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**Investigation of the Solar Energy Production and Contribution
in South Africa**

Silas K Mulaudzi,^{*} Mammo Muchie^{**} & Rudzani Makhado^{***}

Abstract

Energy utilisation in South Africa is by far characterised by high dependence on cheap and abundance available coal. Coal utilisation for energy production makes South Africa to be the largest emitter of CO₂ in Africa. Renewable energy, such as solar energy technologies has the potential to reduce the emission of trace gases to the atmosphere. South Africa has the best solar resources in the world, average daily solar radiation varies between 4.5 and 7 KWh/m². The country has the potential of generating up to 24 000 MW of Concentrated Solar Power (CSP) by 2030. The unfortunate situation is that there are no Concentrated Solar Power (CSP) and Solar Photovoltaic (PV) plants in South Africa. Such gaps jeopardise efforts to reduce emission of trace gases to the atmosphere. The Conference of the Parties (COP17) need to address infrastructural, regulatory framework, skills and funding impediments on climate change mitigation efforts.

This study seeks to establish the production, contribution and growth impediments of solar energy technologies in South Africa, mainly focusing on CSP and solar PV. We also critically review policy challenges with regard to solar energy production in South Africa. Our findings shows that the production of solar energy technologies is mainly hampered by weak institutional arrangement, strict regulatory framework, lack of skills, policy uncertainty and gaps as well as economic climate.

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Current contribution of solar energy technologies to energy security and climate mitigation effort is at this point negligible due to lack of CSP and PV plants. The distribution of solar energy across the country is spread in accordance with economic hub compared to solar energy potential. Areas around North West, Limpopo and Mpumalanga have good solar potential but the application is very minimal.

Keywords: Climate Change, Renewable Energy, Solar Energy, Concentrated Solar Power, South Africa.

JEL Classification: O30, O31, O33, Q55.

1. Introduction

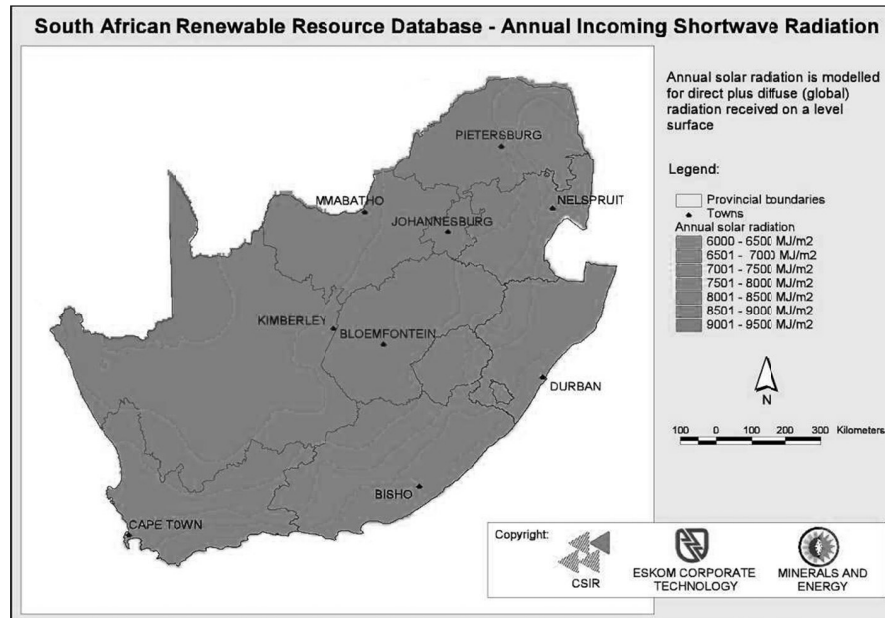
Globally, the renewable energy industry is projected to grow rapidly in the next few years (REN21, 2009). The International Energy Agency estimated that 15-20% of the total energy supply contribution will be generated from renewable energy by the year 2026. Investment in renewable energy sources for electricity, heating and in biofuels has increased considerably. Recent statistics shows that nearly 11 GW of solar PV was produced globally (REN21, 2009; REN21, 2010). According to REN21 (2010) first Solar, which is in the USA, became the first firm ever to produce over 1 GW in a single year. Major crystalline module price declines took place, by 50–60% by some estimates, from highs of \$3.50 per watt in 2008 to lows approaching \$2 per watt (Chinese Renewable Energy status, 2009).

