MicroCHP Product Commercialization Proposal

Produce by Brits Energy,
2020

Table of Contents

Executive Summary

Micro combined heat and power (mCHP) is an efficient and clean approach to generating electric power and useful thermal energy from solar or fuel. Instead of purchasing electricity from the distribution grid and separately burning fuel in an on-site furnace or boiler to produce thermal energy, an industrial or commercial facility can use combined heat and power to provide both services in one, energy-efficient step.

Like many other newly industrialized countries, South Africa is struggling to reorient its national economy toward a low-carbon growth trajectory in order to meet its target under the Paris Agreement. The energy sector contributes close to 80% towards the country's total greenhouse gas emissions of which 50% are from electricity generation and liquid fuel production alone. More action has to be taken to reduce carbon emissions.

mCHP is an efficient energy solution that directly addresses a number of priorities of South Africa: reducing energy operating costs, increasing energy efficiency, reducing greenhouse gas emissions, enhancing our energy infrastructure, improving energy security and resiliency, and growing the economy.

The goal of this report is not only to provide data on mCHP's market potential and but also reference on business model, online PR strategy for stakeholders to design a thorough product commercialization plan to land on South Africa.

This report discusses the mCHP market size, South Africa competitive landscape, local policies, and corresponding risk in product commercialization project. In later part, it also lists possible business models, routes to market, online-PR activities.

Section 1: Electricity Market

1.1 Market Overview

- **South Africa Electricity Market**

The Republic of South Africa is an emerging economy with a fast-growing population of presently about 56 million inhabitants.

South Africa supplies approximately 40% of Africa’s electricity. (Eskom, 2019)The electricity sector in South Africa is dominated by the national utility Eskom, a primary electricity supplier and generates approximately 90% of the electricity used in the country. The balance is supplied by municipalities and redistributors as well as private generators.

According to by Ministry of Energy, by 2019, South Africa’s total domestic electricity generation capacity is 54GW from all sources, which are 39 GW installed capacity from coal, 1.8 GW from nuclear, 2.9 GW from pumped storage, 2.1 GW from hydro, 3.8 GW from diesel and 3.7 GW from renewable energy. According to Eskom, 91% of the energy sold come from coal-fired stations. Besides being already more expensive than renewable energy generation, coal burning, the largest source for South Africa’s current electricity mix, has severe consequences for public health, water and air pollution, external costs which are not included in current accounts. (Department of Energy, South Africa, 2019)

The electricity generated is transmitted through a network of high-voltage transmission lines that connect the load centres and Eskom and municipalities distribute the electricity to various end users. Eskom also supply a number of international customers, including electricity utilities, in the SADC region. However, Eskom has struggled to meet the daily peak demand due to the inactive state of a large number of generating units. This has, among other factors, led to load shedding and several energy crises in the past decade, especially in 2008 and 2015. (Baker L, 2015) (Baker L P. J., 2018)

Eskom sells power directly to some 2703 industrial, 51 848 commercial, 81 638 agricultural and 6 million residential customers. (Department of Energy, South Africa, 2019)

- **Current electricity demand in South Africa**

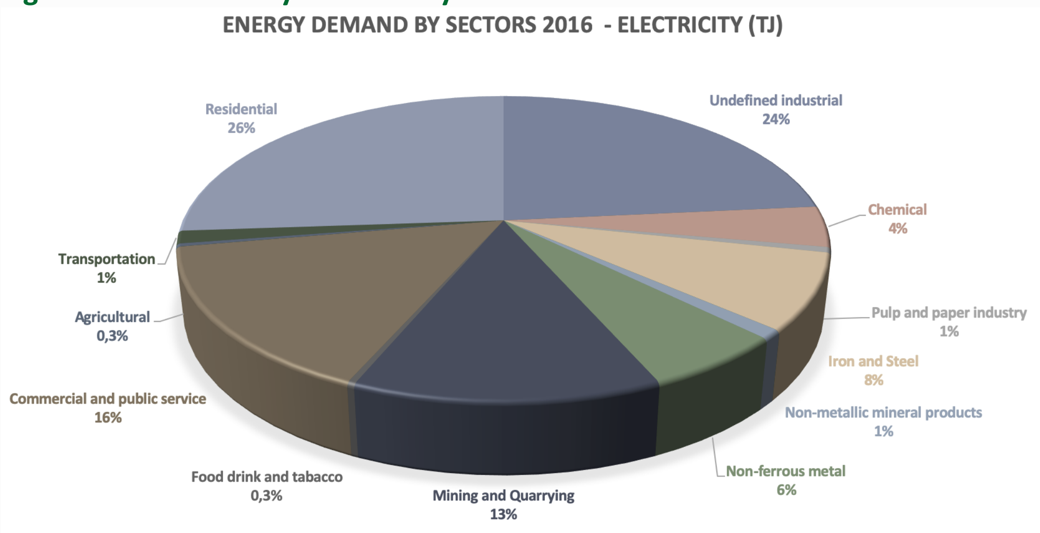
In South Africa Energy Sector Report 2019, Department of Energy published the energy and electricity usage data in various sectors in 2016. From the report, users in Residential, Commercial and public service, Mining and quarrying industry consumed the most electricity. Calculated with the average cost of electricity of $0.0522 per kWh (Eskom, 2019), their market value for electricity supplier were the highest: $3,224 million, $1,925miilion and $1,597million respectively.

