# PRE-FEASIBILITY STUDIES IN FOURTEEN WASTEWATER TREATMENT PLANTS


mineral resources & energy
Department:
Mineral Resources and Energy
REPUBLIC OF SOUTH AFRICA

sanedi
South African National Energy Development Institute

# PRE-FEASIBILITY STUDIES IN FOURTEEN WASTEWATER TREATMENT PLANTS

# TABLE OF CONTENTS

# LIST OF ABBREVIATIONS

| | |
|---|---|
| **CBR** | Capacity Building Report |
| **DMRE** | Department of Mineral Resources and Energy |
| **EE** | Energy Efficiency |
| **EEDSM** | Energy Efficiency and Demand Side Management |
| **EU** | European Union |
| **GBS** | General Budget Support |
| **GIS** | Geographic Information Systems |
| **GPS** | Global Positioning System |
| **HVAC** | Heating, Ventilation and Air Conditioning |
| **M&V** | Measurement and Verification |
| **NEES** | National Energy Efficiency Strategy |
| **PV** | Photovoltaics |
| **SANEDI** | South African National Energy Development Institute |
| **WWTPS** | Wastewater Treatment Plants |

# EXECUTIVE SUMMARY

The Department of Mineral Resources and Energy (DMRE) and the South African National Energy Development Institute (SANEDI) is embarking on an energy performance contract for the implementation of high-efficient technologies in selected wastewater treatment plants. The project will contribute towards the achievement of net-zero energy of wastewater treatment plants (WWTPs) through the installation of energy efficiency and small-scale renewable energy including Biogas Combined Heat and Power system. The project is funded by the General Budget Support (GBS) through grant funding from the European Union (EU) and is aimed at improving the energy performance of WWTPs through the installation of energy -efficient technologies. Moreover, these measures are focused towards minimising supply interruptions, improving the efficiency of electricity usage, and possibly achieving net-zero energy of WWTPs.

This report outlines the overall objectives of the project, the scope of work, methodology, approach and the key data that was collected in each of the plants, analysis and recommendation for energy efficiency and renewable energy technologies. This report is supported by extensive data sheets and photo galleries used during the study. A total of 14 wastewater treatment plants were selected for the pre-feasibility studies, and Energo Power Solutions (Pty) Ltd was appointed to implement the pre-feasibility studies accordingly.

**Approach:** To implement the project, 14 WWTPs were selected as a start for the project where pre-feasibility studies were conducted, and data collected with regards to the plant description and physical location of the WWTPs, energy consumption per month (for the last 12 months), number of pumping stations, capacity (ML/day), tariff used (R/kWh), amount spent on energy consumption per month (for the past 12 months), installed technologies, presence of energy efficient technologies.

**Fieldworkers:** Twenty-eight (28) fieldworkers were appointed to support Energo Power in collecting and analysing data for the pre-feasibility studies. The 28 fieldworkers on this project were sought through the Department of Employment and Labour (DoEL) where three (3) candidates were shortlisted for interviews for the selection of the best two (2) candidates for each plant. The interview panel consisted of officials from the municipalities, SANEDI, GIZ and Energo Power Solutions. The role of fieldworkers included receiving training on energy efficiency and co-generation; conducting site assessments; collecting and capturing data; and drafting and presenting pre-feasibility reports on their respective plants. Of the fieldworkers that were appointed, 25 were youth and 16 were women.

**Mentors:** Seven (7) mentors from the DMRE and SANEDI were requested to support the appointed fieldworkers. The mentors were meant to guide and provide direction to the fieldworkers with the work being done on the WWTPs. Continuous communication was held with the fieldworkers to track the collection of the data and assist them if they encounter challenges.

**Findings of the study:** The key findings from the project are summarised in the tables below. Approximately 43% (six WWTPs) of the plants managed to provide the requested data. The data received indicate that in 93% of the plants (13 WWTPs), the aerators are the highest energy consumers followed by mixers and pumps. The study further found that the overall potential savings for the WWTPs are 10 244 MWh/a with a carbon dioxide ($CO_2$) offset of 11 042 tonnes/a. Potentially, installation of 250kW – 800kW grid-tie Photovoltaic (PV) systems could save 15 366 MWh/a with a $CO_2$ offset of 16 595 tonnes/a.

The report discusses all the relevant data collected for each WWTP and discussed details such as plant overview, plant treatment process description, energy data analysis, key plant findings, proposed hardware and retrofit for each WWTP, onsite energy production opportunities inclusive of greenhouse gas emission reductions and the relevant recommendations.

# CHIEF EXECUTIVE OFFICER'S FOREWORD

Project-specific collaboration between the South African National Energy Development Institute (SANEDI) and the Department of Mineral Resources and Energy (DMRE) is a key step towards a sustainable energy future for South Africa. This initiative exemplifies SANEDI's dedication to improving the country's energy landscape as it closely aligns with its vision of ensuring sustainable and inclusive energy development that influences energy policy goals in South Africa and beyond.

The future that SANEDI envisions is one in which technologies for sustainable energy development, promotes social well-being and economic prosperity. In line with the broader goal of guiding South Africa toward a more promising energy future, we continue to be unwavering in our commitment to supporting innovation and sustainable energy solutions.

A fundamental aspect of SANEDI's strategic plan, centres on the advancement of sustainable energy solutions through research, collaboration, and knowledge dissemination. The project detailed in this report underscores the commitment to innovation, seeking to optimise the energy performance of wastewater treatment plants (WWTPs) through the integration of energy-efficient technologies and renewable energy solutions.

This project adopts a comprehensive approach of strategically selecting fourteen (14) WWTPs to undergo pre-feasibility studies, to determine their status quo. These studies examine the energy consumption baseline of each treatment plant and the energy drivers. The extensive data collected forms the basis for our recommendations regarding sustainable energy solutions.

Projects of this nature provide an opportunity to address socio-economic issues faced in South Africa like high youth unemployment of qualified individuals. We therefore, through design, employed twenty-five (25) fieldworkers who were provided with energy training and given the crucial tasks of energy data gathering, site assessments, and baseline preparation. Out of twenty-five (25) fieldworkers, all of them were classified as youth, with 64% of female, demonstrating our dedication to inclusion, empowerment, and skills development.

In conclusion, the findings and recommendations reveal substantial opportunities for energy savings within WWTPs, particularly in energy-intensive equipment such as aerators, mixers, and pumps. The potential for reducing carbon dioxide (CO2) emissions is significant, and the installation of grid-tie Photovoltaic (PV) systems could further increase the efforts.

**Dr. Zwanani Titus Mathe**

Chief Executive Officer

South African National Energy Development Institute

# GENERAL MANAGER'S FOREWORD

In a joint effort, the South African National Energy Development Institute (SANEDI) and the Department of Mineral Resources and Energy (DMRE) reached a critical milestone with the completion of the pre-feasibility studies of fourteen (14) wastewater treatment plants. This report shows how committed we are to addressing high energy consumption through energy efficiency audits and interventions in wastewater treatment plants (WWTPs) in South Africa.

The projects described in this report, provide the energy consumption baseline (electricity) and potential savings which will ultimately inform the introduction of high-efficiency technologies within these fourteen (14) treatments plants. Furthermore, through the installation of energy efficient equipment and small-scale renewable energy technologies, such as solar PV, biogas and Combined Heat and Power (CHP) these projects hope to make a substantial contribution to the realisation of reduction of the energy in wastewater treatment.

This project was funded through the National Treasury General Budget Support (GBS) Programme, a grant scheme from the European Union, and is an example of global collaboration with a common understanding of sustainability. Beyond supporting infrastructural development, its goals also include municipal sustainability by introducing energy efficiency interventions within WWTPs.

Energy efficiency baseline assessments in fourteen (14) selected wastewater treatment plants for pre-feasibility studies were undertaken over a twelve (12) months period. SANEDI appointed Energo Power Solutions (Pty) Ltd to technically support the studies as wastewater treatment plants are complex systems.

In addition, SANEDI and the DMRE saw a need to address the unemployment rate within the various municipalities where the studies were carried out by appointing unemployed youth within the jurisdiction of where the plants are situated. Twenty-five (25) fieldworkers were appointed, and of those twenty-five (25), sixteen (16) are women. The fieldworkers made essential contributions to the data collection and analysis portion of the studies. These fieldworkers received mentorship from the DMRE and SANEDI, which contributed to the project's success.

A further section of this report provides readers with an in-depth insight into each WWTP assessed, including descriptions of the plants, findings on the consumption baseline, energy drivers, potential for renewable energy solutions and recommendations for energy-saving. The results also highlight the potential for a reduction of carbon dioxide (CO2) if projects are implemented based on a positive business case.

This study represents a commitment to developing a sustainable energy efficient future for South Africa. The findings and recommendations presented here have the potential to spur additional development and innovation in the fields of wastewater treatment and energy conservation. The role of strategic partnerships in transformative change is highlighted by the seamless collaboration between DMRE, SANEDI, Energo Power Solutions, municipalities and fieldworkers. It demonstrates the dedication to fostering thought leadership required to advance South Africa's energy transition as articulated in SANEDI's strategic mandate.

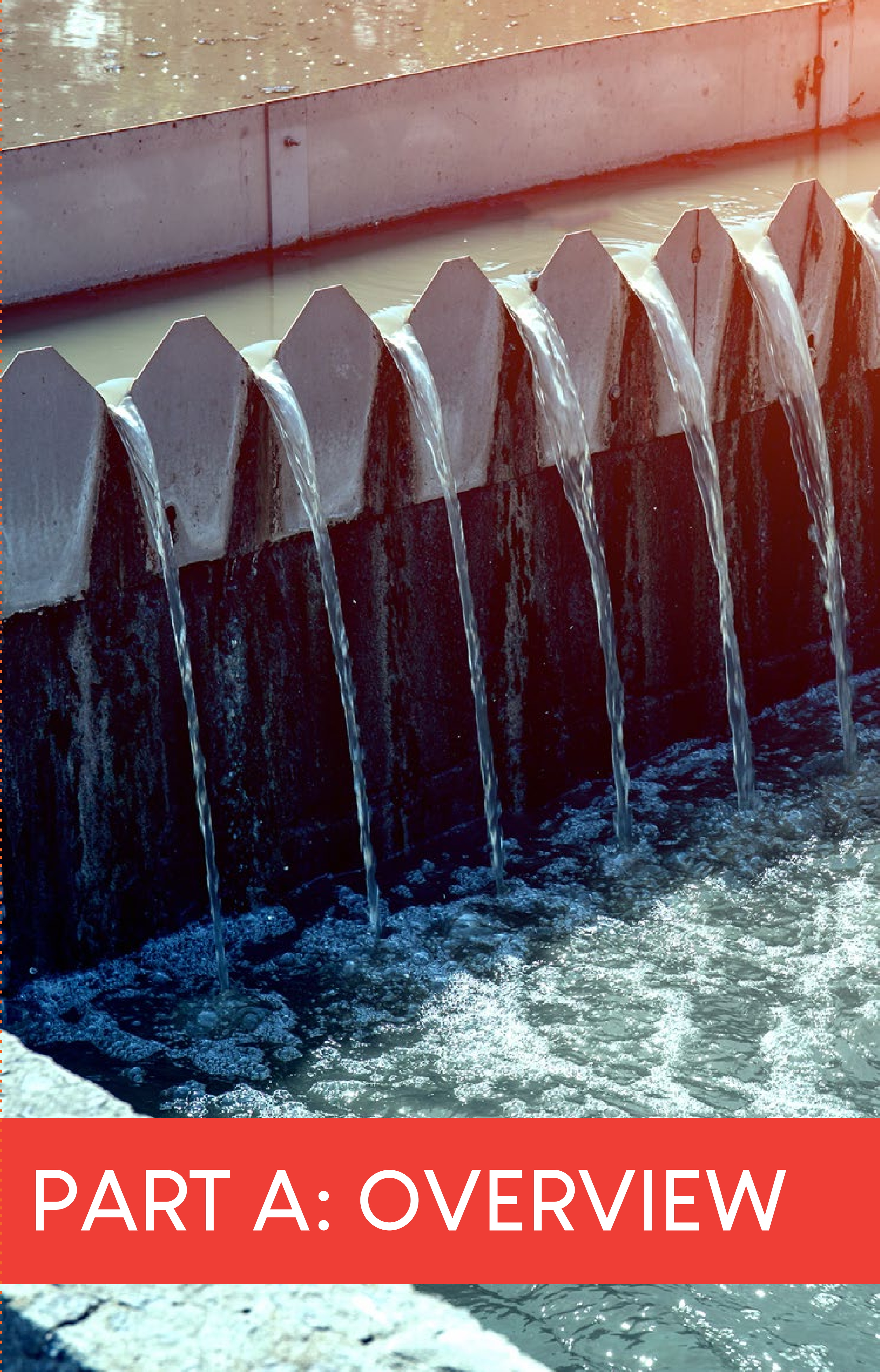
Lastly, I'd like to thank colleagues from the National Treasury, DMRE, SANEDI and participating municipalities, namely, City of Johannesburg, City of Matlosana, eThekwini Metropolitan Municipality, Emfuleni Local Municipality, EMthanjeni Municipality, iLembe District Municipality, JB Marks Local Municipality, Nelson Mandela Bay Metropolitan Municipality, Polokwane Local Municipality, and Thabo Mofutsanyana Local Municipality for their meaningful contribution to this study.

**Mr. Teslim Mohammed Yusuf**

Acting General Manager

Energy Efficiency

South African National Energy Development Institute



# PART A: OVERVIEW

# 1 INTRODUCTION

## 1.1 PROJECT INTRODUCTION

The 2007/2008 electricity crisis in South Africa led to an increase in the importance of energy efficiency (EE) in the country. Public sector facilities and operations are recognised by the World Energy Council as having significant opportunities for EE improvement (GIZ, 2012). The need for sustainable energy provision across the country has led to increased energy awareness across the sectors of the economy. This has also been necessitated by the increase in energy and fuel costs and growing environmental concerns and climate change. The need for energy efficiency and renewable energy sources cannot be over-emphasised due to the rapid increase in electricity tariffs as Eskom continues to request and apply escalation rates above the inflation rate. In that regard, it brings the WWTPs into the spotlight since they are the main energy consumers for the municipalities.

According to South African Cities Network (2014), WWTPs are one of the largest energy consumers within the municipal sector and they account for 17% of the total energy consumed by South African municipalities. Thus, optimising the energy efficiency of these facilities could result in a significant carbon footprint reduction, as well as operating cost savings.