Energy utilisation in South Africa is characterized by high dependence on cheap and abundance available coal. South Africa also imports a large amount of crude oil; but a limited quantity of natural gas is also available (Digest of South African Energy Statistics, 2009). South Africa has among some of the best solar resources in the world, the country has already committed itself to a target of 10,000 GWh of renewable energy by 2013 (DME, 2003). According to the Long Term Mitigation Strategy achieving renewable electricity supply targets of at least 27% by 2030 and 50% by 2050 would require a major rollout of Concentrated Solar Power (CSP) and solar Photovoltaic (PV) generation capacity. CSP is projected to contribute an installed capacity of up to 150 GW and solar PV up to 50 GW by 2050 (Winkler, 2007).

Solar energy is categorized into concentrated solar power, solar photovoltaic and solar water heating. South Africa is regarded as having good solar potential in areas around Limpopo, Northern Cape, North West

and Mpumalanga Provinces (Figure 1). However, solar energy remains untapped thus far (DME, 2003).

Figure 1: Solar Energy Potential in South Africa.



Source: DME *et al.*, (2001)

Solar radiation levels in South Africa are amongst the highest in the world. Average daily solar radiation varies between 4.5 and 7 KWh/m² (Banks and Schaffler, 2005). South Africa has the potential of generating up to 24 000 MW of CSP by 2030 given the excellent solar radiation available and infrastructure to support a project of such a magnitude (Edkins *et al.*, 2009).

The concentrated solar power is the largest existing centralized system that uses parabolic troughs, which focus sunlight into evacuated glass tubes carrying the heat to conventional steam turbines via heat exchangers (see Table 1). Solar photovoltaic cells make up modules that are placed in arrays and convert sunlight into direct current electricity without any moving parts (New Energy Finance, 2009).

Table 1: Solar Energy Technologies	
Solar Photovoltaic	Concentrated Solar Power
• It generates electrical power by converting solar radiation into direct current electricity using semiconductor • Material used for photovoltaic are monocrystalline silicon, polycrystalline silicon, copper indium gallium selenide	• It uses mirrors or lenses to concentrate a large area of sunlight or solar thermal energy onto a small area • Electrical power is produced when concentrated light is converted to heat which drives heat engine connected to an electrical power generator

Source: REN21 (2009); Environment America (2008).

2. The Solar Energy Development

CSP Development

Globally, CSP has four major technology designs, with a total of 430 MW in service and more than 8.7 GW capacity planned (Table 2).

- Parabolic troughs are systems whereby special mirrors shaped as linear parabolas reflect the sun's rays toward an absorption tube suspended at the centre of the trough's arc. The concentrated sunlight heats fluid inside the tube, generally a synthetic oil up to 400°C, which then travels to a collecting unit, where it heats water and generates steam to power turbines (Environment America, 2008). The troughs are typically arrayed on a north-south axis and track the sun throughout the day. The Solar Thermal Energy Generation (STEG) plants in the US demonstrate the longest track record of this technology (17 years), which continues to gain support today, with 395 MW of capacity in service and almost an additional 5 000 MW capacity in planning (Environment America, 2008).
- Concentrating dish/Stirling engines are shaped like a satellite dish. They focus light rays on a single area suspended above the bowl of mirrors, where temperatures up to 750°C heat a thermal fluid, which in turn runs a small steam or Stirling engine (Mills and Morrison,

1997). Although they have in the past been considered more useful as independent, off-grid units, particularly in remote and developing areas, the recent developments announced by Stirling Energy Systems, who plan to build up to 1.75 GW of solar farms in the California desert, indicate their additional attractiveness for connection to the national grid. Unlike the other CSP technologies, Stirling engines do not need water for cooling, though water is still necessary to clean the mirrors (Environment America, 2008).

