An analysis of local manufacturing capacity, economic and trade impact of concentrating solar power (CSP) in South Africa

Cite as: AIP Conference Proceedings **2126**, 130002 (2019); https://doi.org/10.1063/1.5117644
Published Online: 26 July 2019

Omotoyosi Craig, D. Frank Duvenhage, Alan Brent, and Frank Dinter

An Analysis of Local Manufacturing Capacity, Economic and Trade Impact of Concentrating Solar Power (CSP) in South Africa

Omotoyosi Craig[1, 2, a)], D. Frank Duvenhage [1], Alan Brent[1, 4], and Frank Dinter[3,5]

[1] *Solar Thermal Energy Research Group (STERG), and the Department of Industrial Engineering, Stellenbosch University, South Africa*
[2] *Centre for Renewable Energy and Sustainable Energy, Stellenbosch University, South Africa*
[3] *Solar Thermal Energy Research Group (STERG), Stellenbosch University, South Africa*
[4] *Sustainable Energy Systems, School of Engineering and Computer Science, Victoria University of Wellington, New Zealand*
[5] *Fraunhofer Chile Research Center for Solar Energy Technologies, Santiago, Chile*

[a)] toyosi@sun.ac.za

Abstract. The recent signing of outstanding power purchase agreements (PPA's), as part of the Renewable Energy Independent Power Producer Program (REI4P) in South Africa (SA), was received with mixed reactions. While the renewable energy sector and agencies involved in sustainable development applauded the courage of the SA government, the signing was fiercely challenged with industrial actions by local labour unions for the fear of job losses. Wind, Solar PV and Concentrating Solar Power (CSP) dominated the signed PPAs and are thus perceived as major threats to current power-sector labour in SA. Although, the SA court had thrown out the cases against the signed IPPs, it is important to understand the impact of the specific renewable energy technology (RET) on the economy, trade and the local jobs. This study assesses the SA local manufacturing capabilities for CSP related services, and analysed the economic impact of CSP adoption. An expert elicitation was carried out and the strength and the challenges were identified, the economic and social benefits of improvements were estimated, including the employment opportunities, and the overall impacts on trade and economy. It was also found that an increase in CSP manufacturing capability could only be achieved in an emerging market such as SA, if the local economy benefits directly from the deployment of CSP.

INTRODUCTION

The recent signing of outstanding PPA's with renewable energy independent power producers (IPPs) (mainly Wind and Solar PV) by the South African energy minister and the power utility company, Eskom, did not happen without a fight. The decision was fiercely challenged with industrial actions and lawsuits by the National Union of Metalworkers of South Africa (NUMSA), Transform RSA and few other organisations. NUMSA claimed that over 30,000 jobs would be lost at the initial stages with many more to follow if the renewable energy plants become operational or if energy mix policies are implemented. The high court, however, had rejected these organisations' appeals for an interdict to stop the IPP signing activities. In light of this, it is important to analyse each of these new technologies, understand their economic and trade impacts, especially in terms of local capabilities and job creation and/or substitution and present value proposition, that can be used to challenge the prejudice of loss of jobs that often surround new technologies.

The potential of the CSP industry to contribute to the local economy of its host country has been proved, and it has also been established that the development of CSP industry is often accompanied by temporary and permanent employment benefits [1–5]. However, an increase in CSP manufacturing capability would only be achieved in an emerging market, if the local economy benefits directly from the deployment of CSP. A realistic way to achieve this

SolarPACES 2018
AIP Conf. Proc. 2126, 130002-1–130002-7; https://doi.org/10.1063/1.5117644
Published by AIP Publishing. 978-0-7354-1866-0/$30.00

economic benefit is through the improvement of the local manufacturing capabilities. Continuous reduction in the cost of local CSP projects and CSP-related services for both short and long term will be achieved with increased local capacities to manufacture CSP components or to be involved in CSP development. This study assesses the SA local manufacturing capabilities for CSP related services. The strength and the challenges were identified, and the economic and social benefits of improvements were estimated, including the employment opportunities and the overall impacts on trade and economy. CSP technologies were analysed as a single entity in this study, and the effects of increasing or decreasing other energy sources were not considered. However, it has been demonstrated by various energy mix studies, that CSP is technically capable of supporting a stable supply of energy to SA, depending on future cost reductions and resulting competitiveness [6].