As electricity is a critical input for delivering municipal water and wastewater services – usually representing around 30% of the costs of running the service – such costs often represent a high and even unsustainable operating cost (Feng et al. 20121). This sector has been shown to hold the greatest electricity savings potential within municipal operations and is thus a high priority for energy efficiency investment by municipalities (SACN, 2014). Efficiency measures can achieve savings of up to 25% within this area (Feng et al. 2012). Considering the age of the WWTPs in South Africa it is important to note that most plants have old equipment that was installed several years and even decades ago. Given that technologies are evolving with the years there lies several opportunities that can be implemented in WWTPs for energy efficiency and demand side management (EEDSM).

A study on South African metros indicated that this sector could contribute 48% towards all known electricity efficiency opportunities within the operations of a municipality (SACN, 2014). Given this savings potential, this sector should be viewed by municipalities as a high priority for energy efficiency investments, with the potential for high returns – saving the municipality money within an abbreviated period.

It is against this background that the Department of Mineral Resources and Energy (DMRE) conducted energy performance contracting for the implementation of high-efficient technologies in selected wastewater treatment plants with suitable Energy Service Companies (ESCOs) from an existing and approved panel of service providers. Moreover, the project will contribute towards the achievement of net-zero energy of WWTPs through the installation of energy efficiency and small-scale renewable energy including Biogas Combined Heat and Power system.

Energo Power Solutions was appointed to conduct pre-feasibility studies and collect and analyse data in these WWTPs to determine current energy consumption, and energy savings potentials that could be achieved with the installation of high-efficiency technologies such as LED lights, efficient motors, variable speed drives and solar PV systems, where applicable. To implement the project 14 WWTPs were selected as a start for the project where pre-feasibility studies were conducted, and data collected with regards to the plant description and physical location of the WWTPs; energy consumption per month (for the last 12 months); number of pumping stations, capacity (ML/day), and tariff used (R/kWh); amount spent on energy consumption per month (for the past 12 months); installed technologies; and the presence of energy efficient and renewable energy technologies. Also, the project is in line with the post-2015 National Energy Efficiency Strategy (NEES) and is expected to contribute to the target of a 20% reduction in energy intensity (measured as energy consumption per head of population served) of municipal services provision.

## 1.2 PROJECT OBJECTIVES

The overall objectives of the project were to:

- Conduct pre-feasibility studies;
- Collect and analyse data and information;
- Develop energy-saving project concepts in 14 WWTPs; and
- Map the 14 WWTPs using Geographic Information System (GIS) or related tools for ease of reference and identification.

## 1.3 SCOPE

The scope of work for the project included:

- Desktop review of existing information and data on the 14 WWTPs to assess data gaps and information.

- Confirmation of the data collection questionnaires.
- Design database or suitable data analysis tools.
- Design and align with existing reporting template to present collected information; and
- Recruitment of 28 fieldworkers (two fieldworkers per WWTP) to support the data collection process. SANEDI specified the requirements for the fieldworkers and the respective municipalities participated in selecting the fieldworkers.

## 1.4 PROJECT METHODOLOGY

The project was executed in 14 WWTPs across 11 municipalities in South Africa. A total of 28 fieldworkers were recruited to support the project in data collection and analysis. The fieldworkers were taken through an in-depth training on energy systems in a WWTP, data capturing and energy data required for the pre-feasibility studies. The data collected included the name plate data of WWTP machines, flow, electricity and/or energy consumption per month (for at least 12 months), number of pumping stations, capacity (ML/day), tariff used (R/kWh), the amount spent on energy consumption per month (for at least 12 months), and installed technologies on site (i.e., lights) not directly related to the WWTP. Customised data collection tools were used to collect the data onsite. The data was analysed for the purpose of determining the energy intensity per process within the plant and overall energy profiling for the plant. The collected data was also to develop energy efficiency and demand side management project concepts for the respective plants.

### 1.4.1 Energy audit

As part of the EEDSM project for the WWTP program, a walk-through audit of the treatment process was done where all the equipment involved in the processing of wastewater were visited and the specifications used to evaluate the energy usage. The collected data was analysed to develop EEDSM project concepts.

The walk-through audit was done by the fieldworkers with the support of the plant officials and municipal officials. Apart from the equipment specifications some operational data was provided by the operators at the plant.

### 1.4.2 Data collection

The process energy audit was completed by compiling plant description and physical location of the WWTPs, energy consumption per month (for the last 12 months), number of pumping stations, capacity (ML/day), tariff used (R/kWh), amount spent on energy consumption per month (for a period of 12 months), installed technologies, presence of energy efficient and renewable energy technologies. Plant operational data was also used to establish the different seasons of the year. Metering was deployed for real time data collection to support the name plate data collection.

Where available the fieldworkers reviewed equipment inventories to determine the age and power rating of plant equipment from the original design and any modifications or refurbishment to identify major energy consumers within the facility. This information was used to focus the project efforts on major energy-consuming processes within the plant to maximise energy reduction and savings opportunities. Based on the findings, terms of reference will be developed for energy savings potential within the WWTPs.

# 2 SETTING THE SCENE: LITERATURE REVIEW

## 2.1 INTRODUCTION

South Africa has built a substantial wastewater management industry that comprises approximately 970 treatment plants, extensive pipe networks and pump stations, transporting and treating an average of 7 589 000 kilolitres of wastewater daily (DWA, 2009). The country runs a prominent wastewater treatment business with a capital replacement value of greater than R23 billion and operational expenditure of more than R3.5 billion per annum. Frost and Sullivan (2006) estimate the value of the Republic of South Africa's water and wastewater treatment equipment market at US$ 135 million, with growth at 3.8%. This revenue share was split by the treatment segment at 34.5% water treatment, and 65.2% water treatment with an end producer breakdown as 44.2% municipal, 50.6% industrial and 5.2% commercial.

## 2.2 WWTPS IN SOUTH AFRICA

With the rising energy crisis in South Africa, various industries and households are forced to seek alternative energy sources to keep the lights on. These also need to be alternatives that decrease environmental impact, create energy awareness, and promote energy efficiency.  This awareness and the need for energy efficiency (EE) audits will increase as Eskom continues to request and apply escalation rates far above the inflation rate.

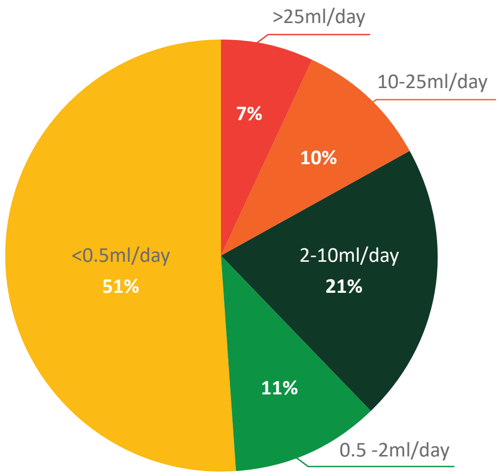
According to the Water Research Commission Report Wastewater Treatment Plants (WWTPs) have been highlighted as one of the major energy consumers in the municipal sector. Water supply and WWTPs use about 17% of the total energy used by South African municipalities. This number rises to 25% when simply taking electricity consumption into account. Power usage accounts for up to 30% of the overall operating costs of an activated sludge-type WWTP.

The majority of WWTPs in South Africa are outdated, utilising machinery that was put in place years or even decades ago. There are numerous options and new technology available to increase the energy efficiency of WWTPs. The potential to use the biogas produced by anaerobic digesters to produce energy further reduces WWTPs' carbon footprint.

Generally, WWTPs can be categorised in the following size categories:

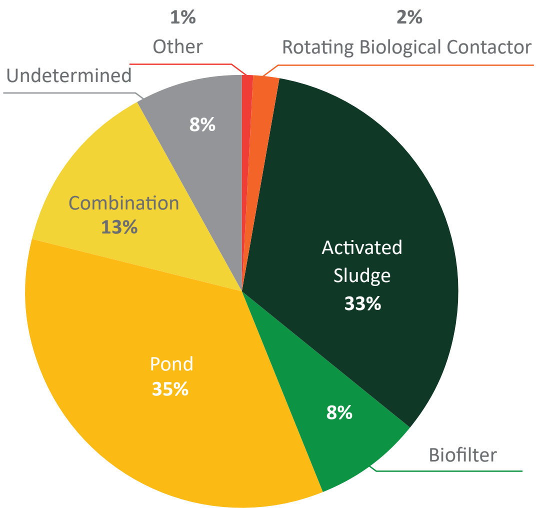
- Micro size plants <0.5 ML/day;
- Small size plants 0.5-2 ML/day;
- Medium size plants 2-10 ML/day;
- Large size plants 10-25 ML/day;
- Macro size plants >25 ML/day.

According to Water Research Commission, the Size Distribution of Wastewater Treatment Plants in South Africa was reported as in the figure below.

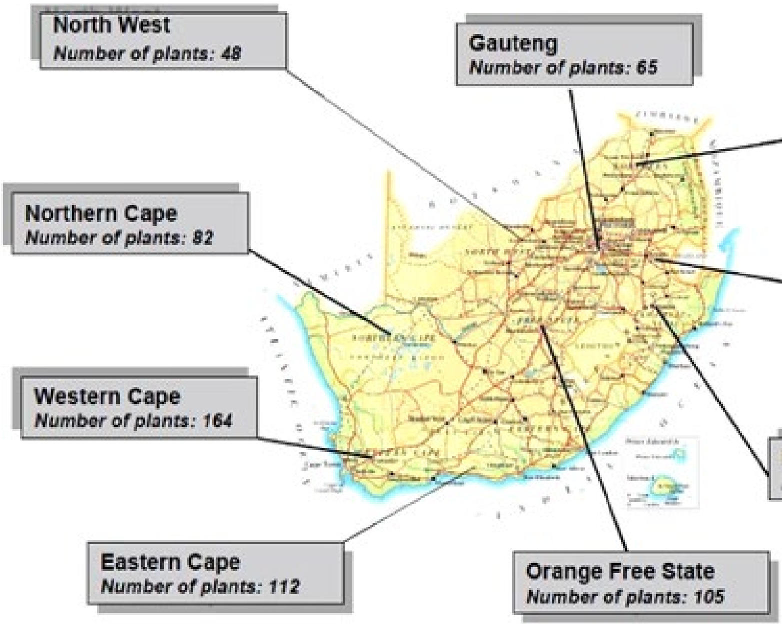



*Size Distribution of Wastewater Treatment Plants in South Africa*

Micro-size WWTPs, treating less than 0.5 ML per day, constitute 51% of all treatment plant facilities in South Africa. Based on this, it is important to note that in terms of selecting appropriate technology, management, operational, and maintenance support the numerous micro plants should not be ignored as they present considerable energy-saving opportunities. In addition, small plants ranging from 1 – 5 ML per day are also numerous and constitute as much as a quarter of all WWTPs in South Africa. This again constitutes many plants which fill a specific make in terms of management, operations, and maintenance. The medium and large plants category includes the other quarter of the wastewater treatment facilities in South Africa. The medium and larger plants would typically have access to better management, operations, and maintenance resources. The most commonly used wastewater treatment technologies in South Africa are activated sludge, bio/trickling filters, rotating biological reactors, wastewater ponds, membrane bio-reactors, wetlands and aerobic granular activated sludge. The figure below shows the range of wastewater treatment technologies that are mostly used in South Africa according to the Green Drop progress assessment of 2012 (DWA, 2012).



The WWTPs are distributed throughout the country and the levels of their operations vary. Generally, the treatment processes are similar throughout the country and they range from basic processes such as anaerobic ponds, and trickling filters to aeration basins to more developed enhanced biological nutrient removal (EBNR) systems (Lutchamma-Dudoo, 2010; Nozaic & Freese, 2009). Most WWTPs in South Africa are relatively small systems (500–2000 $m^3$/day). Ayoyi et al. (2015) outlined the distribution of WWTPs according to the provinces around the country as highlighted in the figure below.

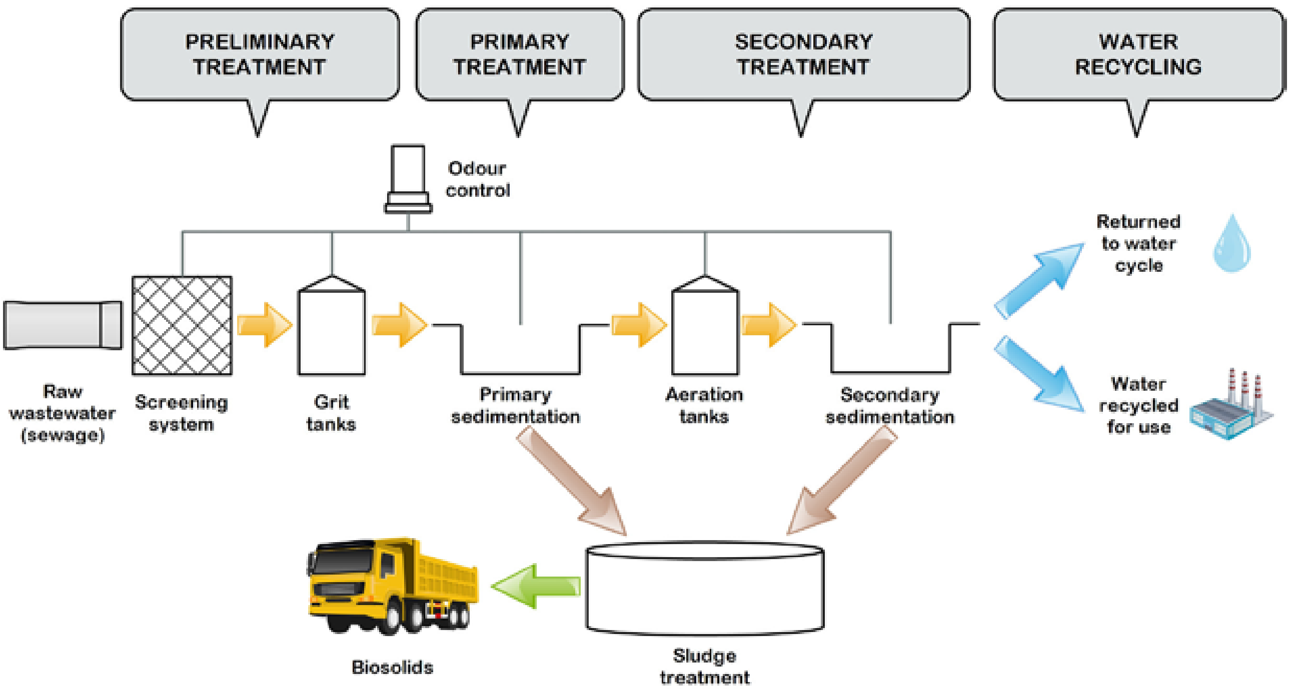



*Distribution Map of the Wastewater Plants*

More than 70% of South African wastewater treatment plants are either micro-, small-, or semi-sized (DWA, 2012; Ntombela et al., 2016). Some plants are required to treat specific wastewater e.g., most waste stabilisation ponds in hospitals only treat wastewater from the hospital. Others are designed to treat domestic and stormwater while some are for industrial wastewater treatment.