- Central receivers/towers use freestanding heliostats (tracking mirrors) in an array to independently track the sun and focus its rays onto a central tower. Temperatures of up to 650°C are achieved, they require less land than parabolic troughs, and because the heliostats used as reflectors are nearly flat, their manufacturing costs are relatively low (Environment America, 2008). Demonstration central receiver plants have been built, beginning with a 0.5 MW test plant in 1981 in Spain and followed by others in France, Italy, Japan, Russia and the USA (Environment America, 2008). The first commercial plant, an 11 MW central receiver plant developed by Abengoa Solar, went online in March 2007 to deliver power to the city of Seville in Spain. Abengoa has since built a second 22 MW plant, with an additional 600 MW capacity in the planning process (REN21, 2009).
- Linear Fresnel reflectors (LFRs) use long rows of nearly flat, rotating mirrors to reflect light at absorbers elevated above the plane of the mirrors. Different absorbers use either a thermal transfer fluid or directly generate steam to power turbines. While not as efficient as parabolic dishes and troughs or central receivers, LFRs offer many potential cost and structural advantages. Like central receivers, their mirrors are made of standard glass in large, flat sheets, which require fewer steel supports than parabolic troughs and can be cheaply mass-produced (Environment America, 2008).

The mirrors' flat-shape renders them more resistant to wind damage and makes them easier to clean (Clean Energy Action, 2007). LFRs' fixed absorbers do not have moving joints, which simplify fabrication and avoid the cost and maintenance challenges presented by joints in parabolic trough arrays, and the recent development of the Compact Linear Fresnel Reflector (CLFR) has removed the problem of shadows (Mills and Morrison, 1997). Demonstration LFR arrays have been built in Australia, Spain and Belgium and in the US (Environment America, 2008). Originally conceived in the early 1990s by Sydney University, CLFR was first commercialised in 2004 in Australia and is now being refined and built on a large scale, with about 1500 MW of capacity in the planning (Environment America, 2008).

Table 2: Summary of CSP Development in 2008				
Technology	In Service Capacity (MW)	Planned Capacity (MW)	Total	Leading Locations (Including Planned Installation)
Trough	395	4 967	5362	US, Spain, China, Israel, Australia, Morocco, Greece, UAE, Algeria, India, Mexico, Iran
CLFR	1	1 489	1490	US, Libya
Tower	33	579	612	Spain, US, South Africa, Egypt
Dish	1	1 750	1751	US
Total	430	8 785	9215	

Source: Staley *et al.*, (2009); Spellmann (2009).

Solar PV Development

Solar PV generates electricity in well over 100 countries and continues to be the fastest growing power-generation technology in the world. Between 2004 and 2009, grid-connected PV capacity increased at an annual average rate of 60 percent (REN21, 2010). In 2010, solar PV installed capacity grew up to 40 MW (Figure 2). Germany again became the primary driver of PV installations, more than making up for the Spanish gap with 3.8 GW added—about 54 percent of the global market. Germany installed a total of 47% of total installed GW capacity globally (Figure 3).

The United States added an estimated 470 MW of solar PV in 2009, including 40 MW of off-grid PV, bringing cumulative capacity above the 1 GW mark with 6% of the total global PV installed (Figure 3).

The crystalline silicon solar cell remains the mainstream of commercialized solar cell nowadays. In international market, over 90% of solar cells are made of high purity polysilicon (Chinese Renewable Energy Status Report, 2009). Polysilicon is material consisting of small silicon crystal that differs from single-crystal silicon and is used for electronics and solar cells, and from amorphous silicon, used for thin film devices and solar cells.

Figure 2: Solar Photovoltaic, Existing World Capacity, 2000-2010, Source: REN21 (2010).

