Decentralised Energy Systems for Zimbabwean Cities: Dilemmas in Going Back to Where We Came From

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Abstract

With reference to mixed methodologies involving document review, interviews and case studies, this article discusses decentralised energy systems as an option for Zimbabwean cities, which currently depend on a centralised and national grid system. It would seem that the problems of power-cuts and load-shedding then began. For Harare, Bulawayo and Epworth, hereby used as case studies, it is noted that the different urban centres have varying challenges that include sustainable funding for the technologies like storage batteries. In terms of governance, centre-local politics and corruption tend to stifle initiatives around such innovations such that a mere technical issue then becomes a cobweb of messy political and power dilemmas. The country is enmeshed in a serious debt as it continuously faces challenges to clear such debt with neighbouring countries. Such a gap would easily be managed by decentralised electricity production systems by allowing industry and commerce to run smoothly in the country. It is suggested that a combination of macro-grid and micro-grid (decentralised) systems be fully embraced by Zimbabwean towns and cities, if sustainable electricity production and supply are to be achieved in the country.

Keywords: *electricity, grid, governance, nexus, environment, sustainability and policy*

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INTRODUCTION

in the late 1990s and early 2000s, the Government of Zimbabwe embarked on an ambitious rural electrification programme. Prior to the country's independence in 1980 and up to 1993, when the Zimbabwe Electricity Supply Authority (ZESA), the national power utility, was promulgated, decentralised power systems existed in various urban areas. Currently, both urban and rural centres have become 'enclaves of darkness' and 'dungeons of energy crisis'. This energy crisis in the country is a watershed for an about-turn towards the earlier energy arrangement of decentralised energy systems where urban local authorities can revert to production and transmission of electricity within their precincts, this time, guided by cleaner energy production and management systems. Decentralised systems for electricity have the advantage of integrating the limited resources towards achieving the food-energy-climate-water nexus. They tend to promote the utilisation of locally available resources like the plentiful sunshine in most African countries. Energy is the lifeblood of a modern society and without the reliable supply of energy, all other sectors of the economy come to a halt.

Access to reliable and affordable energy is one of the significant drivers of socio-economic development of a country today. For decades, Zimbabwe's electricity sector, just like most across the world, has operated on a model of large-scale centralised thermal-based generators, hydroelectric power stations, co-located with the major sources of fuel to distribute the energy supplies to consumers through high voltage (HV) transmission lines. Over the years, the Centralised Energy System (CES) has been vulnerable to disturbances within the network as a result of erratic fossil fuel prices and increasing concerns about climate change. A paradigm shift from a CES comprising of large-scale generation and transmitted over HV network to a Decentralised Energy System (DES), which enables local clean energy generation and storage, is needed (Farrell, 2011). Zimbabwe is facing a critical energy crisis with its CES failing to provide reliable, sustainable and affordable energy. This study identifies a paradigm shift in the drivers for energy, which enables a new path to be taken towards a DES that will provide a more secure and sustainable energy future.

THEORETICAL FRAMEWORK

Decentralised energy (DE) refers to power generation and energy storage systems located at or near the point of use (Mzezewa, 2009). This decentralised energy may also be connected to a local distribution network system or to a high voltage transmission system either directly or through a local distribution network system. DE, in other words refers to stand-alone systems completely isolated from public networks. A decentralised electricity system moves away from the traditional utility model whereby large generation plants produce electricity that flows in one direction through the main national transmission grid and local networks to the consumer. Due to technological breakthroughs, DES have the potential to both deliver lower bills for households and businesses over the medium-term and reduce the costs of grid reinforcement. Demand-side management (DSM) and demand side response programmes are a key enabler of DES. They allow consumers to shift load and redistribute part of their demand to coincide with onsite generation and also avoid periods of peak demand and prices. Instead of being confined to the dichotomy of top-down and bottom-up frameworks, the dynamics of decentralised energy shows its vitality to penetrate the borders of stakeholders and create possibilities in cross-sector/cross-border collaboration and ability to stimulate the flexibility of law and, therefore, it interplays with top-down forces spirally and dialectically (Britton, 2019).