## 2.3 WWTP PROCESSES

A simplified schematic for an activated sludge WWTP wastewater treatment process is shown in the figure below.



### 2.3.1 Inlet works

Bulk solids from the influent are first removed at the inlet works under the primary treatment where screening takes place. The screening of the wastewater can either be done manually or mechanically. According to some studies, mechanical screens have typical power requirements of 0,010 kWh/m3. Screening typically comprises of a coarse screen with large apertures (up to 25 mm) between the screen bars, followed by fine screens with 3-6 mm apertures between the screen bars designed to capture large and small objects respectively.

### 2.3.2 Grit removal

After screening, the wastewater is channelled to grit removal sections, where in most cases vortexes are used for grit to settle at the bottom of the tanks before the influent is taken to the primary sedimentation.

### 2.3.3 Primary sedimentation

The primary sedimentation stage removes a fraction of the organic components present in the influent before secondary treatment. In the Primary Sedimentation Tanks (PSTs) heavier solids are allowed to settle at the bottom of the tanks through gravity after which the solids are pumped to the sludge processing facility.

### 2.3.4 Secondary treatment

This process constitutes the aeration basins and the secondary sedimentation tanks. As reported in the literature, this section is the most energy intensive process within a WWTP consuming about 40 – 80% of the total energy consumed by the plant and is mainly dominated by the activated sludge process (ASP) which is a biological process of developing an activated mass of microorganisms capable of stabilising waste aerobically. Organic waste is introduced into a reactor where a bacterial culture (biomass) is maintained in suspension. The reactor content is referred to as the 'mixed liquor' or activated sludge. The process of aeration involves forcing oxygen into the wastewater and can be achieved by surface aerators or by diffusers. Surface aerators are mounted in the aeration basin on the surface of the water (see pictures below), aeration is achieved through the rotation of blades creating some water droplets to get into contact with air Alternatively, air can be blown into the reactor by a blower (picture on the right). The air bubbles then move upwards through the water, and oxygen dissolves from the bubbles into the water.

During these two processes (aeration and secondary sedimentation) sludge flow is produced. The sludge is sent to a sludge treatment stage through anaerobic digestion to produce biogas, after which it is stabilised and dried for agricultural purposes, construction, or dumped in landfills (Bachmann, 2015). The treated wastewater is then taken for disinfection before it can be released into the environment or reused in industry.

# 3 PROJECT STAKEHOLDERS

## 3.1 DMRE

The Department of Mineral Resources and Energy was merged on the 29th of May 2019 by President Cyril Ramaphosa. The existence of the Department of Mineral Resources and Energy is premised on its vision of becoming a leader in the transformation of South Africa's economic growth agenda through the sustainable development of the mining and energy sectors.

The Department of Mineral Resources and Energy's aim is to develop a mineral resources and energy sector that promotes economic growth and development, social equity and environmental sustainability and mission is to regulate, transform and promote the minerals and energy sectors, providing sustainable and affordable energy for growth and development, and ensuring that all South Africans derive sustainable benefit from the country's mineral wealth.

## 3.2 SANEDI

The South African National Energy Development Institute (SANEDI) was established in 2011 under the National Energy Act No. 34 of 2008. The Act provides for SANEDI to direct, monitor, conduct and promote energy research, development, and technology innovation. Furthermore, it enables SANEDI to undertake measures to foster energy efficiency throughout the economy.

SANEDI's focus is to develop innovative, integrated, clean energy and resource efficient solutions to catalyse growth and prosperity. As technologies develop and mature, opportunities for meaningful innovative energy solutions are critical for improving energy access and minimising the country's carbon footprint.

The institute operates in a global context shaped by several megatrends including climate change, urbanisation, demographic shifts, Fourth Industrial Revolution (4IR) and growing inequalities. We have shaped programmes of action and have adopted three themes to strengthen and drive our mandate. These are: Climate Change and Decarbonisation, Service Delivery within the Municipal Environment, and Information Knowledge (Data and Knowledge Management) and Technological Convergence.

## 3.3 ENERGO POWER SOLUTIONS

Energo Power Solutions Consultancy is an initiative whose main foundation is derived from the past experience of both strong research-based consultant work. The Energo Team is comprised of experts who have been in the energy fraternity for over 12 years conducting both research and contract work to a variety of clients.

Energo Power Solutions Consultancy's vision is to be a leading energy solutions provider, driving sustainable and efficient energy practices across various sectors and their mission is to deliver innovative and tailored energy solutions to our clients, leveraging our expertise and research-based consultancy background.

## 3.4 PROJECT TEAM

### XOLILE MABUSELA

| | |
|---|---|
| **Organisation** | Department of Mineral Resources and Energy |
| **Job Title** | Director for Energy Efficiency Projects |
| **Role Played in Project** | Overall Supervisor for the European Union Achieving Net-zero Energy of Wastewater Treatment Plants Project |
| **Qualification/s** | Master of Business Administration (MBA) (University of KwaZulu-Natal) |

His goal is to continue contributing to energy security and integrating energy efficiency as a response to the national and global energy crisis. He is motivated by his daily activities, which include working on reducing dependence on the electricity grid, contributing to the reduction of carbon emissions, and ensuring minimum energy poverty.

## BRENDA PHAHLAMOHLAKA

| | |
|---|---|
| **Organisation** | Department of Mineral Resources and Energy |
| **Job Title** | Assistant Director at the Department of Mineral Resources and Energy |
| **Role Played in Project** | Project Manager for the European Union Achieving Net-zero Energy of Wastewater Treatment Plants Project |
| **Qualification/s** | Bachelor's Degree in Environmental Management (majoring in chemistry and environmental) |

**The importance of these types of projects for South Africa's energy future and how it will contribute to greater efficiency, reduced emissions and a greener economy and society.**

Awareness and educating people on energy efficiency is important. The projects that we are doing are benefiting the community at large through training and youth job creation.

**What are the key takeaways in the prefeasibility studies project?**

- The lessons learnt in terms of data collection. I can say we now know how to approach data collection for future projects.
- Communication is key.
- We must always have clear goals and passion must be at the fore front of everything we do.
- Data is critical in the energy space for the purpose of planning and allocations.

## LEBOGANG MOSENTHAL

| | |
|---|---|
| **Organisation** | Department of Mineral Resources and Energy |
| **Job Title** | Project Manager: Renewable Energy |
| **Role Played in Project** | Project Manager for the Prefeasibility Studies in 14 WWTPs |
| **Qualification/s** | Honours in Energy Studies (University of Johannesburg) |

**The importance of these types of projects for South Africa's energy future and how it will contribute to greater efficiency, reduced emissions and a greener economy and society.**

My work is important because some of the projects I am involved in contribute towards reduction of energy consumption and promotion of alternative energy sources as part of a way to address the country's energy challenges. It helps to improve quality of life of some of communities, through provision of access to alternative energy.

**What are the key takeaways in the prefeasibility studies project?**

If majorities of municipalities can prioritise the WWTPs and where possible convert them to combined heat and power, they may realise an energy savings from municipal buildings. It is very crucial to maintain the WWTPs and retrofit them such that they operate in a high efficiency way.


## NTSIKELELO MKHITHIKA

| | |
|---|---|
| **Organisation** | Department of Mineral Resources and Energy |
| **Job Title** | Project Coordinator: Energy Efficiency Projects |
| **Role Played in Project** | Mentor for Fieldworkers in eMthanjeni municipality |
| **Qualification/s** | Degree in Developmental Studies (North West University) |

**The importance of these types of projects for South Africa's energy future and how it will contribute to greater efficiency, reduced emissions and a greener economy and society.**

There so many projects that the Department and its partners are implementing that contribute largely to greater energy efficiency. There is EEDSM grant that is allocated to municipalities to change/replace the old and outdated technologies in their infrastructure in terms of public lighting and wastewater treatment plants. These initiatives contribute immensely to the reduction of greenhouse gases.

**What are the key takeaways from in the pre-feasibility studies project?**

The biggest takeaway was giving the 28 fieldworkers an opportunity to be involved in the projects in nine different sites. The pre-feasibility of the WWTPs was also an opportunity for us get the projects that have potential in terms of replacement of old technologies. By changing old technologies, one is contributing towards reducing emissions.

## NELSON NTLOU

| | |
|---|---|
| **Organisation** | Department of Mineral Resources and Energy |
| **Job Title** | Electrical Engineer |
| **Role Played in Project** | Mentor for Fieldworkers in Emfuleni , Rand West and City of Johannesburg municipalities |
| **Qualification/s** | BSc in Electrical Engineering (University of Cape Town) |

**The importance of these types of projects for South Africa's energy future and how it will contribute to greater efficiency, reduced emissions and a greener economy and society.**

My work helps me to coordinate in the space of policy decisions, renewable energy initiatives and municipal service delivery. Also, direction setting for the energy sector.

**What are the key takeaways in the prefeasibility studies project?**

I learnt more about project coordination and people management.

## TESLIM YUSUF

| | |
|---|---|
| **Organisation** | South African National Energy Development Institute |
| **Job Title** | Acting General Manager for Energy Efficiency |
| **Role Played in Project** | Overall Supervisor for the European Union Achieving Net-zero Energy of Wastewater Treatment Plants Project |
| **Qualification/s** | Masters in Engineering Management (University of Pretoria) |

Among a myriad of tasks, his role is rooted in activating South Africa's National Energy Efficiency Strategies. These seek to reduce South Africa's greenhouse gas emissions and see the country through a just and sustainable energy transition that as set out in our mitigation targets stated within Nationally Determined Contribution (NDC) of 2016.

## NQOBILE NGCOBO

| | |
|---|---|
| **Organisation** | South African National Energy Development Institute |
| **Job Title** | EPC Programme Lead |
| **Role Played in Project** | Project Manager for the European Union Achieving Net-zero Energy of Wastewater Treatment Plants Project and Mentor for Fieldworkers in Dihlabeng Local Municipality. |
| **Qualification/s** | Currently pursuing Advanced Diploma in Engineering Technology (University of South Africa, Unisa) |

**The importance of these types of projects for South Africa's energy future and how it will contribute to greater efficiency, reduced emissions and a greener economy and society.**

Energy conservation and energy efficiency are the first stepping stones in addressing climate change. Collecting energy data and conducting awareness and training sensitises the recipient in becoming more energy conscious thus conserving. This energy data that was collected will now be used to inform policy and implementation of energy efficiency interventions within infrastructure such as buildings and wastewater treatment plants.

**What are the key takeaways in the prefeasibility studies project?**

My key takeaways are to acknowledge the importance of data and the lives who were impacted during this project. The collection, analysis and modelling of data within the wastewater treatment plants will allow us to inform policy and also implement energy efficiency. This project also gave jobs to 28 unemployed, qualified youths with National Diplomas, Bachelors and Honours in the STEM fields. This contributed to the decrease of the unemployment rate.

## ROSELINE SANDAMELA

| | |
|---|---|
| **Organisation** | South African National Energy Development Institute |
| **Job Title** | Junior Data Analyst |
| **Role Played in Project** | Project Manager for the Prefeasibility in 14 WWTPs and Mentor for Fieldworkers in Nelson Mandela Bay Municipality |
| **Qualification/s** | Bachelor of Engineering Technology Honours in Industrial Engineering (University of South Africa) |

**The importance of these types of projects for South Africa's energy future and how it will contribute to greater efficiency, reduced emissions and a greener economy and society.**

The projects that we do helps to increase efficiency which essentially lowers the greenhouse gas emissions. They also have economic benefits such as capacity building and job creation.

**What are the key takeaways from in the pre-feasibility studies project?**

In order for us to get to a net zero economy, we need all hands on deck, so team work is essential.

Implementation of energy efficiency should start with the low hanging fruits with low investments such as replacing of inefficient light and optimising operational processes.

## KWENA LEFOKA

| | |
|---|---|
| **Organisation** | South African National Energy Development Institute |
| **Job Title** | Junior Data Analyst |
| **Role Played in Project** | Project Support and Mentor for Fieldworkers in eThekwini and iLembe Municipalities |
| **Qualification/s** | BSc (Honours) in Statistics |

**The importance of these types of projects for South Africa's energy future and how it will contribute to greater efficiency, reduced emissions and a greener economy and society.**

The importance of energy efficiency projects contributes to South Africa's energy future as the more energy efficient the facilities, the less power demand and carbon emissions.

**What are the key takeaways in the prefeasibility studies project?**

1. Proper planning and teamwork enhance work efficiency and prevents poor performance.

2. Data readiness increases data maturity and integrity.

3. Data collection in WWTPs was beneficial as the data collected was analysed to provide factual insights on energy consumption, potential energy saving and cost reductions.

4. Data collected in WWTPs did not only assist on the insights mentioned above, but it also assisted in municipal officials to identify operational problems and make informed decisions.

## PROF. MICHAEL SIMON

| | |
|---|---|
| **Organisation** | Energo Power Solutions |
| **Job Title** | Founder and Director |
| **Role Played in Project** | Project Manager for Energo Power Solutions |
| **Qualification/s** | PhD in Photovoltaics (Energy Performance Monitoring) |

Prof. Simon has evaluated and audited more than 200 measurement and verification projects in both energy efficiency and renewable energy technologies. He has vast expertise in data acquisition and analysis and showcases an extensive project management experience and has in depth experience in Photovoltaic system design and installations.

## DR RUSSEL MHUNDWA

| | |
|---|---|
| **Organisation** | Energo Power Solutions |
| **Job Title** | Engineering Manager |
| **Role Played in Project** | Responsible for energy audit and energy efficiency training, coaching, and mentoring of the fieldworkers |
| **Qualification/s** | PhD in Physics (majoring in Energy Efficiency) |

Dr Mhundwa's experience includes but not limited to design, implement and operation of solar photovoltaic systems, heat pumps, solar water heaters and measurement and verification. He is an expert in designing and installation of data acquisition systems for performance monitoring of complex energy systems and energy users for any sector of the economy.

## 3.5 FIELDWORKERS

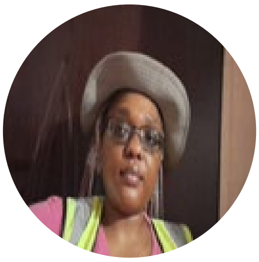
A total of 28 fieldworkers were appointed to support Energo Power in collecting and analysing data for the pre-feasibility studies. The role of fieldworkers included:

- To receive training on energy efficiency and co-generation;
- To conduct site assessments, collect and capture data; and
- Draft and present pre-feasibility reports on their respective plants.

The 28 fieldworkers on this project were sought through the Department of Labour (DOL) where three (3) candidates were shortlisted for interviews for selection of the best two (2) candidates for each plant. The interview panel consisted of officials from the Municipality, SANEDI and Energo Power Solutions.

