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NAVIGATING A PATHWAY TO THE INSERTION OF VARIOUS WASTE TECHNOLOGIES AND THEIR APPLICABLE INSTITUTIONAL DRIVERS AND BARRIERS IN SOUTH AFRICA

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ABSTRACT: Climate change is present and there is a need for active solutions to reduce the impacts of climate change. There are many policies relating to energy needs as well as climate change and emission control in, however policies and frameworks to Waste-to-Energy (WtE) is limited. WtE is a fairly new concept in South Africa which requires a deep dive into the understanding of this technology and its applicable legislations. According to the United Nations Framework Convention on Climate Change (2011) the Kyoto Protocol is an international treaty that obliges countries to reduce greenhouse gas emissions thus reducing and eventually eliminating global warming. South Africa has committed to the CDM component under section 25 of the National Environmental Management Act established by the Designated National Authority (DNA). In South Africa, there is The National Development Plan 2030 which aims to create a better future for all citizens. One of the components is, energy. The energy plan aims to create an energy sector that encourages economic growth and development through suitable investment in energy infrastructure. The plan also visualizes that by 2030 South Africa will have an acceptable supply of electricity and liquid fuels to ensure that economic activity and well-being are not disturbed and that at least 95% of the population will have admittance to grid or off-grid electricity (Government of South Africa, 2019). The evident waste and energy policies highlights the need for cleaner and more advanced energy solutions as well as the heighten demand of energy in South Africa (Department of Minerals and Energy, 2003). This thesis will investigate the various waste to energy legislations from a global context and then focus on South Africa. The policy review looks at the barriers and opportunities in commissioning more waste to energy plants.

Keywords: Waste management, Environmental policies, Legislation, Waste to Energy technology, Institutional barriers, Institutional drivers, Just Energy transition

1. INTRODUCTION

Solid waste management is the sole provision that almost every metropolitan provides for its citizens. While service levels, environmental impacts and costs differ dramatically, solid waste management is one of the most imperative services rendered by the municipality. Currently, world cities generate approximately 1.3 billion tons of solid waste per annum. This volume is projected to increase to 2.2 billion

tons by 2025. It is expected that waste generation rates will more than double over the next twenty years in lower income countries. The above mentioned is quite an alarming statement as the global impact of solid waste is rapidly increasing. Solid waste has the potential to generate large quantities of methane, a greenhouse gas (GHG) that is principally impactful in the short-term (Hoornweg and Bhada-Tata, 2012). A proposed solution for the large quantities of waste is to initiate world-wide utilization of Waste-to-Energy (WtE) technologies.

In South Africa, there is The National Development Plan 2030 which aims to create a better future for all citizens. One of the components is, energy. The energy plan aims to create an energy sector that encourages economic growth and development through suitable investment in energy infrastructure. The plan also visualizes that by 2030 South Africa will have an acceptable supply of electricity and liquid fuels to ensure that economic activity and well-being are not disturbed and that at least 95% of the population will have admittance to grid or off-grid electricity (Government of South Africa, 2019). The White Paper on Renewable Energy of 2003 in South Africa is a policy that commits and details the government's plans relating to the development, demonstration, and execution of renewable energy sources for both small and large-scale components. The policy highlights the need for cleaner and more advanced energy solutions as well as the heighten demand of energy in South Africa (Department of Minerals and Energy, 2003). This paper will summarize the current applicable Waste-to-Energy legislative frameworks in South Africa and highlight the key barriers and drivers of these policies in the implementation and development of Waste-to-Energy technologies. The key elements of the South African roadmap were identified as in Figure 1 (Nell and Trois, 2022):