Prosumers are defined as end energy consumers who install decentralised energy and storage on site, i.e. at the point of final demand. The transition from a CES to a DES in Zimbabwe can be viewed through MLP theory as it chooses a holistic approach to identify the different elements involved in the change of pathways through the interplay between processes at different levels (Gui and MacGill, 2017: 4-5). The MLP theory views transitions as non-linear processes that result from the interplay of developments at three analytical levels: niches (the locus for radical innovations), socio-technical regimes (the locus of established practices and associated rules that stabilise existing systems) and an exogenous socio-technical landscape (Rip and Kemp, 1998). Geels (2010) indicates three different levels that influence the development and transition towards a DES: landscape, socio-technical regime and niches levels.

The landscape level is the wider context of the system and provides the environment that consists of exogenous factors, such as the impact of climate change in the context of energy, that influence the interplay between socio-technical regime and niches level (Allen, 2014: 149; Quezada and Grozev, 2013: 10). Addressing the 'energy trilemma' is considered a landscape factor, which must facilitate regulation and policy, along with engaging actors at the socio-technical regime and niche levels to ensure the transition towards a DES.

The socio-technical regime for an energy system represents rules and incentives, supported by stakeholders (Allen, 2014: 157). A stakeholder can be considered an actor who possesses the power of action. Within the energy system, this can range from governments and actors across the energy supply chain, including prosumers. The rules and incentives are shared beliefs, capabilities, institutional arrangements and regulations, which relate in the energy system (Geels, 2004). The socio-technical regime could be considered, according to Allen (2014: 146-157), as the governance of the energy system in that it consists of the collective decision-making of the stakeholders along with the rules and incentives which enable to achieve the desired outcome of the 'energy trilemma', landscape factor. The rules and incentives, moulded by the stakeholders to now address the 'energy trilemma', will play a crucial role in the switch from a centralised to a decentralised socio-technical regime.

The niche level is defined by Geels (2002) as small-scale socio-technical innovations consisting of emerging technologies and supporting a coalition of actors. In the Australian DES context, this niche level consists of innovations in emerging technologies, such as solar photovoltaics (PV), wind, storage, electric vehicles (EVs) and smart meters that can emerge as a bottom-up approach in providing alternative solutions with the landscape factor of the 'energy trilemma' and exert pressure to break elements of the rules and incentives that enabled the interests of incumbent actors in the lock-in of a CES. Further support of a transition towards a DES can be found with the niche actors working outside the socio-technical regime looking to "break-through and provide a seed for systematic change" (Allen, 2014: 151).

LITERATURE REVIEW

This section pays specific attention to the experiences of DES in both developed and developing countries. The main emphasis is on analysing how various countries have used different ways in dealing with energy and how these countries are generating useful economic benefits.

During and following the Second World War (1939-1945), the 'nationalised period of utility control' led to rapid expansion of utility networks, which became intimately connected, with the drive to improve national economic performance and quality of life (Rydin *et al.*, 2013). In the search for greater economies of scale, the electricity industry built larger power stations and upgraded the national electricity transmission network and the basic assumption was that economic growth would generate new demands for utility services. However, network providers became locked into a centralised logic of network management that focused on improving the quantity and quality of the supply of networked services (*ibid.*). Large generation plants were connected to the high-voltage transmission grid, which transported the electricity over long distances, explaining why the transmission grid is, sometimes, referred to as the 'backbone' of the electricity system (Lammers and Diestelmeier, 2016).

