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

Technical factsheet for **mini-hydro and wind power**

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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:
  - Unpacking feasible options for energy savings and reducing the overall WWTW facility energy bill.
  - Increasing energy independence for a system with backup battery storage.
  - Reducing the carbon footprint of WWTWs.
- Private developers and engineering, procurement and construction companies looking for opportunities to explore the WWTW market.
- Funders and investors interested in interventions to reduce overall consumption of WWTW.

This factsheet discusses:

- The feasibility of a hydropower technology in the context of powering energy-intensive activities in wastewater treatment works, as well as unpacking opportunities for costs and energy savings.
- It further looks at the small wind generation to offset utility energy use.

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Hydro Power

1.1 What is mini-hydro?

Mini-hydro generation technology is a small-scale hydroelectric RE technology that harnesses energy from flowing water to produce usable electricity. The generation capacity typically ranges between 5 kW and 100 KW for micro-hydro[1] and between 100 kW and 1000 kW for mini-hydro. The power generation methodology is based on the gravitational potential of water flowing from a higher to a lower elevation. Hydro-generation typically uses turbines and generators to generate electricity. The flowing water rotates the turbines, which are connected to a generator, which produces electricity.

The installation needs sufficient water flow for stable power generation. WWTWs typically have large amounts of water flowing through them, making them an ideal location for adopting the technology. A key advantage is that the technology can be integrated into the existing plant infrastructure, targeting areas (and processes) with flowing water. This infrastructure synergy makes installations more cost-effective, reducing civil works requirements.

1.1.1 Configuration of mini-hydro

The power potential of a mini-hydro system depends on two key factors: The head (overall drop in elevation) and the water flow potential. For a typical hydro installation, two types of configurations are used when considering movement and utilisation of the water resource.

- **Run-off river:** Systems that use the natural flow of water to rotate the turbines. These systems are simpler to implement and only generate when water flows.
- **Pumped storage:** Systems are designed with an upper reservoir that releases water on demand to generate electricity.

Both configurations are applicable in WWTWs. In addition to the two configurations above, a water conveyance configuration system is tailored explicitly for WWTWs. It is designed to be integrated into the existing WWTW conveyance infrastructures.

The components that make up the system are:

- **Water conveyance tools:** Water flow is diverted through alternative pipes to the turbines.
- **Turbines:** The turbines convert the flowing water's kinetic energy into rotational motion. Turbine selection is based on the flow characteristics identified after a flow analysis has been conducted, and depending on the flow rate, a high or low head would need to be installed. Typical types of turbines include Pelton Turbine, Francis Turbine, and Kaplan Turbine; deciding on the type of turbine would form part of the detailed design.
- **Generator:** A generator is connected to the turbines, and the electromagnetic generator produces electricity each time the turbine rotates.

1 Water Research Commission (WRC).2021. Hydropower: Turning the tide on cleaner energy. Water Research Commission, South Africa

1.1.2 How can a mini-hydro plant reduce the energy consumption of a WWTW?

When considering WWTW plant infrastructure, a suitable location for the mini-hydro turbine would be in drop structure locations that involve water transfer activities. Identification of these locations is essential as it impacts the overall costs of the installation. Typical locations include;

> The headworks (low-head turbine type)

> Aeration tanks

> Clarifiers (high-head turbine type)

An analysis will need to be conducted to assess various flow rates to determine the correct sizing of the turbine. Once the flow characteristics have been determined, considerations are made towards the type of turbine to install: low-head turbines for delicate flow rates and screw turbines (high-head) for strong flow rates.[2]

The generated power will then be used to power the plant's energy-intensive process and large plant equipment.

CONSIDER THIS TECHNOLOGY IF

- Identified areas within your operation with high flow and a decent head that could be used for hydro energy generation.
- Climate projections should be considered prior to the installation in order to ensure that also in future enough water flows through the WWTW.
- Require additional energy to be offset to either save on cost or further decarbonise.

BUSINESS CASE

Payback period: 5 – 10 years[3]
IRR: 10 – 20 %1

2 The Water Research Commission (WRC).2016. Performance Criteria for Package Water Treatment Plants. Water Research Commission, South Africa

3 The Water Research Commission (WRC).2016. Energy Generation Using Low Head Hydro power Technologies. Water Research Commission, South Africa

Wind Energy

1.2 What is wind energy?

Wind energy uses naturally occurring wind currents to rotate a turbine to generate electricity. Small-scale wind generation is not a technology that has seen extensive adoption in South Africa due to its cost and complexity. Multi-year wind studies are needed to validate to project before the implementation.

1.2.1 How can wind energy reduce the energy consumption of the plant?

A wind installation would not influence the operations of a WWTW but be a supplementary infrastructure offsetting the energy use from the grid, similar to the configuration from solar PV [see additional details in the solar PV fact sheet, with hyperlink].

CONSIDER THIS TECHNOLOGY IF
• The WWTW site has a high wind resource and could be harnessed for wind generation. • Require additional energy to be offset to either save on cost or further decarbonise.

BUSINESS CASE
There are not enough case studies available on successful projects yet. The capital cost of systems: 6 000 – 30 000 R/kWp, is very dependent on the application and the type of turbine.

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 1.

Table 1: 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

Mini-hydro	Wind
Conduct a technical feasibility study to outline sizing requirements for plant size, which includes: > Flow rate determination and measurement. > Head determination and measurement. > Intake and pipe type identification and design. • Conduct a financial pre-feasibility study and identify a feasible financial model. • Technical design and specification requirements. • Explore feasible procurement options.	• Conduct a technical feasibility study to outline sizing requirements for plant size, which includes wind resource of the area. • Conduct a financial pre-feasibility study and identify a feasible financial model. • Technical design and specification requirements. • Explore feasible procurement options.

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

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- 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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