Figure 1.1.1: Market value for electricity per user group

Industry	Energy Use (TJ)	Electricity proportion	Electricity (TJ)	Electricity (GWh)	Market Value ($m)
Industrial	1,459,900				
Chemical	216,996	17%	36,889	10,255	535
Pulp & paper	9,343	52%	4,858	1,350	71
Iron & Steel	273,408	25%	68,352	19,001	992
Non-metallic mineral	72,995	11%	8,029	2,232	117
Non-ferrous metal	128,355	40%	51,342	14,273	745
Mining & Quarrying	156,951	70%	110,072	30,600	1,597
Construction				-	-
Food, drink, tobacco	7,842	35%	2,745	763	40
Undefined industrial	605,316	*33%	199,754	55,531	
Commercial & public	428,061	31%	132,699	36,890	1,926
Agricultural	21,484	13%	2,793	776	41
Transportation	567,983	2%	11,360	3,157	165
Residential	244,130	91%	222,158	61,760	3,224

**Assuming 33%, which is the average electricity proportion among industrial users.*
Source: South African Energy Sector Report 2019

Figure 1.1.2 Electricity Demand by sector in 2016



Source: The South Africa Energy Sector Report 2019

According to Eskom 2019 annual report, we can see that industrial, mining and commercial groups bought the most electricity from Eskom (Figure 1.1.3). The annual spending per user is $1,596,096, $941,377 and $10,696 for industrial, mining and commercial respectively. Agricultural user spent $3,729 and residential user spent $101.

In order to figure out the target user, we should look at two important indicators. Firstly, we should make sure that the capacity required per user is not far from the mCHP's capacity. From Figure 1.1.3, the capacity required by industrial and mining user is more than 2000Kw, with an range from 3kw to 20,000kw. On the contrary, commercial user only required capacity of 23kw, followed by agricultural user 8kw and residential user 0.2kw.

Secondly, we should look at the willingness to pay by the user. Assume mCHP (3kw electricity, 25kw heat) sells at $16,490 (£12,850) with payback period of 5 years, the annual spending of a user should be at least $3298, in order to make mCHP economically attractive. From figure 1.1.3, residential group is not qualified.

Combining both indicators, we can safely say the target users of mCHP would be small to large commercials, average to medium agricultural users, large residentials such as community centre or nursing home.

As mCHP is a heat-driven generator, it is crucial to predict the demand in heating and cooling for different user groups. However, there is no available data of South Africa. In Australia, which is at similar latitude level as South Africa, heating and cooling are together the largest energy use (40%) in the average Australian household (DEWHA 2008). For commercial building, 42% of energy consumption is in heating and cooling. (Pitt & sherry, 2012)

Figure 1.1.3 Annual spending and required capacity per user group

User	Share of total usage	Usage (GWh)	#users	Usage/user (kWh)	Capacity /user (kW)	Spending /user ($USD)	Target group
Municipalities	41.9 %	87,285	137	637,116,788			
Industrial	23.40 %	48,746	2,703	18,034,036	2,059	941,377	Small industrial; Capacity range: 3.4kw-20,000kw
Mining	13.90 %	28,956	947	30,576,558	3,490	1,596,096	
Residential	5.60 %	11,666	6,000,000	1,944	0.2	101	Multi-family buildings or nursing homes
Commercial	5.10 %	10,624	51,848	204,907	23	10,696	Small to large commercials
Agriculture	2.80 %	5,832	81,638	71,437	8	3,729	Average to large farms
Others		15,210	360,100				
Total:		208,319	6,497,372				