The main task of the transmission system operator (TSO) was to balance supply and demand, by dispatching electricity (near) real-time, based on increases in demand. However, the size, complexity, pattern and control structure of centralised, large-scale energy supply make it inherently vulnerable to large-scale failures (Bouffard and Kirschen, 2008). Several studies were conducted to emphasise the main shortfalls of the centralised generation paradigm and to elicit the motivation of the agents in keeping distributed generation as a primary source of electricity (El-Khattam and Salama, 2004; Perpermans *et al.*, 2005). As a result, a range of policy measures has been put in place to encourage the uptake of such decentralised energy (Rydin, 2010). The rationale lies in claims that DES can be more resilient and offer greater levels of energy security (Coaffee, 2008) and being more efficient, reliable and environmentally friendly (Alanne and Saari, 2006).

Energy systems in Britain and elsewhere around the world are undergoing fundamental and rapid change towards more decentralised systems, due to a range of drivers (Mitchell *et al.*, 2016). The appetite for decentralised energy solutions and business investment decisions is increasing, that is driven by government policies and subsidies, technology developments and business/consumer demand for more localised integrated energy solutions. During the last 30 years or so, there has been a slow movement towards a more decentralised approach to energy and electricity production (World Energy Council, 2016).

The system has had to adapt to a range of factors from economics to the availability of natural resources and the requirements placed on electricity by consumers (Simmonds, 2002). The privatisation of the Central Electricity Generating Board (CEGB) and the National Grid in the United Kingdom allowed smaller players to enter the market, building a series of smaller gas fired power stations closer to the markets they were to serve and creating multiple commercial operators. Instead of long-distance transmission lines connecting gigawatt-sized power stations with the consumer (losing up to 10 % of the energy, in the process), local energy and electrical networks would potentially be more flexible and able to respond to immediate needs (Britton, 2017). This has seen an emergence of a continuum of off-grid electric systems that do not require the same supporting networks as centralised power generation and overcomes the aforementioned energy isolation barriers in the UK energy system.

Recent international developments suggest that decentralised energy can be a reality in the UK as costs continue to fall around the world and deployment of increasingly advanced decentralised technologies continues. For example, the Solar PV is now at grid parity in approximately 30 countries and 14 US states, according to a Deutsche Bank study in 2015. In the US, President Obama unveiled the Clean Power Plan, a key part of his plan, that had thrust on the rapid build out of decentralised energy (Official White House, 2015). In Europe, Germany currently leads the world in cumulative solar PV installations with approximately 21% of capacity or 38GW (Fraunhofer ISE, Photovoltaics Report, 2015). The German Government is targeting 40% of power generation to be from renewables by 2020, with continued significant growth in decentralised energy.

Development of renewable energy based off-grid energy systems in India could be traced back to the year 1992 when a separate Ministry (originally called the Ministry of Non-conventional Energy Sources (MNES) and re-designated as the Ministry of New and Renewable Energy (MNRE) in 2006, was created at the federal level to deal with the development and promotion of non-conventional sources of energy in the country (Sarangi and Mishra, 2012). Despite several noble attempts that were made at the policy level to mainstream renewable energy based off-grid energy sector in India, the problem of energy access continued to persist for a long period of time. It is contended that the development of renewable energy based off-grid sector in India has been largely limited to techno-economic dimension of project development without paying adequate attention to other critical determinants, such as socio-political, governance, regulatory and institutional, environmental and cultural aspects (Chaurey *et al*., 2004; Balachandra, 2011; Mishra and Sarangi; 2011).

Energy resource provisions in the sub-region of Africa normally centre on stand-alone systems for remote locations, through government rural electrification (Situmbeko, 2017). Unlike her African counterparts, who have low grid integration of distributed generation, South Africa is moving towards promoting private energy generation mainly from renewable energy resources. The National Energy Regulator of South Africa (NERSA) is currently running a Feed-in-Tariff (FIT) programme based on the cost of generation plus a "reasonable profit". From that particular programme, private companies and communities have been inspired to invest in energy generation projects, such as wind farms, concentrated solar power and small medium hydro. The rise of interests by investors in energy generation projects gave birth to the promulgation of regulatory frameworks, which guide investment in energy. For example, the NERSA ensured that all commercially operated small-scale embedded generators were licenced or registered as stipulated by the Electricity Regulation Act of 2006.

