Integrating Energy into Real Estate and Spatial Planning in Urban Zimbabwe

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Abstract

The article attempts to map and discuss innovative ways of integrating energy in real estate and spatial planning in Zimbabwe. This attempt is very essential for development planning in the country. 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. For decades, Zimbabwe's spatial planning, like most countries across Africa, has not effectively integrated energy production into the development process. The article engaged with extensive literature and document review in assessing the relationship between energy and planning in Harare. It emerged from the study that there continues to be a myriad of untapped opportunities through integrating energy into spatial planning and real estate. The realisation of the opportunities is impeded by the absence of policies and frameworks integrating energy issues into spatial planning and real estate. It is recommended that energy mapping tools, integrative energy planning and spatio-temporal modelling be used as innovative ways to enhance the integration of energy into spatial planning and real estate.

Keywords: *energy planning, renewable energy, mapping, policy, energy demand, land-use*

INTRODUCTION

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. For decades, Zimbabwe's spatial planning, like most countries across Africa, has not

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effectively integrated energy production into the development process. The ongoing tendency to separate energy issues from spatial planning has created more real estate developments that are pressuring the already underperforming power infrastructure. Spatial planning in Zimbabwe is still practised as a separate system from energy provision. This lack of integration has affected the capacity to develop zero-carbon, or low-carbon cities, due to the complexity of managing the two-way relationships. In this context, the article attempts to map innovative ways of integrating energy in spatial planning in Zimbabwe. This attempt is very essential in mapping out development planning in Zimbabwe. It must be underscored that spatial planning is about the organisation of real estate in space.

Energy issues and spatial planning are generally, interwoven. One of the vexing features of the link between energy and spatial planning is that they not only cut across two of the most basic scientific concepts, space and energy, but put very different actors with various backgrounds in the same boat (Gernot *et al.*, 2016). This increased complexity of the spatial planning process when energy issues are involved, also requires a new quality for any tool used in this endeavour. The spatial organisation of general real estate development is crucial for energy demand in general, especially, since an increase in real estate has an impact on energy systems (Schubert 2014). However, there is a challenge of balancing the increase in demand and supply for real estate against the adequacy of energy infrastructures in urban areas. This article seeks to provide an insight on integrating energy as innovative thinking in spatial planning in Zimbabwe, using Harare as a case study.

The outcome of the study has the potential to determine various approaches to which the environment can be protected and integrated into spatial planning in Zimbabwe. The Agenda 21 was an agreement between global countries to ensure that all development that was being carried out was sustainable (Guerra *et al.*, 2019). Zimbabwe has been facing energy shortages (Chiteka and Enweremadu, 2016; Chipango, 2018). As such, there is need to ensure that energy management is done in a smart way so that energy demand is easily mapped and met. This study helps in the mapping of potential ways in which energy management can be done, from simple mapping of potential demand to the mapping out of energy needs. The Government of Zimbabwe recently embarked on what it calls Vision 2030, which aims to make Zimbabwe a middle-income economy by the year 2030 (Nengomasha and Chikomba, 2018). Issues of energy are part of the great transformation envisaged by the Government.

CONCEPTUAL FRAMEWORK

The article is informed by three critical concepts that link up together: innovative thinking, systems thinking and spatial planning. Innovative thinking is the process of translating into good/service that creates value (Markman, 2019). It involves deliberate application of initiatives in deriving greater or different values from resources. In this article, innovative thinking is applied on how sustainability and energy can be integrated within spatial planning concerns. Systems thinking is a perspective of seeing and understanding systems, as a whole, rather than as collections of parts (Senge, 1996). This thinking moves the focus away from events and patterns of behaviour (that are symptoms of problems) towards systemic structure and the underlying mental models. In this article, systems thinking seeks to provide an understanding the connections among elements of spatial planning, real estate development and energy. An innovation matrix that identifies how an innovative idea can be integrated into the new systems informs the study. This places four innovation ways into a matrix that include radical and incremental innovation and disruptive and sustaining innovation (Caswell, 2006). It highlights that innovation can be one that completely changes and disrupts the prevailing market systems, while sustaining innovation improves existing systems (Stringer, 2000).