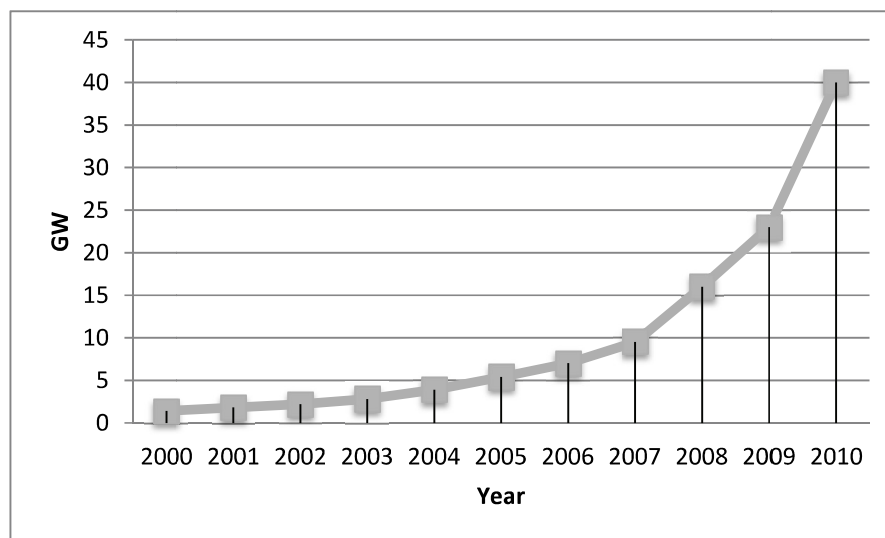
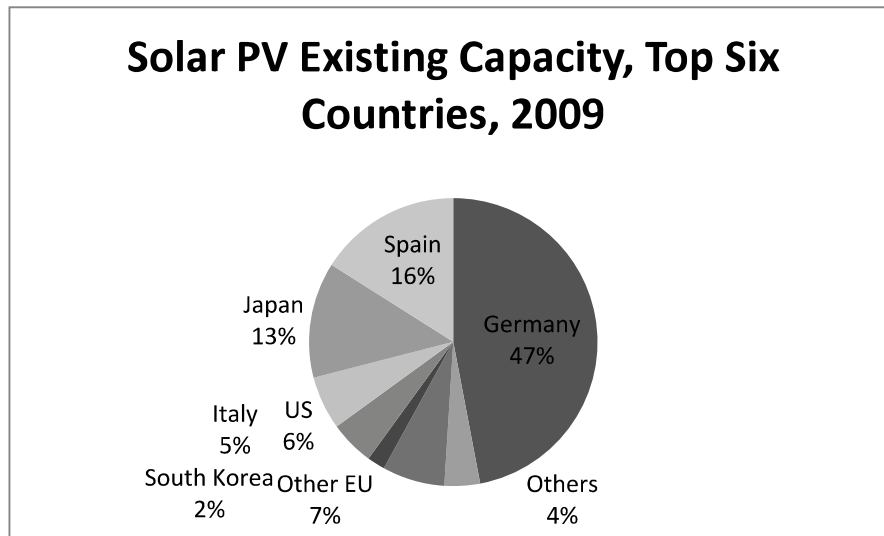


Figure 3: Solar PV existing capacity, 2009 (REN21, 2010)



As the most fundamental materials in PV cell, the high purity polysilicon has become the most significant part in PV industry chain (Chinese Renewable Energy Status Report, 2009). This is the biggest barrier for the PV industry in China. From 2001, the Chinese Polysilicon Production has increased drastically (Table 3). The increase was largely due to polysilicon price was held back. China's solar PV industry is also growing rapidly and the country became the world's largest PV cells producer in 2008 (REN21, 2009).

Table 3: China Polysilicon Production, 2001–2008 (tons)	
Year	Production(tons)
2001	40
2002	50
2003	60
2004	70
2005	80
2006	290
2007	1140
2008	5500

Source: Chinese Renewable Energy Status Report (2009)

3. Solar Energy Status in South Africa

South Africa has among some of the best solar resources in the world, the country has already committed itself to a target of 10 000GWh of renewable energy by 2013 (DME, 2003). Moreover, the country has developed the Integrated Resource Plan (IRP) that has a committed total of 600 MW of solar PV by 2019 and 300 MW of CSP by 2019 (DoE, 2011).

South Africa has various types of renewable energy technologies that are manufactured locally and internationally. Most of the wind and hydro generators are locally manufactured (Table 4). Some of the manufactured hydro, wind and solar Photovoltaic (PV) are exported regionally and across the continent. However, large wind generators and turbines are imported from the American and European countries. Concentrated Solar Power (CSP) is manufactured in Europe and there is no any CSP plant in South Africa thus far.

The government of South Africa has established a mini-grid hybrid system in the Eastern Cape Province in 2004. The Lucingweni Hybrid mini-grid system consisted of power generation, reticulation and premises. The power generation consists of wind turbines, using 6x6 kW Proven Wind Turbine mounted on 6m tall mast and 560 Shell Solar 100W Panels mounted on steel structure and an equipment cabin/shelter constructed on a concrete base (DME, 2006). The total solar PV capacity was 56 000 watts (56 kW).

The hybrid system supplied power to approximately 220 households in Lucingweni area in the Eastern Cape for more than 6 months. According to the DME (2006) the system worked well until the illegal connection started and put much pressure on the supply. Moreover, the power was supposed

to be limited to 2 Amps and it was mistakenly connected at 20 Amps, which resulted in situation where one household could withdraw all power at a specific time during the day. The system was vandalised by the local community and eventually it could not generate any electricity (DME, 2006).

