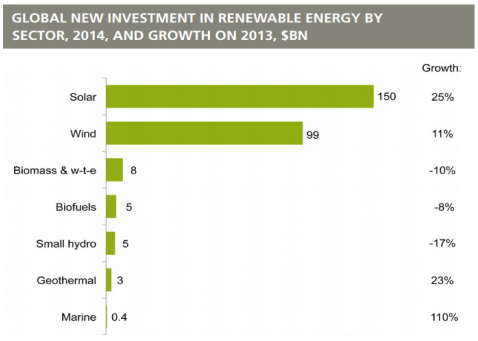
RENEWABLE ENERGY TECHNOLOGIES

INTRODUCTION

In 2014, renewable represented approximately 58.5% of net additions to global power capacity with the market being dominated by wind, solar PV and hydro power. The year ended with renewable comprising an estimated 27% of the world's power generating capacity (REN21:2015, 6). For the first time in over 40 years, the world's economy grew while CO2 emissions decreased.[1] This was due in part to China's massive deployment of renewable technologies and provides a strong impetus for the continued role that RE plays in climate change abatement. Renewable power capacity (excluding hydro) saw a sevenfold increase in the past decade growing from 85 GW in 2004 to 560 GW in 2013. Furthermore, while only 48 countries had renewable energy targets in 2004, by 2014 that number had increased to 144.[2] The consequence of this has been an upsurge in interest in renewable energy technologies with more companies being established to cater specifically for this market, often capitalising on gaps within specific niche areas or exploiting government prescripts for increased localisation such as those enforced by the DTI as South Africa's renewable energy programme gathered momentum. This paper explores opportunities for local companies who are manufacturing renewable energy technologies and suggests options for those wishing to enter this market. The focus here is on the African market as markets elsewhere have been effectively taken over by the more advanced countries.

GLOBAL RE INVESTMENT

Global renewable energy capacity has increased by 120% since 2000. This period witnessed the rapid expansion of renewable into new markets in developing countries. Investment in these countries at $131 billion, was up 36% on the previous year and came the closest ever to overhauling the total for developed economies,

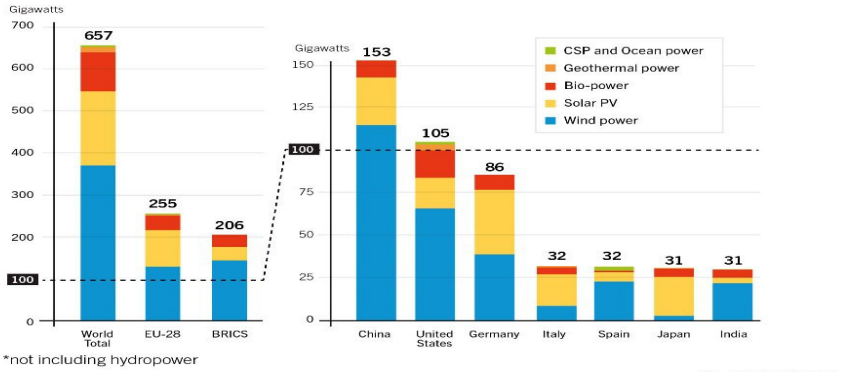


[1] In 2011 the developing world produced more electricity than the developed world
[2] More than 7 million people are employed worldwide in the RE industry.

at $138.9 billion, up just 3% on the year. During 2014 there were record investments in solar and wind, which accounted for 92% of overall investment in renewable power and fuels; investment in solar jumped 29% to $149.6 billion while wind investment increased 11% to a record $99.5 billion.

From an investment perspective, a global focus on low-carbon or carbon-free energy production ultimately induces for the developing world is to build economies that are competitive without carbon. Despite the dramatic fall of the oil price in 2014, renewable energy continued to grow and at least 59% of all new power generated around the world coming from renewable sources. The latest REN21 report, reveals that renewables made up an estimated 27.7% of the world's power generating capacity at the end of 2014 with China leading in renewable power capacity followed by the United States.