### 3.5.1 Fieldworker profiles

#### KELETSO LESUTHU



| | |
|---|---|
| **Age** | 27 |
| **Home Language** | isiZulu |
| **Highest Qualification** | Bachelor's Degree: Environmental Science |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | More than 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Southern Wastewater Treatment Plant

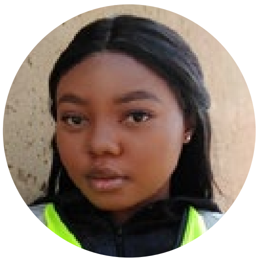
**How was your overall experience during this prefeasibility studies project?**

Enlightening with a few hurdles. It was enlightening because it was an opportunity to learn about WWTPs. The hurdles were how difficult it was to receive some of the requested information. Overall, the experience was educational.

**What were your highlights and challenges of working as a fieldworker?**

Seeing the WWTP in action and having a job. Challenges included having to do most of the data capturing and analysis. My project partner did not have a laptop.

#### LUYANDA MACHEKE



| | |
|---|---|
| **Age** | 23 |
| **Home Language** | isiZulu |
| **Highest Qualification** | Bachelor's Degree |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Randfontein WWTP.

**How was your overall experience during this prefeasibility studies project?**

It was good, I learnt a lot during this time.

**What were your highlights and challenges of working as a fieldworker?**

Going to the plant and learning how water is treated and how to deal with data. The plant is not easily accessible which was difficult.

## THINA NGCAKU

| | |
|---|---|
| **Age** | 24 |
| **Home Language** | isiXhosa |
| **Highest Qualification** | National Diploma: Civil Engineering |
| **Other Qualifications** | N2 Bricklaying and Plastering |
| **Current Position** | Fieldworkers |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | More than 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Fishwater Flats Wastewater Treatment Plant. The plant is in Port Elizabeth under Nelson Mandela Metropolitan Municipality. It treats both domestic and industrial wastewater.

**How was your overall experience during this prefeasibility studies project?**

The experience was quite challenging but very educational.

**What were your highlights and challenges of working as a fieldworker?**

Conducting data collection and analysis. Receiving data from the municipal officials on time and accessing some of the buildings due to flooding of the wastewater and cable theft.

## ANELE GODZE

| | |
|---|---|
| **Age** | 27 |
| **Home Language** | isiXhosa |
| **Highest Qualification** | National Diploma: Civil Engineering |
| **Other Qualifications** | N4: Electrical Engineering |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

City of Matlosana- Stilfontein Wastewater Treatment Plant, one of the smallest plants in the municipality of Matlosana with a capacity of 12ML at a flow rate of 8.

**How was your overall experience during this prefeasibility studies project?**

It was challenging, due to missing data and information from the municipality. Most of the equipment was not working, motors had no nameplate and it was a great challenge auditing electrical equipment. Other than all these challenges the project was a great experience for me, I learned a lot as a graduate with no experience. This project has offered me working experience and practical skills that I can utilise in my near future.

**What were your highlights and challenges of working as a fieldworker?**

- Being creative and optimistic
- Critical thinking
- Problem solving
- Challenges: Compiling reports with missing information
- Unavailable data and information from the municipality
- Vandalised and non-functional equipment.
- Missing nameplates for auditing

## KGOTSO MPEKO

| | |
|---|---|
| **Age** | 26 |
| **Home Language** | Sesotho |
| **Highest Qualification** | Grade 12/ currently completing degree in Chemical Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? and provide a short description of the WWTP?**

Stilfontein Wastewater Treatment Plant. It treats both industrial and domestic wastewater. It was also cleaning AngloGold Ashanti wastewater from Vaal Reefs, but since the mines were sold to Harmony the WWTP no longer treats the mining waste water.

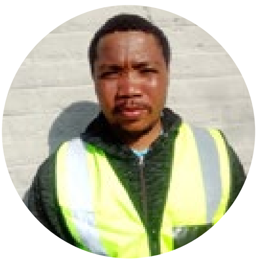
**How was your overall experience during this prefeasibility studies project?**

It was magnificent as during the course of my degree I had to deal most with purification of process water which had a similar process as of the WWTP. I also got to learn the process of energy auditing, the importance of it and how energy saving can be of great help for our nation grid.

**What were your highlights and challenges of working as a fieldworker?**

Seeing how we can improve our WWTP. Having to go through the process of energy audit and the data processing of all the collected data. Finally, a chance to interact with so many intelligent personnel in both private and government sectors. Dealing with different people who have different personalities. One might think it was going to be easy to collect data from people, but it is one hell of a job to do. Having to learn how to approach each one of them, it requires a lot from you as a fieldworker and sometimes it might lead to you feeling like you aren’t doing your job.

## HENDRY LOUW



| | |
|---|---|
| **Age** | 36 |
| **Home Language** | Afrikaans |
| **Highest Qualification** | N6 Diploma |
| **Other Qualifications** | N2 Engineering |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | 2 – 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

De Aar Emthanjeni Municipality WWTP, it is located in the northern part of the town. The plant services the town, industry and Ammunition Depot outside the town.

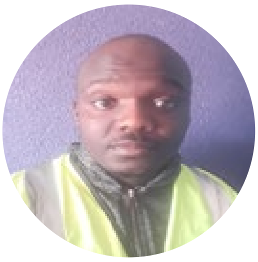
**How was your overall experience during this prefeasibility studies project?**

I experienced that water is one of the main expects in life that cannot be wasted. I learnt a lot about energy and how you can save energy. There are alternative ways to save and create energy. I discovered that water can be re-used if treated well.

**What were your highlights and challenges of working as a fieldworker?**

Operating the equipment and controlling the flow and collecting data from equipment. Transport to site was a challenge, had to make use of private transport that sometimes failed to transport you.

## THABANG MOLETSANE



| | |
|---|---|
| **Age** | 27 |
| **Home Language** | Setswana |
| **Highest Qualification** | N6 Diploma: Electrical Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | 2 – 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Potchefstroom Wastewater Treatment Plant on the southern side of the city.

**How was your overall experience during this prefeasibility studies project?**

I enjoyed working in a team environment, and being able to get along well with process controllers. And I managed to build a work relationship with them and that helped me to adapt to the environment and made my work easy to execute. Mainly my communication with my working partner and process controllers was strong, and helped me to keep calm and work smart.

**What were your highlights and challenges of working as a fieldworker?**

Getting the opportunity to learn and gain knowledge about how energy is used and how to use energy efficiently. Working with a plant supervisor who gave every information to every question asked about the plant. Gaining experience and certificates for the entire project. Losing data several times and have to start all over again. Being referred when we were supposed to get required information and have to wait for some time.

## NOMALANGA KHESWA

| | |
|---|---|
| **Age** | 23 |
| **Home Language** | Sesotho |
| **Highest Qualification** | N6 Diploma: Electrical Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Bethlehem WWTP, a Class B plant situated at a portion of the Pretoriuskloof farm. It is currently running at 19ML/day capacity. The plant caters for both domestic and industrial waste water with the help of ten service pumpstations. It is the main sewer works in Bethlehem, Bohlokong and Bakenpark.

**How was your overall experience during this prefeasibility studies project?**

It was an eye-opening experience. One of the most humbling opportunities I ever came across and I can safely attest to being an energy savvy individual now.

**What were your highlights and challenges of working as a fieldworker?**

My greatest highlight was being on the ground and experiencing first-hand the operations of the wastewater treatment plant, the link between the different processes through to the final stage. Being able to put all that data on paper and analysing the trends and relationships of the variables involved.

Acquiring data from the municipal officials. Capturing data on the KoBo ToolBox. It was also challenging on some instances to capture nameplates of certain motors as they were in odd places or not there at all.

## LUFUNO MAMEDZI

| | |
|---|---|
| **Age** | 29 |
| **Home Language** | Tshivenda |
| **Highest Qualification** | National Diploma: Electrical Engineering |
| **Other Qualifications** | Certificate: Water conservation & demand management |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | 2 – 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Sebokeng WWTP is located in Sebokeng, classified under Class A. It has been registered for the operation of water care works used for purification, treatment or disposal of effluent. The plant capacity is 150ML/day and the plant is treating domestic water.

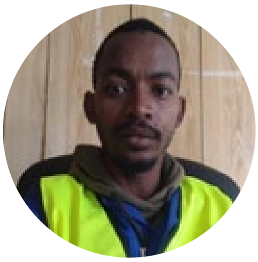
**How was your overall experience during this prefeasibility studies project?**

The experience has been great and amazing. Getting to know amazing young people with different personalities showing their dedication to this project. Also not forgetting skills and the knowledge gained on this project.

**What were your highlights and challenges of working as a fieldworker?**

Learning about energy efficiency and energy efficiency equipment, how the plant operates. Collecting and analysing data as well as presenting was something that I only learnt through this project; it was not easy at first but with time it got better. My co-worker not having a laptop has made it challenging for me, having to do everything alone.

## KABELO MAREDI



| | |
|---|---|
| **Age** | 33 |
| **Home Language** | Sepedi |
| **Highest Qualification** | Bachelor's Degree: Industrial Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | More than 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Potchefstroom WWTP that is based south of the city has two flow processes that spilt into the new works and old works after the inlet. These processes do the same thing but differ in size.

**How was your overall experience during this prefeasibility studies project?**

It was a good experience and I got to learn new things.

**What were your highlights and challenges of working as a fieldworker?**

Analysis of the data and also the hands-on work when assisting the operators. Challenges included finding the required information and data not appearing after being captured.

## MEDUPI MAKEKETLANE

| | |
|---|---|
| **Age** | 33 |
| **Home Language** | Sepedi |
| **Highest Qualification** | National Diploma: Civil Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | More than 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Olifantsvlei Wastewater Treatment Plant, it is located in southern part of City of Johannesburg.

The municipal-owned entity treats all domestic sewage and industrial effluents released into sewers; The capacity of the plant is 240ML. The actual capacity of the plant is 170-210ML/day.

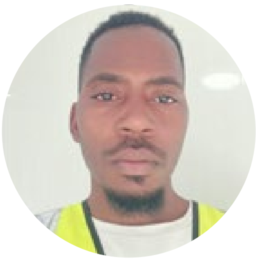
**How was your overall experience during this prefeasibility studies project?**

Overcome challenges on site, leadership, working on spreadsheet as we capture data, learning on doing presentation and presenting on the findings reports.

**What were your highlights and challenges of working as a fieldworker?**

Capturing data and presentation. The plant was big and took us two to three days to understand and plan on how to tackle the collection of data. Presentation, having to compile everything together and presenting two plants. Challenges included not having enough equipment to capture data, like laptop. Not having proper timesheet for daily transport as we went to two different plants, Olifantsvlei and Ennerdale. Stipend was not enough as we travelled and buying data for meetings online.

## FORGET SELOWA



| | |
|---|---|
| **Age** | 32 |
| **Home Language** | Xitsonga |
| **Highest Qualification** | National Diploma: Electrical Engineering |
| **Other Qualifications** | Electrical trade test |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | More than 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Sebokeng Wastewater Treatment Plant is a class A works which operates under Emfuleni Municipality.

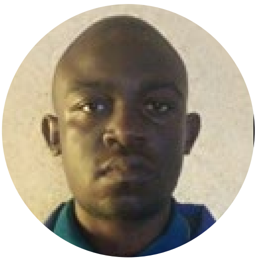
**How was your overall experience during this prefeasibility studies project?**

It was great and interesting.

**What were your highlights and challenges of working as a fieldworker?**

To be in the plant, walking around the plant capturing data. I experienced no challenges.

## NHLAMOLO MATHEBULA



| | |
|---|---|
| **Age** | 26 |
| **Home Language** | Xitsonga |
| **Highest Qualification** | Degree: Chemical Engineering |
| **Other Qualifications** | National Diploma: Chemical Engineering |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | 1 year and 6 months |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Doornkraal Wastewater Treatment Plant. The plant is located in Polokwane and it is the largest wastewater treatment plant in Polokwane with an upgraded capacity of 36 ML/day from 25 ML/day. It is registered as a Class A facility, and it treats both domestic and industrial wastewater.

**How was your overall experience during this prefeasibility studies project?**

My overall experience during the prefeasibility studies project was beneficial for me as I learnt much about public speaking, collaboration, and teamwork. Furthermore, I would like to offer gratitude to SANEDI, DMRE, Energo, Polokwane Municipality, and Doornkraal Wastewater Treatment Plant for granting me an opportunity to acquire knowledge and experience as well as exercise my attributes and skills throughout the energy efficiency prefeasibility studies project.

**What were your highlights and challenges of working as a fieldworker?**

**I** acquired knowledge and experience on how a WWTP operates through Doornkraal Wastewater Treatment Plant Officials, and on ways of saving energy through energy efficiency trainings that were held with Dr. Russel (Field Manager at Energo Power Solutions Consultant (Pty) Ltd.) and Prof. Raj Naidoo (Professor at University of Pretoria). My challenges of working as a fieldworker were communication and delay of personal protective equipment (PPE). I experienced communication challenges due to a speech disorder that I suffer from, which hindered my ability to speak fluently with my colleagues. There was a challenge with PPE that hindered me to commence with energy data collection at the plant. The basic PPE I received from my employers did not coincide with the basic PPE that was required at the plant. I was unable to collect energy data at the plant and only received the required basic PPE at the plant from the employers later.

## SEDUPA MASENYA

| | |
|---|---|
| **Age** | 45 |
| **Home Language** | Sepedi |
| **Highest Qualification** | Bachelor’s Degree: Water and Sanitation |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | 2 -3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Ennerdale Wastewater Treatment Plant

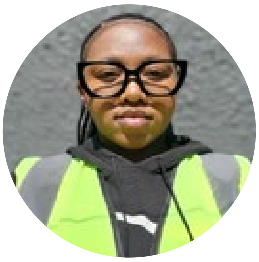
**How was your overall experience during this prefeasibility studies project?**

Good and I have learned a lot through the project.

**What were your highlights and challenges of working as a fieldworker?**

Experience in doing oral presentation and doing field work. The breaking down of the communication.

## MADIKETSO KAMOELO



| | |
|---|---|
| **Age** | 28 |
| **Home Language** | Sesotho |
| **Highest Qualification** | National Diploma: Electrical Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than a year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Bethlehem Wastewater Treatment Works, known as Bethlehem Sewers located 3km north of the central business district in the southern parts of the industrial area. Classified as Class B with design capacity of 26ML/day. It is the largest WWTP and forms sewage works in Bethlehem, Bohlokong and BakenPark with a population of roughly 100 000 people.

**How was your overall experience during this prefeasibility studies project?**

Excellent, I have gained experience about motors, the importance of name plates, using meters, how to analyse results and mostly about wastewater treatment plants of which I never had any interest of before. I now know a lot about energy efficiency, consumption, and conservation and this will really help me in my career.