METHODOLOGY

An expert elicitation was carried out using surveys to access current and possible future capability of local manufacturing companies in SA. The respondents cut across the manufacturing industries, the academia, and related institutions. The responses were compared with the data obtained from owners of existing CSP plants. A SWOT analysis of the local capabilities of the CSP related industries was then carried out. An analysis of the benefit of developing local manufacturing capability for CSP on SA's economy was performed using three scenarios: business as usual, unit development and ambitious (massive rollout). The major assumption was that, the local manufacturing capacity is proportional to the CSP capacity of the nation, and thus new local capacity development will be because of the need for local components in new CSP development.

To understand market dynamics in SA, and how the economy makes room for gradual or radical changes, a comparative analysis of CSP to other successful large-scale local manufacturing sectors was carried out. As an example, the automotive industry accounts for 37 % of new vehicle sales in Africa in 2017 [7], with 200,000 jobs of direct employment in SA. Thereafter, the labour and trade impacts were then determined using socio-economic data from the existing CSP plants in SA as well as expert elicitations. The Jobs and Economic Development Impact (JEDI) models from NREL were used, based on data from existing plants in SA, to assess the validity of the study.

LESSONS FROM OTHER SECTORS

One major limitation which had been emphasized in almost all existing studies on RET manufacturing assessments are the required local content shares which are set by the host government for prospective RET project developers. For CSP in SA, these requirements come with pros and cons, as the overall local manufacturing capability is far above average and it easier for the companies to expand their capacities to develop CSP component capabilities.

SA's economy has been known to easily accommodate large-scale development of local manufacturing over a brief period. An example, once again, is the SA automotive industry which started in the early 20th century, and now manufactures over 80 percent of the total vehicles manufactured in Africa and a total of over 200,000 employment is accredited to the industry in SA [8]. Also, more than 60 percent of the automotive industries demands are met directly by local companies and more than 200 SA companies are leaders in the automotive component manufacturing [9]. Moreover, the SA Department of Trade and Industry identified that "suppliers with an emerging markets presence will benefit from a focus on increased local content, thus acknowledging the economic gain there is to be made through higher levels of local involvement. The success and circumstances that supported the breakthrough in the automotive sector in SA were analysed and the barriers/challenges to CSP breakthrough, with regards to local manufacturing capability as suggested in previous chapters, are summarized as follows: The state of CSP in SA is unclear, as no allocation has been made for building new plants beyond 2030 in the most recent IRP update [10]

- Eskom, the utility company has been reluctant in signing the PPA for Redstone, the youngest CSP plant under development for 2 years 11
- The role and integration procedures of IPP are not too clear with unstable IRP updates, and thus no clear or reliable long-term framework that can convince IPP investors to join in achieving the estimated 43 percent energy mix from renewable sources by 2030
- Unlike the automotive sector which was highly supported by the SA government at its initial stages, CSP is more capital intensive and it will be hard for the state to finance it as it can affect its international credit rating.
- Many financial institutions prefer to fund a more mature or commercial technology, and this will limit the capabilities of local companies to raise funds for expansion or getting into CSP component manufacturing.

- The ongoing blame game and shift of responsibilities among government parastatals on who is responsible to sign PPA's, could discourage many local companies in developing capacities for supplying CSP components.
- The technology is not receiving enough consideration, despite the high-quality solar resources and various ongoing advanced research programs in SA. SA Local Manufacturing Potential

The SA companies involved in CSP components manufacturing (steel, glass, EPC, electronic) and CSP development and services delivery, were analysed based on existing studies and expert elicitation protocol to analyse the local manufacturing potential. The resulting SWOT analysis on the CSP manufacturing value chain in SA is presented in Table 1.