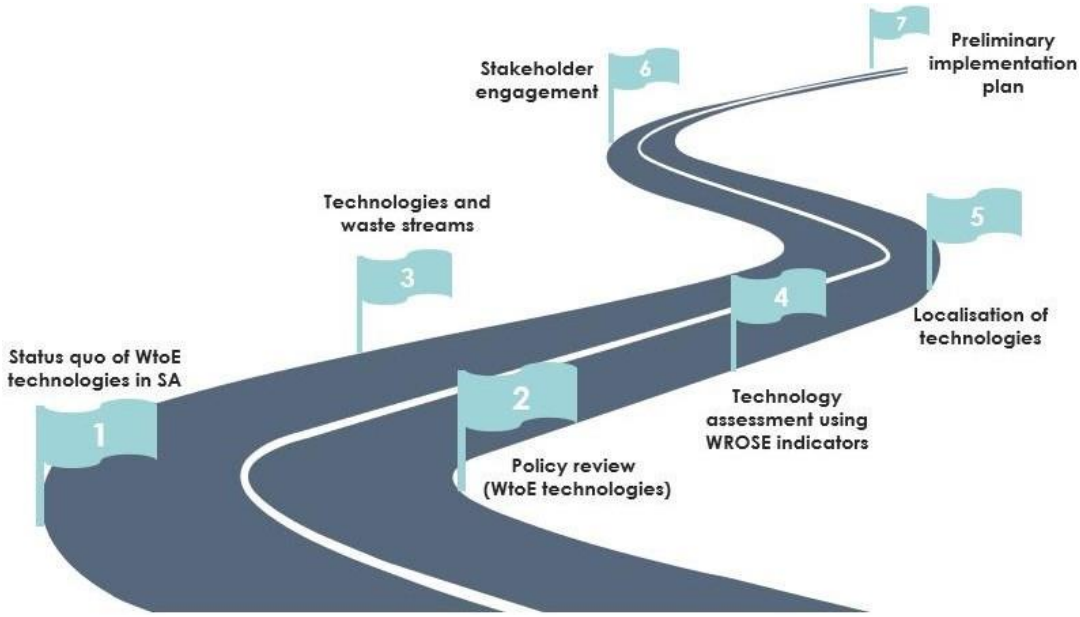

Figure 1. Key elements of the South African WtE roadmap (Nell and Trois, 2022)

2. METHODOLOGICAL APPROACH

The main goal of this thesis was to review the current applicable Waste to Energy legislations in South Africa relating to their barriers and best practices from the WtE perspective, the main approach used was a comprehensive literature review.

3. RESULTS AND DISCUSSION

There are various laws and legislation available for the WtE framework and overall waste management in South Africa. The main governmental departments that facilitate the Waste-to-Energy legislative process in South Africa, include the Department of Mineral Resources and Energy, Department of Environment, Forestry and Fisheries and Department of Water and Sanitation as well as applicable municipal by-laws.

The below are the main applicable regulatory frameworks for South Africa. National Environmental Management Act (NEMA) (Act 107 of 1998) which is the legal basis for sustainable environmental management and incorporates the notions of sustainable development, the precautionary and preventative approach and best practicable environmental option. The NEMA and associated Regulations administers the Environmental Authorizations of waste activities, also provide for the development of guidelines, norms, and standards for specific activities. The National Environmental Management: Waste Act (Act 59 of 2008) which is universally recognized for its' hierarchy of waste management. This Act also outlines the sustainable development requirements for waste generation is avoided, or if it cannot be avoided, that it is reduced, re-used, recycled, or recovered and the final option as treated (which includes incineration) or safely disposed. The National Environmental Management: Air Quality Act (Act 39 of 2004) is systematically substituting the Atmospheric Pollution Prevention Act. The White Paper on Integrated Pollution and Waste Management (2000) is a supervisory policy on pollution prevention, waste minimization, impact management and remediation.