Radical innovation is a sudden change that is totally different from the existing systems, while the incremental slowly adds changes (O'Sullivan, 2008). In the context of this article, following one or two of these kinds of innovations can improve the existing systems of energy and environmental management. Spatial planning refers to the methods used by the public sector to influence the distribution of people and activities in spaces of various scales to improve the built, economic and social environments of communities (Gorzym-Wilkowski, 2017). It takes place at different levels, including regional, master, local, layout, site and building planning. It is critical to take into consideration how energy thinking is considered at different spatial levels in Zimbabwe.

This has an influence on how cities should be designed up to building planning in a way to integrate energy.

LITERATURE REVIEW

The attention to the urban and territorial aspects of energy emerged at the international level close to the first energy crisis in the early 1970s and it considered, from the beginning, the integration of energy variables in urban planning as a crucial theme (Ratti *et al.*, 2005). Between the 1920s and the 1940s, a few urban plans had considered the relationship between land-use and energy consumption with the aim of reducing direct energy costs to achieve an economic growth (an example is the Tennessee Valley Authority [TVA] project and other consumption reduction plans in the USA). In Europe, spatial planners have been creating modules to try and improve the planning professionals in the context of energy planning (Jay, 2010). This effort can be seen in the legally binding plans that are developed by spatial planners in trying to respond to the needs of spatial planning (Meiner, 2010). Planners working at national levels within Europe in countries, such as Ireland, have begun working on how best to deal with the environment and energy in their spatial plans. These spatial planners have been playing a significant role in facilitating and mapping the spatial interpretation of energy and planning information for development (Nijkamp and Perrels, 2018). These interactions in energy and spatial planning have gone a long way in planning for energy and development.

Energy planning is a cross-sectorial task that involves many activities and a variety of different professional capabilities. It is important in determining the 'optimal mix' of energy sources to satisfy a given energy demand. The major difficulty of this issue lies in its multi-scale aspect (temporal and geographical) and in the necessity to take into account the quantitative (economic, technical) and the qualitative (environmental impact, social criterion) criteria (Thery and Zarate, 2009). Developing an integrated energy plan within spatial development and real estate is an effective and important first step to ensure that decisions on energy demand and supply infrastructures involve all stakeholders, consider all possible energy supply and demand options and are consistent with overall goals for national sustainable development.

The spatial organisation of cities is crucial for energy demand in general (e.g. transportation and locations for energy production) since urban density determine the most suitable type of energy supply (UNDP, 2009). Dense cities allow more options for reducing energy demand and resource consumption by providing a higher quality of life (World Bank, 2010). Energy production and its implications for landscape and space patterns has been a topic of scientific work, especially, with regard to spatial distribution of energy production and use and material flows (Jenssen, 2010). The energy system has a strong spatial (and, especially, urban) dimension in which not just technical, but also social processes are reflected. Urban energy landscapes display spatial patterns of urban energy systems, that are visible in the built environment. Landscape is the territorial expression of socio-ecological relations, in this case, how urban dwellers manage and use energy and how uses relate to resource and ecosystem exploitation (Castán Broto *et al.*, 2014). Urban energy landscapes are experienced as a continuous arrangement of artefacts that mediate the transformation of energy resources to provide different, but simultaneous, services.

The structure, form and design of urban areas have a significant influence on both energy demand, per person and the way that energy is used (Smith *et al.*, 2017). Planning has a fundamental role to play in creating and supporting spatially appropriate energy solutions based on an understanding of settlement areas, land-uses and the built environment. The main reasons for exponential growth of the real estate business are related mostly to land market issues, such as vacant land scarcity, higher land value, land speculation and remittance inflow for land purchases (Hasan *et al.*, 2013). However, the transformation of real estate development quality in the existing planned settlement schemes has deteriorated, due to huge violations of predefined land-use, illegal plot subdivisions and increased building heights. The changes and violations in terms of building use, land-use and population density have also had serious impact on utility service facilities (e.g. electricity, water) and transportation in both inter-neighbourhood and other surroundings. Recent research shows that suitable urban forms can positively affect energy demand and production, for example, by controlling urban sprawl, improving solar exposure of buildings or promoting mixed-use districts (Ratti *et al.*, 2005).

