MPUMALANGA GREEN CLUSTER AGENCY

JUSTSA

# INDUSTRY BRIEF

Exploring energy efficiency and renewable energy intervention opportunities at municipal wastewater treatment works in Mpumalanga

## LIST OF ACRONYMS

| | |
|---|---|
| **DFFE** | Department of Forestry, Fisheries and the Environment |
| **DWS** | Department of Water and Sanitation |
| **EIA** | Environmental Impact Assessment |
| **EE** | Energy efficiency |
| **EEDSM** | Energy Efficiency and Demand-Side Management |
| **Ml/d** | Million litres per day |
| **NESS** | National Energy Efficiency Strategy |
| **GHG** | Greenhouse Gases |
| **SAWIS** | South African Waste Information System |
| **SPC** | Specific Energy Consumption |
| **RE** | Renewable energy |
| **VROOM** | Very Rough Order of Measurement |
| **WSA** | Water Service Authority |
| **WWTW** | Wastewater treatment works |

## MAIN INSIGHTS

- Wastewater treatment works (WWTWs) are large consumers of energy, with water supply and wastewater treatment constituting approximately 17% of the total energy consumed by South African municipalities.
- A relatively low adoption of energy efficiency (EE) and renewable energy (RE) interventions at municipal WWTWs in Mpumalanga Province (and in South Africa in general) is resulting in missed opportunities for cost savings, carbon emission reductions and enhancing energy security.
- The key energy efficiency intervention opportunities relevant to WWTWs include plant optimisations and alterations such as upgrading pump systems, optimising motor driven systems - which include replacing motors with energy efficient motors (e.g. IE3/IE4 motors), upgrading the aeration process by installing variable speed drives and load shifting.
- There are limited policies and regulations that specifically promote the application of EE and RE technologies in municipal WWTWs.
- The upgrading of wastewater infrastructure creates an enabling environment for the uptake of EE and RE, enabling better energy management and providing less carbon intensive energy alternatives.

**This brief is written for:**

Policy makers, municipalities, investors and solutions providers that are interested in the market, and covers the following:

- Background to Mpumalanga wastewater infrastructure and estimated energy consumption and/or management.
- Potential energy efficiency and renewable energy options.
- Key policies and regulations.
- Drivers and barriers to the uptake of EE and RE at municipal WWTWs in Mpumalanga.

# 1 CONTEXT

The Mpumalanga province of South Africa faces socio-economic and environmental challenges arising from its resource intensive economic activities that contribute to climate change. Carbon intensive industries like mining, power generation and petro-chemicals are the core economic drivers in the province. The region is also currently navigating high levels of unemployment, inequality and poverty, even as pressure mounts to transition away from its current coal based economy.

The Mpumalanga Green Cluster Agency together with its implementation partners under the Just SA project support the implementation of pathways towards a just transition towards an environmentally sustainable, climate-change resilient, low-carbon economy and just society.

Water and wastewater supply and treatment constitutes ~17% of the total energy consumed by South African municipalities, with a high-energy technology WWTWs typically attributing 25-30% of its budget to energy cost (SALGA, 2020). Particular attention should be paid to the typical energy intensive wastewater treatment process stages, such as pumping systems, aeration processes, and sludge management. The typical energy consumption of activated sludge processes is shown in **Table 1**.

**Table 1:** Typical energy allocation for various treatment stages

| Process stage | Typical energy consumption |
|---|---|
| Aeration | 13 - 80% |
| Sludge treatment | 5 - 35% |
| Pumping | 4 - 31% |
| Other | 1 - 38% |

Wastewater treatment data from across the world reflect specific energy consumption (SPC) figures ranging from 0.26 kWh – 1.6 kWh per m³ of wastewater treated. Specific energy consumption figures exceeding 1 kWh/m³ could be considered to be high. For South African plants, the average SPC varies from 0.289 to 2.37 kWh/m³, which is high compared to global averages, implying that energy inefficiencies exist that need to be corrected (DWS, 2022). International SPC benchmarks of wastewater treatment processes at different plant sizes are shown in **Table 2**.