Renewable Power Capacities* in World, EU-28, BRICS, and Top Seven Countries, 2014



REN21 *Renewables 2015 Global Status Report*

MANUFACTURING AND EXPORT

There is a growing urgency amongst South Africa's policy makers that the country has to secure its future as producer and exporter of value added goods as Africa industrialises. The idea being that as Africa develops and industrialises, its energy needs will become more acute and South Africa can leverage the continent's plans, beneficiate and operate within the global market as a producer and exporter. As evidence of government's determination in this area is the recent establishment of the National Exporter Development Programme

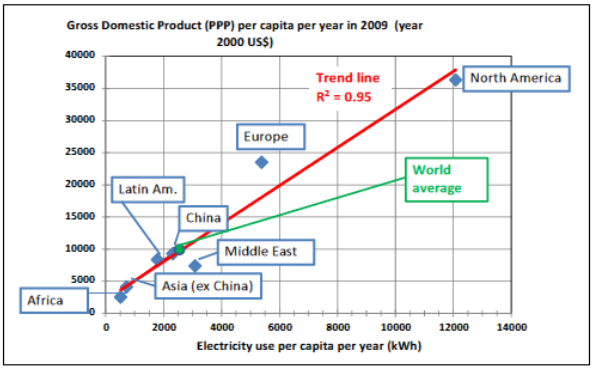
which will enable existing and emerging exporters at different stages of development to increase exports within specific product lines (Odendaal;2015:13)

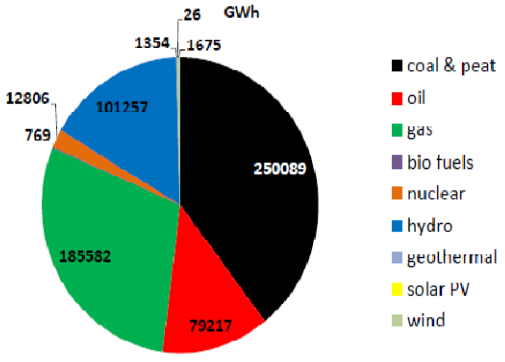
Africa is regarded as the most strategic market for South Africa's value added exports, a fact borne out by the fact that it is the destination for 17 of the DTIs trade missions for the current financial year which are expected to generate R3.5 billion in trade in the current financial year. The KwaZulu-Natal Growth and Development Strategy has identified the Green Economy as a key export sector based particularly on its ability to create jobs and attract investment. In addition South Africa has a significant market presence in many African countries including Zambia, Mozambique, the DRC and Malawi

KwaZulu-Natal has the second highest contribution to GDP (17%) after Gauteng and its manufacturing sector is similarly the second largest after Gauteng. It contributes 15% to the provincial GDP and generates 14% of provincial employment. The province has thriving aluminium and steel industry which if leveraged and supported properly, could provide essential components particularly of solar and wind technologies, and also, at a push some of the fabrication required of biogas digesters or anaerobic digester systems. Historically, the province has been a large exporter or unwrought aluminium and stainless steel and demand for renewable energy technologies growing amongst African countries that do not have a comparable manufacturing base. The province's enviable track record in the auto industry should allow a shift in skills from that to renewable energy module assembly due to the similarity of processes and skills and this sector is ideally suited to contribute towards the SADC renewable energy market (Brent,2014:4)