A holistic or integrated approach comprehending energy efficiency/saving and urban planning is a prerequisite for effective integration of energy within spatial planning (*ibid.*). Integrating the transformation of the energy system into spatial planning and policy does not only require a consideration for the spatial configuration and prerequisites, but also of the governance dimensions of various sustainable energy solutions. Interventions that mobilise the restructuring capacity of energy infrastructure can be developed only at a collective scale and, therefore, need to go beyond the individualism in spatial planning and development. The resulting systemic-critical framework of the relationship between energy and physical-functional organisation has outlined the relevance of including energy-related planning and strategies in the spatial planning (Pascali and Bagaini, 2018).

Urban master plans and policies should, instead, internalise and foster the energy transition to a low-carbon urban system, making the energy issue relevant to daily life. On-holistic sector-oriented policies and administrative practices might lead to wrong steering from an overall perspective (Stoeglehner *et al.*, 2016). Multi-sectorial systems face strategic challenges of optimal development owing to the complexity of interacting perspectives, interests, preferences of decision-makers and stakeholders (non-alignment of sectors). Thus, improving the collaboration and coordination between various departments in the local administration is essential for integrating energy-related strategies into each process, policy and action carried out by the local authority.

Cities account for about two thirds of global primary energy consumption, which offers significant potential to optimise renewable energy production and enhance energy efficiency in urban planning. Many developed countries integrate energy in urban development policies, at least in principle. The European Commission, for example, recognises the importance of integrated planning within the broader agenda of sustainable urban development (COM, 2004). Several models and frameworks have been proposed to integrate energy optimisation into urban planning. Centric Austria International (CIA) introduced a methodological framework called Energy Integrated Urban Planning (EIUP) with the intention of helping cities address local-level energy problems on short and long-term strategies and action plans (Todoc, 2008).

This methodology is a very broad vision of urban planning, rather than an early design of urban residential settlement planning projects.

Studies done by Jones, Pejchar and Kiesecker in 2015 sought to assess the energy-land nexus in terms of a quantified energy footprint. It discussed how energy sprawl and land-use intensity production influences land-use change in the United States. While hydrocarbons continue to impact land resources, some trends indicate that a 'post-carbon' energy transition, dependent upon spatially extensive production facilities, infrastructures and consumer networks, radically transformed land resources (Huber and McCarthy, 2017). Georgiadou and Hacking (2011) investigated sustainable building and low-energy housing at a neighbourhood or city district scale. The article examines how future thinking on energy performance can be integrated into the selection of building components, materials and low or zero-carbon technologies. The study also noted that the use of renewable energy technologies, low embodied energy components and new methods of construction relate to a demonstration project or any specific regulatory requirements.

De Pascali and Bagaini (2018) have analysed the evolution of spatial and energy planning integration, seen as a way to foster local development, from the birth of the theme to the current prospects of shared sustainability and Decentralised Energy System (DES) solutions. The article explains that there is lack of integration between energy and city physical-functional organisation and planning. In the context of energy spatial planning and development, there still exists a gap in most African countries including Zimbabwe, in the context of trying to merge the operations. Countries in Africa have energy bodies that produce and allocate energy based on the supply they have, rather than informed designs (Korkovelos *et al.*, 2018). This implies that energy is provided on areas that are accessible only after the design and construction of properties (Euston-Brown and Borchers, 2018).

Various countries in Africa have applied different approaches in trying to deal with energy. Countries, such as South Africa, Kenya, Ghana, Egypt and Nigeria, have advanced efforts and mechanisms in energy planning. Since the 1980s, the Egyptian government has devoted efforts to identify and implement several electricity grid interconnection projects in cooperation with other Arabian countries (IRENA, 2018). This enhanced the reliability and exchange of generated electricity at a sub-regional level. Again, Egypt continues to work with the European Union to evaluate feasible options to facilitate future exchange of electrical power across the Mediterranean, through possible interconnections with Tunisia, Italy, Cyprus and Greece. These prospective interconnections would serve to transfer electricity generated from renewable sources to Europe (EEHC, 2016b). Egypt has already achieved remarkable progress in developing an enabling policy regulatory and institutional framework for the deployment of renewable energy and gaining experience in the implementation of a wide range of renewable projects, particularly for solar and wind electricity generation.