Despite all the efforts to register operators grid integration of distributed energy resources is marred by hurdles, that have hindered the full operationalisation energy generation projects in South Africa. de Joode *et al.* (2009) note that the transformation of the current electric system that is designed around large-scale centralised electricity generation, towards a future electric system with a large role of small-scale distributed electricity generation requires an efficient integration of distributed generation from market integration and network integration. However, South Africa has scored great success with its Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), but, is still lacking on support for small-scale distributed energy resource deployment mechanisms (Climate Scope, 2015).

Apart from South Africa, Botswana is making progress with policy development though it is still far from achieving significant distributed energy resource deployment. Botswana facilitated the participation of IPPs. IPPs in electricity generation through the Energy Supply Act of 2007 (Mzezewa, 2009). Despite this facilitation role to Independent Power Producer, Botswana Power Corporation (BPC) is still centralising the responsibility for the generation, transmission and distribution of electricity in the country. The state-owned corporation is configured on the vertically integrated utility model and currently there are not specific plans to unbundle the utility functions to IPPs.

Zimbabwe's power infrastructure is starved of new investments. Investments towards expansion of power generation infrastructure in Zimbabwe have not been done since 1988, when HTPS was constructed (Pushak and Briceño-Garmendia, 2011). The power generation, transmission and distribution infrastructure have been further corroded, due to damage and theft. This has decreased the capacity of installed infrastructure to only 60% (World Bank, 2010). This vandalism produced losses of about 400,000 United States Dollars a month in 2009, of which only 40% was recovered (World Bank, 2010).

Apart from theft and vandalism which were done to the power infrastructure, the unsustainable financial situation in Zimbabwe crippled ideas and ambitions for new power investments in the country (Pushak and Briceño-Garmendia, 2011). For example, ZESA faced financial problems in purchasing raw materials, such as water and coal. Sixty-eight percent (68%) of Zimbabwe's installed capacity is thermal as of 2008 and the power utility uses 2.4 million tonnes of coal per year for thermal power generation. Over half of its coal comes from the state-owned Hwange Colliery Company, that has continuously subsidised the coal ZESA buys. Other inputs, such as water (for hydropower generation) and transportation services are also provided at below-market costs (World Bank, 2008b).

Despite the highly subsidised prices, ZESA was unable to pay Hwange for its coal supply, due to the unsustainable financial situation in Zimbabwe. ZESA's inability to pay its debts weakened the financial capacity of Hwange which used to supply coal hence, negatively affecting the latter's production capacity. This resulted in Hwange operating at only 35% capacity, leaving Zimbabwe increasingly dependent on its neighbours for coal and electricity imports to satisfy power demand. It was noted that Zimbabwe imported 20–35% of its power from South Africa, the Democratic Republic of Congo, Mozambique and Zambia (Pushak and Briceño-Garmendia, 2011). However, the supply of imported electricity is in jeopardy as ZESA's weak financial position has resulted in non-payment for power imports from neighbouring countries. in the late 2000s, power imports declined by 44%, due to ZESA's inability to make timely payments to Zambia, Mozambique and the Democratic Republic of Congo (World Bank, 2009b). ESKOM—South Africa's power utility—converted the debt into a loan for Zimbabwe (Kaseke, 2009). ZESA's inability to repay the loans required government support and by February 2009, the government-guaranteed external debt owed by ZESA was at $400 million, all of that has become due.

Given the challenges, being encountered in Zimbabwe as a result of CESs, there is dire need to change the approach towards provision of energy. The key to the energy crisis is DES. The DES involves restructuring energy governance to better integrate national and local systems and provide direction, flexibility, legitimacy and participation (Painuly, 2001). However, there are some challenges in successfully integrating distributed generation in electricity systems, including technical, commercial or regulatory in nature (Peças Lopes *et al.*, 2007). The diversity of the potential barriers is significant and varies from structural to behavioural (Shove, 1999). It is believed that the main barriers for the implementation of DE projects are financial and technical and this opinion is reflected in the policies and regulations, aimed at economic opportunities, such as financial and regulatory mechanisms and technical challenges (Michalena and Hills, 2012). Most electricity systems throughout the world have been liberalised. However, due to natural monopoly characteristics the network related part of the system has remained regulated (Joskow, 2005).