**Average electricity price 90.01c/kWh, Capacity per user = Annual usage per user/ 365(days)/24 (hour)*
Source: Eskom 2019 annual report; The South Africa Energy Sector Report 2019

1.2 Market Trends

The NDP (South Africa National Development Plan) envisages that, by 2030, South Africa will have an energy sector that provides reliable and efficient energy service at competitive rates; that is socially equitable through expanded access to energy at affordable tariffs; and that is environmentally sustainable through reduced emissions and pollution. In formulating its vision for the energy sector, the NDP took as a point of departure the Integrated Resource Plan (IRP) 2010–2030 promulgated in March 2011.

As mentioned, South Africa is struggling to reorient its national economy toward a low-carbon direction under the Paris Agreement. South Africa is a signatory to the Paris Agreement on Climate Change and has ratified the agreement. In line with INDCs (submitted to the UNFCCC in November 2016), South Africa's emissions are expected to peak, plateau and from year 2025 decline. The energy sector contributes close to 80% towards the country's total greenhouse gas emissions of which 50% are from electricity generation and liquid fuel production alone. There is action to reduce emissions with investment already in renewable energy, energy efficiency and public transport.

a. Cleaner energy

South Africa is highly dependent on coal burning for power generation, but does have a number of small-scale hydroelectric plants and only one nuclear power station. The economy relies on heavy industry, mining, and cheap energy generated from domestically produced coal.

At the same time, South Africa is regarded as a prime candidate for increased use of renewable energy with its abundant natural resources of sun and wind, which lends itself very well for solar water heating and electricity generation.

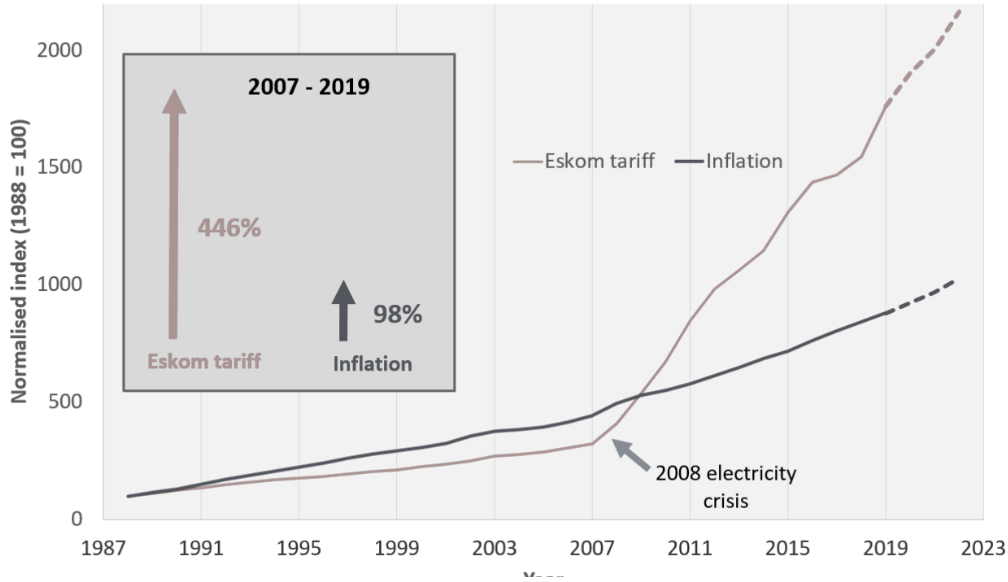
Given the ever-rising cost of traditional fossil fuel-based energy, renewable energy is becoming a viable option. South Africa is presently rated as the 12th most attractive investment for renewable energy (IPPPP An Overview, 2019). The Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) has to date, attracted investment (equity and debt) to the value of R209.7 billion (US$12 billion), of which R41.8 billion, (US$2.5 billion) (20%) is foreign investment (IPPPP An Overview, 2019). This augurs well for South Africa, as the programme has received international acclaim for fairness, transparency and the certainty of this programme.

b. Off-grid option

As wholesale and retail electricity tariffs rise, we can expect more electricity users to look for alternatives like rooftop PV systems (residential) or utility scale PV generation (mines and other big industrial users) and migrate away from the electricity grid.

