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Enablers towards establishing and growing South Africa's waste to electricity industry

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ABSTRACT

In South Africa the electricity generation mix is relatively un-diverse whereas globally the transformation of the sector is advancing rapidly. Coal remains the predominant fuel source and limited success has to date been achieved in the renewable energy sector. The electricity generation sector is therefore hindered from moving towards an electricity generation landscape where alternative fuel sources is utilised. This research is aimed at gaining insight into the enablers that led towards an increasing trend (observed globally) in exploiting waste as a fuel for electricity generation, and to outline the presence of obstacles that hinder separation of waste for electricity use in the South African context. Furthermore it is an attempt at informing what appropriate interventions (operational and policy) may be considered suitable for South Africa to overcome these barriers in order to enable a sustainable South African waste to electricity (WTE) Industry. Findings show that numerous barriers to a WTE exists in the South African context, however overcoming these barriers is not as simple as adopting the European model with the aim to modify the electricity generation mix and waste management landscape. Selected enablers deemed appropriate in the South African context are adapted from the European model, and are greatly influenced by the prevailing socio-economic status of South Africa. Primary enablers identified were, (i) government support is needed especially in the form of subsidisation for green energy, (ii) increase landfill costs through the implementation of a landfill tax, (iii) streamline the process for Independent Private Power Producers (IPPPs) to connect to the national grid with off-take guaranteed and the inclusion of WTE into an electricity roadmap (effectively government's strategy). The proposed enabling interventions would help in overcoming the barriers for a South African WTE industry.

1. Introduction

Globally the demand for energy and in particular for electricity is intensifying. Electricity plays a vital role in individual and collective daily activities, and is easily the most mobile source of energy consumed on a daily basis. Overall it enables humans to lead an enhanced quality of life (Armaroli and Balzani, 2011) and is referred to as the driver of economic growth (Keho, 2016). Ramírez-Camperos et al. (2013), states that electricity is a fundamental input into society's well-being and a country's corresponding economic development. Therefore a lack of generating capacity is likely to have a negative effect on a country's economic outlook (Balachandra, 2006; Keho, 2016). Overall the world experienced a significant increase in demand for electricity during the 21st century, stimulated by a growing world population, industrialisation, urbanisation, income growth and modernisation (Pazheri et al., 2014; Keho, 2016). According to the EIA, 2016 energy outlook report, energy demands are expected to increase from 524 quadrillion Btu (2010 levels) to almost 820 quadrillion Btu by 2040 (EIA, 2016). On the other hand Pavlović et al. (2012) predicts that in the next 15 to 20 years the consumption of electricity will double. The bulk of this increase is expected to be stimulated by developing countries (Balat, 2006).

At present the primary fuel source used for electricity generation is coal (Aslani et al., 2012). Jamel et al. (2013) and Balat (2006) states that the bulk of global electricity generation capability is built on fossil fuels (66% of electricity generated utilising coal as a fuel) however South Africa in particular even more dependent on coal compared to the overall trend observed globally. Pazheri et al. (2014) reveals that more than 90% of the electricity generated in South Africa is based on coal. Thopil and Pouris (2015) states that 95% of South Africa's electricity generation capacity is based on non-renewable energy with the delta made up by nuclear energy sources. On numerous occasions Eskom failed to satisfy the demand for electricity in South Africa which led to load shedding in order to keep the grid stable and to avoid a total blackout.

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The aim of this research is to identify/investigate the enablers that led towards an increasing trend (observed globally) in exploiting waste as a fuel for electricity generation (hence the establishment of a WTE industry/sector), and then to identify what local barriers exists in the South African context. Based on a thorough understanding of these identified local barriers, enablers which can lead to establishing a sustainable WTE industry specific to the South African context are proposed and tested. The overall objective is therefore to reveal the absence of a waste to electricity (WTE) industry in South Africa, what obstacles is preventing this industry from being embedded into the local electricity generation mix and finally what enablers (operational and policy interventions) should be considered to give effect to a sustainable WTE industry. This research is relevant particularly for developing countries where waste disposal is still skewed towards land filling and where electricity generation is still dominated by fossil fuels. The process followed in this research can be used in identifying the local factors (or barriers) that need to be considered for the development of a local WTE industry.

Diversifying South Africa's electricity generation mix by including waste as a resource carries a number of benefits. It conserves natural resources and in the process reduces the volume of waste that is landfilled and thereby contributes to environmental protection (Menikpura et al., 2016; Brunner and Rechberger, 2015; Ruth, 1998). Waste quantities is increasing and the corresponding amounts must be treated (Münster and Meibom, 2011). Pavlas et al. (2010) states that the landfill option's capability to manage waste which has not been pre-treated in order to reduce its organic content is limited, and thus requires more effective methods of waste processing. This reality leaves municipalities with an ever increasing concern about this matter. WTE is now being considered as an option to tackle the growing waste management challenges in developing countries (Menikpura et al., 2016; Bidart et al., 2013; Ouda et al., 2013; Ofori-Boateng et al., 2013;, Guerrero et al., 2013; Melikoglu, 2013). Further Saidur et al. (2011) claims that WTE can simplify disposal and can potentially be an inexpensive source of heat.