TABLE 1:SWOT analysis of SA local manufacturing capability

Strength	**Weakness**
• Existing local manufacturing sector that can compete globally (Automotive industry) – possibility for development of other sectors. • Local manufacturers are experienced with designing and building large energy plants (e.g. Merdupi and Kusile). • Local industries involved in CSP components including steel, mirrors, tracker and pipes, now produce to global standards, which are used locally and some exported. • Existing local CSP research with significant output (e.g. Helio 100) which can support local industries component development. • Large presence of established construction companies. • Several global companies already involved in the CSP sector, with projects in SA.	• The local basic R&D is still behind as compared to advanced research within international companies and universities. • Limited local industrial R&D as compared to other competing countries. • Local productivity lower compared to other CSP favoured countries. • Raw materials for most CSP components are more expensive when sourced from the local market. • Scarcity of required CSP skills and limited training programmes. • High cost of transportation of imported components (distance to ports). • Unstable political will.
Opportunities	**Threats**
• One of the best locations for CSP in the world with regards to solar resources. • High local content requirements from the SA government. • Possibility for hybridisation with existing conventional power plants or conversion of old power stations. • Technology is still new, opportunities for pioneering and innovation. • Export opportunities to neighbouring SADC* countries with good solar resources and other sub-Saharan African countries. • Local companies are open for international co-operation and technology transfer. • Coal is still the major source of energy in SA, suggesting opportunities for near baseload RETs, such as CSP.	• Limited equity from foreign financial institutions. • Difficulty in securing financial due to preference for more mature technologies such as Solar PV. • REI4P bids qualification are too restrictive to the interested local companies. • Low MW allocation to CSP in the previous REI4P rounds and possibility of no allocation to CSP beyond 2030. • Other manufacturing companies in countries with poor DNI resources produce CSP components for export, result in tough market competition. • Future of CSP in SA in uncertain due to political inconsistencies. • Continuous reduction in investment and generation costs of other RETs battery storage. • Government's over-ambitious demand for local manufacturing. • Lack of experience in CSP-specific component manufacturing.

*** Southern African Development Community** (Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe)

To facilitate development in the local manufacturing capabilities for CSP in SA, partnerships between major leaders in the CSP industry, whom already own plants in SA, and the relevant local companies must be strengthened. This will encourage technology transfer and localisation of required technical skills and knowledge. Considering this, the current state of relevant local companies, and the capability of local industries to participate in CSP component manufacturing and development, was analysed. It was found that the relevant the relevant local companies and industries have 60 to 70% capable, and therefore require 40 to 30% more skills or advancement.

SCENARIOS FOR SOUTH AFRICAN LOCAL MANUFACTURING FOR CSP

Three scenarios were considered to analyse the benefit of developing local manufacturing capability for CSP to SA's economy. The major assumption in this section is that the local manufacturing capacity is proportional to the CSP capacity of the nation, and thus new local capacity development will be because of the need for local components in new CSP development.

Scenario 1: Business as usual

In this scenario, the current 600 MW CSP capacity is retained, the uncertainties around the future of the technology persist, and the existing local CSP companies involved in glass and steel manufacturing continue at the same capacity and majority of other CSP components are imported.

Scenario 2: Unit development

With only 600 MW of CSP in SA since 2010; and no new CSP PPA's signed since 2015; and due to the inconsistent MW allocations in the IRP for future plants, this scenario assumes that there will be limited CSP plants PPA signing in SA over the coming years. This will be majorly as a result of global progress rate and the new change in government. It is expected that CSP will amount to a total capacity of 1 GW installed in SA in 2030, if accompanied by tougher laws for local content. As a result of this progress, demand for CSP components will experience a slight gradual increase, necessitating the manufacturing of these components locally. The relevant local companies involved in CSP become stronger and they form moderate knowledge-sharing and technology transfer partnerships.