In response to electrical shortage, Kenya has developed an Open Source Spatial Electrification Toolkit (OnSSET) which provides the optimal electrification mix for household electrification (grid vs. off-grid technologies) (Mentis *et al.*, 2015). OnSSET uses a GIS-based approach to estimate, analyse and visualise the most cost-effective electrification option for residential demand. Kenya has also devolved responsibility for energy planning to county level, offering an opportunity for the government to better understand and respond to the needs of the people. The local governments play a central role in the energy picture of their cities as they are usually responsible for the distribution of electricity and for billing and may be responsible for some generation capacity (UN-HABITAT, 2018).

It is also noted that African countries like Ghana have energy planning frameworks that govern the provision of energy. Ghana is one of the first United Nations (UN) member countries that embraced the former's Sustainable Energy for All (SE4ALL) initiative and it conducted rapid assessment and gap analysis of its energy sector as the first step to participate in the initiative (UNDP, 2015). The country subsequently developed its SE4ALL Country Action Plan, based on the three objectives of the SE4ALL initiative of doubling the rate of improvements in energy efficiency. Ghana made remarkable progress at expanding access to electricity to its population, with over a 70% nationwide electrification rate, but rural areas still lag behind with only 40% of the rural population enjoying access to electricity. In 2006, the government of Ghana formulated a Strategic National Energy Plan to ensure a secured and adequate energy supply for sustainable economic growth (Government of Ghana, 2015). Apart from the Strategic National Energy Plan, the Energy Ministry launched the National Energy Policy in 2010 to quickly increase installed power generation capacity, from about 2,000 to 5,000 megawatts and increase electricity access from the current level of 66% to universal access by 2020.

South Africa also implements a central energy planning paradigm with the strategic energy planning framework being defined by an overarching Integrated Energy Plan (IEP) that informs resulting plans, roadmaps and policy (National Planning Commission, 2018). In South Africa, the Integrated Resource Plan (IRP) is very critical as it directly informs policy direction and resulting investments in the electricity sector. Unlike other 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 rise of interests by investors in energy generation projects gave birth to the promulgation of regulatory frameworks, which guide investment in energy.

The transformation of the current electric system, 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 (de Joode *et al.*, 2009). However, the efforts to register operators into grid integration of distributed energy resources is marred by the bundling or energy production, transmission and distribution and the lack of competition from IPPs outside Eskom, a state functional utility. Such hurdles have hindered the full operationalisation of energy generation projects in South Africa.

In 2015, the United Nations coined various sustainable development goals (SDGs) that tried to respond to the needs of sustainability in development. Specifically, SDG7 speaks to the provision of affordable clean energy to households, commerce and industry (Griggs *et al.*, 2013). This SDG7 indicates a global action towards the sustainability in energy production in the context of spatial planning. The World Energy Issues Monitor of 2019 is one organisation that focuses on energy production, demand and management across the globe (Chu and Majumdar, 2012). It tracks innovation in energy production. The organisation identified that in the years 2008-2019, there were key innovations in energy shaping an energy transition, ranging from innovative transport, renewable energies, decentralisation of systems, electricity storage to digitalisation.

METHODOLOGY

Evidence to weave the article was drawn from literature and document reviews involving scanning of archival materials and websites on energy planning and spatial planning. The research used Harare City as the study area. For data analysis, the article made use of thematic and textual analysis.

RESULTS

Harare is the capital city of Zimbabwe, lying in the north-eastern part of the country. The city was founded in 1890 at the spot where the British South Africa Company's Pioneer Column halted its march into Mashonaland (Parrott-Sheffer, 2018). Harare lies at an elevation of 4,865 feet (1,483 metres) and has a temperate climate. The city has kept on expanding from independence up to date. Various spatial plans have been designed and approved. This has given birth to real estate development that is a mixture of both coordinated and uncoordinated developments. The adjoining townships have been developed without integration into the current energy infrastructure that have resulted in high power-cuts in the city. The power station, located in Harare (Workington area, along Coventry Road), could not meet the daily demand of energy in the city. 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.