**What were your highlights and challenges of working as a fieldworker?**

Being given the opportunity to present my findings. Sharpening my presentation skills and report writing skills were my highlights as a fieldworker. One of the main challenges was not getting the required data from the municipality. I personally don't like to waste my time and effort. You will go to work expecting to get documents and you will not get them or wait for them the whole day. Unproductive days were one of my biggest challenges. But I understand not everything will go my way, especially the things or situations I cannot control.

## MIYELANI MABUNDA

| | |
|---|---|
| **Age** | 33 |
| **Home Language** | Xitsonga |
| **Highest Qualification** | National Diploma: Civil Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Olifantsvlei WWTP.

**How was your overall experience during this prefeasibility studies project?**

Knowing how the cycle of water works was the best experience.

**What were your highlights and challenges of working as a fieldworker?**

How important waste is and how it is treated. Difficulties included not having supervisor or mentor at first, sometimes we were doing nothing on site since we had to wait for someone to be allocated for us daily. The breaking down of the communication.

## NEO MONNAHELA

| | |
|---|---|
| **Age** | 29 |
| **Home Language** | Sepedi |
| **Highest Qualification** | National Diploma: Electrical Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | 2 -3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Orkney Waste Water Treatment Plant, a plant located 10km outside of Klerksdorp under the City of Matlosana Municipality. It is a class B waste water treatment plant that is designed to treat 20 kilolitres in a 24-hour period.

**How was your overall experience during this prefeasibility studies project?**

My overall experience was a good one with a lot of learning as to how water is treated, which made it an experience which was intriguing and boggles one to try and combat the high levels of power consumption from the treatment with the knowledge and skills previously acquired and how we can design efficient automated security measures within the treatment plants.

**What were your highlights and challenges of working as a fieldworker?**

The knowledge that I was able to acquire on how water is treated and the level of engineering especially electrical that was well designed in treating water. The limited resources (computers and personal protective equipment) and support from the municipality to collect and compile data was a challenge.

## MELLISSA PHOLOHOLO

| | |
|---|---|
| **Age** | 30 |
| **Home Language** | Tshivenda |
| **Highest Qualification** | Bachelor's Degree: Environmental Science |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | 2 – 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Randfontein Wastewater Treatment Plant, located in the Rand-West City Local Municipality, a class A plant treating both domestic and industrial wastewater registered for the operation of water care works.

**How was your overall experience during this prefeasibility studies project?**

I can say I had a very positive experience throughout the project as it was interesting and productive academically. I was very excited to be part of this opportunity.

**What were your highlights and challenges of working as a fieldworker?**

Doing hands on work with the team and seeing so many focused and motivated people in the same field working for the same goal. Safety was my major concern as the WWTP is located in the middle of nowhere in Randfontein.

## SIZWENKOSI MSIBI

| | |
|---|---|
| **Age** | 33 |
| **Home Language** | Sesotho |
| **Highest Qualification** | National Diploma: Electrical Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | More than 3 years |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Klerksdorp Wastewater Treatment Plant. Wastewater around Klerksdorp is treated, removing impurities and suspended solids from wastewater.

**How was your overall experience during this prefeasibility studies project?**

My overall experience was very positive as I've learned the importance of saving energy, wastewater treatment plants, how to communicate and build relationships with the people I worked with.

**What were your highlights and challenges of working as a fieldworker?**

Presentations and doing research. A challenge was having to wait for data from the municipality.

## OMPHILE RIET

| | |
|---|---|
| **Age** | 30 |
| **Home Language** | Setswana |
| **Highest Qualification** | National Diploma: Power Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Klerksdorp Wastewater Treatment Plant located in the City of Matlosana.

**How was your overall experience during this prefeasibility studies project?**

My experience was enlightening. I learnt a lot within the project.

**What were your highlights and challenges of working as a fieldworker?**

Interacting with municipal officials of different levels. Also learning how a WWTP operates. Proper communication and sharing of data was a challenge.

## MOOKHO MAHLOPHE

| | |
|---|---|
| **Age** | 25 |
| **Home Language** | Sesotho |
| **Highest Qualification** | National Diploma: Electrical Engineering |
| **Other Qualifications** | - |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Ennerdale Wastewater Treatment Plant. It is located at Elandsfontein, south of Johannesburg. The treatment plant has design capacity of 8 ML/day but actually receives 12MLdue to the developments within the service areas.

**How was your overall experience during this prefeasibility studies project?**

Good experience, managed to learn about wastewater treatment plant.

**What were your highlights and challenges of working as a fieldworker?**

Being able to take part in workshop presentations. It was hard not being able to get certain information.

## NOMPUMELELO MKHIZE

| | |
|---|---|
| **Age** | 25 |
| **Home Language** | isiZulu |
| **Highest Qualification** | Bachelor's Degree: Environmental Science |
| **Other Qualifications** | Certificate of SHE administrator |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Stanger WWTP, it is a type C plant and handles most of the wastewater in Kwa-Dukuza area. It treats both industrial and domestic waste. It is located on the Mbozamo River.

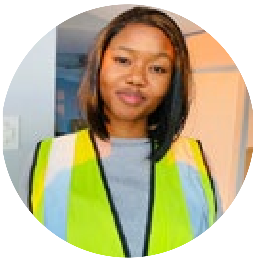
**How was your overall experience during this prefeasibility studies project?**

It was interesting and insightful, I really enjoyed getting to know more about energy efficiency.

**What were your highlights and challenges of working as a fieldworker?**

I was very fortunate to have been working at the iLembe Municipality and got exposed to many more projects. This was exciting and I also enjoyed being on the site and collecting data. The site was not working which made collection of accurate data difficult.

## BATHABILE MONYELA



| | |
|---|---|
| **Age** | 25 |
| **Home Language** | Sepedi |
| **Highest Qualification** | Bachelor's Degree: Environmental Health |
| **Other Qualifications** | Certificate of SHE administrator |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Doornkraal WWTP. It is the largest WWTP in Polokwane with an upgraded capacity of 36ML/day from 25ML/day and it's located at sewer works St., Polokwane. It treats both domestic and industrial wastewater.

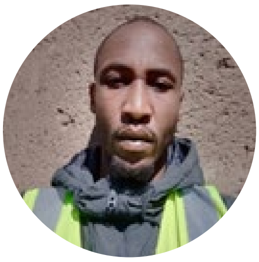
**How was your overall experience during this prefeasibility studies project?**

The overall experience was benefits, it has improved my ability to speak publicly and work as a team. I've also acquired knowledge and experience throughout the energy efficiency pre-feasibility studies project.

**What were your highlights and challenges of working as a fieldworker?**

With the knowledge acquired through energy efficiency training with Dr Russel, I'm now able to practice ways of saving energy at home. I've also acquired knowledge on the operations of WWTP. Challenges were the delay of personal protective equipment which hindered me from performing my duties as early as possible.

## NKULULEKO ZONDI



| | |
|---|---|
| **Age** | 30 |
| **Home Language** | isiZulu |
| **Highest Qualification** | Bachelor's Degree: Statistics |
| **Other Qualifications** | Short courses in energy data collection and analysis, fundamental of energy efficiency |
| **Current Position** | Fieldworker |
| **Company** | Energo Power Solutions |
| **Total Years of Work Experience** | Less than 1 year |

**What is the name of the wastewater treatment plant you are based at throughout the pre-feasibility studies project? Provide a short description of the WWTP?**

Southern Wastewater Treatment Works.

**How was your overall experience during this prefeasibility studies project?**

It was a good chance for me because I learned a lot and gained a lot of experience.

**What were your highlights and challenges of working as a fieldworker?**

The experience I gained working with the teams at the WWTP.' The unavailability of the information we were looking for and a lack of assistance in the plant were challenges experienced.

# PART B: CASE STUDY ON FOURTEEN WASTEWATER TREATMENT PLANTS IN ELEVEN MUNICIPALITIES

# 1 BETHLEHEM WASTEWATER TREATMENT PLANT

## 1.1 PLANT OVERVIEW

The Bethlehem WWTP is the largest WWTP in the Dihlabeng Local Municipality and is situated 3km north of the central business district, in the southern parts of the Bethlehem industrial area. The Bethlehem WWTP serves the population of Bethlehem which is estimated to be 68 700 people. This plant is a Class B registered WWTP with a design capacity of 26 ML/day.

The current treatment process incorporates a combination of microbiological, physical and chemical processes to treat wastewater. This includes PSTs, biofilters, activated sludge basins and clarifiers to treat the effluent stream. Sludge is treated with dissolved air flotation, anaerobic digestors and sludge drying beds. The plant is currently in the process of refurbishment and many process units were not operating during the site inspection for this project.

## 1.2 PLANT TREATMENT PROCESS DESCRIPTION

Figure 1.1 shows the Google image for Bethlehem WWTP with all the treatment processes.


*Figure 1.1: Aerial View of Bethlehem WWTP.*

The annotations in Figure 1.1 represent the following:

| | |
|---|---|
| **A** | Inlet Works |
| **B** | Humus Tanks |
| **C** | Biofilters |
| **D** | Clarifiers |
| **E** | Primary Settling Tanks (PST) |
| **F** | Sequential Batch Reactor (SBR) |
| **G** | Aeration Basins (Activated Sludge) |
| **H** | Digestors |
| **I** | Anaerobic Digesters |
| **J** | Sludge Drying Beds |

The inlet works consist of two (2) mechanical fine screens as well as a standby manual bar screen, grit classifier, grit removal, screw conveyor, compactor and the lifting pump station which consist of seven (7) pumps in total. The raw sewage (influent) flows directly through two (2) mechanical fine screens (20mm to 50mm) which operates alternately with a timer basis, but during high inflows, both mechanical fine screens operate at the same time.

The manual screen (20mm – 50mm) does not require power and is used as an emergency screen. A manual bar screen is designed to be used when both mechanical fine screens are not operating. The lifting pump station is divided into two stations. Pump Station 1 consists of four (4) pumps in total with different volumes and power ratings; one (1) biofilter pump (motor rated at 37kw) and SBR C pump (rated at 37Kw); and two (2) SBR B pumps (motor rated 45kw). Pump Station 2 consists of three (3) SBR pumps (motor rated at 55kw).

### 1.2.1 Overall plant control system

At the inlet works, specifically the lifting pump station, the two (2) T6 pumps, the two (2) T8 pumps and three (3) reactor pumps have ON/OFF switches (MCCBs) coupled with contactors and timers located at the inlet works panel. However, the three (3) reactor pumps are fitted with float switches which turn on when the level of water rises. The equipment on both the old and new activated sludge sections have ON/OFF switches, MCBs located near the equipment and MCCBs located at their respective panels as well as a DO (Dissolved Oxygen) meter installed at each section, which detects the concentration of oxygen in the wastewater and gives an indication whether to switch off the aerator(s) or to continue aerating.

### 1.2.2 Influent data

The inflow readings taken over 12 months indicate that Bethlehem WWTP has an average daily flow of 59 8500 m3/ month or 19 675.76 m3/day.

Historical information shows the following:

- Capacity MLday: Average Wet Weather Capacity – 36ML/day
- Operational Capacity ML/day: Average Dry Weather Capacity (Based on organic load) – 36ML/day
- % hydraulic capacity in use – 62%
- Design Loading (COD kg/day) – 23.4kg/day
- % of loading capacity in use – 93%
- Current WWTP utilisation as % of capacity - 93%
- Sludge produced (dry tonnes per day) – 0.07tonnes/day
- Solid waste disposal (m3/day) – 0.67 m3/day
- Total influent received (ML/day) – 25 ML/day
- Operating hours per day – 24

## 1.3 ENERGY DATA ANALYSIS

### 1.3.1 Energy sources

Electricity is the main source of energy at Bethlehem WWTP which is used in the treatment process as well as for outside lighting and in the buildings and is supplied by Eskom.

### 1.3.2 Energy tariff

Historical observations on 2018/2019 tariffs for Bethlehem WWTP are that cost of energy differs from the time of use during a 24-hour cycle and per season of the year..

In addition to the active energy charge - the c/kWh paid for power consumed, several additional charges apply.

### 1.3.3 Baseline energy use and cost

#### *1.3.3.1 Energy cost*

Figure 1.1 give the breakdown of the monthly electricity costs for Bethlehem WWTP. In 2021/22, the plant was billed about R 1752 478.90 for electricity usage. The supplied bills did not differentiate between consumption, demand, and fixed charges. Cost is separated into peak, off-peak, high demand and low demand seasons, during which time different tariffs apply. It is observed that 71% of the total energy cost was paid during the low season and 29% for the high demand season.

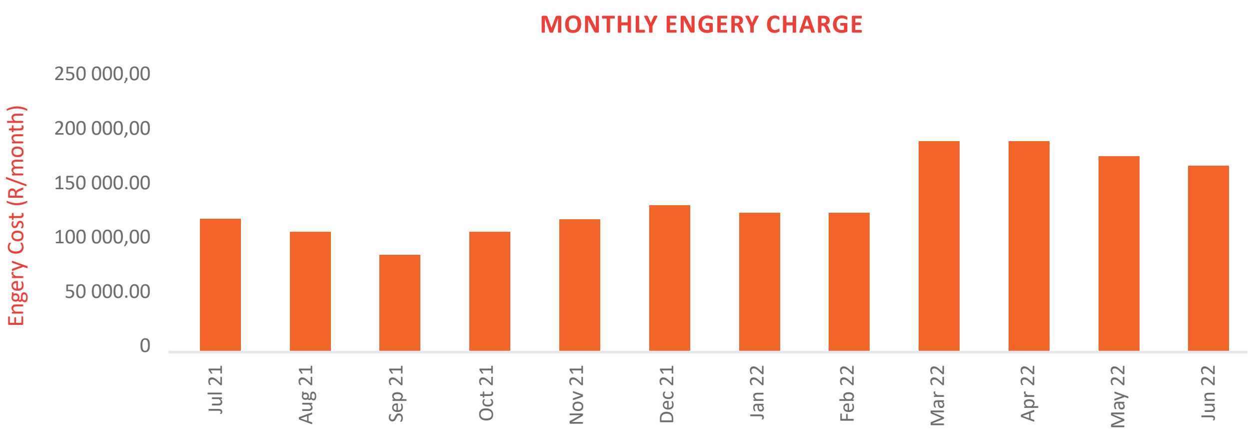



*Figure 1.2: Monthly Energy Charge for Year 2021/22.*

### 1.3.4 Energy Split

The plant demand distribution by section of the treatment plant is shown in Table 1.1. Insufficient information was provided on the energy split and cost distribution.

