 is R11;
- Depreciation of the Rand at 5% p.a. in real terms results in the imported share of the system becoming increasingly expensive;
- O&M annual cost is static at R550 per MW per annum;
- Plant delivers a load factor of 41%;
- Plant has a useful lifetime of 30 years.

Procurement

- Government procures CSP capacity on the basis of power purchase agreements; either 20 year (as per Scenario A) or 30 year (Scenario B);
- A real discount rate of 5% applies in the calculation of the recovery factor applicable to the LCOE calculation.

Jobs

- Jobs are estimated per MW capacity procured, in FTE annual equivalent;
- Jobs are specified at three levels: manufacturing, construction and O&M (operations and maintenance); and
- Construction will take place over 2 years, while O&M activities run for 30 years.

Economic multipliers

- Sectoral output multipliers are as per Pan African Investment and Research Services (2011), namely:
  - Manufacturing: 1.13
  - Construction: 0.81
- These numbers are roughly consistent with other sources such as Burrows and Botha (2013).
Scenarios

Conducting the Economic Benefit Analysis two scenarios are assumed:

Scenario A: Internally Focused
- South Africa buys limited CSP electricity to service its own needs, adding a total of 2.7 GW over the period 2016-2030;
- Procuring entity is Eskom and procurement model is the REIPPPP, based on conclusion of PPAs over 20 year periods;
- 200 MW CSP capacity is procured p.a. for 13.5 years (total of 2700 MW additional capacity procured), spread across a variety of CSP technologies;
- Local content is constant at 40%; and
- There is no substantial local manufacturing and no export capability develops over the period.

Scenario B: Export focused
- South Africa procures 300 MW CSP capacity p.a. over 10 years from 2016-2025, all tower technology, adding a total of 3 GW capacity;
- Exporting CSP components starts after 2020 with South Africa supplying a portion of Africa’s export demand, as projected in IEA (2014). South Africa supplies tower plant components between a low-cap of plant capacity of 300 MW and a high-cap of 600 MW up to 2030 (total of between 2100 MW and 4200 MW); and
- Local content will escalate over the period in line with projected growth in local industrial capabilities.

Background and Methodology

The economic benefit of the CSP localisation is determined by means of an analysis that shows how a direct impact shocks the economy and ripples through all the economic sectors. The three potential spheres of economic impact are:

- **Direct** – Direct expenditure on suppliers, in this case power purchase agreements (Provided in this study);
- **Indirect** – Indirect impacts refer to the additional economic activity that is created by local industries as a result of demand from suppliers, in this case manufacturing and construction (Provided in this study); and
- **Induced** – Induced impacts refer to household expenditure that is generated from wages paid to employees directly and indirectly (Not provided in this study).

Local content evolution: Scenario B

Assumptions
- The reference plant is a 200 MW net capacity tower plant with 6 hours storage, dry cooled (Black & Veatch 2012);
- Requirements for products still to enter design phase (e.g. linear actuators):
  - If a component has not yet been custom designed, assume it takes 2-3 years of design, lab testing and application for patent registration
  - For 5 years, 1 plant (maximum 150 MW net capacity) tests a technology in the field before the rest of the market adopts it
- If capability to manufacture already exists for a service or component that has been already designed, it is deployed on 1 plant for 5 years before rest of market adopts supplier (e.g. EPC services).
### Table 6: Share of local content: Projection of South Africa’s ability to supply goods and services into utility scale CSP tower plants, 2015-2030