National Waste Management Strategy (1999) introduced action to ultimately implement an integrated waste related to waste management. The White Paper on the Renewable Energy Policy (2004) intends to promote renewable energy and amalgamation of renewable energies into the mainstream energy economy. One source of energy recognized in the policy is biomass from organic matter, which includes residues from agriculture or forestry and organic components in municipal and industrial wastes. Another applicable legislation to comply to is The National Energy Regulator of South Africa (NERSA): According to the Electricity Regulation Act (Act 4 of 2006), any person who operates any electricity generation, transmission or distribution facility, imports or exports electricity or is involved in the trading of electricity must apply for a license from NERSA. The application process steps include 1. Production of Gas, 2. Importation of Gas, 3. Transmission of gas for own exclusive use or 4. Small biogas projects not connected to the national gas pipeline grid. However, before the NERSA registration and approvals, other steps are required for the development of a biogas facility, these include bidding under the REIPPP (Renewable Independent Power Producer Programme) Procurement Programme thereafter applicability to The National Environmental Management Act 107 of 1998- GN 327, 325 and 324 and The National Environmental Management: Waste Act 59 of 2008- GN921 which includes either Baseline Assessment (BA) which takes 7-9 months to conclude at an estimated cost of R100 000.00 or a full Environmental Impact Assessment (EIA) which takes 9-14 months to conclude at an estimated cost of R170 000.00. In the EIA, the assessment will also look at any triggers within the following regulations, The National Environmental Management: Air Quality Act 39 of 2004; biodiversity consents including, The National Forests Act 84 of 1998- GN248 and The Protected Areas Act 57 of 2003; The National Water Act 36 of 1998 regarding a water use license; The National Heritage Resources Act 25 of 1999; The Environmental Conservation Act 73 of 1989 and finally any impact to civil aviation routes and land use zoning changes. If applicable to triggers, there will be additional permits or regulations which will add costs and additional time to the construction of the biogas facility. The main applicable policy to be discussed falls under the National Environmental Management Act (NEMA) (Act 107 of 1998) which relates to thermal treatment of waste. According to The National Policy on the Thermal Treatment of General and Hazardous Waste (2009) incineration and co-processing are internationally established technologies for the treatment of general and hazardous waste, additionally as the recovery of energy and raw materials. Finally, The Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (1989; SA Ratification 1994) intend towards the decrease and minimization of hazardous waste and treatment and disposal to close proximity.

Table 1. Waste to Energy relevant South African regulatory frameworks barriers and drivers:

Current Policies	**Barriers**	**Drivers**
National Environmental Management Act (NEMA) (Act 107 of 1998)	NEMA (Act 107 of 1998): Overarching framework for WtoE technologies which include the applicable BA/EIA, hazardous substance permit with the regional office with DEFF. However, other permits are required from the Department of Water and Sanitation and Department Mineral Resources and Energy-and NERSA. There is great overlap on processes/approvals and causing confession between stakeholders (developers and governmental officials) Costly process (from approval to construction)- municipal finance management act to assist	The Department of Environmental Affairs will remain endorsing the Waste Management Hierarchy ~National Policy on the Thermal Treatment of General and Hazardous Waste, 2009
National Environmental Management Waste Act 59 of 2008	NEM: WA (Act 59 of 2008) Application of waste management license and handling/storage of hazardous substances/waste license. Some argue, the "waste "being used is not classified as waste rather a raw material/resource so a license application is not required however then the process of waste classification to be endured. There is also no threshold on the volume of waste so even a micro WtoE will not a permit which is not financially feasible and a lengthily process. Still a lengthily process and requires more clarity around the NEM: Waste Act Regulation 921 Categories A & B: Waste Management License if this is applicable to waste to energy plants.	This act encourages the waste management hierarchy and influences decisions through the national waste management strategy
National Energy Act 34 of 2008. Electricity Regulation Act (Act 4 of 2006) (REIPPP & Gas regulators); Electricity Regulation Act, 2006 (Oct 2020, Amendments on New Generation Capacity, 2011) and (2021, Amendment on Schedule 2)	Despite progress in legislation there is still difficulty in understanding the legal context (developers and governmental officials are not aligned) and no specific WtE policy	Latest amendment in 2021 under the Electricity Regulation Act 4 of 2006 under schedule 2 amendment which states an increase in the threshold for embedded generation from the previous 1 MW to 100 MW, without the need for a license. National Energy Regulator of South Africa: According to the Electricity Regulation Act (Act 4 of 2006), any person who operates any electricity generation, transmission or distribution facility, imports or exports electricity or is involved in the trading of electricity must apply for a license from NERSA. Register to 1. Production of Gas, 2. Importation of Gas, 3. Transmission of gas for own exclusive use or 4. Small biogas projects not connected to the national gas pipeline grid