*Table 1.1: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Pumps | 45.89% |
| 2 | Aerators* | 43.01% |
| 3 | Mixer | 10.84% |
| | **TOTAL** | **99.47%** |

**Note during the site visit the plant was under refurbishment*

As expected, the bulk of power consumption occurs in aeration, pumping and mixing applications (biological treatment, pumping sections), representing 99.74% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

The estimated energy usage per year is summarised in Table 1.2.

*Table 1.2: Estimated Yearly Energy Usage.*

| Plant Section | Energy (kWh/year) |
|---|---|
| Inlet Works | 902 304 |
| Biological Treatment | 3 886 083 |
| Process Units (Sections) | 8 147 |
| Secondary Clarification | 12 965 |
| **Total** | **4 809 499.14** |

The biological treatment section accounts for the highest energy consumption of 9 231 726.00 kWh/year with secondary clarification consuming the least energy (40 646.40 kWh/year).

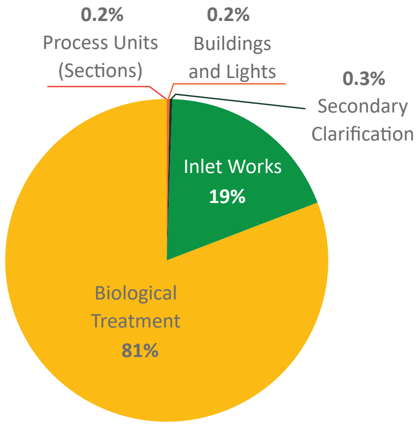



*Figure 1.3: Electricity Consumption Distribution for the Whole Plant*

Onsite Renewable Energy Production Opportunities should be explored in the form of a solar PV system.

*Table 1.3: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 7 800 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 1 399 038.81 |
| Eskom price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 10 276 210.00 |
| Internal Rate of Return (IRR) | 15.9% |
| Pay Back Period | 7.81 years |

Based on the estimates the returns on a project of this nature show that this option is economically viable for the plant and can be considered. The above analysis is based on many assumptions, and it is recommended that a thorough analysis be performed, if not already done by the municipality, to verify the viability of installing a grid-tied solar system.

### 1.3.5 Aeration

Aeration accounts for 43% of consumption at Bethlehem WWTP, approximately 2 068 383 kWh/year. Due to the requirements to meet the effluent discharge standards the aerators are operated continuously. The existing extent of DO control was estimated to be 50%. With these assumptions and estimates the aerators present significant opportunities for energy savings of up to 24%through the implementation of VSD. These savings translate to about 928 592.42 kWh/year, making the feasibility of the initiative very high.

*Table 1.4: Aeration Optimisation.*

| Description | Quantity |
|---|---|
| VSD, DO loggers and Installation & Specialised Study | R 3 065 688.00 |
| NPV & IRR Calculation period | 5 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 1 550 749.00 |
| Eskom price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 2 500/month | R 30 000.00 |
| Net Present Value (NPV) | R 3 552 150.00 |
| Internal Rate of Return (IRR) | 48.1% |
| Pay Back Period | 1.91 years |

### 1.3.6 Pump efficiency

There are two pumps 22 kW and 37 kW which contribute 6.6% to the total energy consumption. Improving the efficiency of these pumps will result in 2% in energy savings which is equivalent to 48 094 kW/year.

*Table 1.5: Pump Optimisation.*

| Description | Quantity |
|---|---|
| Biofilter & WAS Pump (Installation & Specialised Study) | R 112 966.00 |
| NPV & IRR Calculation period | 5 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 80 316.00 |
| Eskom price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 1 200/month | R 14 400.00 |
| Net Present Value (NPV) | R 229 788.00 |
| Internal Rate of Return (IRR) | 71.1% |
| Pay Back Period | 1.40 years |

Implementing EE and RE initiatives at Bethlehem could lead to 21% in energy savings per year (i.e., 2 019 582.96 kWh/year) based on the estimated consumption of the plant (since billing information was not complete).

*Table 1.6: Summary of Savings.*

| Summary of energy savings/gains | Contribution to EE & RE outcome | SPC Before kW/m$^3$ | SPC After kW/m$^3$ | Payback years | Saving/gain kWh/a | Feasibility of EE measure | Saving/gain R/a | Investment Rand (excl) |
|---|---|---|---|---|---|---|---|---|
| Aeration saving | 46% | 0.450 | 0.321 | 1.98 | 928 592.42 | Very High | 1 550 749.35 | 3 065 687.94 |
| Pump efficiency | 3% | 0.204 | 0.196 | 3.02 | 60 796.29 | Very High | 101 529.81 | 307 072.02 |
| EE motors | 4% | - | -0.011 | 7.78 | 77 756.18 | High | 129 852.82 | 1 010 693.60 |
| P/F correction (only demand charge) | 0% | - | 0.000 | 2.79 | - | Very High | - | 400 000.00 |
| **Total EE saving** | **53%** | **0.65** | **0.51** | | **1 067 144.90** | | **1 782 131.98** | **4 783 453.56** |
| Solar PV | 47% | - | -0.133 | 4.89 | 952 438.06 | Very High | 1 590 571.57 | 7 770 456.62 |
| **Total RE gain** | **47%** | | | **4.89** | **952 438.06** | | **1 590 571.57** | **7 770 456.62** |
| **Grand Total** | **100%** | **0.65** | **0.51** | **4.89** | **2 019 582.96** | | **3 372 703.55** | **12 553 910.18** |

# 2 DOORNKRAAL WASTEWATER TREATMENT PLANT


## 2.1 PLANT OVERVIEW

Doornkraal WWTP is the largest treatment facility in Polokwane, constructed in 1958. The plant is located just outside the CBD of Polokwane at Ladana. Doornkraal is a Class A registered plant. The plant treats both a combination of domestic and industrial wastewater from Polokwane. The plant is designed to receive and treat 25.6 ML/day. Raw data indicates an operational flow of 29 – 35 ML/day. The technology incorporated is Pasveer Bioreactor, conventional trickling filters, brewery plant (currently not functional), drying beds and anaerobic digestion for the sludge streams. The plant uses two different treatment processes. The old section of the plant is based on the conventional bio-filtration process, whereas the new section consists of an activated sludge process utilising a Pasveer ditch.

Doornkraal WWTP uses electricity supplied from the Polokwane Municipality as the main energy source on the site. There is no backup generator that can be used to power up process equipment and buildings when there is power failure.

## 2.2 PLANT TREATMENT PROCESS DESCRIPTION

Figure 2.1 shows the Google image for Doornkraal WWTP with all the treatment processes.


*Figure 2.1: Aerial View of Doornkraal Wastewater Treatment Plant.*

| | |
|---|---|
| **A** | Inlet Works |
| **B** | Primary Settling Tank |
| **C** | Biofilters |
| **D** | Aeration Module |
| **E** | 5 Secondary Clarifiers |
| **F** | Humus Tanks |
| **G** | Aerobic digesters |
| **H** | Sludge Dewatering |
| **I** | Anaerobic digester |
| **J** | Chlorination Building – Brewery plant |
| **K** | Brewery Plant |
| **L** | Sludge drying beds |
| **M** | Was pump station |
| **N** | Main building |

### 2.2.1 Overall plant control system

The overall plant control system of Doornkraal Wastewater Treatment Plant is done manually. Supervisory Control and Data Acquisition (SCADA) was not in operation during the time of the study. The plant uses a portable dissolved oxygen (DO) meter to regulate the levels of DO in wastewater.

### 2.2.2 Influent data

Doornkraal WWTP previously had a design capacity of 25 462 m$^3$/day with 30 000 m$^3$/day of raw influent wastewater. The plant has since been upgraded to 36 000 m$^3$/day to discharge 13 140 000 m$^3$/a of treated effluent into three maturation ponds and the discharge of final effluent into Sand River and irrigation with water containing waste of 83 220 m$^3$/a. Figure 2.2 illustrates the variation of inflow at the plant.

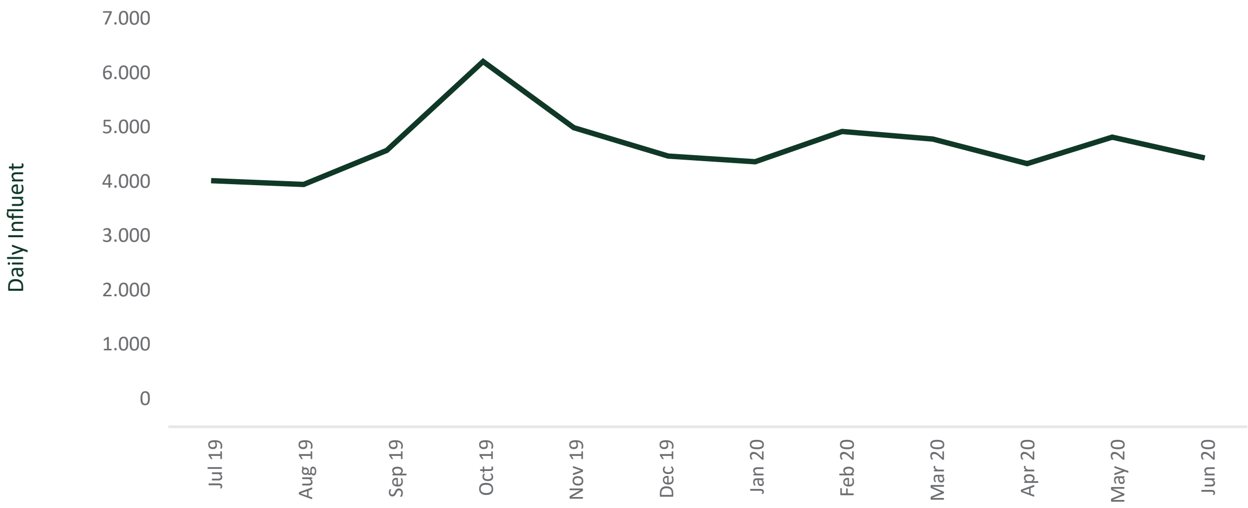



*Figure 2.2: Daily influent at Doornkraal WWTP.*

Data from the reviewed documentation reveals that an average flow of 936 200 $m^3$/month (July 2019 – June 2020) was received at the plant; this translates to an average of 31.2 ML/day. At this flow, the hydraulic design capacity of 25.6 ML/day was exceeded.

## 2.3 ENERGY DATA ANALYSIS

### 2.3.1 Energy sources

Electricity is the main source of energy at Doornkraal WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by Polokwane Municipality.

### 2.3.2 Energy tariff

Electricity at Doornkraal WWTP is supplied by Polokwane Municipality and the municipality uses a block tariff structure as indicated in Table 2.1.

*Table 2.1: Tariff structure for Polokwane Municipality (used for Doornkraal WWTP).*

| | | |
|---|---|---|
| Basic Charge | R 1890.74 | |
| Voltage | **High Voltage** | **Low Voltage** |
| Active Energy Charge (R/kWh) | 1.0184 | 1.0364 |
| Demand Charge (R/kVA) | 282.14 | 286.23 |

### 2.3.3 Baseline energy use and cost

#### *2.3.3.1 Energy use*

Energy consumption and cost for 2021 to 2022 were not available, thus historical data for 2019 to 2020 was used. Since electricity at Doornkraal WWTP is supplied by the Polokwane Municipality, peak and off-peak rates do not apply as the municipality is under block tariff structure. The total and average annual energy consumption were evaluated as 51 594 444 kWh and 4 299 537 kWh, respectively from 2019 to 2020 as shown in Table 2.1. Figure 2.3 shows the percentage of energy consumption per season during 2019 to 2020.

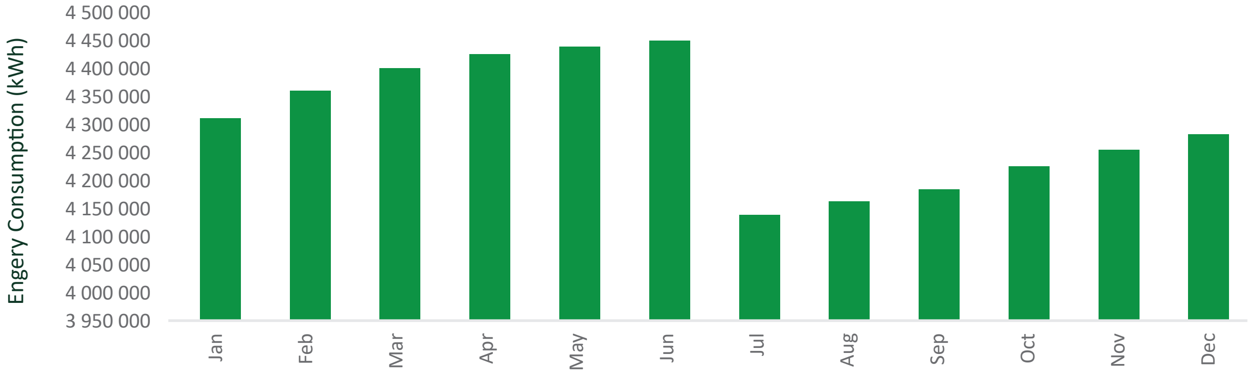



*Figure 2.3: Energy Consumption profile for Doornkraal WWTP*

#### *2.3.3.2 Energy cost*

In 2019/2020, the plant was billed about R 43 796 084.12 for electricity usage.

### 2.3.4 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 2.5. Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and/or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

As expected, the bulk of power consumption occurs in aeration, pumping and other applications (biological treatment, pumping sections), representing 97.77% of total power consumption excluding buildings.

*Table 2.2: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerators | 69.27% |
| 2 | Pumps | 28.50% |
| | **TOTAL** | **97.77%** |

#### *2.3.4.1 Anticipated energy savings*

A simulation of the grid ties solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 2.4.

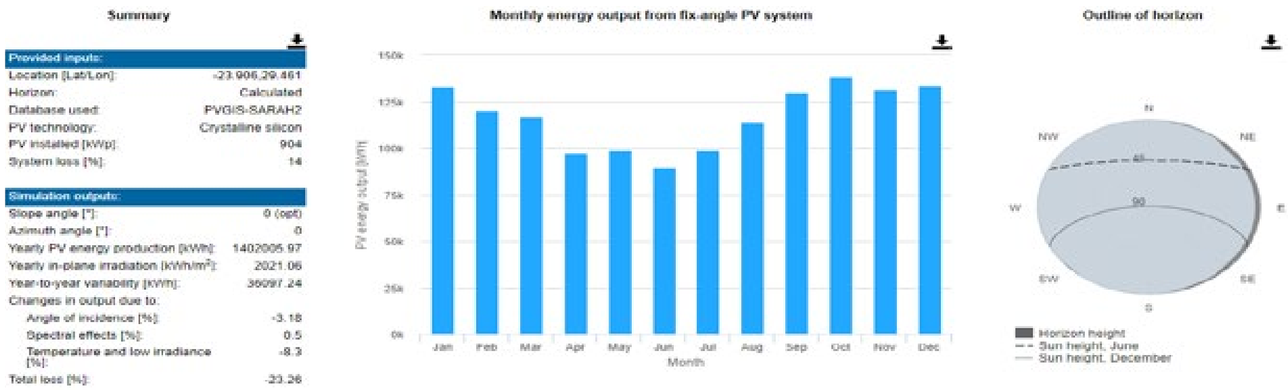



*Figure 2.4: Performance of Grid Tied PV System at Doornkraal WWTP.*

The estimated energy production will be 1 402. 006 MWh/year and corresponds to the energy savings that can be realised by the plant. About 21.2% in potential energy savings per year could be realised from the Solar PV installation. The potential economic justification of the Solar system is shown in Table 2.3

*Table 2.3: Solar Power Installation Evaluation*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 11 757 086.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 2 103 008.96 |
| Eskom price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 15 414 734.00 |
| Internal Rate of Return (IRR) | 23.0% |
| Pay Back Period | 5.10 years |

Based on the estimates the returns on a project of this nature show that this option is economically viable for the plant and can be considered.