Figure 1.2.1 below shows the Eskom tariffs from 1988 to 2019, plotted against CPI (Consumer Price Index) or inflation over the same period. It also shows projections up to 2022, based on currently projected increases as approved by NERSA (8.1% in 2020 and 5.2% in 2021), as well as Stats SA and the Bureau for Economic Research's inflation projections. (2019 update: Eskom tariff increases vs inflation since 1988 (with projections to 2022), 2019)

Figure 1.2.1 Eskom average tariff vs. inflation (CPI)



Source: poweroptimal.com

c. Fuel switching

More fuel switching is to be expected, particularly in regard to the thermal load (water heating, cooking and space heating) as electricity tariffs increase and alternatives like LP Gas become available and cost effective.

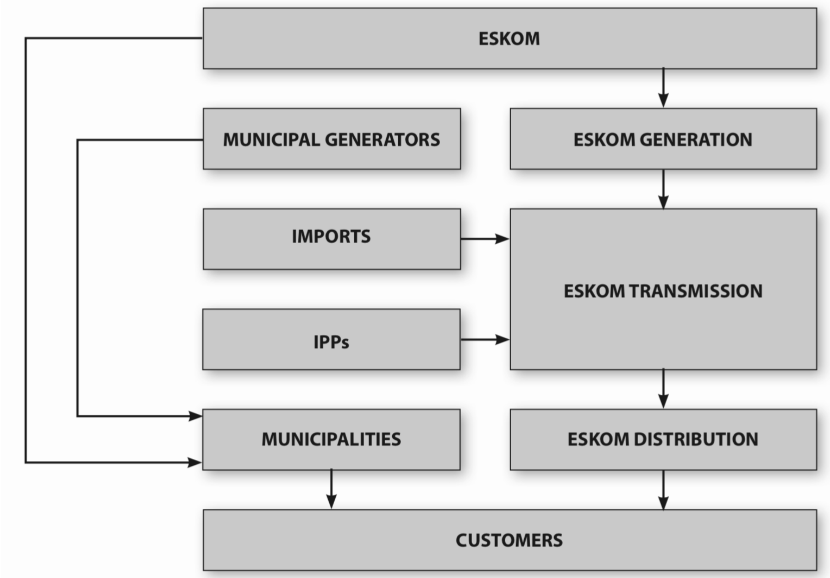
Requests by industrial and commercial electricity users to deviate from the IRP and to develop their own generation exemplify the trend. While at this stage it is not quantified, most residential estates, commercial parks and shopping centres have installed PV systems to supplement grid supply. (Department of Energy, South Africa, 2019)

1.3 Value Chain

Electricity infrastructure comprises of three sub-sectors, namely: generation, transmission and distribution. In South Africa, Eskom dominates the generation and transmission of electricity. Eskom generates, transmits and distributes electricity to industrial, mining, commercial, agricultural and residential customers, and to municipalities, who in turn redistributes electricity to businesses and households within their areas.

Eskom also purchases electricity from Independent Power Producers (IPPs) in terms of various agreement schemes as well as electricity generating facilities beyond the country's borders. Most power stations are located in Mpumalanga, except for Lethabo and Matimba which are located in the Free State and Limpopo provinces respectively.

Figure 1.3.1 Electricity Generation, Transmission and Distribution



Source: Eskom 2019 annual report

1.4 Electricity Demand Forecast

- **Africa Market**

Electricity demand in Africa today is 700 terawatt-hours (TWh), with the North African economies and South Africa accounting for over 70% of the total. Yet it is the other sub-Saharan Africa countries that see the fastest growth to 2040. Electricity demand more than doubles in the Africa Case to over 2300 TWh in 2040, with most of the additional demand stemming from productive uses and emerging middle- and higher-income households.

Figure 1.4.1 Electricity demand in Africa by scenario, 2018-2040

	Transport (TWh)	Productive Uses (TWh)	Households with Access (TWh)	Household gaining Access (TWh)	Total(TWH)
2018	6	448	231		700
2040 AC*	40	1196	751	334	2300

**Africa Case (AC): A new Africa Case AC was developed for the Special Focus on Africa in WEO 2019 that reflects the Agenda 2063, in which African leaders set out their vision for the future growth and development of the continent.*
Source: IEA

Renewables play a leading role in meeting this demand. To date, the continent Africa with the richest solar resources in the world has installed only 5 gigawatts (GW) of solar PV, less than 1% of the global total. However, Africa's vast renewables resources and falling technology costs drive double-digit growth in deployment of utility-scale and distributed solar photovoltaics (PV), and other renewables, across the continent.