The National Water Act 36 of 1998	If applicable, General Authorization: Water Use License which requires specialist input and additional time and costs. Application of water use license however still confusion on the applicable to WtoE technologies.	N/A
National Policy on the Thermal Treatment of General and Hazardous Waste, 2009	National policy on thermal treatment of General and Hazardous Waste (2009) despite detailed goals of this policy to assist with certain WtoE technologies, it does stipulate the assistance of DEFF to facilitate all permits between the departments for waste, water, and air licenses, however in particular terms when a developer does go to DEFF for WtoE plants they are not assisted as per this policy for facilitation of permits. This is a useful policy however it still needs more input and tools for proper implementation a suggestion is to use a decision tree for the various types of WtoE technologies available and include thresholds of waste. Financial terms are not included in this policy which is seen as a barrier and despite detailed goals of this policy to assist with certain WtoE technologies, it does not include assistance to pyrolysis plants.	National policy on thermal treatment of General and Hazardous Waste (2009) The Department of Environmental Affairs will remain endorsing the Waste Management Hierarchy which seems to provide support for WtoE technologies based on individual merit of each project.
National Environmental Management: Air Quality Act 39 of 2004	Despite progress in legislation there is still difficulty in understanding the legal context (developers and governmental officials are not aligned)	Biogas plants legislative requirements have been building momentum and one of the latest progressions in 2019 was from the NEM: AQA Section 21 notice on biogas installations under category 10 which states biogas installations are not a listed activity and therefore does not require an air emissions license however they are required to manage and monitor odour produced from the plants.
National Environmental Management: Waste Act: Norms and standards for the treatment of organic waste (Draft, 2021)	N/A	National Environmental Management: Waste Act: Norms and standards for the treatment of organic waste (Draft, 2021) details possible WtoE technologies under organic waste and provides a good guideline on the process from construction to decommissioning
White Paper on the Renewable Energy Policy, 2004	Requires a focused and detailed waste to energy policy	Introduces aspects of waste to energy plants, very high-level policy
The White Paper on Integrated Pollution and Waste Management, 2000	Requires more details on how waste to energy can assist with the waste management strategy and more tangible information	High level waste management policy, waste to energy can be seen under the strategic goals solution for future plans
National Environmental Management: Integrated Coastal Management Act 24 of 2008	Applicable if area selected for the waste to energy plant is on a classified coastal land – requires specialist studies with additional cost and time to the total project	N/A