#### *2.3.4.2 Aeration*

Based on the collected data, aeration forms a significant part of consumption at Doornkraal WWTP 69.27% which amounts to approximately 4 627 578.71 kWh/year. Due to the requirements to meet the effluent discharge standards the aerators are operated continuously; the composition of the aerators is shown in Table 2.4.

*Table 2.4: Large Motors in the Aeration Section.*

| Power Rating (kW) | Quantity | Estimated Energy (kWh/year) |
|---|---|---|
| 55.00 | 3 | 1 352 684.52 |
| 45.00 | 6 | 2 336 410.53 |
| 37.00 | 1 | 324 120.00 |
| 22.00 | 3 | 416 028.29 |
| | | **4 429 050.00** |

The aeration benchmark range of 0.15 - 1.5 kWh/m3 was considered as the lower and upper limits,

At Doornkraal WWTP the existing extent of DO control was estimated to be 50%. With these assumptions and estimates the aerators present significant opportunities for energy savings of up to 12.9% through the implementation of VSD. These savings translate to about 571 372.39 kWh/year, making the feasibility of the initiative very high.

*Table 2.5: Aeration Optimisation.*

| Description | Quantity |
|---|---|
| VSD, DO loggers and Installation & Specialised Study | R 2 788 804.00 |
| NPV & IRR Calculation period | 5 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 954 191.89 |
| Eskom price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 2 500/month | R 30 000.00 |
| Net Present Value (NPV) | R 2 501 088.00 |
| Internal Rate of Return (IRR) | 41.3% |
| **Pay Back Period** | **1.99 years** |

#### *2.3.4.3 Pump efficiency*

There are about eight (8) big pumps ranging from 11 kW to 300 kW contributing 15.99% to the total energy consumption. Improving the efficiency of these pumps will result in 1.3% in savings which is equivalent to 84 459 kW/year.

*Table 2.6: Pump Optimisation.*

| Description | Quantity |
|---|---|
| Screw pumps, RAS & WAS Pump (Installation & Specialised Study) | R 371 553.00 |
| NPV & IRR Calculation period | 5 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 127 532.00 |
| Eskom price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 1 200/month | R 14 400.00 |
| Net Present Value (NPV) | R 158 675.00 |
| Internal Rate of Return (IRR) | 21.2% |
| Pay Back Period | 3.06 years |

#### *2.3.4.4 Summary of energy savings*

Table 2.7 summarises the anticipated energy savings that could be realised from EE and RE initiatives at Doornkraal WWTP. The figures presented in this section are based on the information gathered onsite.

*Table 2.7: Summary of Energy Savings.*

| **Summary of energy savings/gains** | **Contribution to EE & RE outcome** | **SPC Before kW/m³** | **SPC After kW/m³** | **Payback years** | **Saving/gain kWh/a** | **Feasibility of EE measure** | **Saving/gain R/a** | **Investment Rand (excl)** |
|---|---|---|---|---|---|---|---|---|
| Aeration saving | 34% | 0.336835485 | 0.27 | 2.17 | 849 754.13 | Very High | 1 283 128.73 | 2 788 804.34 |
| Pump efficiency | 3% | 0.080340087 | 0.07 | 2.91 | 84 458.52 | Very High | 127 532.37 | 371 552.92 |
| EE motors | 5% | - | -0.01 | 7.71 | 128 219.77 | High | 193 611.86 | 1 491 896.15 |
| P/F correction (only demand charge) | 0% | - | 0.00 | 1.24 | - | Very High | - | 400 000.00 |
| **Total EE saving** | **43%** | **0.502439567** | **0.42** | | **1 062 432.42** | - | **1 604 272.96** | **4 652 253.41** |
| Solar PV | 57% | - | -0.11 | 6.11 | 1 402 611.30 | High | 2 117 943.06 | 12 934 452.50 |
| **Total RE gain** | **57%** | **0.502439567** | **0.26** | | **1 402 611.30** | | **2 117 943.06** | **12 934 452.50** |
| **Grand Total** | **100%** | **0.502439567** | **0.17** | | **2 465 043.72** | | **3 722 216.02** | **17 586 705.91** |

The findings from the study reveal that implementation of EE initiatives at Doornkraal WWTP presents an attractive payback period and the feasibility is high with a total anticipated savings of 2 465 043.72 kWh/year which is about 37%.

# 3 FISHWATER WASTEWATER TREATMENT PLANT

## 3.1 PLANT OVERVIEW

The Fishwater WWTP is situated in Gqeberha under the Nelson Mandela Metropolitan Municipality. The plant handles both domestic and industrial sewage from the various areas of the city, it was designed to handle 80 ML/day of domestic sewage and 40 ML/day of industrial sewage. The plant has been recently upgraded to handle 150 ML/day of capacity i.e., 100 ML/day of domestic and 50 MℓL/day of industrial.

## 3.2 PLANT TREATMENT PROCESS DESCRIPTION

Figure 3.1 shows the Google image for Fishwater WWTP with all the treatment processes.


The raw sewage is delivered to a low-level sump at the inlet works. It is raised by means of first-stage screw pumps and second-stage screw pumps to a level which allows it to flow by gravity through the rest of the works. The first purification is to remove stones and other larger, heavy materials by allowing them to deposit in the stone traps. The flow then passes through mechanically raked bar screens which remove rags and the larger pieces of floating material, etc. Next in line are degritters. These remove the abrasive grit that was too small to be caught by the stone traps and would damage the pumps or silt up in other parts of the process. From the inlet works the streams pass to their respective sedimentation and aeration sections. In doing so they pass an overflow weir whereby excessive stormwater flow can pass to the stormwater tank or to the sea outfall.

### 3.2.1 Overall plant control system

The inlet works and filters building work automatically with ultrasonic sensors. Most of the processes in the plant are controlled through PLC (Programmable Logic Controller) which is programmed to switch off any unnecessary machinery at a specific time. Also, some of the equipment have VSDs to cater for varying loads.

### 3.2.2 Influent data

The inflow readings taken over the period of May 2021 to April 2022 indicate that Fishwater WWTP has an average daily flow of 130.47 ML/day. The estimated yearly inflow is 1 436 170 ML.

## 3.3 ENERGY DATA ANALYSIS

### 3.3.1 Energy sources

Electricity is the main source of energy at Fishwater WWTP used in the treatment process, as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by the Nelson Mandela Bay Metropolitan Municipality. The plant is equipped with generators which are supposed to keep the critical processes operational during loadshedding.

### 3.3.2 Energy tariff

Tariffs for Fishwater WWTP are the cost of energy and differs from time of use during a 24-hour cycle and per season of the year.

### 3.3.3 Baseline energy use and cost

#### *3.3.3.1 Energy cost*

In 2020 and 2021, the plant was billed about R 31 821 461.70 and R 31 082 038.49 respectively for electricity usage. There is a noticeable reduction of R 739 423.21 (2.32%). Charges are separated into peak, off-peak, high and low seasons. On average, energy consumption accounted for 71% while demand charges were 15.77%. Peak, standard, and off-peak period charges accounted for 73.91% and 68.76% during the high demand and low demand season, respectively.

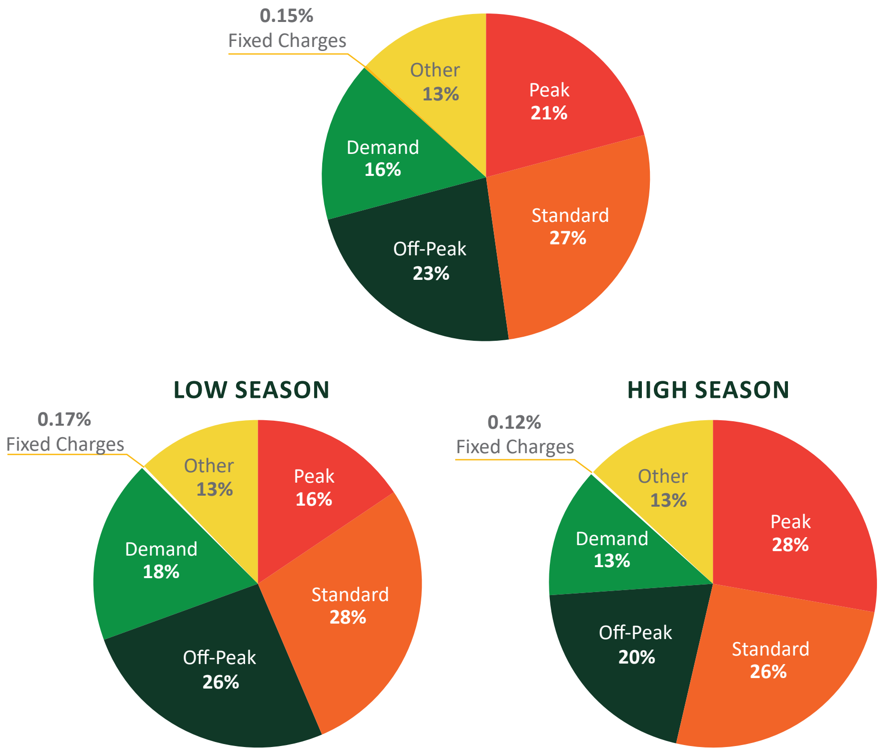



*Figure 3.2: Summarised Cost distribution (2020/2021).*

### 3.3.4 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 3.1. Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and/or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by the process controller as well as based on the plant operational manual.

*Table 3.1 Demand distribution by Equipment*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerators | 48.26% |
| 2 | Pumps | 36.97% |
| 3 | Other Drives | 12.47% |
| | **TOTAL** | **97.71%** |

As expected, the bulk of power consumption occurs in aeration, pumping and other applications (biological treatment, pumping sections), representing 97.71% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

The estimated energy usage per year is summarised in Table 3.8

*Table 3.2 Average Yearly Energy Usage per Process (2020/2021).*

| Plant Section | Energy (kWh/year) |
|---|---|
| Inlet Works | 3 538 768.26 |
| Biological Treatment | 12 713 010.07 |
| Primary Sedimentation | 268 540.59 |
| Process Units | 4 343 196.53 |
| Secondary Clarification | 17 902.71 |
| **Total** | **20 881 418.17** |

The biological treatment section accounts for the highest energy consumption of 12 713 010.07 kWh/year, with secondary clarification consuming the least energy (17 902.71 kWh/year). The biological treatment section consumes the most energy of about 12 706 008.66 kWh/year which is equivalent to R13 548 375.88 /year.

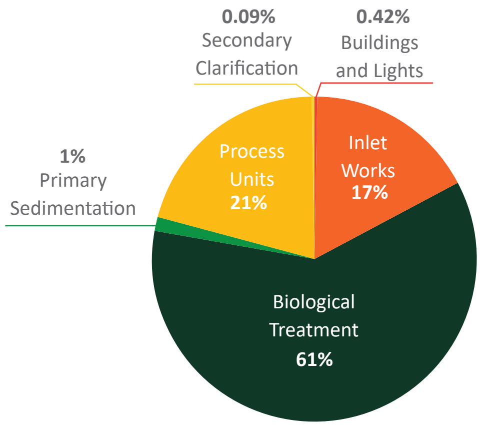



*Figure 3.3: Electricity Consumption Distribution for the Whole Plant*

### Renewable Energy

Onsite Renewable Energy Production Opportunities should be explored in the form of a solar PV system.

#### *3.3.4.1 Anticipated energy savings*

A simulation of the grid tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 3.4.

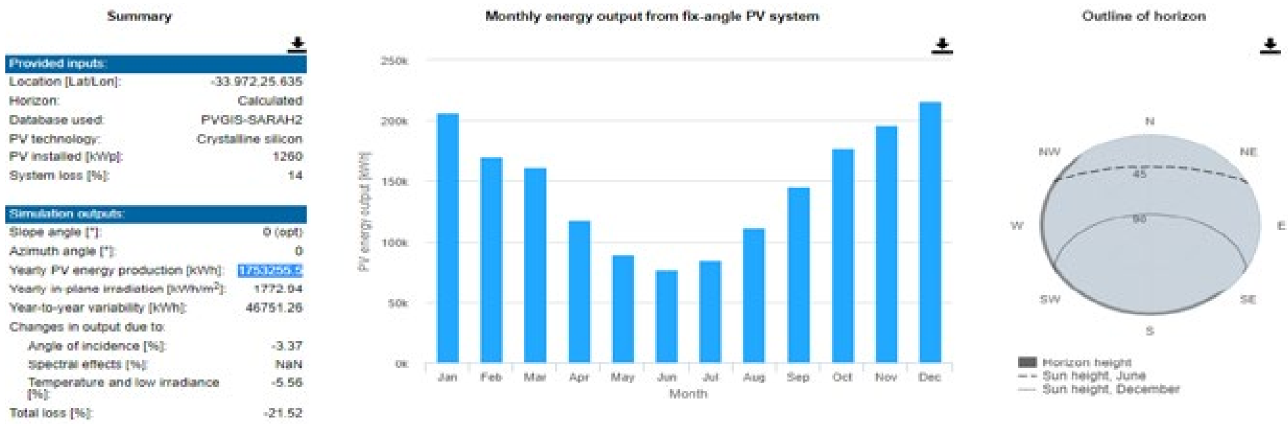



*Figure 3.3: Performance of Grid Tied PV System at Fishwater WWTP.*

The estimated energy production will be 1 753.26 MWh/year and corresponds to the energy savings that can be realised by the plant. About 8% in potential energy savings per year could be realised from the solar PV installation. The potential economic justification of the solar system is shown in Table 3.3.

*Table 3.3: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 16 380 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 2 629 883.25 |
| Eskom price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 3 529 074.00 |
| Internal Rate of Return (IRR) | 12.5% |
| Pay Back Period | 8.78 years |

Based on the estimates the returns on a project of this nature shows that this option is economically viable for the plant and can be considered.