METHODOLOGY

The article engages a case study approach to some of the initiatives spawning. A case study approach was used to examine reports and journals, purposely to shed light on DES in both developed and developing countries. The goal is to expose the dynamics and intricacies of DES in Zimbabwe. The analysis discloses the challenging assumptions that undergirded expectations on moving from centralised energy system to decentralised systems for countries, such as Zimbabwe.

RESULTS

Zimbabwe's power is generated from hydroelectric power and coal. The energy supply options for Zimbabwe have a mixture of hydroelectricity, coal and renewable sources. Much of Zimbabwe's electricity is produced at the Kariba Dam Hydroelectric Power Station (about 750MW), at Hwange Thermal Power Station, that has an installed capacity of 920MW and. at three minor coal-fired stations. Tables 1 and 2 show thermal and hydroelectric power plants in Zimbabwe.

Table 1: Thermal /Coal Power Plants in Zimbabwe. (ZERA, 2014)

Plant	Capacity (MW)	Year completed
Hwange	920	1987
Munyati	100	1957
Bulawayo	90	1957
Harare	80	1955

Table 2: Hydroelectric Power Plants in Zimbabwe (ZERA, 2014)

Hydroelectric station	Community	Type	Capacity	Year completed	River
Kariba South	Kariba	Reservoir	666	1977	Zambezi river
Kariba South Bank Extension	Kariba	Reservoir	300	Under construction	Zambezi river
Tokwe Mukosi Dam	Masvingo	Reservoir	12	Under construction	Tokwe river

However, capacity is a major concern in Zimbabwe. It was noted from the study that no new developments have occurred in the country's electricity generation sector since the commissioning of the Hwange Coal Plant in 1988. The past decade has seen a significant reduction of domestic generation owing to lack of regular maintenance of electric generation equipment, while imports have been reduced, due to the failure by ZESA to settle its import bills to regional power utilities (Magala *et al.*, 2014). Table 3 is showing Zimbabwe power stations capacities from the year 2000 to 2009.

Table 3: Zimbabwe Power Stations Capacities from 2000 to 2009 (Munyoro *et al.*, 2016)

Category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Installed capacity										
Hwange	920	920	920	920	920	920	920	920	920	920
Kariba	694	722	736	750	750	750	750	750	750	750
Small thermal plants	250	250	250	250	250	250	250	250	250	250
Total	**1864**	**1892**	**1906**	**1920**	**1920**	**1920**	**1920**	**1920**	**1920**	**1920**
Dependable capacity										
Hwange	780	780	780	780	780	780	780	780	780	780
Kariba	694	722	736	750	750	750	750	750	750	750
Small thermal plants	245	245	245	245	245	245	245	245	245	245
Total	**1719**	**1747**	**1761**	**1775**	**1775**	**1775**	**1775**	**1775**	**1775**	**1775**
Available capacity										
Hwange	496	716	659	498	583	579	435	421	388	287
Kariba	511	531	588	701	723	725	711	727	747	746
Small thermal plants	133	105	101	43	110	42	26	26	34	13
Total	**1140**	**1352**	**1348**	**1242**	**1416**	**1346**	**1172**	**1174**	**1169**	**146**
As % of installed capacity	61.2	71.5	70.7	64.7	73.8	70.1	61.0	61.1	60.9	54.5
Peak demand	1986.0	2013.0	2028.0	2007.0	2069.0	2066.0	1904.0	1758.0	1429.0	1403.0
Supply deficit	**846.0**	**661.0**	**680.0**	**765.0**	**653.0**	**720.0**	**732.0**	**584.0**	**260.0**	**357.0**

The table reveals that from 2000 to 2009, the power stations have not reached their full capacity/installed capacity power generation. There has been a gulf between the installed capacity of the power stations and the available capacity. As a result, the supply of energy from the various power stations was far below the peak demand during the period 2000 to 2009, creating power shortages in the nation. The availability and access to electricity in Zimbabwe has become a major concern over the years and this has been evidenced by the erratic power supply of electricity from the national grid.