RENEWABLE ENERGY IN AFRICA

There are currently 600 million people in Africa (60%) without access to electricity and with rapid urbanisation, and population growth, this number will increase to 1 billon quite soon). In most economically developed countries, close onto 33% of total electricity is used in industry and by services for wealth creation. The average electricity consumption per person per year on the African continent is 500kWh this is about 20% of the global average of 2500kWh. However if one subtracts electricity usage for Northern and South Africa then this figure is even lower(180kWh) meaning that roughly 80% of Africa's population use less than 7% of the global average.[3] It is readily apparent Figure 1 (above) which explores the **relationship between electricity use and GDP in the world**[4] that electricity usage increases productivity and therefore it is no surprise that the African continent scores lowest in electricity use per capita as well as GDP per capita. Africa contains close onto 15% of the world's population but consumes just 3% of the world's energy output while close onto 587 million people including ¾of those living in sub Saharan Africa have no access to electricity via national grids. Furthermore less than 1 in 6 rural Africans have access to the national grid supply and the country stats are dire: 84% of Kenyans, 81% Ugandans and 65% of Sudanese are off the grid.[5] Consequently, if the continent is to become a global engine of growth, there needs to be a more sustained drive towards ensuring that substantially more electricity is provided. However, this is all set to change as





[3] Klimstra, J Africa yearns for electricity
[4] Klimstra, J (ibid)
[5] Pflanz, M (2013)

the continent's 4.1% growth has ensured that its per capita energy consumption is growing faster than almost any other country. Recently a British firm announced its intention to build the world's fourth largest solar power (155MW) plant in Western Ghana while Africa's largest wind farm is being built in northern Kenya. In Africa, close onto 40% of electricity is produced by coal, by natural gas it is 30%, while hydro contributes 15% and oil provides 12%

Between 2010 and 2012, the uptake of modern renewable energies grew by 4% globally with East Asia, representing 42% of new renewable energy generation leading the way. In countries like Bangladesh, 70000 jobs were created through the installation of more than 3.5 million solar homes systems that were part of the government's sustainable development strategy. Morocco's renewable energy target of 42% of total electrical capacity by 2020, looks to integrate solar power, wind power, hydropower and biomass. Consequently renewable energy investment in Morocco grew from $297 million in 2012 to $1.8 billion in 2013, due in part to reduced fossil fuel energy subsidies. South Africa's Renewable Energy Independent Power Producer Programme has through the last four bidding rounds attracted more than R100 billion worth of investment and has ensured that prices for onshore wind at 676 MW is R0.62 per kWh, solar photovoltaic at 415 MW is R0.79 per kWh, biomass at 25 MW is R1.45 per kWh and small hydro at 4.7 MW is R1.10 per kWh .

SOLAR

Rapidly falling costs have made solar PV-generated electricity cost competitive with fossil fuels and in 2014 an estimated 40GW installed for a total capacity of 177GW. Although it is able to generate power on a large scale to consumers in the developed world, it is in Africa that it has the greatest potential to provide power on a smaller scale to assist with electrification, desalination, water pumping and water purification. Water pumping combines solar powered well pumping, a water tower and a holding tank as well as a solar water purifier. Once operational these systems which can pump hundreds of litres of water per day can be consumed directly by rural communities and also be used to irrigate fields, in the process assisting to stave off drought and famine. Often these systems are powered by a

photovoltaic panel array and pumps have been installed in Chad and Sudan (250 installed in the last decade) and produces water that meets standards set by the World Health Organisation.

Thus far, the contribution from the renewable energy sector towards energy provision within the South African Power Pool, has been relatively modest. As indicated though, in the table below of **Electricity production in the SAPP** there is now a considerable interest from many African countries to consider low carbon options and it is estimated that by 2030, the renewable share to the SAPP could increase to 46%.