Scenario 3: Ambitious

This scenario was based on the promises made by the SA minister of energy at SAIREC 2015, where interest was shown in signing off several RET contracts, thereby strengthening confidence in the REI4P. The aim being to encourage mass development of these technologies, with a target of exporting an appreciable amount of the electricity produced to the neighbouring SADC countries and other sub-Saharan African countries. The CSP market volume in SA was assumed to become 2 GW and the locally manufactured export components reaching 1 GW by 2030. The participation of local industries is seen to increase with many local companies becoming involved in the manufacturing of high-tech CSP components of very high quality for the global market. By 2030, most of the local companies involved are now global contenders and supplying components to both the local market and manufacturing for exports. There is a high progress ratio, high learning rate and reduced cost of raw materials for CSP in SA, which will contribute to reducing the investment costs of CSP.

FUTURE OF LOCAL MANUFACTURING OF CSP COMPONENTS IN SA

Existing studies [1,12,13] have shown that new CSP projects will contribute immensely to the SA economy and could play and important role in future industrialisation, also stimulating other sub-Saharan African countries. World Bank projections on similar studies for the Middle East and North Africa indicated that CSP projects will lead to foreign direct investment because of a rise in the citizen's purchasing power [14]. Conversation with the experts during the elicitation process carried out in this study also shows that supporting CSP projects will improve the public image of the government since such projects will lead to the creation of direct and indirect jobs, as identified earlier in this study, as well as demonstrate a commitment to progressive climate change targets.

Economic Impact of a Strong CSP Components Local Manufacturing Capability

This section aims to evaluate the economic benefits of the scenarios presented in Section 5. To determine the direct and indirect economic impacts of developing the local manufacturing capability for CSP in SA, the JEDI model for CSP by NREL was used [15]. The model allows users to analyse the development of CSP projects and its accompanied economic impacts using project specific data. The analysis was done on a 100 MW CSP plant (for both central receiver

and parabolic trough). The cost input data are from data retrieved from WWF reports and Black & Veatch [3,16]. The solar resources input is from WWF data and updated with NREL data use [17], while solar field and other project descriptive data were taken from NREL [18]. The model calculates in 2009 USD rate and the result was converted to the February 2018 Rand value.

The economic impact of each of the scenarios on the SA GDP is presented in Table 2. The direct economic impact in Table 2 is defined as the effects of improved local capabilities in design, fabrication, operations and continuous maintenance of CSP plants in SA. The induced economic impacts are the resulting effects of supply chain, because increase in the demand, increased multiplier effects.

TABLE 2: Estimated economic impacts over two CSP project life cycle in SA

CSP technology type/Scenario	Business as usual	Unit development	Ambitious
Total impacts during construction period (Earnings ZAR million)	4773.49	5465.52	7489.79
Total impacts during operation year Earnings/Annual (ZAR million)	99.22	107.52	229.22
Total impacts during construction period (Earnings ZAR million)	3968.66	4544.01	6183.43
Total impacts during operation year Annual Earnings (ZAR million)	109.96	117.88	117.88

The direct and indirect employment generated from the development of local capabilities for CSP are also presented. The model used in this analysis does not consider the SA government's local content requirements in REI4P or other local labour laws including Broad-Based Black Economic Empowerment (BBBEE). These policies demand that a prospective bidding company must have a certain percentage of black investors or that a percentage of any procurement done by any foreign investor must be achieved locally, even if these capacities do not yet exist. A regulated, robust and open market will provide an opportunity to foreign investors to join in the development of the local RET market in SA, which will eventually build local capacity for CSP and thus spreads to other aspects of the economy, including contributing to the goal of BBBEE, namely to economically uplift and empower previously disadvantaged racial groups.

Labour and Trade Impact

Operation and maintenance of CSP systems will ensure continuous jobs throughout the life cycle of the plants [14]. It can also be argued that with the low labour cost in SA, more people can be employed for these services over longer periods with the same budget, than compared to the number that would be employed in developed CSP competitive countries. The continuous increase in automation in CSP plant maintenance could reduce these numbers, however, there will always be a need for human capital. The resulting jobs and impact of multiple 100 MW CSP plant in SA during construction (see Figure 1) and during the operational life of the plant (see Figure 2) were calculated in the JEDI model based on data from a CSP plant in SA, the analysis was performed for the three scenarios for the jobs created by the various sector and the results are presented below.

