Renewable energy and energy efficiency for wastewater treatment works in South Africa

Technical factsheet for **sludge management**

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This factsheet on sludge management forms part of a series of ten (10) factsheets that highlight the renewable energy (RE) and energy efficiency (EE) technologies relevant to wastewater treatment works (WWTWs). The full list of technologies and factsheets can be found [here].

WWTWs are large consumers of energy, with water supply and wastewater treatment constituting approximately 17% of the total energy consumed by South African municipalities.

Innovative approaches to efficient energy use in municipal WWTWs, specifically through increased EE and greater adoption of RE technologies such as biogas, solar, wind power, thermal power and hydropower, can reduce spend on energy bills and enable sustainable delivery of water services. The adoption of EE and RE technologies supports climate change mitigation as it decreases the amount of electricity consumed and the associated greenhouse gas (GHG) emissions while improving resilience to disruptions such as planned power outages (loadshedding).

This factsheet is written for:

- Municipal officials interested in:
  - Unpacking feasible options for energy savings, and reducing the overall WWTW facility energy bill.
  - Reducing the carbon footprint of the WWTW.
- Businesses and engineering, procurement and construction (EPC) companies that are looking for opportunities to explore in the WWTW market.
- Investors interested in identifying feasible renewable energy and energy efficiency projects at WWTWs.

This factsheet discusses:

- The opportunities for energy efficiency in the sludge management process.
- The business case to implement sludge interventions that enhance energy efficiency.

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01 Introduction

Sludge management includes the processing, drying and thickening of sludge from the primary secondary and tertiary wastewater treatment stages. Sludge management is critical when it comes to ensuring compliance and minimising operational risks at a WWTW. The consequences of inadequate sludge management include severe health and environmental concerns. In an activated sludge WWTW, sludge treatment and disposal account for up to 35% of the total energy consumption of the plant.

There are various interventions that can be applied in the primary and secondary sedimentation, thickening, digester feed and other stages that can significantly reduce the energy consumption of these processes.

1.1 Primary sedimentation

Effective primary sedimentation is vital to feed anaerobic digestors (for biogas production), reduce the organic load in the aerobic biological processes and prevent blockages, which reduces the electricity consumption of the WWTW. To ensure that a primary sedimentation tank (PST) is performing optimally, certain key operating criteria must be monitored. These can be seen in Table 1.

Table 1: Performance indicators to evaluate the effectiveness of the primary sedimentation tank (Water Group Holdings Pty (Ltd))[1]

INDICATOR	DESCRIPTION	TARGET	OPPORTUNITIES FOR EFFICIENCY IMPROVEMENTS
Solids loading rate (kg/m²/day)	Monitor the influent and effluent into the PST to determine the solids removed.	10 – 20 kg/m²/day	• Provide even flow distribution. • Change weir and baffle settings. • Optimise sludge pumping cycles.
Suspended solids (SS) removal efficiency (%)		45 – 65%	• Increase frequency and duration of sludge withdrawal. • Use all tanks available and divert recycle flows.
Total and volatile solids	Monitor a composite sample of the sludge underflow to provide information on the percentage of dry solids in the sludge and the loading on the anaerobic digesters.	2 – 5% Up to 11% with pre-treatment.	
Chemical oxygen demand (COD)	Influent and effluent monitored to assess efficiency of the PST and to provide information for the downstream biological process.	Reduction in the PST: Effluent should be 30 – 40% less than influent.	–

For a full list of indicators, visit Anaerobic Digestion: A Practical Guideline.

1 For further information, consult – Anaerobic Digestion: A Practical Guideline prepared by Water Group Holdings (Pty) Ltd available at www.sagen.org.za

1.2 Sludge dewatering and thickening

Sludge dewatering and thickening is required to increase the solids concentration of the sludge for effective anaerobic digestion. The removal of water from sludge generally saves more energy than it would consume during subsequent treatment or transportation. The following methods are used for sludge thickening in order of energy intensity:

Table 2: Technologies for sludge dewatering and thickening (Water Group Holdings Pty (Ltd))

MECHANICAL TECHNOLOGY	BENCHMARK SPECIFIC POWER CONSUMPTION (KWH/TONNE SS[2])	OPPORTUNITIES FOR ENERGY EFFICIENCY
Drying beds	0 (Solar evaporation is used)	No electrical power required
Belt filter press	10 - 25	Optimise belt speed Optimise belt pressure
Pressure filtration	20 - 40	Ensure correct pressure is applied to the sludge
Centrifugation	30 - 60	Optimise the rotation speed for the throughput
Dissolved air flotation (DAF)	0.05 – 0.075 (kWh/m^3)	Optimise aeration based on input flow rates

For a full list of energy efficiency opportunities in the sludge dewatering process, visit Anaerobic Digestion: A Practical Guideline.