**Table 2:** Benchmarks for specific power consumption of secondary treatment processes
Source: Feng 2012, NEWRI, 2010, Green Drop 2022

| Plant size (Ml/d) | <0.5 (Ml/d) | 0.5 - 2 (Ml/d) | 10 - 25(Ml/d) | >25 (Ml/d) |
|---|---|---|---|---|
| Trickling filter (kWh/m³) | 0.43 | 0.68 | 0.28 | 0.17 |
| Activated sludge (kWh/m³) | 0.39 | 0.59 | 0.37 | 0.31 |

* Advanced treatment systems use 0.31 - 0.14 kWh/m³    Ml/d = mega litres per day

Since most WWTWs in South Africa are aged, advances in technology and existing well-proven equipment have enabled the potential to improve the energy efficiency (EE) of WWTWs. This unlocks several opportunities to greatly decrease the amount of electricity consumed and the associated greenhouse gas (GHG) emissions.

# 2 BACKGROUND TO MPUMALANGA WASTEWATER INFRASTRUCTURE AND ENERGY MANAGEMENT DATA

In Mpumalanga, there are 17 local municipalities, delivering wastewater services through a sewer network comprised of 76 wastewater treatment systems. There is a total design (installed) treatment capacity of 352 million litres per day (Ml/d) in these 76 WWTWs, with the majority of this capacity (92%) residing in the 43 medium, large and macro-sized treatment plants. The four local municipalities with the largest combined operational capacities are Emalahleni (44.2 Ml/d), Govan Mbeki (24 Ml/d), Mbombela (47.3 Ml/d) and Steve Tshwete (28.7 Ml/d). **Table 3** provides an overview of the large and macro sized WWTW located in these four municipalities. The estimated energy consumption is estimated based on the operational capacity and the energy benchmark based on the system classification [1].

**Table 3:** Large and macro WWTWs in eMalahleni, Govin Mbeki, Mbombela and Steve Tshwete local municipalities

| WWTW | Municipality | Design capacity(Ml/d) | Operational capacity (Ml/d) | Secondary treatment | No. of anaerobic digesters | SPC[2] | Estimated energy consumption (kWh/day) [3] |
|---|---|---|---|---|---|---|---|
| Klipspruit | eMalahleni | 10 | 10.30 | Activated sludge | 2 | 0.314 | 3 234 |
| Naauwpoort | eMalahleni | 10 | 6.80 | Activated sludge | 2 | 0.314 | 2 135 |
| Riverview | eMalahleni | 11 | 11.11 | Activated sludge | No information | 0.314 | 3 489 |
| Ferrobank | eMalahleni | 17 | 9.18 | Biological filtration | 5 | 0.314 | 2 883 |
| Thubelihle | eMalahleni | 10 | 0.7 | Activated sludge | 1 | 0.314 | 220 |
| Embalenhle | Govan Mbeki | 8 | 3.2 | Activated sludge | No information | 0.314 | 1 005 |
| Evander | Govan Mbeki | 16 | 15 | Activated sludge | 3 | 0.314 | 4 710 |
| Kanyamazane | Mbombela | 12 | 4.02 | Activated sludge | 0 | 0.2 | 804 |
| Kingstonvale | Mbombela | 26 | 20.25 | Activated sludge | 3 | 1.19 | 24 098 |
| Boskrans | Steve Tshwete | 45 | 25.2 | Activated sludge | 0 | 0.298 | 7 510 |
| Total | | 165 | 90.8 | | | | 50 086 |

Of the WWTWs listed in **Table 3**, three WWTWs achieved a 2022 Green Drop score of above 80%: Kanyamazane (84%), Kingstonvale (88%) and Boskrans (88%). In addition, these three WWTWs are located in municipalities (Mbombela and Steve Tshwete) that both received unqualified audit outcomes for the 2021/22 financial year (Auditor General, 2023).

Data for the energy efficiency of WWTWs in Mpumalanga is not available to the public at the time of writing. However, energy efficiency management, is reported in the Green Drop report (DWS, 2022) as follows:

- Dr JS Moroka, Mbombela and Thaba Chweu municipalities conducted energy audits in the past 24 months.
- System SPCs are calculated by Steve Tshwete (0.3 kWh/m³ not system specific), Mbombela (0.91 kWh/m³ for plants operated by Silulumanzi), and Nkomazi (4.7 kWh/m³ for 3 systems) municipalities.
- For these systems that reported, all used more energy per m³ treated than the SPC industry benchmarks.
- Kingstonvale WWTW in Mbombela, was the only system that could account for carbon dioxide equivalents associated with energy efficiency.
- Steve Tshwete, Nkomazi and Mbombela (Silulumanzi) municipalities had knowledge of their energy cost (R/m³).

The overall finding from the Green Drop report is that municipalities in the provinces are not monitoring energy as part of the wastewater business. Furthermore, energy efficiency measures are not yet embedded in their treatment processes, and as a result they are forfeiting the potential cost savings.

