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

Technical factsheet for **solar photovoltaic (PV) technology**

01 Energy management and optimisation

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03 Primary and tertiary treatment

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10 Energy audits and process optimisation

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].

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 (load shedding).

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.
  - Reducing the carbon footprint of WWTWs.
- Private developers and engineering, procurement and construction (EPC) companies that are looking for opportunities to explore in the WWTW market.
- Investors interested in identifying feasible RE and EE projects at WWTWs.

This factsheet discusses:

Solar PV technology's feasibility in powering energy-intensive activities in wastewater treatment works and unpacking opportunities for costs and energy savings.

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01 Introduction

Solar PV technology is a clean power generation technology that leverages sunlight to generate electricity. This technology comprises multiple interconnected solar cells, which form solar panels/modules designed to capture sunlight converting it into electricity.

The inherent characteristic of the technology allows for generation during the day, and these operational hours are referred to as solar hours. The deployment of this technology depends on the availability of solar resources, and South Africa has very good solar potential – making it a great location for the installation and adoption of the technology. Additional trends making it an increasingly attractive option are the continuously declining technology costs and the national utilities' year-on-year above-inflation electricity tariff increases[1].

Solar PV modules are arranged in arrays and are composed of additional system components such as inverters, cabling and other safety devices, also referred to as the Balance of System (BOS) components, that converts the generated DC power to usable AC power.

1 Energy Services MIR 2023: https://greencape.co.za/wp-content/uploads/2023/04/ES_MIR_2023_DIGITAL_SINGLES.pdf

Configuration

Within the municipal context, solar PV systems can be configured in two different ways:

1 Grid-tied with no battery storage

The solar system supplies power to the WWTW facility and feeds excess energy back into the grid.

2 Grid-tied with battery storage

The solar systems supplies power to the WWTW facility, charges the battery, and feeds excess power back into the grid. (refer to energy storage factsheet)

Space availability is a key consideration for the type of installation, and the different installation arrangements are given below.

- **Ground mounted systems:** Arrays are installed on mounting racks anchored to the ground. In scenarios where the municipality does not own the land area, lease agreements must be signed.
- **Floating solar systems:** Arrays are installed on mounting racks suspended over a body of water, such as a settling tank.
- **Rooftop mount systems:** Arrays installed on mounting racks mounted on the roof of a municipality-owned building near the WWTW facilities.

Ground mounted solar PV

Floating solar pilot

Rooftop solar PV

Installations are not limited to only one type of installation configuration. In space-constrained scenarios, hybrid configurations can be considered by combining the installation types listed above.

How can solar PV reduce the energy consumption of the plant?

Solar PV systems can power energy-intensive processes of the facility - effectively reducing energy consumption requirements from the utility and offsetting the municipality's energy bill.

Grid-tied with no battery storage

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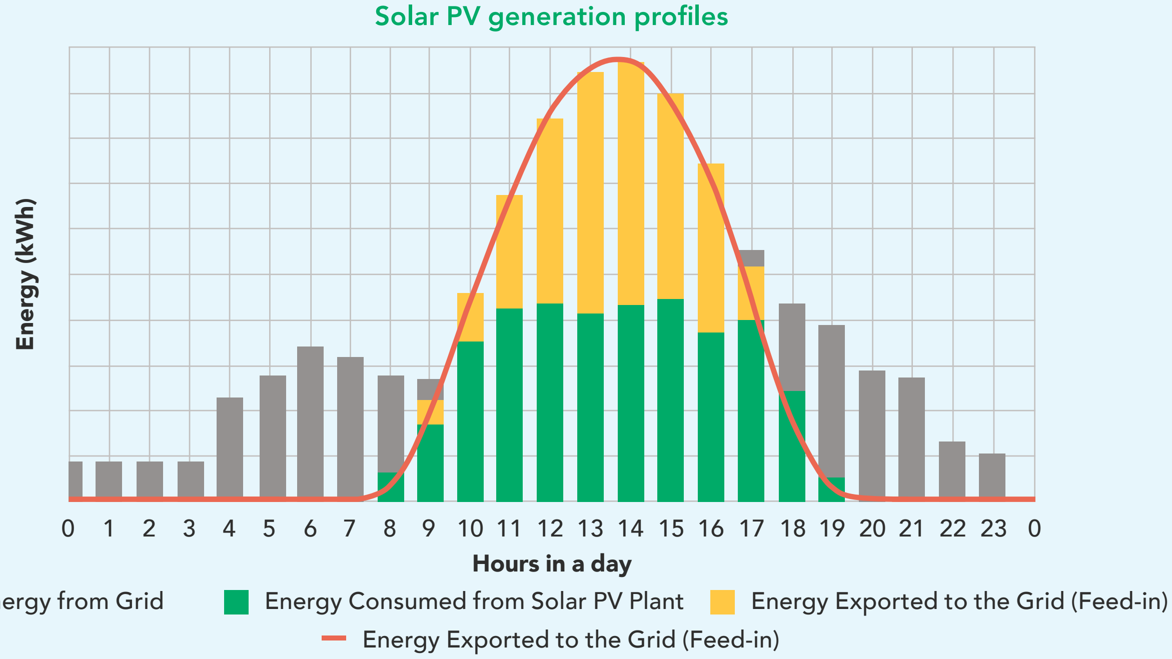
Generation patterns of a solar PV system