Table 4: Renewable Energy Manufacturing Companies in South Africa

Company	Business type	Technology	Location
Solar Deluxe	Manufacturers, wholesale supplier	Solar water heating	Cape Town, Western Cape
Budget Solar (Pty) Ltd	Manufacturers/wholesale/importer	Solar electric power	Somerset West, Western Cape
Pre-plan energy	Installer/developers	Wind, biogas, Solar Photovoltaic	Alberton, Gauteng
Solartech	Manufacturers and installers	Solar water heating	Lonehill, Gauteng
Solar heat exchanger	Manufacturers and installers	Solar water heating	Johannesburg, Gauteng
Solar Beam	Manufacturers/installers	Solar water heating	Rivonia, Gauteng
Environment Save Energy	Manufacturer	Wind turbine and solar photovoltaic	Port Elizabeth, Eastern Cape
Green Wind Power and automation	Manufacturer/wholesale supplier	Wind turbine	Cape Town, Western Cape
Solardome SA cc	Design and installation	Solar water heating, solar thermal storage	Stellenbosch, Western Cape
Renenergy Technologies	Manufacturer, exporter, importer	solar panel, solar batteries, solar water heating	Elandsfontein, Gauteng
All power trust	Manufacturers/ importers/exporters	Solar electric power	Port Elizabeth, Eastern Cape
Inti Solar	Manufacturers and installers	Solar water heating	Fourways, Gauteng

Source: See:

<http://energy.sourceguides.com/business/byGeo/byC/SouthAfrica>

4. Objectives of the study

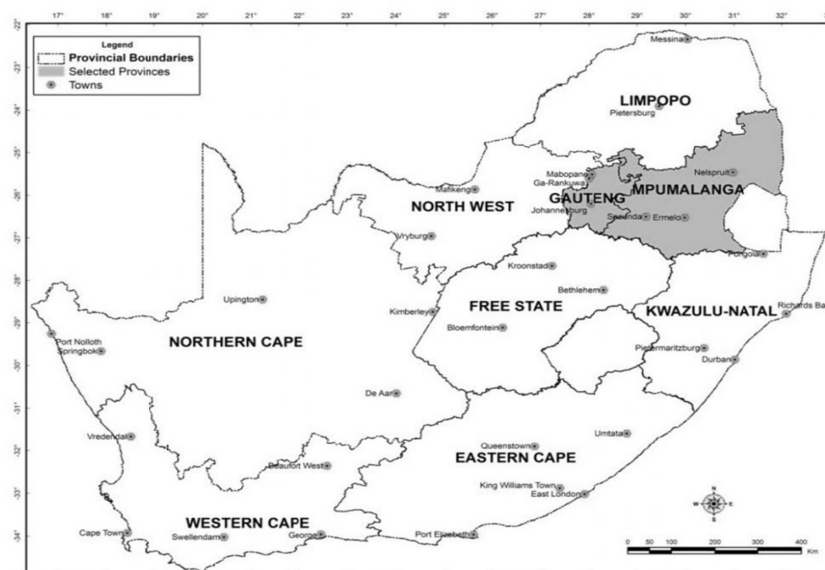
The objectives of this paper are:

- To establish the import and export relationship between the domestic and international firms that manufacture solar energy technologies;
- To investigate the production and contribution of energy in South Africa's energy growth; and
- To determine the impediments hampering the growth of solar energy manufacturing industry in South Africa

5. Methodology

The study was conducted in South Africa, thus covering nine Provinces of the country. However, electricity consumption data was collected in five Provinces, namely: Gauteng, Mpumalanga, Free State, Northern Cape and North West (see Figure 4). Other data was collected through the distribution of questionnaire in various organisations in Provinces across the country.

Figure 4: Study Area for the Research (Location where the Study was conducted)



The mixed (qualitative and quantitative) technique for data collection and analysis was used in this paper. The primary data was collected randomly through interviewing the respondents. A questionnaire was used to capture the collected data and information. Secondary data was collected from various sources including books, newspaper, journals, television and government statistics.