In the case of electricity, this would require tripling the average number of people gaining access every year from around 20 million today to over 60 million people. Grid extension and densification is the least cost option for nearly 45% of the population gaining access by 2030, mini-grids for 30% and stand-alone systems for around a quarter. LPG is used by more than half of those gaining access to clean cooking in urban areas across sub-Saharan Africa, while improved cookstoves are the preferred solution in rural areas. Electrification, biogas, ethanol and other solutions also play important roles. (International Finance Corporation, World Bank, 2020)

- **South Africa Market**

According to IEA (International Energy Agency) in Africa Case, from 2017 to 2040, the energy use in residential and transportation will grow the faster at 4.0%-4/1%, compared to 1.1% in Productive use. Productive use will remain the largest portion in energy use, but it will drop from 78% to 62% gradually.

However, there is a risk that the predicted number may not materialize due to a number of factors. These include, among others, lower economic growth; improved energy efficiency by large consumers to cushion against rising tariffs; the closing down or relocation to other countries of some of the energy intensive industry.

Figure 1.4.2 Electricity final energy consumption in South Africa by scenario, 2018-2040

Sector	2017 (GWh)	2040 AC (GWh)	Annual Growth Rate
Productive use	154,679	179,102	1.1%
Industry	116,765		
Agriculture	5,687		
Commercial and public service	28,086		
Residential	38,646	98,855	4.1%
Transportation	3,756	11,630	4.0%
Total:	197,082	289,587	

Source: Electricity final energy consumption in South Africa by scenario,2018-2040, IEA

1.5 Market Breakdown by Industry

South Africa Market

- **Type 1: Residential**

South Africa has the highest grid access rate (86%; Rural 66%, Urban 93%) in Africa. (SOUTH AFRICA POWER AFRICA FACT SHEET, 2020) However, South African are subject to frequent outages due to insufficient generation capacities and/or poor transmission and distribution infrastructure. The demand for off-grid comes from both off-grid users and users with unstable grid.

Demand from off-grid users

In South Africa, there are 3-million households without access to grid-based electricity. With each household spending an average of US$200 per year on power in Africa, this represent a commercial opportunity of US$600 million per year. (KLEOS ADVISORY LTD , 2020)

According to the Minister of Mineral Resources and Energy, faced with an old generation infrastructure and load shedding crisis, South Africa must invest in new generation capacity. Electrification through grid connections has been effective in providing lighting and small power, but it is inappropriate for providing thermal energy for cooking and space heating. A significant thermal energy load still needs to be provided for, by providing solutions side by side with off-grid technologies, particularly in those areas that are too remote to build grid-based infrastructure. mCHP would be a great option to satisfy the need in the off-grid community.

Demand from users with unstable grid

By 2019, there are 6 million residential users with unstable grid in South Africa. Each of residential user spent average $1,944 per year on electricity.