While energy production capacity of the power station has decreased in

Zimbabwe, population growth has increased drastically. Zimbabwe's population has grown by 74% from 1982 to 2012, registering an average annual growth of 3.1%, 1.1% and 1.2% between 1982 and 1992, 1992 and 2002 and 2002 and 2012, respectively (ZIMSTAT, 2013). This has strained the available power stations as demand of energy has increased creating energy supply deficit. Thus, most if not all power stations in Zimbabwe are in need for major upgrading as they currently have frequent production stops or are not producing at all. This has led to frequent and long-lasting blackouts in the country. Imports of energy from neighbouring countries are not enough to solve the under-capacity problem. As a result, power outages continue to affect the economic performance of industries and services. Small-scale power generators are used all over the country to ease this situation.

The study also revealed that the hydroelectric power stations in Zimbabwe are hit by climate change. For example, Zimbabwe's main hydropower dam, Kariba, is running out of water, due to the current drought. In the years 2015-2016, a drought triggered by the El Nino weather event hit hydro-power production at Kariba, internal electricity generation fell sharply, resulting in rolling power-cuts that left households in the dark for up to 18 hours a day. The dam is only 41% full, according to the Zambezi River Authority, which oversees the dam. According to the National Energy Policy, Zimbabwe had been targeting a combined 1 500MW of hydro power from the expansion of Kariba, new plant at the Batoka Gorge and building hydro stations within inland dams and rivers at Pungwe providing a cumulative 24MW in two phases, Tokwe-Mukosi 12MW, Gairezi 30MW and Kondo 100MW (*Herald*, March 2019). Massive blackouts prompted the use of other alternative sources of energy in Zimbabwe, such as solar and gas energy.

CASE STUDIES

In a way to develop an understanding of the trends in energy supply and demand in Zimbabwe, three cases, Harare, Bulawayo and Epworth are engaged. These cases provided information on how the expansion and development of these areas have affected the national grid.

Harare Power Station
In Harare, there is a power station that is located in the Workington Area of the city along Coventry Road. Power Station 1 was commissioned in 1942 with a capacity of 21MW but was decommissioned in 1970. Station 2 had an initial capacity of 75MW when it was commissioned in 1955, but it was de-rated to 20MW, due to uneconomical units. Currently, one of the turbo alternators is not in service as it is awaiting turbovisory equipment for it to return to service. Stations 2 and 3 operate independently but they are linked electrically through four interconnector transformers. Presently, the dependable capacity for Station 2 is 20MW while Station 3 has a dependable capacity of 30MW. With the population of Harare increasing from 1.87 million in 1997 to 2.24 million in 2014 and 2,123 132 in 2012, the supply of the power station has been outpaced. This has increased power shortfalls i.e. demand and supply mismatch, due to low water levels at Kariba Power Station, generation constraints at Hwange Thermal Power Station (HTPS) and limited imports. Thus, as new residential areas have mushroomed around Harare, there has been an increased demand of electricity from the national grid resulting in high power-cuts and load-shedding.