Table 1: **Electricity production in the SAPP**

	Total Electricity Production GWh	Coal and Coal Products	%	Oil and Oil Products	%	Hydro	%	Nuclear	%	Biofuel	%	Solar Energy	%	Natural Gas	%	Wind	%
Angola[1]	5 651	0	0.0%	1 644	29.1%	4 007	70.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Botswana[1]	372	372	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Congo, DRC[1]	7 882	0	0.0%	6	0.1%	7 847	99.6%	0	0.0%	0	0.0%	0	0.0%	29	0.4%	0	0.0%
Mozambique[1]	16 830	0	0.0%	0	0.0%	16 810	99.9%	0	0.0%	0	0.0%	0	0.0%	20	0.1%	0	0.0%
Namibia[1]	1 430	20	1.4%	6	0.4%	1 404	98.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
South Africa[1]	262 538	243 412	92.7%	197	0.1%	5 019	1.9%	13 502	5.1%	284	0.1%	21	0.0%		0.0%	103	0.0%
Tanzania[1]	5 302	60	1.1%	41	0.8%	2 615	49.3%	0	0.0%	0	0.0%	0	0.0%	2 586	48.8%	0	0.0%
Zambia[1]	11 454	0	0.0%	40	0.3%	11 414	99.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Zimbabwe[1]	8 925	2 258	25.3%	27	0.3%	6 572	73.6%	0	0.0%	68	0.8%	0	0.0%	0	0.0%	0	0.0%
Africa	694 858	262 119	37.7%	70 407	10.1%	114 593	16.5%	13 502	1.9%	868	0.1%	245	0.0%	228 877	32.9%	2 680	0.4%

Source: International Energy Statistics 2011

Between 2010 and 2030, close onto 80% of new capacity will emanate from renewable technologies and in so doing the decentralised renewable technology options would achieve some level of parity with grid expansion, more particularly in rural areas. It is anticipated that total investment in the region would amount to $314 billion. It is predicted that by 2030 close onto 90GW of solar PV and CSP will be available in Africa.

THE MARKET

	Centralised		Decentralised	
	Total	Renewable	Total	Renewable
Angola	3,101	2,051	295	185
Botswana	1,375	139	163	60
Dem. Rep. Congo	12,629	12,629	354	341
Lesotho	271	230	36	12
Malawi	877	877	39	32
Mozambique	2,982	1,822	80	76
Namibia	968	567	103	51
South Africa	50,257	32,928	22,005	21,907
Swaziland	281	231	84	53
Tanzania	6,013	5,025	1,254	1,214
Zambia	5,159	5,055	590	300
Zimbabwe	2,679	1,227	707	493
Total	86,593	62,781	25,710	24,725

Any manufacturer hoping to penetrate the African market would be well advised to consider countries within the Africa Clean Energy Corridor, particularly those within the Southern and Eastern African power Pool. It is expected that solar technologies will dominate new additions within the SAPP over the next two decades. Equally important are the centralised and decentralised renewable energy technologies in the formal grid (table above right that shows **Capacity addition from 2010 to 2030 per country in MW**)[6].

Table 3 Energy Acces in rural Areas[7]

	Electricity Need GWh	*Off Grid 0.05kW*	*Off Grid 0.3kW*	*Mini-Grid 25kw*
Angola	2 039	101 951 998	16 992 000	203 904
Botswana	944	47 222 191	7 870 365	94 444
Congo, DRC	2 230	111 520 151	18 586 692	223 040
Lesotho	123	6 144 860	1 024 143	12 290
Malawi	843	42 170 387	7 028 398	84 341
Mauritius	12	582 683	97 114	1 165
Mozambique	1 172	58 601 399	9 766 900	117 203
Namibia	658	32 914 919	5 485 820	65 830
Sychelles	1	64 248	10 708	128
South Africa	11 933	596 669 367	99 444 894	1 193 339
Swaziland	79	3 929 033	654 839	7 858
Tanzania	1 425	71 264 754	11 877 459	142 530
Zambia	2 884	144 187 571	24 031 262	288 375
Zimbabwe	3 762	188 120 737	31 353 456	376 241
	Total:	1 405 344 298	234 224 050	2 810 689

The relevance here being that renewable energy technologies for both centralised and decentralised additions will have equal significance over the next two decades. The rural sector holds enormous promise particularly with regards off-grid solutions and it is

[6] Brent, 2014:, pgs 7 and 8
[7] Brent,2014:11

estimated that PV installations will run into millions (mini-grid systems) and billions (small-scale rooftop applications) as is evident from the table that shows the **number of units required to address energy access needs in rural areas.**[8]