Primary data was collected from the randomly selecting the following sectors as shown in Table 5:

Table 5: Sources of Primary Data	
Sector	Organization
Manufacturing	• Inti solar Company • Okhela renewable energy corporation • Concentrix solar
Academic institutions	• One respondent from University of Johannesburg • One respondent from Fort Hare Institute of Technology • One respondent from University of Cape Town • One respondent from Wits University
Consumers	• 10 respondents from Secunda • 10 respondents from Tshwane • 5 respondents from Bloemfontein • 2 respondents from Kimberly • 2 respondents from Johannesburg
Generators/Producers	• 3 respondents from Eskom

The level of investigation was sampling. The data collected from sampling gave a good indication of the measurement, facts and other parameters of the entire population from which samples are drawn. In this paper sampling was used because it involves less cost, less amount of time to complete and is more practicable.

A stratified random sampling was used to select the sample in order to give all individual in a population equal chance for being included in the sample and is free of biasness. It was used because the data is required from two or more different types of attributes such as government, Non-governmental organizations (NGOs) or private organization. People that

were sampled for interviews were from Industry Associations representatives, State Owned Entities (SoE), individuals from the households, private sectors that deal with energy issues in South Africa. The collected data was captured and stored in MS Excel 2003 software. Data was analysed both quantitatively and qualitatively. Data was analysed quantitatively using descriptive statistics, analysis of variance.

6. Results and Discussion

Import and Export Relationship between the Domestic and International Firms that Manufacture Solar Energy Technologies

This study found that many solar PV firms in South Africa are subsidiaries of European and North Americans' firms. It was found that 80% of the firms were established as sub-divisions of the European firms. The majority of firms at this point in time are highly involved in marketing the products to the commercial and industrial customers in the country whilst waiting for the Government of South Africa to finalise the feed-in tariff scheme. It was found that 5 commercial and industrial companies have installed solar PV for own use power generation.

This study further found that the raw materials are exported to the parent firms in Europe and North America. However, few quantities of Solar PV cells are manufactured in South Africa whereas majority are manufactured outside the country. It was found that South Africa import the most solar PV from Europe, Asia and America. The reasons given are that it is cheaper and cost effective to transport raw materials than equipment. Moreover, the raw materials will enable the firms to create more jobs and skills development in South Africa.

The DME established Lucingweni mini-grid hybrid system in the Eastern Cape, which was a combination of wind and solar PV modules. The solar PV modules had a total capacity of 56 kW. The PV cells were imported from UK and Germany. These substantiate the fact of export and import of raw materials and final product from and to South Africa.

We found that there's a substantial interest from the Europeans and Americans intending to establish CSP in South Africa. The Northern Cape Province is targeted for the establishment of the CSP. The Government of South Africa has signed Memorandum of Understandings (MoU) with many Asian and European countries on solar energy development. It transpired

that the technology advancement moves at faster rate than the policy and regulatory framework of South Africa. That is if the government had finalise the subsidy schemes including feed-in tariff the country would have substantial amount of electricity generated from CSP and solar PV and the industrial development including manufacturing sector for solar would be highly advanced.

Preference of Energy Sources (Per Province)

In this study the residents in two Provinces (Gauteng and Mpumalanga) were interviewed in this paper. The purpose was to determine which source of energy between nuclear, coal and solar would residents prefer given a choice. The respondents were middle class and educated. The questions asked were what source of electricity would they like to consume and why do they prefer to consume electricity generated from such sources?

In both two Provinces, approximately 60% of the respondents chose solar energy as the preferred source of energy. The reasons cited were that it is natural and has no negative effect such as greenhouse gas emissions. About 31% chose coal because it is abundant in South Africa and has created many jobs in the mining sector, while 7% chose nuclear because it is reliable and has no side effects such as greenhouse gas emissions and would be best if the health hazards risks are managed well. The remaining 2% of the respondents chose to use gas and oil because they can be extracted for multiple uses such as petrol for vehicle, gas for cooking and electricity (see Figure 5).