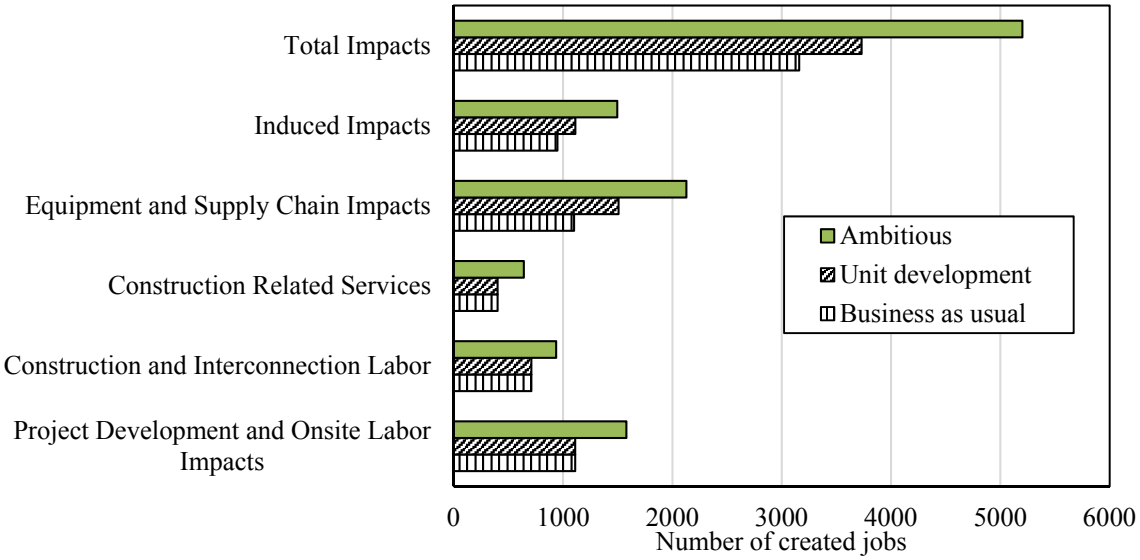

FIGURE 1. Jobs created during the *construction period*.