1.3 Sludge stabilisation

After the sludge is thickened, stabilisation occurs to remove odours, reduce pathogens and organic materials and inhibit further decomposition. Stabilisation is necessary to ensure sludge is of a suitable quality for landfilling or stock piling. Opportunities for energy efficiency in sludge stabilisation are shown in Table 3:

Table 3: Opportunities for energy efficiency in sludge stabilisation

TYPE OF STABILISATION	METHOD	OPPORTUNITIES FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY
Chemical	Lime dosing	No electrical power required
Biological	Anaerobic digestion	• Methane gas can be used for power generation using combined-heat power (CHP) • Use biogas to fire incinerators • Use biogas to heat the anaerobic digester
Biological	Aerobic digestion	Optimise aeration based on flow and quality of incoming sludge

2 Suspended Solids (SS) are small solid particles which remain in suspension in water

Business case

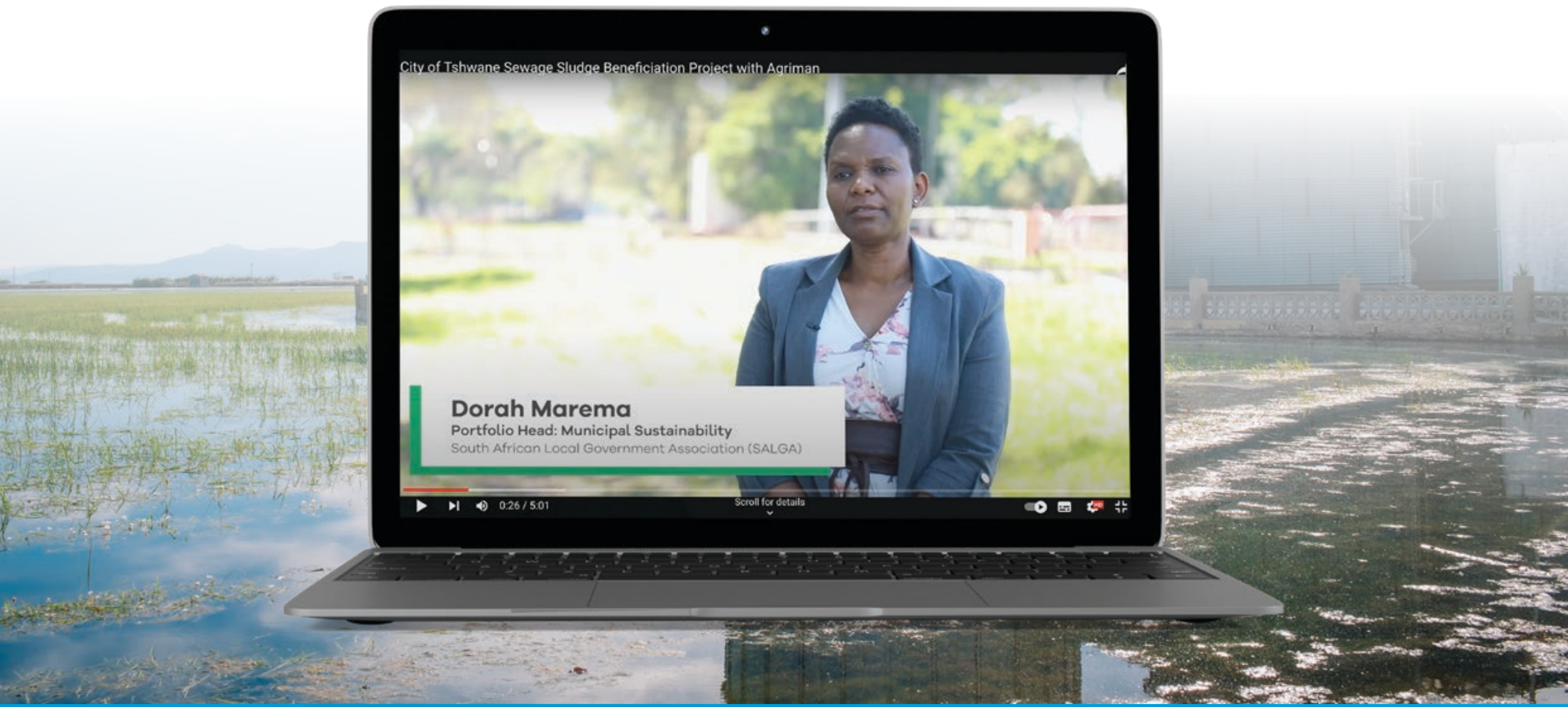
Sludge processing and monitoring is essential to meet effluent discharge standards. Poor sludge handling is the cause of many WWTWs failing to meet final effluent quality standards. The Green Drop 2022 reports indicated that most municipalities are not achieving regulatory and industry standards for sludge compliance.