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heliostats (38%)</td>
<td>7.9%</td>
<td>14.8%</td>
<td>5.9%</td>
<td>9.4%</td>
<td>10.0%</td>
<td>2.0%</td>
<td>6.0%</td>
<td>14.0%</td>
<td>8.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mirrors</td>
<td>4.0%</td>
<td>0.0%</td>
<td>5.9%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>4.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>39%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gears/ Drives</td>
<td>4.0%</td>
<td>0.0%</td>
<td>5.9%</td>
<td>3.5%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>4.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>42%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structures</td>
<td>4.0%</td>
<td>0.0%</td>
<td>5.9%</td>
<td>3.5%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>4.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>42%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>4.0%</td>
<td>7.4%</td>
<td>5.9%</td>
<td>3.5%</td>
<td>2.5%</td>
<td>1.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>4.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>53%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receiver</td>
<td>7.9%</td>
<td>7.4%</td>
<td>5.9%</td>
<td>3.5%</td>
<td>2.5%</td>
<td>1.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>8.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>61%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tower</td>
<td>7.9%</td>
<td>7.4%</td>
<td>5.9%</td>
<td>7.1%</td>
<td>2.5%</td>
<td>1.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>8.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>65%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>7.9%</td>
<td>7.4%</td>
<td>5.9%</td>
<td>7.1%</td>
<td>2.5%</td>
<td>1.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>8.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>65%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power block</td>
<td>7.9%</td>
<td>14.8%</td>
<td>5.9%</td>
<td>7.1%</td>
<td>5.0%</td>
<td>2.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>8.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>76%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPC services</td>
<td>7.9%</td>
<td>14.8%</td>
<td>5.9%</td>
<td>7.1%</td>
<td>5.0%</td>
<td>2.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>8.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>76%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner’s costs</td>
<td>7.9%</td>
<td>14.8%</td>
<td>5.9%</td>
<td>7.1%</td>
<td>5.0%</td>
<td>2.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>8.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>76%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (contingency)</td>
<td>7.9%</td>
<td>14.8%</td>
<td>5.9%</td>
<td>7.1%</td>
<td>5.0%</td>
<td>2.0%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>8.0%</td>
<td>15.0%</td>
<td>7.0%</td>
<td>76%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Own analysis based on interviews

### Procurement led industrial strategy for RE: International case studies

**Globally deployed RE procurement models**

There are currently three major RE procurement models used globally at utility scale: auctions (such as the REIPPPP), renewable energy procurement standards (effectively quota systems) and feed-in tariffs (REFIT). A brief overview of each follows below, with an assessment of suitability for South Africa.
Auctions

Auctions, such as the REIPPPP, are most often employed to encourage competitive bidding where price dominates in terms of award criteria. Following the termination of fiscally expensive and unsustainable REFIT regimes in several countries during the recent recessions, auctions are becoming increasingly popular.

The main benefits of auctions are as follows:
- Tariffs and access to the grid are guaranteed for a fixed period of time with the signature of a PPA, reducing investment risk for developers as a result of an assured market;
- Cost efficiency is promoted through encouraging competition on the basis of price;
- Government and utility budget control is supported through limiting volumes purchased and price paid (especially when a ceiling price is set);
- Integrating non-price criteria can allow for achievement of a variety of policy objectives, e.g. local content;
- Auction award processes are often more transparent, minimising potential for corruption.

However, there are also several weaknesses relating specifically to countries like South Africa which wish to develop local component manufacturing capacity:
- Making awards primarily on the basis of price (tariff) does not incentivise power producers to invest locally, taking the risk that new local components will eventually be as cost competitive and reliable as international ones. Where investment is made regardless, it is most likely to occur for better established technologies in a very large local market (as in Brazil, India and China, where auctions have resulted in high local content for PV and wind) or where a market presents a diversity of market opportunity (e.g. there are a variety of buyers of energy or energy system components in the country, not all driven by the central energy procurement programme). Neither of these prerequisites are found in South Africa.
- The stop-go cycles of many auction schemes deter investment into local manufacturing facilities and further supply chain development unless scheduled on a predictable, fixed interval basis. In the case of the REIPPPP, several delays in various rounds – including the most recent, Round 4 – and uncertain future demand (in terms of further Ministerial Determinations) reduce the likelihood of a perceived credible commitment to regularly purchase RE.
- Risk of underbidding exists. So far this risk has been contained in the REIPPPP by the use of fully wrapped EPC contracts and fully financed bids. However, IPPs are now considering the use of EPCM contracts, and putting pressure on Government to remove the requirement for full financing as a result of locking in lifecycle costs at the zenith of project risk (pre-construction). The risk could thus arise in future; it has, for example, become a problem in the Indian CSP market.

Renewable Portfolio Standard (RPS)

The RPS model is working effectively in mature markets such as the USA, UK, Belgium and Sweden. Energy distributors are required to buy a certain share of energy from RE sources under stipulated quotas. The RPS is usually associated with a variety of investment and production tax incentives, loan guarantees and financing from renewable energy funds.
The major advantages of the RPS are as follows:
- Competition and cost-effectiveness are encouraged as IPPs bid for limited quote;
- Large-scale plants are promoted as a mechanism to drive RE prices down;
- As with auctions, the emphasis on competitive pricing supports continued fiscal support.