[1] The system classification of the WWTWs in Table 1 is advanced treatment with a benchmark SPC of 0.314 kWh/m³
[2] The systems with no reported SPC were given the advanced treatment benchmark SPC of 0.314 kWh/m³.
[3] The estimated energy consumption was calculated as operational capacity multiplied by the typical SPC for the system classification. The plants marked with * had reported SPC from the GreenDrop report.

# 3 POTENTIAL EE AND RE OPTIONS AT WWTWS

**Table 4** lists various options for EE at WWTWs. As there is very limited information available on the current EE measures in place, more detailed investigations need to be undertaken to ascertain the most appropriate options. SALGA published a report that developed a comprehensive framework to perform an energy audit at a municipal WWTW. Energy audits are conducted to create a baseline of the energy consumed in a system, this would allow for improvements to be identified and implemented and for their impact and performance to be evaluated over time. The energy consumption differs across stages depending on the plant design and, specifically, the installed equipment type. Across the system, commonly recommended energy efficiency interventions include:

- Plant optimisations and alterations, such as upgrading pump systems, optimising aeration systems and maximising gravity feeding.
- Optimising motor driven systems, which include replacing motors with energy efficient motors (e.g. IE3/IE4 motors [4]).
- Upgrading the aeration process by installing variable speed drives, automated dissolved oxygen and automated ammonia control on aeration systems.
- Load shifting which involves adjusting the timing of energy-intensive processes to off-peak hours.

**Table 4** gives a summary of the interventions and the estimated energy saving with the capital payback period.

**Table 4:** Summary of interventions to improve energy efficiency and their business case
Source: Feng et al. (2012); NERSYDA, (2010); SEA (2020) and SEA (2017)

| Intervention | Potential overall/sectional energy savings (%) | Payback period (years) |
|---|---|---|
| Energy audits and EE interventions implemented | 10 – 50* | |
| Process controls and automation | 5 – 20* | |
| Peak shaving | < 50 | 4 - 6 |
| Aeration process optimisation<br>Fine bubble diffusers<br>VSDs in blowers and mechanical mixers<br>Dissolved oxygen control | 30 – 70<br>20 – 75<br>10 – 50<br>20 – 50 | 1 – 7<br><1<br>2 – 7<br>2 – 3 |
| Pumping system optimisation<br>VSDs in motors<br>Improve power factor of motors<br>Eliminate pump throttling valves | 15 – 30<br>10 – 40<br>5 – 10<br>Up to 50 | <3<br><5<br>< 2 |
| Optimisation of dosage and type of sludge conditioning agent | Up to 30 | |
| Optimisation of dosage and type of sludge conditioning agent | 15 – 65 | |

* Overall energy savings

If the EE interventions have already been implemented, RE sources such as solar power, wind energy, combined heat and power (with or without cell lysis), sludge beneficiation through biogas opportunities like anaerobic digestion and incineration, and mini hydro (turbine) can be considered. Provided there is sufficient space onsite, solar PV (without battery storage) is generally well-suited to many WWTWs. Typical capital costs for solar PV systems (without storage are: 10 000 R/kWh – 14 000 R/kWh for capital costs with a fixed operation and maintenance costs of 2% of the capital cost and the typical payback period ranging from 4 to 8 years.

[4] International efficiency (IE) class 3 and 4 motors are more efficient than classes 1 or 2

# 4 KEY POLICIES AND REGULATIONS

There are limited policies and regulations that specifically promote the application of EE and RE technologies in municipal WWTWs. The majority of the existing policies, and regulations (**Table 5**) broadly focus on energy efficiency and demand-side management (EEDSM) and diversified energy sources to promote energy security, environmental protection (reduction of GHG emissions), and climate change adaptation. In the existing relevant ones, there is no explicit strategy, no clear targets and aligned plans, and/or guidelines on how local government will implement EE and RE generation when providing water services. For example, the National Energy Efficiency Strategy (NEES) targets 20% savings from municipal services including water supply, water and wastewater treatment. However, it lacks clarity on how government plans to reach this target, apart from the EEDSM grant administered by the Department Mineral Resources and Energy (DMRE) and South African National Energy Development Institute (SANEDI).