The use of EE and RE practices in the sludge management process can result in the following benefits:

- Reduced electricity consumption.
- Potential to use biogas for heating requirements of the plant.
- Potential for production of electricity from biogas using combined-heat power. This could supplement the electricity consumption of the treatment work.

In addition, treated sludge can be beneficiated (either onsite or offsite) into products for agriculture, energy recovery or other commercial uses, which can potentially reduce costs, or generate revenue, for a municipality. Furthermore, the treatment of sludge can result in a reduction of greenhouse gas emissions.

The City of Tshwane Metropolitan Municipality adds value to bio-solids produced at waste water treatment facilities. See case study here: https://www.youtube.com/watch?v=rv5nsPHxd2Y



Further information on sludge beneficiation can be found on:

GreenCape website: Circular economy solutions for primary, waste activated and digested wastewater sludge

South African-German Energy Programme: Anaerobic Digestion of Municipal Wastewater Sludge: A Practical Guideline (Sludge Classification p55)

Water Research Commission (WRC): Guidelines for the Utilisation and Disposal of Wastewater Sludge

Financing mechanisms

Potential EE projects can be financed through various mechanisms, depending on the nature of the project, municipality's implementation capacity, financial strength, borrowing capacity, revenue base and commercial financing environment. Some examples are shown in Table 4.

Table 4: Financing mechanisms for energy efficiency projects

MECHANISM	DESCRIPTION	EXAMPLES
Municipal budget	EE projects funded from municipal revenues.	EE projects motivated and included in IDP, WSDP, SDBIP and Project business plans.
Grants	Non-repayable funds from government or donors to municipalities.	Conditional grants (MIG, RBIG, WSIG), Green Fund and EEDSM
Concessional loans (Dedicated credit lines)	Soft public loans to municipalities for EE projects from foreign funders. They usually have lower interest rates.	AFD, SEFA (AFDB), DBSA
Commercial bank loans	Commercial banks lend money to municipalities for EE projects or through Energy services companies (ESCos).	Most commercial banks fund sustainable projects.
Energy performance contracts (Vendor credits)	Financing of EE equipment/ services covered by the ESCos with repayments based on estimated future energy savings. Alternatively, the initial costs are paid by the municipality and the ESCo is required to guarantee energy savings and pay the difference if the expected savings are not achieved.	City of Cape Town SANEDI ESCo register
Climate financiers	Finance for activities aiming to mitigate or adapt to the impacts of climate change.	See: https://greencape.co.za/archives/green-finance-databases/

Source: ESMAP: Financing Municipal Energy Efficiency Projects; NBI: Private Sector Energy Efficiency Programme; and SALGA: Financing Energy Efficiency and Renewable Energy

AFD = French Development Bank, DBSA = The Development Bank of Southern Africa, ESCo = energy service companies, MIG = municipal infrastructure grant, RBIG = Regional bulk infrastructure grant; SEFA = Sustainable Energy Fund for Africa;

WSIG = water services infrastructure grant

Next steps

- 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 to promote EE.
- Conduct a financial pre-feasibility study and identify a feasible financing model/s.
- Explore other EE and RE interventions [biogas, hydro power, pre and post treatment, pumping, sludge management, solar PV, and thermal beneficiation].

Pipeline development to deploy **clean energy technology solutions in municipal wastewater treatment works of South Africa**

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