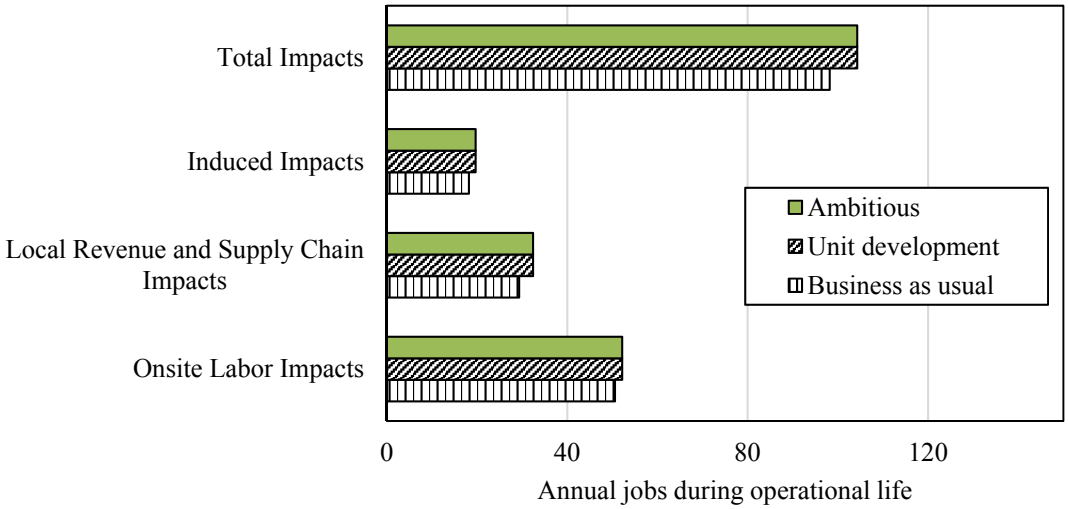

FIGURE 2. Jobs during the operational life of a 100 MW CSP plant in SA

The assumption made in the analysis of trade impact is primarily that there is local demand for CSP components in the SADC region, and secondarily in the rest of the world. This is only possible under the ambitious scenario, where CSP components, such as solar field equipment, can be exported to the global market. Depending on the progress rate of CSP in SA, and the current ongoing reduction in cost of CSP components, export of these materials could begin in SA by 2020. This is expected to be accompanied by an increase in job creation and direct positive impact on the SA economy. If an accelerated CSP component development plan would be supported, sub-Saharan Africa could earn over US $ 3.6 billion from exporting locally manufactured CSP components by the year 2030 [14,19,20].

CONCLUSIONS

The SA economy has been known to easily accommodate large-scale development of local manufacturing over a brief period. Currently, the SA local capability to grow a CSP component manufacturing sector is between 60-70 %. However, the aspects that are missing had been identified, and this can be developed with time. The economic and trade impacts under various local CSP development scenarios were presented. The study also showed that growing the CSP industry is the best way to prevent loss of jobs as a result of renewable IPPs, because, it involves the use of existing technical know-how with little training. It provides room for existing companies in established industrial sectors such as chemicals, steel, glass, electricals, etc. to easily integrate into CSP component manufacturing.

The results from this study can also serve as policy instruments for stakeholders involved in IPPs and PPA services relating to CSP technologies in emerging economies.

REFERENCES

[1] T.O. Craig, A.C. Brent, and F. Dinter, South African J. Ind. Eng. **28**, 14 (2017).

[2] O.O. Craig, A.C. Brent, and F. Dinter, **28**, 1 (2017).

[3] WWF, *Concentrated Solar Power: A Strategic Industrial Development Opportunity for South Africa* (Gland, Switzerland., 2015).

[4] FS-UNEP, *Global Trends in Renewable Energy* (Frankfurt, 2016).

[5] R. Guedez, M. Arnaudo, M. Topel, R. Zanino, Z. Hassar, and B. Laumert, AIP Conf. Proc. **1734**, 070011 (2016).

[6] D.F. Duvenhage, O.O. Craig, A.C. Brent, and H.L.S. William, in *SolarPACES 2017* (AIP Publishing, Santiago Chile, 2017).

[7] AIEC, *South Africa Automotive Export Manua* (Pretoria, 2017).

[8] DTI, *State of the Automotive Industry Report* (Pretoria, 2003).

[9] NAAMSA, *NAAMSA Members Statistics* (2016).

[10] DOE, *Integrated Resource Plan (IRP) Update Assumptions, Base Case Results and Observation* (Pretoria, 2016).

[11] SolarPaces, Sol. Paces News (2018).

[12] P. Gauché, T.W. Von Backström, and A.C. Brent, in *South. African Sol. Energy Conf.* (South Africa, 2012), pp. 1–12.

[13] O.O. Craig and R.T. Dobson, in *South. African Sol. Energy Conf. 2015* (Skukuza, South Africa, 2015), pp. 278–282.

[14] N. Kulichenko and J. Wirth, (2012).

[15] NREL, (2016).

[16] Black and Veatch, *COST REPORT COST AND PERFORMANCE DATA FOR POWER GENERATION* (2012).

[17] NREL GIS, Natl. Renew. Energy Lab. Dyn. Maps, GIS Anal. Tools Data (2015).

[18] NREL, NREL SolarPACES CSP Database 1 (2016).

[19] Fichtner, *Study on Conditions for Development of CSP Projects in Sub-Saharan Africa* (Stuttgart, 2014).

[20] Fichtner, *Assessment of Technology Options for Development of Concentrating Solar Power in South Africa* (2010).