KWAZULU-NATAL'S RENEWABLE ENERGY TECHNOLOGY EXPORT OPTIONS

Polycrystalline silicon manufacturing

There are numerous areas of the PV value chain that allows for participation of KZN companies. The first would be in the production of single crystal wafers which is the substrate for silicon-based solar cells and semi conductors. The production of solar power systems is dependent on the manufacturing of high quality polycrystalline silicon. Silica contains silicon or pure silica dioxide. Quartzite can contain 90% silica and is found in KZN and Gauteng. It takes roughly one week of intensive refining to convert quartzite to polycrystalline silicon. Recent interest in Pietermaritzburg around the possibilities of establishing just such a production facility with an investment value of between R150 – R200 million has renewed interest in this sector. It is hoped that initial production will result in exports to those countries with the technology to manufacture PV cells and there is every reason to believe that this could also lure companies to KZN especially as the DTIs localisation of renewable energy technologies gains momentum. The province is therefore well positioned to manufacture the polycrystalline silicon material or solar PV cells and this is turn can be extended in the long term to introduce PV cell production.

PV modules

Although the market is largely dominated by international manufacturers, there are a few local players making their presence felt. The local market comprises c-Si PV and thin film modules with varying quality levels. The current capacity of established PV module

[8]Brent,2014:11

manufacturers is 158MW, of which a large portion was exported and it is estimated that this capacity could increase to 450MW. The REI4P process, together with the DTIs localisation strategy has already attracted other international module and panel manufacturers. Over the past few years the cost of PV modules has plummeted and currently local prices vary between R5.7W and R7.5W while wholesale prices vary between R7.5W and R11.5W. A large portion of this mark up (roughly between 30-50%) is due to transportation costs, mainly because most of the producers are based in the Western Cape who are catering for demand in Gauteng and KwaZulu-Natal. Consequently KZN manufacturers who are able to distribute to areas of highest market demand are in a strong position and their case is strengthened immeasurably by the province's logistics platform.

Inverters

The local inverter[9] market is still in its infancy and currently is mainly comprised of local distributors of internationally manufactured products. However, a few local companies have started manufacturing with a specific focus on the small to medium scale residential and commercial segment. Furthermore, since most of the components can be sourced locally, there is immense localisation potential for the value chain and since the estimated potential for reaching local content is between 55%-85%, there is enormous capacity for local sourcing and manufacturing. With global giants such as SMA already operating in South Africa and through the REI4P programme servicing the domestic market, efforts should be made to ensure their penetration into the rest of Africa.

Mounting structures

All PV modules need some form of mounting structure for structural support and protection and this applies irrespective of whether these modules are rooftop or land mounted. Most mounting structures are predominantly pre-engineered used aluminium or steel and having

[9] Inverters are electronic devices that convert direct current (output of solar PV modules) to alternating current to match the load requirements of the customer that the system is connected to.

experienced a huge growth spurt, this market has shifted from rooftop towards ground mounted. The structures comprise steel, stainless steel or aluminium, and these are all established local industries. Close onto 85% of the mounting structure costs are located in the stainless steel/aluminium profiles while the rest is made up of fasteners and overheads. Recent estimates put local content potential at roughly 95% and at least one company, Thekwini Tool and Die has already established a commanding presence in this field, providing units for solar farms throughout the country.

Cabling

PV modules are connected by DC cables to the junction boxes and inverters and from there AC cables ensure connection of the system to the grid. The 12 companies that operate locally account for 59% of the power cable market. The bulk of the cost in the cable manufacturing process resides in the conductors (copper/aluminium rods) and insulation (PVC/polymers) all of which can be sourced locally and the localisation potential of these components is substantial. Consequently these companies are well placed to produce for the rest of the African market. Companies such as LAPP Cables already have a strong presence in Durban and are well placed to extend their reach into the SADC region.