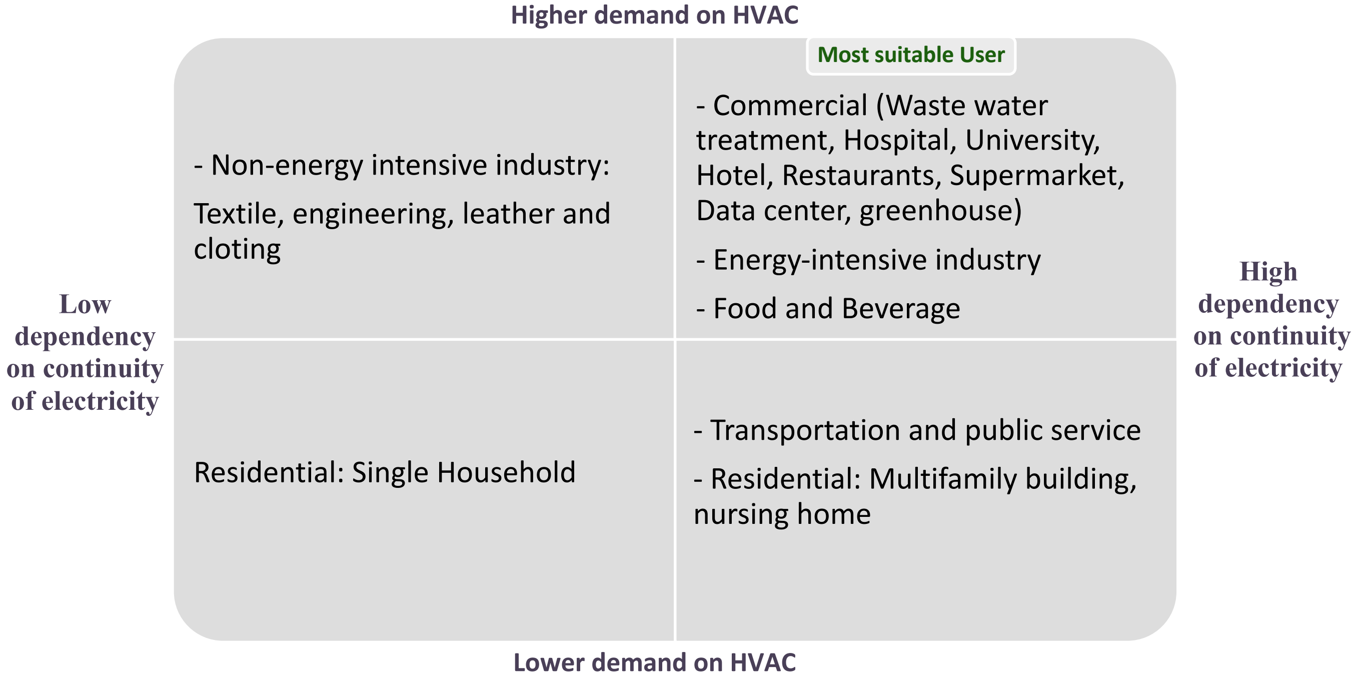
The average annual outage hour in South Africa is 50 and the average outage duration is 4.5 hours. In 2018, at the height of the load shedding crisis, South Africans had their power interrupted 12 times in a four-day period for two hours at a time affecting commercial, industrial, and residential entities. To manage blackouts, many South African businesses and individuals have backup diesel generators. However, due to Cyclone Idai's disruption to diesel imports, the cost of using diesel generation rose as a result of the fuel shortage and higher demand. Even without disruptions, diesel generators are rarely an efficient solution to supply electricity: in many African countries where backup generators are used to supplement or support unreliable electricity grids, the cost of electricity can be up to three times higher than it would be if the grid were reliable due to individual fuel and maintenance costs for the generator. Every year, South Africans spend US$160 millions on backup electricity. (DeVynne Farquharson, 2018)

Demand from others, such as nursing home or multifamily building Multifamily buildings have high needs for hot water and space conditioning (location dependent). In US, most CHP systems at multifamily buildings are smaller (~100kW), compared to their other commercial and industrial counterparts. They are typically fuelled by natural gas and use reciprocating engines or microturbines as the prime mover. (Anne Hampson, 2016)

- **Type 2: Productive use**

Productive use is defined as any agricultural, commercial, or industrial activity. Based on the research below, four groups of users are categorized based on their demand on Heating, ventilation, and air conditioning (HVAC) and dependency on continuity of electricity.

Figure 1.5.1: Relative Ranking of suitable users



- **Industrial**

Many warehouses operate 24/7 and consume electricity for lighting, electric forklifts, administration, kitchen appliances with hot water for showers and kitchen.

There is a large difference among how the power sector and the industry sector meet their demand. Whereas in the power sector energy production has to meet the demand, (a small portion of the electricity can be stored and returned to the system to flatten the load profile), the production processes of energy-intensive industries do not follow cyclical short-term behavior of the demand. Therefore, in general terms, the industry tends to operate at full capacity to ensure maximum returns for their intensive capital investments (i.e. normal ranges of utilisation are between 80% and 90% for the chlor-alkali process, 80% for mechanical wood pulp production, around 95-98% for the aluminium electrolysis, 75% for the electric arc furnaces and around 80 % for the cement mills (Moritz and Borggret, 2011). In some cases, it can be feasible certain shifting or rescheduling of the load aiming at relieving the peak of the demand of electricity, but always without affecting the production. This shifting of the load aims at obtaining some discount in the electricity bill (Bassols et al, 2002). Therefore, it can be said that, in general, all energy intensive industries operate at the same rate (with the same load factor) without any seasonality, whereas in non-energy-intensive industries their heat demand is more dependent on production and working hours of employees, i.e.on social components. (European Commission Joint Research Centre, 2012)

The most usual division of the sector is among energy-intensive industries and non-energy-intensive industries. The industries included in the first group are i) Iron and Steel industry, ii) non-ferrous metal industry, iii) chemical industry, iv) non-metallic mineral products industry and v) pulp and paper industry. The rest of industries (food, drink and tobacco, textile, leather and clothing, ore extraction, engineering and other metal industry) are included in the group of the non-energy-intensive industries. This is the common approach followed by the European Commission in its trends up to 2030 (European Commission, 2007a) and by the International Energy Agency (IEA, 2007; IEA, 2009a, IEA, 2009b, IEA 2010).