The major disadvantages of the RPS are as follows:
- RPS models are less successful than other models at localisation and supporting investment in a target level of local CSP capacity;
- RPS schemes promote investment in cheaper, well established and less risky technologies: this mechanism is hence not really suitable to CSP specifically (Kulichenko & Wirth 2012);
- RPS schemes are perceived as more risky than REFIT or REIPPPP models since electricity offtake is not always guaranteed for the plant lifetime. Furthermore, the offtaker entity has lower creditworthiness than the state, suggesting that financing costs may be unattractively high unless credit enhancement is provided or cheap state or DFI funding is made available.

In South Africa, regulated electricity distribution prices would create a distinctive for any distributor to purchase CSP, which remains a high cost-gap energy source for now. Furthermore, the bulk of CSP plants will be located in areas away from large municipalities (electricity distributors).

**Renewable Energy Feed-in Tariffs (REFIT)**

REFIT regimes are still the dominant procurement RE procurement model globally, with 65 countries utilising this procurement mechanism by the end of 2012 (Michaelowa & Hoch 2013). Setting the price at a fixed level allows for evaluation based entirely on non-price criteria, for example sector development benefits such as the achievement of high local content or a requirement for global OEMs to form local partnerships. In China, auctions were initially used for price discovery on CSP, with feed-in tariffs recently replacing these.

The major advantages are as follows:
- If prices are set correctly, IPPs are compensated sufficiently for a variety of risks and costs, related, for example, to trialling innovative new techniques or technologies or investing in local manufacturing facilities at own risk;
- A transparent and predictable REFIT trajectory, where price falls in parallel with anticipated learning rates, provides robust long-term price signals for investors. This can be extremely supportive of local investment in manufacturing capability.

The major disadvantages are as follows:
- If price levels are not well monitored and continuously reduced to reflect actual learning rates, this can impose a large fiscal – and ultimately – consumer burden. For this reason, REFIT schemes have come under pressure during the recent global recession.
- If programme design does not support economically operating plants and manufacturing activity, costs may not fall to competitive levels.

Feed-in tariffs were initially preferred as the mode of procurement of RE in South Africa. However, legal opinion sourced by Department of Energy and National Treasury stated that procurement at fixed prices is non-competitive and thus
prohibited by public finance and procurement regulations, leading to abandonment of this approach (Eberhard et al 2014).

**International case studies**

**Morocco employs a public-private partnership (PPP) approach to CSP energy and industry development, with risk sharing between industry (CSP developers), Government and IFIs in early-stage technology and industry development.** As part of its 2009 Solar Plan which seeks to achieve 2 000 MW of solar energy by 2020, Morocco has embarked on a project to build 500 MW of CSP in Ouarzazate, currently the biggest CSP project in the world (Clean Technology Fund 2012). To fund this project, Morocco has secured concessional low-interest loans from a number of international financial institutions including the Clean Technology Fund, French Agency for Development, International Bank for Reconstruction and Development, the European Investment Bank and African Development Bank with a combined equity stake of $474 million (IRENA 2013).

The project, which is set to be implemented in four phases, is designed as a partnership between the Moroccan Solar Energy Agency (MASEN), with a 25% stake, and a private partner, with a 75% stake (CTF 2012 and IRENA 2013). The use of a PPP has been instrumental in de-risking this very large CSP project and securing financing (IRENA 2013). It has also enabled the procurement and testing of various CSP technologies, since each individual procurement round (Noor I, II and III) pre-specifies these details. Required individual plant capacities have ranged from 100-200 MW, supporting competitive bids.

Private partners are to be selected through a competitive bidding process in a two-phase auction scheme (IRENA 2013). A 25 year PPA with MASEN is awarded to the winning bidder. During pre-qualification, bidders are selected based on pre-defined criteria such as technical experience, financial capacity and access to finance (IRENA 2013). In the second phase, evaluation, bidders make commercial bids in an auction-like phase where price determines award. Local content requirements must also be met. In terms of the local content requirements, developers are expected to procure at least ‘30% of the plant’s capital cost (local equipment manufacturing, operation and maintenance, R&D)’ from local industry (IRENA 2013). To support local content development, MASEN is responsible for promoting training, R&D and education (IRENA, 2013). MASEN has also been involved in commissioning the EIAs and pre-feasibility studies for each of the project sites. This has served to minimize the cost of CSP per kWh (IRENA 2013).