Restriction and Prohibition of Organic Waste to Landfill	Management Restriction and Prohibition of Organic Waste to Landfill under the National Waste Management Strategy (20020), states organic waste cannot go to landfill which can be seen as a barrier for lower volumes of waste input as organics cannot go to landfill this relates specifically to LFG plants	This can be a driver for non-LFG plants which can utilize organics waste in their process and have higher volumes if the organics waste cannot go to landfill
Civil Aviation Act 13 of 2009	Applicable if area selected for the waste to energy plant is on route or impacting the civil routes in the region– requires specialist studies with additional cost and time to the total project	N/A
National Environmental Management: Biodiversity Act 10 of 2004	Requires specialist studies with additional cost and time to the total project	N/A
The National Heritage Resources Act 25 of 1999	Applicable if area selected for the waste to energy plant is on a classified national heritage site land – requires specialist studies with additional cost and time to the total project	N/A
National Environmental Management: Protected Areas Act (NEM: PAA) Act 57 of 2003	Applicable if area selected for the waste to energy plant is on a classified protected land – requires specialist studies with additional cost and time to the total project	N/A
Environment Conservation Act 73 of 1989	Applicable if area selected for the waste to energy plant is on a classified conservation site – requires specialist studies with additional cost and time to the total project	N/A
Atmospheric Pollution Prevention Act 45 of 1965	This act links to the NEM: AQA regarding air emissions licensing, which requires further clarity and applicability for waste to energy plants	N/A
National Forests Act 84 of 1998- GN248	Applicable if area selected for the waste to energy plant is in a classified forest – requires specialist studies with additional cost and time to the total project	N/A
Gas Regulator Levies Act 75 of 2002	This act provides the imposition of levies by the National Gas Regulator for anyone who produces gas, these levies will add additional costs to gas energy plants	N/A
Electrical installations must comply with standards and regulations (ATEX approval)	This regulation requires specific adherences for all electrical installations which is required in a waste to energy plant which is additional specialist electrical work, time, and costs	N/A

Municipal Systems Act 32 of 2000	Despite legalization progress, this can still cause confusion and could lead to additional lead time on the project	"In Oct 2020, there has been gazette amendments to the Electricity Regulations on New Generation Capacity, 2011 (the ""Regulations"") in terms of the Electricity Regulation Act, 2006 (the ""Act""), providing scope for municipalities to develop their own power generation projects, subject to certain requirements: The key amendments are as follows:-The Regulations have been limited in application, providing that only organs of state active in the energy sector may procure new generation capacity; and such procurement now includes, amongst others, base load, mid-merit load, peak load new generation capacity, and energy storage;-Municipalities, as organs of state, are now eligible to apply to the Minister for the procurement or purchase of new generation capacity in accordance with the Integrated Resource Plan. A municipality that does apply as such must:1. Conduct and submit a feasibility study where it intends to deliver the new generation capacity project through an internal mechanism as contemplated in section 76(a) of the Municipal Systems Act;2. Submit proof that it has complied with the provisions of section 120 of the Municipal Finance Management Act and the Municipal Public-Private Partnership Regulations, where it intends to deliver the new generation capacity project through an external mechanism as contemplated in section 76(b) of the Municipal of the Municipal Systems Act; and3. Submit proof that the application is aligned with its Integrated Development Plan. -Finally, the conclusion of power purchase agreements between buyers or procurers and IPPs will be further subject to any approvals required in terms of the Municipal Finance Management Act or the Municipal Systems Act, together with the Public Finance Management Act. This is a key driver in the push for WtoE technologies from municipal level".
Occupational Health and Safety Act 85 of 1993	Additional protocols and costs to comply	N/A
Local Government: Municipal Structures Act 117 of 1998	Specific to each municipal and could add additional lead time on the total project	N/A

Municipal Public Private Partnerships Regulations, 2005	There is progress on the legislation however still requires further clarity regarding waste to energy plants partnerships	N/A
Municipal Finance Management Act (with reference to: Supply Chain Management, Asset Management)	According to the Municipal Finance Management Act (2003) under section 33, there are limitations on the contract terms up to 36 months however some off-takers require ten-to-fifteen-year commitments and therefore require a section 21A process, which is contrary to the act which can become a barrier in contracts or commitments of starting a waste to energy plant in South Africa. Therefore, cost analysis and financial management is a key aspect in the development of waste to energy plants and can become a barrier if not addressed correctly	N/A
National Health Act 61 of 2003	To be applied with the OHS Act regarding employee health from construction to development of the waste to energy plant	N/A
Hazardous Substances Act 15 of 1973	If applicable, hazardous substances license for hazardous waste handling and storage. This is additional time and cost to the total project.	N/A
Pressure Equipment Regulations, 2009	If applicable, if pressure equipment is being installed and strict adherence to this guideline which is additional cost and time.	N/A
GRAP: Generally Recognized Accounting Practices 17 & 19	N/A	GRAP can be utilized to embed practices for waste to energy plants under the municipal finance management act
Municipal Specific By-Laws – Building plans –Fire Safety	To be utilized during construction phase and specific to each municipality's requirements	N/A
National Building Regulations and Building Standards Act No 103 of 1977	To be utilized during construction phase	N/A
Land Use Planning Ordinance 15 of 1985	N/A	N/A
Land Use Management Bill, 2008	To be utilized when selecting the area of the plant and limits areas where the plant can be construction	N/A
Conservation of Agricultural Resources Act (CARA, Act 43 of 1983)	Applicable if area selected for the waste to energy plant is on a classified agricultural and conservation land – requires specialist studies with additional cost and time to the total project	N/A