Table 1: Summary of Harare and Energy Issues (ZimSat, 2012; Ministry of Energy and Power Development, 2012)

Land Area (km^2)	960.6
Population	2,200,000
Wards in the core city	45
Wards in the Greater Harare	78
Energy Needs	Households, industry, commerce, institutions, transport and services
Energy Types	Thermal, hydroelectric, solar, biogas
Energy Demand (kilowatt hours (kWh)	1,022
Energy generated at Harare Power Station	50 Mw

Spatial planning in Harare is a mixture of incremental developments with legal and illegal settlers. Expansion of residential, commercial, institutional and industrial uses have strained the national electricity grid already deteriorating (Mbara and Pisa, 2019). This has led to high power-cuts and load-shedding in the country. Adding salt on the wound, Zimbabwe is enmeshed in a serious electric bill debt as it continuously faces challenges to clear such debt of electricity supply to neighbouring countries – South Africa and Mozambique. This indicates a lack of coordination and integration amongst energy and spatial planning.

Spatial planning in spearheaded by the Department of Physical Planning (now Department of Spatial Planning and Management), which approves all spatial plans in Zimbabwe (Samu *et al.*, 2019). Harare, as an urban local authority, has the responsibility of carrying out planning work and delivering services as guided by the Urban Councils Act (Chapter 29:15). Spatial planning is guided by a cocktail of policies and legislations chief among that is the Regional Town and Country Planning (RTCP) Act (Chapter 29:12, of 1976, revised 1996), which guides planning authorities in the preparation of master and local plans and, development planning and control in urban areas. There are also several allied statutes that impinge on land-use planning and these include the Urban Councils Act, the Land Acquisition Act and the Building Societies Act. Moreso, there is the National Housing Policy (2012) which guides the provision of low-cost housing in urban areas. Harare City Council is guided by its Strategic Plan which emphasises on effective urban planning and management, managing vehicle emissions and land-use controls and preventing people from building on hazardous areas (City of Harare, 2012). The strategic plan acknowledges solar energy harvesting as an opportunity for improved clean energy use. However, the master plan detailing how such clean solar energy will be planned for and integrated in urban planning is yet to be finalised (City of Harare, 2012).

Energy policies and frameworks that apply for Harare have a national focus (Nyemba and Mbohwa, 2018). Harare, as a city, has no stand-alone policy framework that guides energy production, supply and consumption, apart from its Strategic Plan which speaks to solar harvesting as an opportunity for redressing effects of climate change but with no clear operational and implementation plans. National policies guiding energy supply and demand are the National Energy Policy (2012), the National Renewable Energy Policy, the National Energy Policy Implementation Strategy, the Energy Regulatory Act (2011); the Electricity Regulatory Bill and the Electricity Act of 2002 (Mzezewa and Murove, 2017; Renewable Energy Cooperation Programme, 2015). In particular, the 2012 National Energy Policy aims at, among other things, developing renewable energy sources, promoting research and development in energy sector, increasing affordability of energy sources and stimulating economic growth.

The Energy Regulatory Act of 2002 regulates the "procurement, production, transportation, transmission, distribution, importation and exportation of energy derived from any energy source" (Mzezewa and Murove, 2017: iv). Other statutes in the energy sector include the National Electricity Act (2002) which provides for the establishment of the Zimbabwe Electricity Regulatory Commission that is responsible for licensing operators in the electricity sector. With regards to institutions, the Ministry of Energy and Power Development is the main authority that has overall responsibility for energy issues in Zimbabwe. There is Zimbabwe Energy and Regulatory Authority (ZERA) that is a regulatory board focusing on energy issues and enforces the Energy Regulatory Act.

Energy and spatial planning bodies that exist operate independently of each other, placing energy, environment and spatial planning and development into the custody of different organisations that operate using different sets of regulations. This means that, in some cases, spatial plans may be approved and developments done, while they are *ultra-vires* the regulations of energy sector policies. As such, there is a disconnection between spatial planning, real estate development and energy.

There is a varied mix of energy sources used in Harare. Mostly, purchased sources of energy are relied on in Harare. These sources include electricity, fuelwood, gas and many more modern fuels. The dominant energy source in Harare is electricity. In residential areas, over 90% of households use electricity (Chambwera, 2004). Other energy sources, such as, firewood and charcoal, are consumed insignificantly and they constitute less than 1%

(Mzezewa and Murove, 2017). There is an increase in the use of solar energy in Zimbabwe, due to electricity blackouts that have been experienced for over a decade. This energy source is mostly used for commercial and industrial uses.

