

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

## Technical factsheet for **energy efficiency in secondary treatment technologies**

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This factsheet on energy management and optimisation forms part of a series of ten (10) factsheets which 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 [\[here\]](#).

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.

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:
  - > Identifying feasible options for energy savings and reducing the overall WWTW facility energy bill.
  - > Reducing the carbon footprint of WWTWs.
- Private developers and engineering, procurement and construction (EPC) companies that are looking for opportunities to explore the WWTW market.
- Funders and investors interested in interventions to reduce overall energy consumption of WWTWs.

### This factsheet discusses:

- Energy consumption of secondary treatment technologies.
- Different types of interventions that can be deployed to reduce the energy consumption of secondary treatment technologies at WWTWs.
- Financing options for energy saving projects at WWTWs.



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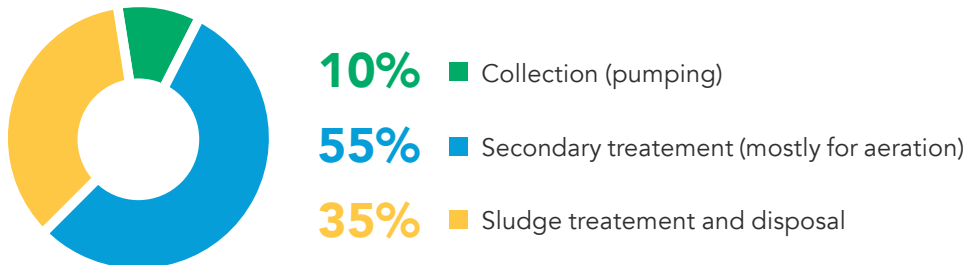


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# 01 Introduction

The energy usage of a WWTW varies across plants and is mainly influenced by the specific type of equipment that has been installed. The secondary treatment<sup>1</sup> stage uses the highest fraction of energy across the stages of the WWTW, as shown in [Figure 1](#). Thus, the largest potential energy savings would be from the implementation of RE and EE in the secondary treatment stage.



**Figure 1:** Energy use of an activated sludge municipal wastewater treatment plant (SALGA, 2020)



## 1.1 Specific Power Consumption (SPC) and energy benchmarking

The SPC represents the power consumed per m<sup>3</sup> of water treated. The overall energy efficiency of the facility and the secondary treatment stage can be benchmarked against local and international benchmarks such as the specific energy consumed (kWh/m<sup>3</sup> treated and kWh/kg COD), if available.

The typical specific power consumption for the secondary treatment stage per technology type and their best practice benchmarks can be seen in [Table 1](#). These values represent the estimated energy intensity for typical large wastewater treatment facilities (about 380 000 m<sup>3</sup> per day) in the United States (Feng, Ouedraogo, Manghee, & Danilenko, 2012). This can be seen in [Table 1](#) below.

**Table 1:** Typical SPC for Large WWTWs<sup>2</sup>

STAGE	EQUIPMENT TYPE	TYPICAL SPC (kWh/m <sup>3</sup> )
Trickling Filter	Recirculation pump	0.177
Activated Sludge	Activated sludge oxidation (COD removal)	0.272
Activated Sludge	MLE activated sludge	0.314
Activated Sludge	Activated sludge with nitrification	0.412
Secondary Sedimentation	Scraper mechanism	0.012
Secondary Sedimentation	Recirculation pump	0.030 – 0.226
Oxidation Ditch Technology	Aerator	0.30 – 2.07

<sup>1</sup> Secondary treatment typically involves biological processes where microorganisms, such as bacteria and protozoa, are used to break down the organic matter in the wastewater

<sup>2</sup> Visit '[A practical guideline for Energy Efficiency Audits at Wastewater Treatment Works](#)' by Water Group Holdings (Pty) Ltd for more information

Systems that use activated sludge have a higher SPC value due to the use of aeration and additional recycles and pumping requirements for more advanced treatment of wastewater. It is reported that in newer WWTWs that utilise activated sludge treatment, aeration alone often accounts for about 50% of the overall treatment process energy use.