Spatial Planning and Land Use Management Act (SPLUMA) Act 16 of 2013	To be utilized when selecting the area of the plant and limits areas where the plant can be construction	N/A
Subdivision of Agricultural Land Act (SALA) Act 70 of 1970	Applicable if area selected for the waste to energy plant is on a classified agricultural and conservation land – requires specialist studies with additional cost and time to the total project	N/A
NEMA: EIA listing Notice and triggers	Adds more cost and time to the project for either BA or EIA	N/A

Figure 2. Process flow for relevant Waste to Energy technology and regulatory framework:

3.1 Waste-to-Energy policy barriers in South Africa

South Africa has numerous prominent waste management policies, plans and strategies that support the waste management hierarchy. However, the development and application of certain waste management alternatives, which would allow waste to be better managed within the waste hierarchy, have been limited partially due to the absence of decisive national policy related to waste treatment and retrieval through thermal processes, including dedicated incineration and co-processing in cement production. The privation in policy course has resulted in or underwritten to several limitations. In many occurrences, these limitations include poor environmental performance related to waste management in the country, the lack of, late or conflicting decision-making regarding the authorization of waste incineration and co-processing activities, uncertainty in Government and industry regarding investigating and developing these technologies as waste management options and noteworthy opposition from certain sectors of society that oppose any form of thermal waste treatment. Another element relating to the waste hierarchy, is that landfilling is seen as the best solution due to the ease of disposal and the costing feasibility with low gate fees, this barrier can therefore deter waste to energy projects as the solution for waste disposal.

An evident barrier is the legal costs of obtaining relevant permits regardless of the size of the plant. It is also noted the high cost of the permits and required steps, a Basic Assessment is approximately R100 000,00 (2021 estimate data) and Environmental Impact Assessment is approximately R170 000,00 (2021 estimate data) which does not include any specialist studies that could be required. According to the Municipal Finance Management Act (2003) under section 33, there are limitations on the contract terms up to 36 months however some off-takers require ten-to-fifteen-year commitments and therefore require a section 21A process, which is contrary to the act which can become a barrier in contracts or commitments of starting a waste to energy plant in South Africa. Therefore, cost analysis and financial management is a key aspect in the development of waste to energy plants and can become a barrier if not addressed correctly.

Another barrier includes the NEMA (Act 107 of 1998) which is an overarching framework for WtE technologies which include the applicable Basic Assessments or Environmental Impact Assessments, hazardous substance permit with the regional office with Department of Environment, Forestry and Fisheries. However, other permits are required from the Department of Water and Sanitation and Department Mineral Resources and Energy-and NERSA. There is great overlap regarding the processes and approvals and causing confession between stakeholders (developers and governmental officials).

Regarding thermal treatment through pyrolysis under the national policy on thermal treatment of General and Hazardous Waste (2009) despite detailed goals of this policy to assist with certain WtE technologies, it does not include assistance to pyrolysis plants.

Under the Management Restriction and Prohibition of Organic Waste to Landfill under the National Waste Management Strategy (20020), it states organic waste cannot go to landfill which can be seen as a barrier for lower volumes of waste input as organics cannot go to landfill.