Harare has the largest share of population and commercial activity compared to other cities in Zimbabwe. As such, the demands for energy are higher compared to other cities. Increased urbanisation and population growth in Harare have resulted in an increase in requirements for energy. This energy requirement is both in the form and quantity of energy demanded. Energy demands and consumption patterns in Harare vary according to land-use types. There are five main land-uses, that are commercial, residential, industrial, recreational and institutional uses. In residential areas, electricity blackouts have resulted in an increase in the use of gas as a complementary energy source for cooking.

In industrial uses, both the use of energy for business purposes and the misuse of energy during operations have resulted in increased demand for energy in Harare. For instance, industrial areas in Harare consume lots of energy, due to inadequate modernisation of industrial plants, continued use of obsolete technologies, the use of less efficient lighting systems and high specific energy consumption (Mungwena and Rashama, 2013).

The increasing demand for renewable sources of energy in Harare and the nation at large, requires spatial planning in relation to spatial electricity demands and energy consumption. Planning for energy use in Harare calls for the integration of various professionals and stakeholders. In Harare, the integration of energy and urban planning is still limited. The City of Harare consults and engages the Zimbabwe Electricity Supply Authority (ZESA) on the provision of servitudes for power lines and power stations and on approval of plans (Nyemba and Mbohwa, 2018). On servitudes, ZESA has the right to access and use land within the jurisdiction of the City of Harare. ZESA is also consulted by the City of Harare before approval of any layout plans and boundary wall plans. Moreso, ZESA is consulted on the preparation of master and local plans. ZESA is engaged to assess the electricity needs on proposed layouts and plans, whether there are existing power lines or not, on development proposals and to provide recommendations on building lines from its power lines. However, this consultation is limited to ZESA and not to other institutional frameworks in the energy sector.

Energy efficient spatial structures are identified by urban areas that are compact and offering mixed-uses and, density of population and workforce nearness. This spatial arrangement of structures reduces energy demand. They leave open spaces that can be used for renewable energy, for instance, solar plants. Compact and mixed-use designs can be easily supplied with grid-bound renewable energy. In Harare, a study by Lall, Henderson and Venables (2017) revealed that about 30% of land within 5km radius of Harare Central Business District (CBD) remains undeveloped, not by design, but, rather by inefficient use of land. Such inefficient use of land has difficulties in the supply and provision of energy, as it is costly. With design and planning, the undeveloped spaces can be utilised for local energy generation and supply the local area.

Energy consumption and demand in Harare, like any other city in Zimbabwe, do not influence the supply of energy. There is an irregular spatial distribution of energy demand and supply sources in Harare. Different relationships between energy characteristics and urban characteristics are ignored as energy is supplied mainly from state energy sources, such as electricity generated in Hwange and Kariba. It is only the sub-stations that are sited in Harare, for instance, the electricity sub-station situated along Bulawayo Road, opposite Kuwadzana residential area. Energy designs for energy facilities, such as Liquefied Petroleum (LP) gas and solar facilities are super-imposed on Harare's spatial plans. Currently, Harare has no energy planning and design principles that feed into its spatial planning. As such, energy technologies. such as LP gas are yet to be fully promoted as energy options for use in Harare. The planning of gas refilling facilities is not emphasised much in residential areas to promote convenience and accessibility (Nyemba and Mbohwa, 2018). Moreso, the planning of mini-grids at strategic centres is silent as much emphasis was centred on national electricity supply and less on local energy sources. The same can be said of other energy sources, such as biomass and biogas in Harare.

There is one electricity plant in Harare that is managed by Zimbabwe Power Company (ZPC). As of 2012, the power plant was only generating 16 Units (MW). Harare has five sewage treatment plants. Of the five treatment plants, only two have biogas digesters. The two treatment plants with digestors are Crowborough Treatment Plant and Firle Treatment Plant. However, it is argued that most of the gas collected from Firle and Crowborough Treatment Plants is flared into open air. Some of the gas is used only for heating digester sludge that requires a temperature of approximately 36^0 C for digestion process (Mzezewa and Murove, 2017). The rest of the gas produced is not utilised and is flared as waste gas.