The first auction for a 160 MW plant, Noor I, was concluded in 2012. The successful bidder, ACWA, came in with a very competitive price of $0.19/kWh. Tariffs as low as $0.16/kWh have been received for Noor II (200 MW PT plant) and III (100 MW tower plant), with Abengoa and ACWA among the most competitive bidders (El Yaakoubi 2014). A key driver for these low bids has been the concessional debt, which has provided lower interest rates of approximately 3% and a payment grace period, during which only interest is paid. Such finance could not have been secured from commercial lenders (IRENA 2013).

**China has been hugely successful in developing a globally competitive RE manufacturing sector through large-scale procurement and high local content requirements linked to international technology transfer.** China is the global leader in total RE capacity (not including hydropower) (WWF 2013).
Its success in building an RE base has been based on a massive RE procurement-led industrial strategy facilitated by a number of factors. One major driver has been strong and coordinated policy interventions, driven by strong political will to develop RE (WWF 2013). With the introduction of a comprehensive RE framework in 2006, clear targets and time frames were set for large-scale deployment of RE and the development of a manufacturing base (WWF 2013), providing clear investor signals.

Secondly, what distinguishes China is that, unlike a number of other countries whose focus has been directed at deployment of RE at a price which can compete with non-renewable sources, it has placed equal emphasis on establishing a local manufacturing base. Use of existing manufacturing capabilities (WWF 2013), strict local content requirements, a strong emphasis on technology transfer and consistent and large RE allocations have allowed Chinese manufacturers to become global leaders for certain technologies in a very short space of time.

Thirdly, a key contributor has been international partnerships in manufacturing, often with companies from developed countries providing design and engineering services while China produces equipment under license or in a JV structure. Chinese firms prefer to develop technologies in partnership with foreign partners, moving rapidly and efficiently towards the technology frontier as they learn from current best practice. A classic example is provided by the partnership between Goldwind, a Chinese manufacturing firm, and Vensys, a German company, which in 2003 sold a license for production of its advanced gearbox: a key wind plant component. Goldwind started targeting export market opportunities less than 10 years later. More recently, the international innovation partnership format is changing to joint R&D initiatives and foreign acquisitions (Matteson 2014).

With respect to procurement, China's Renewable Energy Law provides the legislative framework for RE development, providing that electricity tariffs are to be determined through auction schemes. This mechanism has been used for offshore wind, solar PV and CSP. Support schemes are technology specific with independent administrative measures, regulations and laws developed for each technology. A consumer surcharge, collected by grid operators, is held in a fund managed by the Ministry of Finance to cover the cost of RE-based electricity (IRENA 2013).

China’s onshore wind industry provides an excellent example of the country’s approach to RE, the establishment of a local manufacturing base and learning by doing. Since 2000 it has built a sufficiently strong domestic wind industry to start moving into export markets, with anticipated jobs potential of 720 000 by 2050 (Matteson 2014). Its first onshore wind auction was opened in 2003 and was aimed at price discovery. Auctions were site-specific; bids were tendered for projects in predetermined areas. Land and environmental permits were secured by the Chinese Government and the costs thereof recovered from bidders. The lowest bidder was selected to supply the first 30,000 full load hours to the grid at the price auctioned. Thereafter, the tariff would match the average price in the local electricity market (IRENA 2013). In addition, a minimum of 50% local content was imposed (IRENA 2013).

In the second onshore wind auction in 2005, local content requirements were increased to 70% with a minority share – 40% weighting – allocated to price. Local economic benefits and company’s technical expertise and experience in project management were also introduced as criteria in the evaluation process. The following year, the weight allocated to price was reduced further to 25% and
the requirement that wind manufacturers had to participate in the bid (either individually or as a supplier) was introduced. Manufacturers were required to submit a complete plan for localization. In the 2007 auction, to avoid underbidding, the average price as opposed to the lowest price bid, was selected. In other words, bidders closest to the average price were selected over the lowest bidders. Finally, in 2009, with success in utilizing auctions for price discovery and a strong, cost-competitive local manufacturing base established, a FIT was introduced for onshore wind and local content requirements were abandoned (IRENA 2013).

China’s approach to onshore wind has been successful, not only in determining the real price of wind, but also in establishing a domestic wind industry. In fact, by 2010, three of the global top ten wind technology leaders were Chinese companies. By 2012, 4 Chinese manufacturing companies ranked in the top ten global suppliers with a combined market share of 27%. Furthermore, three of the leading international wind manufactures have set up facilities in China (IRENA 2013).