A policy barrier under the NEM: WA (Act 59 of 2008) which is the application of a waste management license and handling/storage of hazardous substances/waste license. Some argue, the "waste "being used is not classified as waste rather a raw material/resource so a license application is not required however then the process of waste classification to be endured. There is also no threshold on the volume of waste so even a micro WtE will require a permit which is not financially feasible and a lengthily process and the NWA (Act 36 of 1998) which is the application of water use license however there is still confusion on the applicable to WtoE technologies. This barrier under the national policy on thermal treatment of General and Hazardous Waste (2009) despite detailed goals of this policy to assist with certain WtoE technologies, it does stipulate the assistance of Department of Environment, Forestry and Fisheries to facilitate all permits between the departments for waste, water and air licenses, however in particular terms when a developer does go to Department of Environment, Forestry and Fisheries for WtoE plants they are not assisted as per this policy for facilitation of permits. This is a useful policy however it still

needs more input and tools for proper implementation a suggestion is to use a decision tree for the various types of WtE technologies available and include thresholds of waste. It is also evident that the various policies do not include financial terms and timelines for processing permits which is critical for project management and feasibility studies.

3.2 Waste-to-Energy policy drivers in South Africa

A key policy driver is the national policy on thermal treatment of General and Hazardous Waste (2009), the Department of Environment, Forestry and Fisheries will remain endorsing the waste management hierarchy which seems to provide support for WtE technologies based on individual merit of each project.

Another driver is the National Environmental Management: Waste Act: Norms and standards for the treatment of organic waste (Draft, 2021) details possible WtoE technologies under organic waste and provides a good guideline on the process from construction to decommissioning

The management Restriction and Prohibition of Organic Waste to Landfill under the National Waste Management Strategy (20020), states organic waste cannot go to landfill which can be seen as a driver under this technology as an alternative route from landfill and moves up the waste hierarchy which is aligned the National Waste Management Strategy.

Another driver, which is the latest amendment in 2021 under the Electricity Regulation Act 4 of 2006 under schedule 2 amendment which states an increase in the threshold for embedded generation from the previous 1 MW to 100 MW, without the need for a license. Project developers will be exempted from applying for a license, but they will still be required to register as an energy generator with NERSA.

As seen above, the National Policy on the Thermal Treatment of General and Hazardous Waste (2009), addresses the barriers of the development of WtE plants in South Africa and with the implementation strategy, it is seen as the South African government fully supporting this new way of managing waste through WtE technologies.

Another important framework for biogas plants in South Africa the is National Energy Regulator of South Africa (NERSA) which regulates the biogas plants relating to the production, importation, and distribution of the piped gas within South Africa. All biogas plants constructed in South Africa are required to register with NERSA and comply with relevant legislation which is based on the relevant municipality and national requirements. Biogas plants legislative requirements have been building momentum and one of the latest progressions in 2019 was from the NEM: AQA Section 21 notice on biogas installations under category 10 which states biogas installations are not a listed activity and therefore does not require an air emissions license however they are required to manage and monitor odour produced from the plants. This is progression for the biogas sector and shows improvements between industry and government in creating an easier and clear plan for more biogas installations.

There has been significant progress on Waste-to-Energy policies in South Africa which is the move in the right direction in creating a clear roadmap to the development of Waste-to-Energy technologies in South Africa.

4. CONCLUSIONS

Waste-to-Energy technologies is a solution to the waste and energy crisis in South Africa. There is a need for a specific waste to energy policy to address issues like financial management with funding opportunities, a decision tree based on the relevant required legislation per waste to energy technology, thresholds on waste volumes and scale of the project as well future plans on emerging technologies. This policy can also include a decarbonization strategy specific for municipal action which can be included in each municipalities waste management plan. There are various drivers and barriers in the policy frameworks from development to implementation and all stakeholders need to work together for clarity of the frameworks to ensure successful implementation of these Waste-to-Energy technologies in South Africa.

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