DISCUSSION

There is a missing framework to integrate energy issues in contracts or competitions. Policies and frameworks for energy and planning are stand-alone and separated from each other, despite the intricacy of energy and planning. Policies and legislations are silent on the relationships between energy designs and spatial planning principles (Mungwena and Rashama, 2013). Thus, there is no coordination between spatial planning and the principles of energy plans and designs. Spatial planning in Harare continues to operate without much focus on planning for energy. Energy designs and plans are, therefore, imposed on existing spatial plans and this risks issues on mismatch and poor coordination of spatial and energy plans.

Renewable energy is emerging as an option for clean energy use in urban areas. However, for renewable energy sources to effectively function, they need to be well integrated in spatial planning processes. The article has noted that there are renewable energy policies in Zimbabwe, such as the National Renewable Energy Policy. These policies, however, are not well integrated into urban spatial planning process. Through spatial planning, competing land-uses are allocated space for efficiency and wise utilisation of land. This spatial planning is guided by master and local plans. Imposing energy plans on already existing spatial plans that were designed, without considering perspectives of local energy demand and supply is, sometimes, challenging.

Urban areas have the potential to generate energy from solid and liquid waste (Mzezewa and Murove, 2017). The article has noted that energy is generated at Crowborough and Firle Treatment Plants. Harare has five sewage treatment plans and only two are used for energy generation. The city has an opportunity to generate more energy on the remaining three treatment plants. The generated energy at Crowborough and Firle Treatment Plants is, however, not fully utilised as it is not supplied to meet the energy demand in the city. Instead, a significant amount of energy generated from the treatment plants is flared as waste gas, due to weak linkages between urban local authorities and the energy sector. There is great potential that sewage treatment plans in Harare can be strategically linked to power grids that supply energy to settlements within the city.

CONCLUSION AND POLICY OPTIONS

It has emerged, in this article, that energy and spatial planning and real state are not well integrated in Harare. Integrating energy into spatial planning and real estate presents several opportunities that include increased energy efficiency and the promotion of renewable energy sources. Yet, these opportunities continue untapped, due to the absence of policies and frameworks integrating energy issues into spatial planning and real estate. Drawing from the findings, it is recommended that energy mapping tools, integrative energy planning and spatio-temporal modelling be used to enhance the integration of energy into spatial planning and real estate.

Energy mapping tools can be used as essential tools for energy data generation and aid in the development of energy policies linked to planning. They map spatial energy demands and, therefore, can be linked to spatial planning on master planning, local development planning and even layout plans. They also generate energy maps that clarify spatial energy patterns in relation to possible energy supply sources. Energy maps will assist in the siting of urban localised energy centres, be it in residential districts or industrial hubs. These will contain data, such as spatial distribution of energy demand, potential energy supply sites, spatial population distribution, spatial land-use distribution, location of energy grids and the presence and location of anchor loads.

It is recommended that integrative energy planning be considered in urban and regional planning. Energy aspects need to be included in urban planning and real state in the early stages of planning urban areas. The energy demand-side and supply-side need to be critically analysed before settlements are designed and created. In Harare, emerging settlements need to consider the supply of local energy, the sitting of local energy sources and the distribution of local energy sources to proposed developments. Energy infrastructure needs to be integrated into the urban and real estate infrastructure right from settlement planning to settlement development and occupation. The point of entry is a dialogue process involving various disciplines and departments. These disciplines and departments will involve the urban planning, housing and works, Ministry of Local Government, Ministry of Energy and the ministry responsible for environment. The private energy companies are also key in the dialogues and have to be involved and general public.

Spatio-temporal modelling can be used as a technique to model energy demand and supply potentials at local level. This approach can be adopted as it aids in generating data on energy demanded by buildings and settlements within specific zones. Moreso, the tool can be used to generate data on local (Harare) energy supply potentials. For instance, the local biogas supply potential at Crowborough and Firle Treatment Plants can be observed and linked to the energy demand. When energy demand and supply are modelled, grid systems and storage capacities can be planned for through integrated planning involving stakeholders from both planning field and the energy sector.

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