Batteries

Batteries are integral to PV systems which utilise various battery types from lead-acid to lithium-ion and sodium sulphur batteries and these are connected to the PV module to provide protection against overcharging or discharging. South Africa has well established local companies such as Willard, Powertech and First National. Although imported batteries are generally more expensive than those that are manufactured locally, they nevertheless allow for more charge-discharge cycles. Close onto 25% of the cost of small to medium scale PV systems is allocated to battery storage and while this substantially increases the cost of off-grid PV systems, the scale of the growth of this market serves as an inducement for the

industry to improve its capacity especially with regards providing additional storage capacity.

Building-Integrated Solar PV

There are numerous other areas of the solar PV spectrum that local manufacturers can capitalise on. As solar PV reaches grid parity and begins to compete with conventional sources such as coal fired power stations (as is currently the case in South Africa) other innovations such as building integrated PV (BIPV) which includes solar PV-integrated building materials will come to the fore. The range of BIPV applications includes roofing materials and solar glass, the latter referring to the integration of BIPV into architectural glass, the local manufacture of which could overcome the burden on exorbitant shipping costs of imported varieties. One suggestion includes the integration of thin film PV on a roll to roll basis into building materials. Another option would be to include solar PV as a standard option for prefabricated homes.

BIOENERGY

Bioenergy refers to renewable energy derived from biological sources that includes wood, algae and waste products. It is used to generate electricity and provides fuel for transport and heating applications and is used in solid (biomass), gaseous (biogas) and liquid (biofuels) forms and remains one of the most commonly used (and cheapest) forms of generating heat and energy in South Africa, particularly amongst the poor. [10] Despite the more traditional uses of bioenergy it is estimated that an existing 325MW electricity capacity is spread throughout East and South Africa and there is abundant feedstock from forestry, agriculture and waste. It is however the biogas and bio-digester technologies which can be mass produced and manufactured for different market levels which provide the greatest opportunities. Biodigesters facilitate the decomposition of organic material to produce

[10] Close onto 80% of sub-Saharan Africa's population relies on firewood and charcoal for heating and cooking.

methane gas as well as high grade organic fertiliser. It should come as no surprise that these technologies predominate in KZN, seeing as most of the country's biomass originates there, while the fact that close onto 23% of South Africa's current electricity needs could be met through biomass has refocused attention on this sector, particularly from within the business community that is keen to expand their operations in their search for new markets. Furthermore, if organic wastes were utilised in bioenergy-related process, close onto R5billion per annum could be added to the economy. Similarly an additional 50 000 tonnes per annum of sugar produced for ethanol would result in an additional R3.2 billion being added to the industry. This would also generate an additional 1500MW worth of electricity valued at R8billion per annum. In total, utilising all bioenergy resources, close onto R69 billion per annum could be realised (Brent:2014:11)

Biogas is probably one of the most untapped sources of natural and sustainable energy available and it has tremendous capacity to supply at a commercial level. It is the product of the decomposition of animal and plant waste and can be used either directly or mixed with natural gas in order to produce fuel for cooking and heating (Smeddle,58). It is used all over the world with countries such as India which has 12 million digesters, being particularly prolific. As a source of energy it requires low technological input and is relatively cost effective to implement and also meets the requisite criteria relating to environmental sustainability. The biogas industry's waste, generated from the conversion of the initial organic waste into gas, is further beneficiated into compost for the agricultural sector while the conversion of waste to gas also produces thermal heat. This therefore ensures the supply of supply of electricity to rural regions that Eskom is unable to reachThere are a variety of designs currently in existence in South Africa with some companies such as Agama and BiogasPro being the most dominant.