Figure 5: Preferred Source of Electricity in the Mpumalanga and Gauteng Provinces

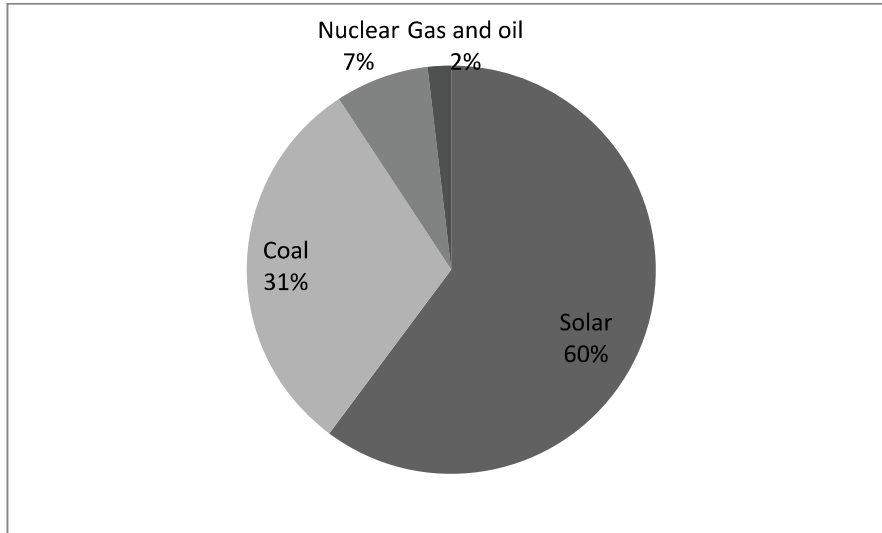


Table 6 shows the preferred source of electricity between Mpumalanga and Gauteng provinces. About 75% of respondents in the Mpumalanga Province prefer to use solar, while 55% in the Gauteng also prefer to use the same source of electricity. Ten percent of respondents in Gauteng indicated that they prefer to use electricity generated from coal, whilst 45% in Mpumalanga prefers to use coal as source of electricity. The highest percentage (45%) in Mpumalanga prefers to use coal for electricity generation because coal is more abundant, and that coal mining contribute significantly in the GDP of the province as well as job creation and economic development. Twelve percent of respondents in Gauteng and 4% in Mpumalanga prefers to use nuclear as source of electricity. The use of gas and oil only accounted for 3% in Gauteng and 1% in the Mpumalanga provinces (see Table 6).

Table 6: Preferred Electricity Source in Gauteng and Mpumalanga

Source	Gauteng (%)	Mpumalanga (%)
Solar	75	55
Coal	10	45
Nuclear	12	4
Gas and Oil	3	1

Growth Impediments in the Solar Energy Manufacturing Industry in South Africa

South Africa is well-endowed with natural resources that are abundant. It is clear that renewable energy development will require financial incentives. While the Government intends to provide the necessary incentives, South Africa's fiscal resources are limited, and there are competing high priorities social and economic programs, particularly in providing services to historically disadvantaged communities (DME, 2003).

The academic, research, Government and association institutions were interviewed about the growth impediments in the industry and it was found that there are major factor hampering the development of solar energy in South Africa. The barriers vary from the institutional arrangement, regulatory framework, capacity building, training and skills, policy uncertainty and gaps as well as research and development.

Regulatory Framework

It was found that slow pace of finalising feed-in tariff and other related regulations to support renewable energy in general and solar PV and CSP in particular is a critical stumbling block that is hampering the development of solar energy in South Africa. It was acknowledged that the introduction of renewable energy tariffs by the National Energy Regulator was a step in the

right direction. However, it is high time for government to expedite the process.

It was further acknowledged that the Independent Power Producer (IPP) programme that has been recently introduced is a break through and the expression of interest advertised where the IPP could apply was a great progress to the realisation of solar energy in South Africa.

According to DoE (2011), the firm commitment necessary for now requires 1200 MW of solar PV at 300 MW from 2012 to 2015 and 100 MW for CSP in 2016. The final commitment of a total of 1200 MW from solar PV starting from 2016 at 300 MW until 2019 (DoE, 2011). The CSP has final commitment of a total 300 MW for 3 years at 100 MW each year from 2017 to 2019 (DoE, 2011).

Policy Uncertainty and Gaps

The White Paper on Renewable Energy set a target of 10 000 GWh by 2013. This was a good move towards promotion of renewable energy in general and solar energy in particular. The White Paper's target was reviewed in 2009 and no any pronouncement was made ever since. The absence of renewable energy target as well as specific renewable energy technology target leaves gap in the sector with uncertainty as to where the country is moving to regarding renewable energy.

According to the Integrated Resource Plan (DoE, 2011), which has published the energy carriers for 2010 – 2030, there is a good solar PV and CSP allocation from 2016 to 2019 committed. This was seen as a good positive move towards the introduction of renewable energy and diversification of energy resources in South Africa.