**Table 5:** Summary of key policies and regulations relevant to the implementation of energy efficiency and renewable energy interventions at WWTWs

| Legislation, policy and/or strategy | Relevance |
|---|---|
| **National Water Act (No. 36 of 1998)** | Overarching governance of any action that relates to water. |
| **National Environmental Management Act (No. 107 of 1998, and Amendment Act 62 of 2008)** | Overarching governance of any action that poses a risk to environmental protection. This act has implications for RE in that prior approval is required before setting up a RE generation facility. |
| **National Environmental Management: Waste Act (No. 59 of 2008)** | The act promotes RE generation from wastewater and/or sludge at WWTWs as a means of reducing, recycling and recovering resources from waste. This prevents and minimises the generation of waste, and prevents pollution and ecological degradation envisioned by the act. |
| **National Environmental Management: Biodiversity Act (NEMBA) (No. 10 of 2004)** | NEMBA provides the platform for identifying and classifying sensitive environments, rare and endangered species. This may restrict the implementation of a RE project if the chosen site will trigger the NEMBA. |
| **Environmental Impact Regulations (Notice R 982 of Gazette No. 38282, 04 December 2014)** | The treatment, handling or processing of wastewater sludge may trigger an Environmental Impact Assessment (EIA) or Basic Assessment, to acquire a Waste License. |
| **Norms and standards for disposal of waste to landfill (Notice R 636 of Gazette No. 36784, 23 August 2013)** | Sets the commencement date (August 2019) of the nationwide ban of liquid waste disposal to landfill. |
| **Electricity Regulation Act (ERA) (No. 4 of 2006) as amended by Amendment Act 28 of 2007** | Guides the issuance of licences for generators and transmitters, wheelers, and distributors of electricity. |
| **The 2022 amendment of Schedule 2 of the ERA 4 of 2006** | This amendment subsequently amended the 100MW threshold license exemption and registration requirements for trading, generation, transmission, and distribution of electricity. The amendment however requires generation facilities of any capacity with/out battery storage such WWTWs supplying one or two customers (i) without wheeling, and (ii) with wheeling where the generator has entered into a connection agreement with the holder of a transmission/distribution licence to comply with the code and must be registered. Municipalities are exempt from holding or applying for a licence in this regard. |
| **Preferential Procurement Policy Framework Act [PPPFA, Act 5 of 2000, S2 (1)]** | Provides that the preferential procurement may be implemented for the purposes of promoting equality and transformation e.g. contracting with persons, or groups, that were historically disadvantaged by unfair discrimination based on race, gender or disability. |

| | |
|---|---|
| PPPFA Regulations, 2022 S11 (1) (effective from 16 January 2023) | The new 2022 Regulations require organs of state to consider specific goals stipulated in the Reconstruction and Development Programme (RDP) in the development of their procurement policies. The specific goals may include contracting with persons, or categories of persons, historically disadvantaged by unfair discrimination on the basis of race, gender and disability including the implementation of programmes of the RDP. |
| National Energy Efficiency Strategy (NEES) (2005, 2008, post 2015) | The strategy for the municipal services sector is to "accelerate the reduction in the specific energy consumption per resident in delivering municipal services". The strategy further sets a national energy savings target of 20% from savings in energy intensive municipal services, which include water supply, water and wastewater treatment. |
| Confronting the Energy Crisis: An Action Plan to End Load shedding (2022 Update 2023 ) | Sets out the key intervention to tackle the country's load shedding crisis and is overseen by the National Energy Crisis Committee |
| Mpumalanga climate change mitigation Strategy and implementation plan 2022 [Goal 2: Improve energy efficiency(EE)] | DARDLEA has developed this Strategy and Implementation Plan for the province to complement the province's Climate Change Adaptation Strategy and provide the province with a comprehensive climate change response strategy. Goal number 2 outlines the province's plan to encourage and provide technical assistance to provincial entities to implement EE measures in in mining processes, water infrastructure and wastewater treatment |

# 5 DRIVERS AND BARRIERS TO THE UPTAKE OF EE AND RE INTERVENTIONS AT WWTWS

**Table 6** summarises some of the drivers and barriers to uptake of EE and RE interventions at municipal WWTWs.

**Table 6:** Drivers and barriers to the uptake of EE and RE interventions at WWTWs

| Drivers | Barriers |
|---|---|
| Energy savings, including possibility of becoming a net energy supplier. | Lack of technical skills and capacity at municipalities. |
| Improved energy supply reliability. | Municipal creditworthiness. |
| Potential to improve operational efficiency, operational cost and effluent quality. | Municipality procurement regulations and processes. |
| Sustainability goals such as the reduction of GHGs. | Vandalism and theft of wastewater infrastructure. |
| | Lack of EE and RE technology demonstration at WWTWs. |