In order to describe the quality of the heat demanded by the industry, it is followed the approach defined in (Ecoheat & Power, 2006) considering three temperature intervals in the industrial sector. The lower range, temperatures lower than 100°C, corresponds to processes as washing, rinsing, food preparation and it also may correspond to the energy needed for space heating of the industrial facilities and hot water preparation. corresponds to processes of drying or evaporation. This energy is normally produced by steam. The higher range, temperatures over 400°C, the energy is used for the transformation processes that take place in the industry; reduction of the ore, calcination, electric induction, etc.

- **Commercial**

Unlike industrial facilities, which have consistent thermal and electric demands, commercial buildings typically exhibit seasonality in on-site power and thermal needs. Thermal needs in the commercial sector include space heat, space cooling, and water heating. Examples of commercial buildings most suitable for CHP include those with year-round thermal needs such as waste water treatment facilities, hospitals, colleges and universities, and military campuses.

Some commercial buildings, such as hospitals, military campuses, data centres, supermarkets, office buildings, and multifamily buildings, have high and stable demands for cooling. These buildings can be served using a CHP system with an absorption chiller that uses the heat from the CHP system to generate chilled water. (Anne Hampson, 2016)

Hospital: (CHP works as standby source) Electricity demand in South African hospitals ranges from 5000 kVA for a large institution to 50 kVA (from 2500kw to 25kw, assuming power factor equals to 0.5) for a small clinic type hospital. Hospitals require a highly reliable supply of electricity, and most are equipped with diesel/alternator standby plant, to run essential services in the case of grid failure. (Rycroft, 2019)

CHP systems can be designed to maintain critical life-support systems, operate independently of the grid during emergencies, and be capable of black start (the ability to come online without relying on external energy sources). Hospitals regularly experience failures with backup power systems during grid outages, and CHP systems can offer a more seamless, reliable power alternative than traditional emergency generators, because they are already up and running.

Waste Water Treatment: Waste water treatment plants that have anaerobic digesters and operate 24 hours a day are prime candidates for

CHP. In US, Most CHP systems at waste water treatment plants are between 100kW – 10MW. The majority are fueled by biomass or natural gas, and use combustion turbines or reciprocating engines as prime movers.

Colleges/Universities: Similar to hospitals, colleges and universities have coincident power and thermal loads that are often optimal for CHP systems. The typical college or university campus has a high thermal load for conditioning dormitories, classrooms and research labs. These systems are often served by central utility plants with chilled water and steam or hot water distribution systems. In US, the average college or university CHP system is about 10MW.

Data Centres: Data centres require high quality, reliable power and have large thermal loads for space cooling. In US, CHP systems at data centres range in size from a few hundred kilowatts up to 10MW. (Anne Hampson, 2016)

Figure 1.5.2: Industrial, Commercial, and Residential CHP potential in South Africa

Category	Business Type	# of sites in South Africa	% in 50-500kw scale*
Industrial	Food	1,800 (Ntloedibe, 2019)	68%
	Textiles	20+ (Research and Markets, 2018)	56%
Commercial	Farms	40,122	/
	Bakery	5,000+ (South African Chamber of Baking, 2005)	/
	Hotels	5,779	87%
	Hospital & Clinics	5,083	46 %
	Waste Water Plant	824	93 %
	University Campus	250	54 %
	Retail Store	937 (Veneto Promozione S.c.p.A, 2013)	94%
	Restaurants	/	99%
	Data Centre	52 (Cloud Scene, n.d.)	83%
Residential	Multi-family building	1,356,700+ (SA Residential Building Statistics , 2019)	68%
	Nursing homes	1,150 (Roxanne Jacobs, 2020)	97%

*The percentage is based on CHP applications in US (US Department of Energy, 2016)