Capacity Building, Training and Skills, and Research and Development

It was found that there is a great need for capacity building, training and skills in the solar energy sector. The country's Further Education Training (FET) should be geared to training students and enhance skills for sector specific. According to the research institution interviewed there is no sufficient solar energy training and skills enhancement programme in most of the FET colleges. The academic institutions indicated that the established hubs for renewable energy such as the Stellenbosch University should be

equipped with all resources including sufficient funding to accommodate more students.

With the development of PV industry, the related training activities, organizations and mechanism begin their development as well. But with the prediction of explosive growth of PV industry in the coming 15 years, in order to satisfy the huge training demands from vocational education, university education even public awareness dissemination, a comprehensive, sustainable and capable training system is important (Chinese Renewable Energy Status report, 2009).

The research institutions are not sufficiently funded to embark on a comprehensive research and development programme for solar energy. According to the International Energy Agency (IEA, 2008), government energy research and development budgets in many countries have declined between early 1980s and the 1990s from USD 18 billion to 8 billion in 1997. Where the research and development investments are made, returns can be high; the average return on research and development firms is estimated to around 20% - 30% (IEA, 2008).

It was emphasised that the government should invest significantly in the research and development through the relevant institutions such as SANEDI, CSIR and the Department of Science and Technology. The research and development institutions should be empowered to establish a comprehensive programme on researching and developing CSP and PV technologies that could gain from South Africa's present industry-base, which are aimed at encouraging domestic CSP component production, CSP technologies that allow for greater storage abilities and technologies that result in less water use, such as dry cooling or using ocean water for cooling. The international funding such as Renewable Energy Market Transformation is supporting renewable energy sector including solar energy technology, however, further CSP research and development, as well as diffusion, need to take place (Edskin *et al.*, 2009).

The China Renewable Energy status report (2009) shared the same sentiment that it is meaningful to establish national solar PV and CSP research and development centre for enhancing the core technology and comprehensive technology indicators of PV and CSP industry. The establishment of a sustainable solar PV industry supporting system includes fundamental research and development, key technology, industrialized equipment production, public research and testing accreditation platform (Chinese Renewable Energy Status Report, 2009).

7. Recommendations

The results of this research have both negative and positive impacts in the development and production of solar PV and CSP in South Africa. There is therefore a scope for improvement from all role players in the industry. To this end, the following recommendations are made:

Regulatory framework

The government should structure the feed-in tariff and the IPP programme in such a way and manner that it will accommodate small players also. At this point in time the regulatory framework requires IPP to have a start-up or capital costs, this accommodates big players only and the foreign firms in particular. The side effect is that the emerging firms are isolated from this scheme.

It is also recommended that the IRP increase the solar PV and CSP allocation in the final report. It is believed that (figure 1) there is a huge solar energy potential that remains untapped thus far, and therefore the 600 solar PV and 300 CSP allocated by 2019 is minute and insufficient.

Capacity building, training, skills and awareness

This paper recommends that FET colleges and the established hubs across the country be empowered to offer comprehensive training on solar energy technologies. There should be a proper coordination whereby the graduates from the FET colleges are sent to the training centres whereby they be offered experiential learning.

There should be a policy on skills retention to ensure that the trained personnel in the country should serve in the domestic firms for a certain number of years. This will further enable the experience graduate to transfer skills to the newly graduates.

It is further recommended that there must be a comprehensive awareness and education to all South Africans. This could be done in different coordinated forms such as annual conference targeting school learners, University and college students and the community at large. The awareness could further be conducted at a local municipal area by the responsible local authority as a road show. The awareness could further be done through the community newspapers whereby local residents could

read and understand the significance, benefits and opportunities offered by the solar PV and CSP.

Research and Development

It is recommended that government should invest in the research and development through different coordinated ways. The research institutions such as SANEDI and CSIR should be allocation sufficient funding to introduce variety and comprehensive solar PV and CSP technologies. It is believed that these institutions are unable to embark on comprehensive solar energy programme due to lack of funding. The government and private organisations should continue offering bursaries and scholarships to empower graduates to further their studies.

Policy uncertainty and gaps

It is recommended that the government should clarify its renewable energy policy position, targets and objectives. This will substantiate the commitment made in the IRP for the solar PV and CSP allocation until 2019. The policy should further disaggregate the allocation of solar PV and CSP as to how will it be achieved.

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