One major challenge China is now facing as a result of its rapid RE deployment is integrating this electricity into the grid (WWF 2013). To address this problem, subsidies for grid improvement have been introduced and US250 billion grid upgrades have been announced (WWF 2013). Furthermore, the Ministry of Science and Technology has outlined detailed plans for the construction of a smart grid in its Smart Grid Major Science and Technology Industrialization Projects as part of its Special Planning under the 12th Five-year Plan (WWF 2013). Although these problems persist and will continue to into the future (WWF 2013), what this shows is China’s ability to identify and address barriers on its Renewable Energy path.

India’s focus on competitive energy costs has favoured procurement allocations to the cheapest RE sources, notably PV, but development has been uneven and several projects have fallen through due to lack of feasibility. India is the 6th largest market for Renewable Energy globally (REN21 2012) with a comprehensive RE strategy which focuses on the deployment of solar, wind and hydro (GIZ). Targets for Renewable Energy development are set out in the National Five-Year Plans and its National Action Plan on Climate Change (WWF 2013). As with China, the development of domestic manufacturing capability has been one of the major objectives of the RE procurement programme, with local content featuring prominently as a bidder requirement.

A number of mechanisms to incentivise Renewable Energy at a national level exist, including tax incentives, generation-based incentives, capital subsidies, grants, rebates, public investment, loans, and feed-in-tariffs for some technologies such as solar’ (KPMG 2011). These appear to have been successful with the targets set in the 11th Five Year Plan having been surpassed by 1.6GW – a total of 14 GW was deployed from 2007-2012 (ABPS 2009). Whereas National Policies have been successful in creating market certainty, sending strong signals regarding enforcement and incentivising deployment generally, at a state level, RE deployment has been uneven (WWF 2013). The Renewable Portfolio Obligations scheme which provides for renewable energy certificate trading – available at a state level – has only been taken up by certain states with the result that some states account for the majority of RE in the country (MOSPI 2012).

The National Solar Mission (previously called the Jawaharlal Nehru National Solar Mission) has been instrumental in incentivising the deployment of more than 1 100 MW of solar in just over three years (January 2010-March 2013). It has targeted the
deployment of ‘20GW grid connected solar power capacity (including rooftop) by 2022’ to be allocated in 3 phases (Stadelmann et al 2014). The programme has been successful in bringing the costs of solar down (WWF 2013). The reverse bidding process saw the tariffs drop from $0.35/kWh to less than $0.17c/kWh in less than a year (MNRE 2012b).

Nevertheless, Phase I of the National Solar Mission has encountered problems, with some projects unlikely to come online, as witnessed in CSP. Inexperienced developers, selected on the basis of aggressive pricing and high local content commitments have struggled to achieve financial viability (WWF 2013). On average, the tariff from the bidding process was around 25% lower than the one set by Government or offered in other markets like South Africa or Spain (Stadelmann et al 2014). Concern was expressed in the CSP industry about the economic feasibility of the projects awarded, with less than half of the 470 MW allocated installed by 2014 (interview with B. Padigala, WWF India office). In fact, 4 of the 7 projects awarded have experienced significant delays and cost overruns and risk being cancelled as a result (Stadelmann et al 2014). This highlights the need for the inclusion of technical and project experience in the selection of successful bidders as well as improved monitoring and evaluation.

Underbidding and challenges in large-scale procurement from emerging suppliers in a local supply chain have not been the only difficulty for CSP development in India. Inaccurate Direct Normal Irradiance (DNI) data resulted in overestimations of the solar resource and consequent overestimations of plants performance (Stadelmann et al 2014). More accurate data showed the actual DNI to be 15% lower than initial projections (Alcuasa 2014). Second, because plants were located in water scarce areas and projects elected to use wet cooling, water sourcing became a challenge (interview with B. Padigala, WWF India office). Third, securing financing was difficult because lenders were risk averse to investing in relatively new technology in a completely untested environment. It is suggested that one of the features of the more successful CSP projects under phase I was that they were ‘all backed by financially strong parent companies...(and) also all managed to source debt with relatively long tenors from public-owned banks, thereby improving their projects’ economies’ (Stadelmann 2014). Fourth, unlike solar PV which enjoyed both national and state level support, states did not provide additional incentives for CSP developers over and above those from National Government.