Bulawayo Power Station
The Municipality of Bulawayo commissioned the plant between 1947 and 1957 as an undertaking. It joined the Zimbabwe Electricity Supply Authority in 1987 after the amalgamation of all the Local Authority Electricity undertakings, the Electricity Supply Commission power station at Munyati and Hwange and the Central African Power Corporation station at Kariba. Unbundling of business units has resulted in the plant joining Zimbabwe Power Company. While Bulawayo Power Station initially had an installed capacity of 120MW, a refurbishment exercise in 1999 on the ageing plant gave it a new lease of life. The station capacity is now 90MW. The

main materials needed for the generation of electricity are coal, water, chemicals, oil, grease and spare parts for maintenance. The station currently generates an average of 30MW. As the energy supply is dwindling in Bulawayo, the city is expanding rapidly. This has created a huge deficit between the supply of energy and the demand for energy. New residential developments around the city of Bulawayo which stood at a total population of the province of 653 337 (ZIMSTAT, 2012), are straining the already deteriorating power stations, generating energy below capacity.

Epworth Settlement

Epworth farm was gazetted as Epworth Local Government Area and government appointed the Epworth Local Board responsible for administration of the settlement in 1986. In 2008, Epworth housed over 18000 informal settlers who had settled on school and hospital sites and electricity substations earmarked for development (Brown, 2001). The matchbox houses did not seem to conform to any standard and were not serviced with electricity; water and sewage systems while what were called roads were untarred and run-down strips (*Herald*, 05, April 2014). However, as Epworth was regularised, the area was recognised as an urban settlement. Like any other urban settlement in Zimbabwe, Epworth electrification was part of a US$35.8 million fund to build substations in Mufakose, Glen Norah, Greystone Park and Luna in Borrowdale (*Chronicle*, 24 April 2011). The expansion of the settlement has mounted pressure on the already deteriorating and underperforming power stations in the country. Epworth has a high proportion of households using wood for cooking, as they are reliant on the national grid.

Growth Points and Rural Towns

The Expanded Rural Electrification Programme (EREP), together with the Electricity End Use Infrastructure Development from the Rural Electrification Agency (REA), provided rural communities with electricity and, at the same time, equipping them with the necessary machinery to utilise the electricity (REA, 2011). Many cottage industries, including tailoring and welding and grocery and workshops had sprung up, due to the establishment of electrified rural service centres. This has enabled self-sustaining and repairs to be done within the major growth point, thereby speeding up the turn-around times for most activities. Apart from the growth points and rural service centres benefiting from rural electrification, schools, business centres and some villages also benefited as shown in Table 4.

Table 4: National statistics on the status of the Electrification Programme for Rural institutions as at 31 December 2014 (REA, 2014)

Province	Primary school	Secondary school	Rural health	Govt Ext office	Chiefs	Business centre	Small-scale farms	Villages	Others	Total
Manicaland	370	210	154	65	26	187	58	298	119	**1487**
Mash central	308	151	104	44	27	121	132	52	111	**1050**
Mash East	244	169	104	27	22	107	148	170	161	**1152**
Midlands	224	179	121	43	27	163	50	163	81	**1050**
Mat North	236	113	77	50	36	53	50	20	56	**1073**
Mat South	153	104	78	41	21	98	15	120	61	**674**
Masvingo	355	151	69	32	21	61	179	116	66	**777**
Total Electrified	**2136**	**1184**	**787**	**331**	**220**	**909**	**105**	**1112**	**698**	**8082**

In an effort to provide electricity to the growth points and rural areas, the programme of rural electrification was embarked on in various provinces as shown in Table 4. Most institutions across the provinces, including schools, rural health centres, chiefs' homesteads, villages and business centres, benefitted from the programme. Though Zimbabwe has intensified its embankment on rural electrification programme, aimed at providing electricity to highly dispersed and low productive rural areas, this has strained the already overloaded electricity grid.

DISCUSSION

The article has deliberated on the benefits and challenges that face the full-scale integration of distributed energy resources in the current conventional centralised energy systems. Delivering a decentralised energy future is predicated on addressing a number of challenges – from the physical nature of the changing system, to the behavioural engagement with citizens that is required to support them in the transition from a known system to an unknown, yet to be realised system. There is need to bring together debates on energy system change and local governance change to explore how roles, relationships and institutions can change to support a decarbonised, DES. Studying energy demand is inherently inter-disciplinary, calling for an understanding of changing technologies, the institutional and policy frameworks within which technical and social decisions are made and the interactions between these. The liberalisation of electricity systems has been regarded as the most important requirement to achieving decentralised energy.