The figure below illustrates the typical generation pattern of a solar plant and how it supports the consumption requirements of the energy-intensive processes based on their varying load profiles.

TYPICAL DAY WITH A SOLAR PV SYSTEM: ENERGY CONSUMPTION AND GENERATION



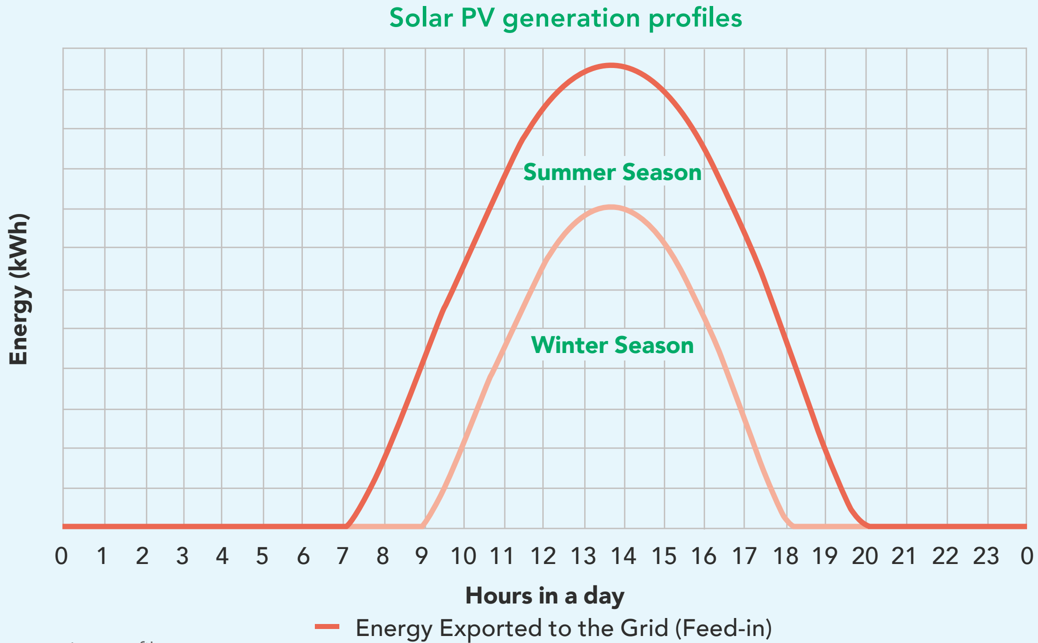


Figure 1: Solar generation profiles

Consider this technology if:

> An energy audit has been conducted, with all feasible interventions identified (refer to energy management and optimisation factsheet)

> There is interest in:

- Decarbonising the WWTW facility
- Reducing the operational cost of the WWTW facility
- Implementing measures to improve energy security

It's important to note that solar PV generation on its own won't protect against loadshedding, it would need to be combined with energy storage or diesel generation to create energy security

Business case

The expected financial metrics used to provide insights into the project's performance, costs and returns are shown below: [Energy Services Market Intelligence Report, Municipal PV Procurement Guideline]

Solar PV system excluding energy storage

- **Payback period range:** [4 to 8] years
- **IRR range:** [12 to 25]%
- **Typical capital cost of project range:** 10 000 R/kWh – 14 000 R/kWh
- **Fixed O&M costs 2% of capital costs**
- **Carbon emissions reduction range:** [1100 to 2100] kgCO_2 per KW per annum

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

- Conduct a comprehensive preliminary level 1 energy audit of WWTWs. [A detailed guideline for EE audits at WWTWs can be found (here)].
- Conduct a financial pre-feasibility study and identify a feasible financing model.
- Conduct technical pre-feasibility and feasibility study to outline sizing requirements for plant size.
- Ensure that all other energy efficiency interventions have been concluded or at least quantified (this could influence the future energy requirements which can influence the size of the installations).
- Conduct and map out technical design and specification requirements.
- Explore feasible procurement options.
- Conduct risk management assessment of each phase.

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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