It further holds the benefit that WTE can conserve valuable energy resources and protect the environment by conserving energy and natural resources (Ruth, 1998; Menikpura et al., 2016). Psomopoulos et al. (2009) states that according to actual operating data collected in the United States, that on average combusting 1 tonne of MSW in a modern WTE plant, results in the generation of approximately 600KWh of electricity and further avoid the mining of 0.25 tons of coal or the importing of a barrel of oil. In addition Hartenstein and Horvay (1996) as well as Psomopoulos et al. (2009) claims that WTE is the only way of sustainably disposing non-recyclable municipal waste.

The paper starts of by proposing an initial model for the local WTE industry drawn from European cases, in particular Sweden (Williams, 2011). Gaps in the model are then tested through two rounds of expert views. Throughout it is clear that the socio economic reality in South Africa is strongly influencing the emerging views. These emerging views and data collected (determining relevance of barriers to test for convergence) then necessitated a variation to the initial model that takes the South African socio-economic constraints into consideration. The revisited model and formulation process can be applied for other countries with similar waste disposal challenges and socio economic conditions.

2. Background

The generation of municipal solid waste (MSW) driven by rapid urbanisation is an unavoidable consequence due to human activity and is the most prevalent by-product (Lino and Ismail, 2011; Teixeira et al., 2014; Brunner and Rechberger, 2015). Urbanisation is predicted to continue and by 2025 the world population is projected to reach the 8 billion mark with 5 billion residing in urban areas (Menikpura et al., 2016). The World Bank estimates that the number of urbanised inhabitants will reach 4.3 billion by 2025, of which each person will generate approximately 1.42 kg/-capita/day of municipal solid waste that totals to 2.2 billion tons/year globally (Hoornweg and Bhada-Tata, 2012). This represents a sharp increase from the current estimates of 1.3 billion tons/year. Consequently this growth brings about many challenges as far as the management of MSW is concerned (Assamoi and Lawryshyn, 2012). The conventional means globally to manage MSW is predominantly landfilling, composting, recycling and WTE (Psomopoulos et al., 2009). In the National waste information baseline report (Department of Environmental Affairs, 2012), South Africa's waste volumes were modelled/estimated drawing from the 2011 census data and previous work done in 2005 determining the mass and per capita waste generation per province. Department of Environmental Affairs (2012) concludes that South Africans generate in total 108 million tons per annum of waste. General waste makes up 59 million of this total, hazardous waste 1 million and the remainder is unclassified. Of the general waste 10% is recycled, equating to 53.1 million tons assumed to be landfilled. This report also indicated that MSW quantities is growing faster in some cities than the country's economy.

Waste disposed to land presents a number of environmental challenges such as emissions of gases, water and land pollution, noise, vermin, dust and odour (Teixeira et al., 2014; De Feo et al., 2013). Waste to energy provides for a suitable waste management solution, and in addition addresses energy supply concerns within a region (Monni, 2012; Miranda and Hale, 1997). The European Union (EU) now classifies energy efficient waste incinerators as waste recovery units and therefore the activity moved up on the waste hierarchy (Münster and Meibom, 2011). This certainly plays a critical role when engagement with stakeholders is required, especially during authorisation applications for the erection of such facilities. Waste incineration reduces CO_2 emissions achieved through the removal of organic components from landfills (thus avoiding anaerobic degradation) which under certain conditions would have generated biogas that would normally be emitted into the ambient air even in the presence of landfill gas capturing systems (Menikpura et al., 2016; Zheng et al., 2014). Ang and Su (2016) puts forward that electricity generation sector's potential to reduce greenhouse gas (GHG) emissions is great by switching to non-fossil fuels especially away from coal. In a review undertaken by Psomopoulos et al. (2009) on WTE plants in the United States it was found that emissions of acids, dioxins/furans, mercury as well as greenhouse gases (GHG) is significantly lower than what is detected from conventional coal fired power plants. In addition the emissions are significantly lower when compared to the European Union and United States Environmental Protection Agency standards for all pollutants. Monni (2012) found that emissions from WTE plants dedicated to electricity generation was 35–60% lower when compared to electricity production within the same district from fossil fuel fired power plants when taking avoidance of emission from landfills into account. It is therefore verifiable that WTE provides cleaner and reliable energy compared to conventional fuels (Habib et al., 2013; Pavlas et al., 2010). Lastly WTE plants has a negligible impact on land use (and land cost) partly because if properly maintained it can last well over 30 years (Psomopoulos et al., 2009) and it will not require more land than initially earmarked unless a WTE facility is expanded to handle more waste.

A causal relationship exists between electricity consumption and economic growth (expressed as Growth Domestic Product). In the Association of South East Asian Nations (ASEAN), Yoo

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