Its proponents claim that while the renewable-energy sector could produce 1.9 jobs for every MW installed, the biogas industry could create 5-10 times more, and in the process of developing biogas specific products, evolve into a R10-billion industry. There are currently, 300 biogas digesters in operation in South Africa most of which are small scale, compared Lesotho 600, most of which are subsidised by the government

KawZulu-Natal is the site for numerous bioenergy projects as highlighted in the table below. These large scale projects have provided the necessary stimulus for a range of smaller more widespread projects

Table 4: Current bio-energy capacity in KZN

Mondi Richards Bay Biomass Project	Biomass residues used for co-firing boilers and to drive steam turbine	±5.3 MW (13.2 MW x 40%)[1]	Electricity/Heat
Ethekwini Municipality	Durban Landfilling gas to electricity project – Marianhill landfill	1 MW	Electricity
Sappi SA Mills	Sappi uses co-generation and generates electricity on site (using biomass and residues)	± 92.2 MW (230.5 MW x 40%)[1]	Electricity/Heat
Tongaat Hulett Sugar	Uses co-generation to produce electricity at Felixton, Amatikulu and Maistone mills	±20.8 MW (52 MW x 40%)[1]	Electricity/Heat
Ubuhle Renewable Energy	Sugarcane-based bioethanol (Jozini, KZN)	50 million litres/year	Fuel

Source: Brent, 2014:14

Further evidence of interest in this technology can also be seen from the projects currently under review

Table 5 Bioenergy projects in Ungungundlovu

AREA	FEEDSTCOK	PROJECTED YIELD
Kamberg	Pig farm and 8 Dairy Farms	10MWe
Albert Falls	Cattle feedlots, piggeries and Poultry	10MWe
Thornville	Abattoir	9MWe
Midmar	Poulty, Piggery and Dairy	3MWe
Escourt	Abattoir, chicory and poultry	2MWe
Pmb	Restaurants, food processors, oil	2MWe
Camperdown	Poultry and piggery	tbc

Source; Jogiat 2013

There are other projects as well. The SA Canegrowers is currently piloting a biogas plant for small scale farmers which, if successful will be rolled out to include most of the small sugar cane farmers throughout the province, eventually producing 50MW of electricity. In addition to these there are other projects such as the proposed R120million AD plant planned for the north coast. The scale of these projects would serve as a useful stimulus for further industry growth, especially into other African countries. There exists numerous types of digesters many of which are manufactured locally and in some cases, their modular design allows for local moulding and fabrication.

Table 6: Different ypes of digesters

	Fixed dome	Floating drum	Polyethylene tubular
what	Operated by feeding manure mixed with water	Operated by feeding manure mixed with water into a digester inlet pipe	Operated as PFRs with semi-batch flow.
construction	Constructed of masonry, inside a pit dug in the ground	Constructed of steel on a guide frame; drum floats on water	Constructed of two layers of polyethylene plastic in a tubular form
advantages	Have no moving parts, costs are low and has a 20 year design lifespan	Operator can visually see how the digester works; are easy to operate; gas tightness is easier to maintain	Least expensive and easiest to construct
disadvantages	Special sealants are required; high technical skills required for construction and gas pressures fluctuate	Steel drum is expensive and requires frequent maintenance; design life of between 5-15 years. They are harder to maintain resulting in increased cost.	Very short lifespan (2-10 years)

Source:Author's own

For some manufacturers of biogas digester tanks, a steel panel tank is the best option in terms of cost, speed of construction and functionality is concerned. Steel bolted panel tanks can however also be used for any type of storage requirements, whether for drinking water, effluents (sewerage, chemical, etc) or foods and grains in the municipal, agricultural, industrial, commercial or mining sectors. Two South African developed biogas digesters earned their inventor second place in the SA Cleantech Competition. AGAMA Biogas was recognised for the innovation and the quality of its BiogasPro and SmartTop prefabricated biogas digesters. The first small digester to achieve certification from the South African Pipeline Gas Association, the BiogasPro is a patented system that is engineered, designed and manufactured in South Africa.

This paper has argued that renewable energy, particularly solar and bioenergy, look set to dramatically alter the continent's energy landscape. As the continent grows so too will the demand for electricity provision and it is in this space and the urgency of the demand, that will provide the requisite stimuli for the renewable energy market. . There are enormous opportunities for manufacturers that are involved in specific components, be they cables or inverters and over and as the African market improves, they could benefit enormously from an aggressive expansion drive, particularly in the SADC countries.

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