# 6 CONCLUSION AND WAY FORWARD

There is an opportunity for solutions providers and investors to offer EE and RE solutions to municipalities, thereby reducing municipal energy costs and carbon emissions and improving energy security. The upgrading of wastewater infrastructure creates an enabling environment for the uptake of EE and RE, enabling better energy management and providing less carbon intensive energy alternatives. The typical interventions mentioned above are in line with the infrastructure plans to bring the works to functionality as shown in the VROOM estimation [5]. For a municipality interested in implementing energy efficiency and /or renewable energy interventions at WWTWs, the first steps are:

- Conduct a comprehensive preliminary Level 1 energy audit of WWTWs. [A detailed guideline for EE audits at WWTWs can be found **here**].
- Identify areas of high energy demand and feasible interventions.
- Conduct a financial pre-feasibility study and identify a feasible financing model/s.

For technology and service providers, GreenCape has published an industry brief on **entering the South African water market**, which guides readers through general water sector procurement requirements and recommendations. Mpumalanga Green Cluster published an **industry brief** on sludge beneficiation which highlight opportunities that is linked to energy cogeneration.

For more information on this opportunity, please contact **water@mpumalangagreencluster.co.za**.

**Disclaimer:** While every attempt was made to ensure that the information published in this brief is accurate, no responsibility is accepted for any loss or damage that may arise out of the reliance of any person or entity upon any of the information this brief contains.

## REFERENCES


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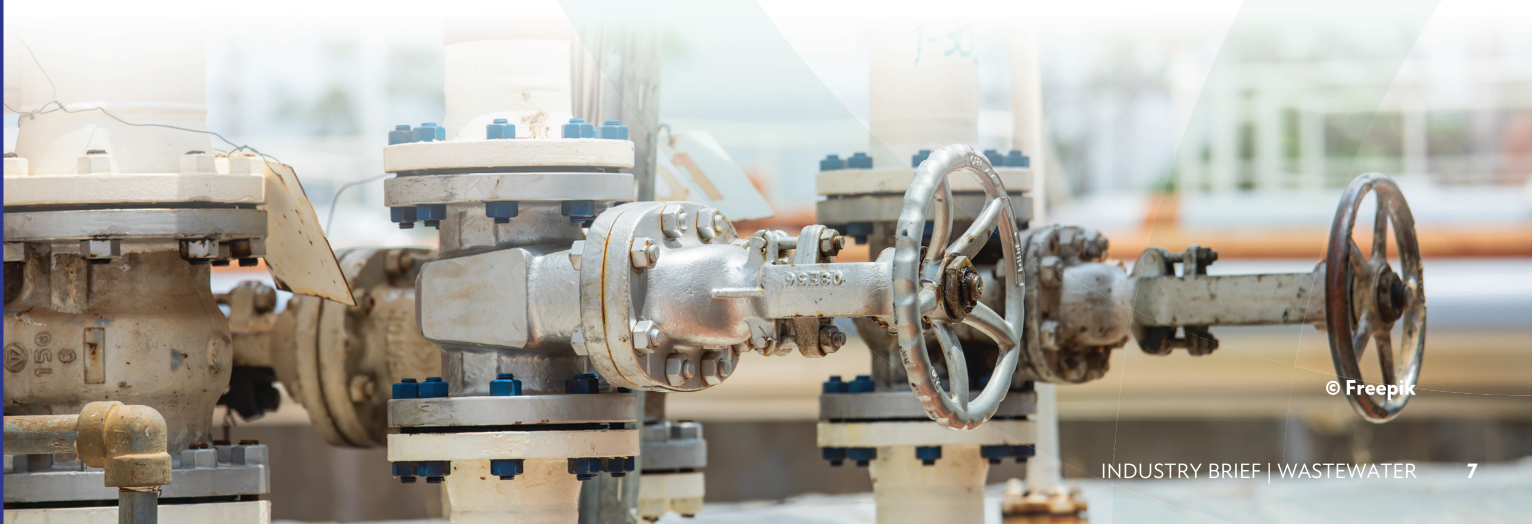
[5] The Very Rough Order of Measurement (VROOM) model was incorporated in the 2022 Green Drop Reports and provides insights on the state of the key elements of the wastewater infrastructure and provides an order of magnitude estimate of the cost to return infrastructure to a functional condition. The 2022 MIR summarised these interventions with the associated projects costs estimates.



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