Not surprisingly, the allocation for CSP under Phase II is less than it was under Phase I. Whereas under phase I there was a 50/50 split between solar thermal and solar photovoltaic, under Phase II there is a 70/30 split in favour of photovoltaics.

Like China, electricity infrastructure is also a barrier in India (WWF 2013). Measures have been taken to address these problems, such as the commissioning of a study into the feasibility of Green Energy Corridors (MNRE 2012a) and the securing of a concessional loan for 1 billion euro from Germany to begin developing part of this corridor (WWF 2013). Another barrier which has been identified is a scarcity of local skills (Government of India 2006). Research centres have been established in part to address this, including the Centre for Wind Energy Technology, the National Institute for Renewable Energy and the Solar Energy Centre (Government of India 2006). This suggests that like China, the Indian Government is proactive and not afraid to intervene when faced with barriers to its RE development.
Spain used an uncapped Feed-in Tariff to procure large quantities of CSP, creating a globally dominant local CSP industry at the cost of long-term fiscal sustainability. Drawing on the work of Frisari and Feás (2014), this section shall show that Spain provides an interesting example of a country that was hugely successful in triggering its CSP industry but unsuccessful in maintaining it. Spain introduced policy measures that drove rapid CSP deployment, incentivised its technology development and created the right conditions for the creation of a globally dominant CSP industry in a very short space of time. However, its policy measures also failed to provide the right environment for the sector to be sustained.

Spain’s use of a Feed-in Tariff and Feed-in Premium were instrumental in CSP’s rapid deployment, a total of 2.3 GW in less than five years. The FIT guaranteed developers a fixed cost for a period of 20 years. The FIP allowed them to choose to sell electricity at daily market prices, i.e. not at the tariff determined by the FIT. This also incentivised innovation and technology development. Developers sought, through rapid learning and technological innovation, to maximise revenue under the FIT or to exploit the FIP. By reducing the cost of generation, developers could capitalise under the FIT. By developing thermal storage, developers could dispatch electricity at points in the day when prices were at their highest. The rapid deployment of CSP also encouraged the development of a local manufacturing base as manufacturers had the market certainty necessary to invest in production. Ten years later, Spanish manufacturers had already captured 75% of the domestic market and more than 55% of the market globally.

However, Government’s support for CSP became unsustainable, especially when the global recession hit. Not only was it heavily subsiding CSP through the FIT, but its failure to cap the quantity of CSP procured also meant that it majorly underestimated the amount it would be spending. Furthermore, the cost of investment hardly came down, despite significant CSP development, because market competition had not been encouraged. In response, the Spanish Government retroactively cut its CSP support and also ‘introduced a project approval process to stagger connections on an annual basis’ (Frisari and Feás 2014). This brought the market to a complete halt. Since 2012, no new investments have been made and existing projects find themselves under massive financial pressure.
WWF

WWF is one of the world’s largest and most experienced independent conservation organisations, with over 5 million supporters and a global network active in more than 100 countries. WWF’s mission is to stop the degradation of the planet’s natural environment and to build a future in which humans live in harmony with nature, by conserving the world’s biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

The Global Climate & Energy Initiative (GCEI) is WWF’s global programme addressing climate change and a move to 100% renewable energy through engagement with business, promoting renewable and sustainable energy, scaling green finance and working nationally and internationally on low carbon frameworks. The team is based over three hubs – Mexico, South Africa and Belgium.

www.panda.org/climateandenergy
Concentrated solar power: A strategic industrial development opportunity for South Africa

CSP during peak period at R4/kWh competes favourably with diesel-powered open cycle gas turbine peaking plants at R5-6/kWh at current fuel prices.

13 000 JOBS
in manufacturing and construction by the mid-2020s will be one of the direct economic benefits of successful CST industrial development and CSP procurement.

70-85% OF THE CAPITAL COST
of a utility scale CSP tower plant can be produced domestically over the long-term.

CLEAN SOURCE OF ENERGY
CSP is a clean source of energy which, in combination with storage, offers a scalable alternative to base load coal fired power and can offset peaking diesel power plants while contributing to network stability.

© 1986 Panda Symbol WWF-World Wide Fund for Nature (Formerly World Wildlife Fund) © “WWF” is a WWF Registered Trademark. WWF, Avenue du Mont-Blanc, 1196 Gland, Switzerland – Tel. +41 22 364 9111 Fax +41 22 364 0332. For contact details and further information, please visit our international website at wwf.panda.org