It is also assumed that the more the electricity system liberalises, the higher participation of citizens can be. However, this assumption simplifies the different levels of liberalisation of electricity systems, which can be classified into energy production, conversion, transmission, distribution, storage systems and electricity markets. A prerequisite to decentralised energy is the government's empowerment of enterprises and the public's right to produce energy. Electricity is produced by the cogeneration of the public, instead of by one single provider, such as a company or government. This refers to one-way empowerment from the government and from the bottom-up, such as individuals, communities, local-based enterprises and other related organisations struggling for autonomous energy as shown in Figure 1.

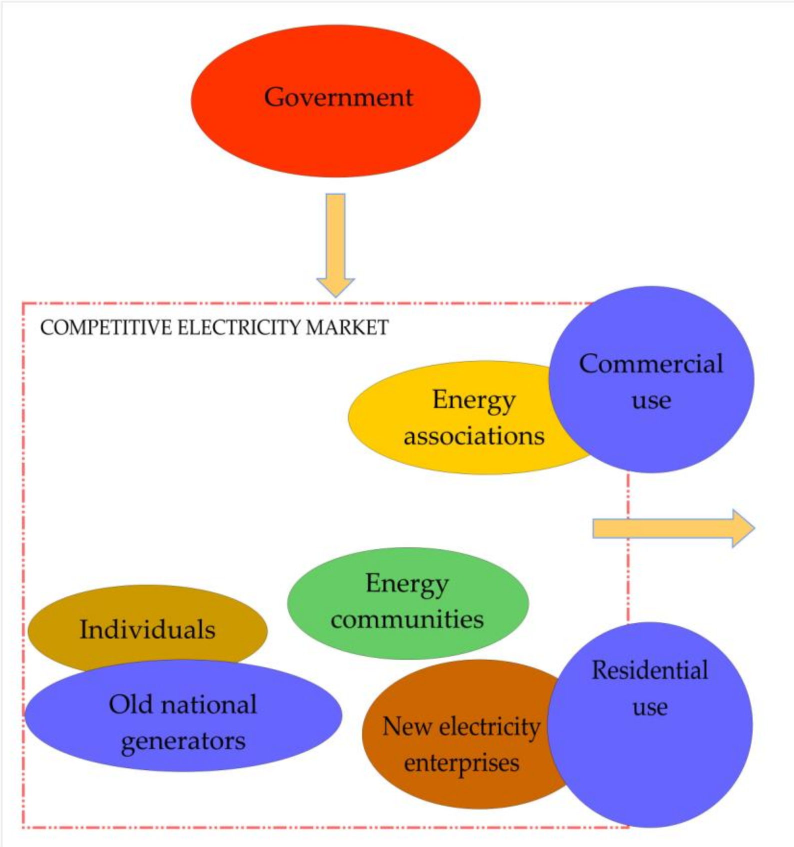

Figure. 1: Empowerment of electricity and the forming of liberalisation of electricity market (Lammers and Arentsen, 2016)

CONCLUSION

From the study, it was noted that the energy supply is way below the energy demand in Zimbabwe. Expansion of residential, commercial, institutional and industrial uses have strained the national electricity grid, that is already deteriorating. This has led to high power-cuts and load-shedding in the country. Zimbabwe is enmeshed in a serious debt with neighbouring countries, particularly, South Africa and Mozambique. Poor governance, centre-local politics and corruption tend to stifle initiatives around refurbishment of deteriorating power stations to meet the energy demands of the country and it has become a cobweb of messy power dilemmas. However, such a gap would easily be managed by decentralised electricity production systems, allowing industry and commerce to run smoothly in the country. It is suggested that a combination of macro-grid and micro-grid (decentralised) systems be fully embraced by Zimbabwean towns and cities, if sustainable electricity production and supply are to be achieved in the country.

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