The SPC value for the secondary treatment stage should be compared to benchmarks available in literature. SPC values are typically not only averages over time, but are also highly dependent on the configuration and equipment present at the WWTW, on the quality of the water going in and out of the facility, flow rates and the specific treatment processes used.

[‘Assessment Framework for the Feasibility of Energy Efficiency and Renewable Energy at Municipal Wastewater Treatment Plants’](#), a Water Research Commission report authored by the Water Group, recommends the establishment a national SPC benchmark database for municipal WWTWs in SA as a dataset that can be used to assess the viability of EE and RE interventions.

**The following is recommended for WWTW’s with regards to SPC:**

- Regular estimation of SPC by measuring the power consumption of the plant and the volume of water treated
- Compare the plant’s SPC value with benchmarks available in literature
- Train process controllers to be aware of energy intensive equipment and how to operate more efficiently



## 1.2 Energy efficiency interventions and their business case

There are a number of energy saving best practice measures that can be implemented in the secondary treatment stage of a WWTW depending on the type of technology deployed. Measures such as energy assessments, energy monitoring and skills training have a low or no cost and yield energy savings of up to 20%, depending on the actions taken. Table 2 highlights additional measures, with most requiring capital and technical skills<sup>3</sup>.



<sup>3</sup> Further information can be found in the report [‘Assessment Framework for the Feasibility of Energy Efficiency and Renewable Energy at Municipal Wastewater Treatment Plants’](#) by the WaterGroup

**Table 2:** Energy reduction interventions for secondary treatment (SALGA, 2020)

INTERVENTION	DESCRIPTION	ESTIMATED ENERGY SAVING (%)	ESTIMATED PAYBACK PERIOD (YEARS)
Aeration system	Determine if system is operating efficiently (comparison of SPC with other similar plants)	30% – 70% of total aeration system energy consumption	1 year
	<p><b>Consider switching to energy efficient technology such as:</b></p> <ul style="list-style-type: none"> <li>• Fine bubble aeration</li> <li>• Dissolved oxygen control</li> <li>• Variable air flow rate blowers</li> </ul>		3 – 7 years (retrofits)
	<p><b>Optimise aeration system, with the following interventions:</b></p> <ul style="list-style-type: none"> <li>• Align control parameters with effluent discharge standards</li> <li>• Optimise Dissolved Oxygen (DO) set points to reduce energy requirements from blowers</li> <li>• Adjust DO sensor position to accurately assess DO levels</li> <li>• Automation of DO controls</li> </ul>		>2 years
Post aeration	Install a cascade aeration system for post aeration applications. If the topography is favourable, this technology provides re-aeration of the effluent by increasing the water turbulence over the steps, with no need for electricity	Up to 100% of post-aeration requirements	Depends on existing infrastructure
Optimise Dissolved Air Flotation (DAF)	<ul style="list-style-type: none"> <li>• Add polymers to sludge</li> <li>• Optimise air to solids ratio</li> </ul>	Variable	>1 year



# 2 Financial 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 3](#).

**Table 3:** 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.	<a href="#">Conditional grants</a> (MIG, RBIG, WSIG), <a href="#">Green Fund</a> and <a href="#">EEDSM</a>
Concessional loans (Dedicated credit lines)	Soft public loans to municipalities for EE projects from foreign funders. They usually have lower interest rates.	<a href="#">AFD</a> , <a href="#">SEFA</a> (AFDB), <a href="#">DBSA</a>
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.	<a href="#">City of Cape Town SANEDI ESCo register</a>
Climate financiers	Finance for activities aiming to mitigate or adapt to the impacts of climate change.	See: <a href="https://greencape.co.za/archives/green-finance-databases/">https://greencape.co.za/archives/green-finance-databases/</a>

**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

### The project acknowledges the following partners:

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- > Department of Water and Sanitation
- > Department of Mineral Resources and Energy
- > Department of Cooperative Governance and Traditional Affairs
- > Department of Science and Innovation
- > Development Bank of Southern Africa
- > National Treasury
- > South African Local Government Association
- > Municipal Infrastructure Support Agent
- > South African National Energy Development Institute



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