### 3.3.5 Aeration

Based on the collected data, aeration forms a significant part of consumption at Fishwater WWTP of 49% which amounts to approximately 10 833 038.51 kWh/year. At the Fishwater WWTP the existing extent of DO control was estimated to be 50%. With these assumptions and estimates the aerators present significant opportunities for energy savings of up to 4.5% through the implementation of VSD on 12 aerators.

*Table 3.4*

| Description | Quantity |
|---|---|
| VSD, DO loggers and Installation & Specialised Study | R 13 570 112.00 |
| NPV & IRR Calculation period | 5 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 1 550 749.00 |
| Eskom price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 2 500/month | R 30 000.00 |
| Net Present Value (NPV) | R 3 293 346.00 |
| Internal Rate of Return (IRR) | 11.0% |
| Pay Back Period | 6.84 years |

### 3.3.6 Pump efficiency

There are about 33 big pumps of 30 kW, 90 kW and 110 kW which contribute 28.44% to the total energy consumption and approximately R 6 355 200.56 kWh/year. The various flow rates for the different pumps could not be verified during the audit. It is therefore recommended that long term monitoring of the flow rates and pump operating data be considered for pump efficiency adjustments.

### 3.3.7 Summary of energy savings

Table 3.5 summarises the anticipated energy savings that could be realised from EE and RE initiatives at Fishwater WWTP. The figures presented in this section are based on the information gathered onsite.

*Table 3.5: Summary of Energy Savings*

| Summary of energy savings/gains | Contribution to EE & RE outcome | SPC Before kW/m3 | SPC After kW/m3 | Payback years | Saving/gain kWh/a | Feasibility of EE measure | Saving/gain R/a | Investment Rand (excl) |
|---|---|---|---|---|---|---|---|---|
| Aeration saving | 25% | 0.185 | 0.167 | 8.55 | 950 877.01 | High | 1 587 964.60 | 13 570 111.85 |
| Pump efficiency | 8% | 0.109 | 0.103 | 7.35 | 302 233.35 | High | 504 729.70 | 3 707 393.70 |
| EE motors | 22% | - | -0.016 | 7.30 | 865 839.47 | High | 1 445 951.92 | 10 548 454.35 |
| P/F correction (only demand charge) | 0% | - | 0.000 | 0.33 | - | Very High | - | 400 000.00 |
| **Total EE saving** | **55%** | **0.293** | **25%** | | **2 118 949.83** | | **3 538 646.22** | **28 225 959.90** |
| Solar PV | 45% | - | -0.092 | 8.78 | 1 753 255.50 | High | 2927936.685 | 16 380 000.00 |
| **Total RE gain** | **45%** | **0 -** | **0.09** | | **1 753 255.50** | | **2 927 936.69** | **16 380 000.00** |
| **Grand Total** | **100%** | **0.29** | **0.16** | | **3 872 205.33** | | **6 466 582.90** | **44 605 959.90** |

# 4 OLIFANTSVLEI WASTEWATER TREATMENT PLANT

## 4.1 PLANT OVERVIEW

The Olifantsvlei Wastewater Treatment Plant treats water and sanitation from three areas in its catchment including western parts of Soweto (e.g., Protea Glen extensions), southern and south-eastern parts of Johannesburg (supporting the Turffontein "Corridor of Freedom" as well) and Lenasia (e.g., Lehae). The treatment technology comprises of a combination of physical, chemical and microbiological processes to meet the required effluent limits and bio solids specifications set by the Department of Water and Sanitation. The plant incorporates a combination of seepage, gravity-fed and pumped wastewater to the inlet works, screening and gravitated grit removal. Unit 2 consists of modified extended aeration activated sludge with BNR process; Unit 3 consists of activated sludge with BNR process (referred to as a 4-stage Johannesburg process) and chlorination. The treated effluent is discharged via a maturation pond to the Klip River. The waste sludge, combined with WAS received from Bushkoppies and Goudkoppies undergoes anaerobic digestion (eight digesters) and belt press dewatering. Thereafter the dewatered sludge is blended with a bulking agent before being composted, screened and cured. Finally, removal from the site for agricultural use takes place.

Olifantsvlei WWTP consist of three (3) modules with a total capacity of 230ML/day.

## 4.2 PLANT TREATMENT PROCESS DESCRIPTION

Figure 4.1 show the Google image for Olifantsvlei WWTP, the four-stage process flow and full plant process flow diagram.


*Figure 4.1: Aerial View of Olifantsvlei WWTP.*

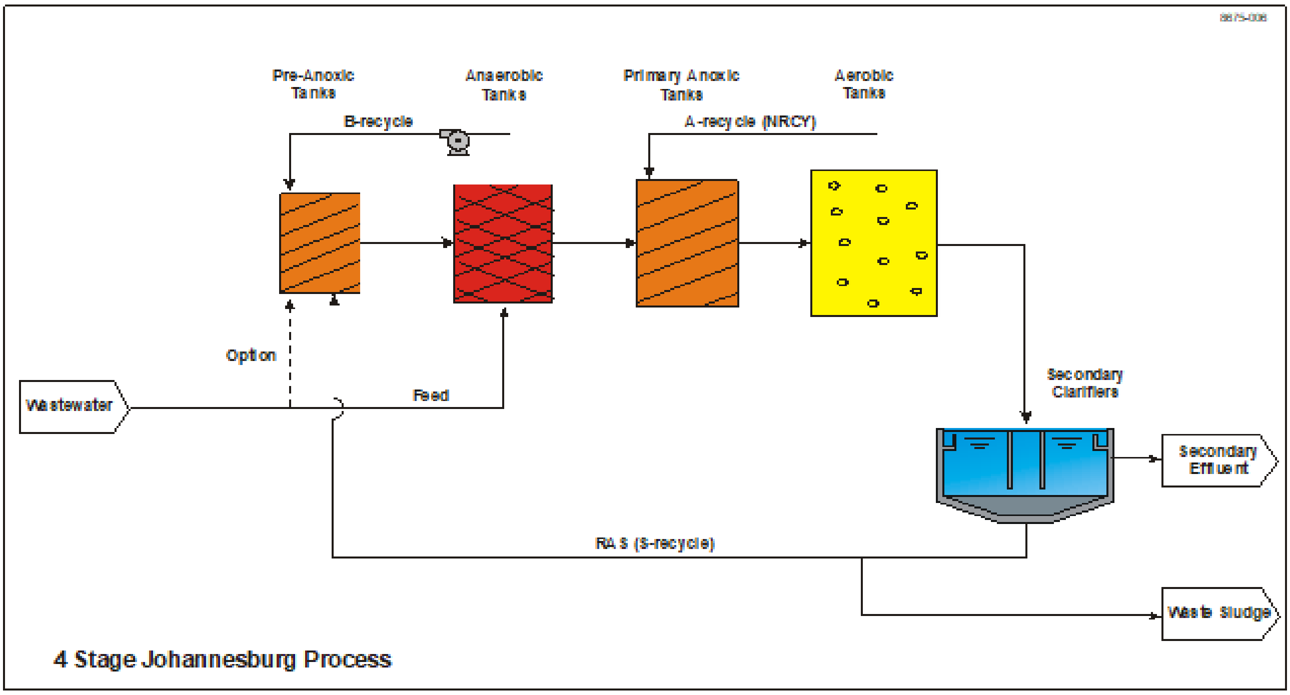



*Figure 4.2: Four Stage Process Flow.*

### 4.2.1 Overall plant control system

The process is automatically controlled by Programmable Logic Controller (PLC) and SCADA to monitor and run plant processes, track information coming in from equipment, enter commands, and make changes to their programming while the PLC is used to control the motors and machines.

### 4.2.2 Influent data

The inflow readings taken over the period of July 2020 to June 2021 indicate that Olifantsvlei WWTP has an average daily flow of 185.79 ML/day. The estimated yearly inflow is 67 814 ML.

#### *4.2.2.1 Sewage effluent limits*

Historical data indicate the following for the plant:

- Capacity ML/day: Average Wet Weather Capacity - 240
- Operational Capacity ML/day: Average Dry Weather Capacity (Based on organic load) - 200
- Percentage  hydraulic capacity in use - 88.3%
- Design Loading (COD kg/day) – 127 200
- Percentage of loading capacity in use – 85%
- Current WWTP utilisation as a percentage of capacity - 87%
- Sludge produced (dry tonnes per day) - 47
- Solid waste disposal (m3/day) – 5.0
- Total influent received (ML/day) – 212
- Operating hours per day – 24.

## 4.3 ENERGY DATA ANALYSIS

### 4.3.1 Energy sources

Electricity is the source of energy at Olifantsvlei WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by the Johannesburg Metropolitan Municipality (City Power).

### 4.3.2 Energy tariff

Tariffs (the cost of energy) for Olifantsvlei WWTP differ according to the time of use during a 24-hour cycle and per season of the year, however, for the analysed bills only standard time was used.

### 4.3.3 Baseline energy use and cost

#### *4.3.3.1 Energy use*

Electricity bills for 2020/21 were analysed. A summary of the monthly consumption and demand is shown in Table 4.3 and graphical representations of the values are given in Figure 4.3. The monthly consumption generally varies between 2 526 500 and 3 283 501 kWh.

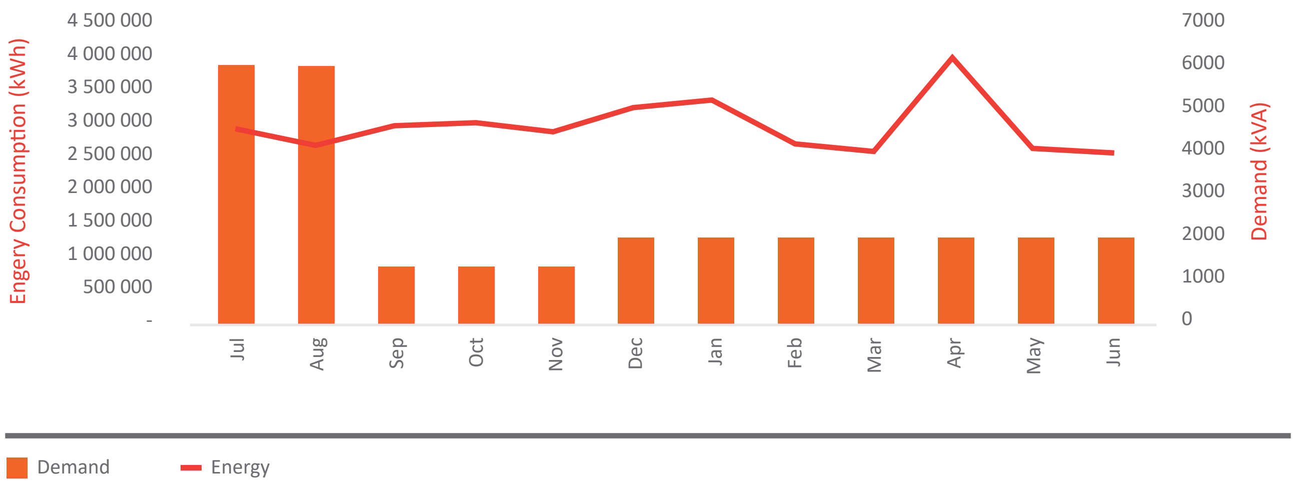



*Figure 4.3: Energy Consumption and Demand Profile.*

#### 4.3.3.2 ***Energy cost***

In 2020/2021, the plant was billed R 78 253 352.27 with energy consumption accounting for R 71 447 698.05 (i.e., 91.3%).

### 4.3.4 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 4.5. The power usage in the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and/or the plant manual.

*Table 4.1: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Pumps | 45.60% |
| 2 | Aerators | 39.79% |
| 3 | Other Drives | 9.63% |
| | **TOTAL** | **95.03%** |

As expected, the bulk of power consumption occurs in aeration, pumping and other applications (biological treatment and pumping sections), representing 95.03% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

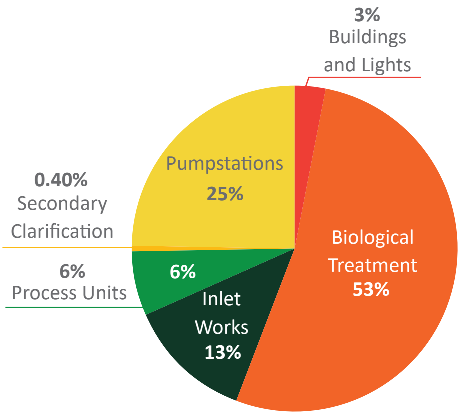



*Figure 4.4: Whole Facility Energy Distribution.*

Onsite Renewable Energy Production Opportunities should be explored in the form of a solar PV system. The estimated solar PV system in the form of a grid-tied option will assist to offset consumption during daytime which will lead to a reduction in energy consumption.

#### *4.3.4.1 Anticipated energy savings*

A simulation of the grid tied solar PV system was done using the information gathered onsite. The estimated energy production will be 7 539.47 MWh/year and corresponds to the energy savings that can be realised by the plant. About 22% in potential energy savings per year could be realised from the solar PV installation. The potential economic justification of the solar system is shown in Table 4.2.

*Table 4.2: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 62 400 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 11 309 201.97 |
| Eskom price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 83 719 967.00 |
| Internal Rate of Return (IRR) | 23.3% |
| Pay Back Period | 5.04 years |

### 4.3.5 Aeration

Based on the collected data, aeration forms a significant part of consumption at Olifantsvlei WWTP 39.79% which amounts to approximately 13 998 874.03 kWh/year. Due to the requirements to meet the effluent discharge standards the aerators are operated continuously. At Olifantsvlei WWTP, the existing extent of DO control was estimated to be 50%. With these assumptions and estimates the aerators present significant opportunities for energy savings of up to 4.5% through the implementation of VSD on 12 aerators. These savings translate to about 950 877 kWh/year, making the feasibility of the initiative very high.

*Table 4.3: Aeration Optimisation.*

| Description | Quantity |
|---|---|
| VSD, DO loggers and Installation & Specialised Study | R 13 570 112.00 |
| NPV & IRR Calculation period | 5 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 1 550 749.00 |
| Eskom price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 2 500/month | R 30 000.00 |
| Net Present Value (NPV) | R 3 293 346.00 |
| Internal Rate of Return (IRR) | 11.0% |
| Pay Back Period | 6.84 years |

### 4.3.6 Pump efficiency

There are 48 big pumps of 22 kW to 160 kW which contribute 40.13% to the total energy consumption and approximately 14 118 492.46 kWh/year. The various flows rate for the different pumps could not be verified during the audit. According to some literature, incorporating VSDs on the pumps will save up to 20% (pending further investigation).

Improving the efficiency of these pumps will result in 8.0% (Ref: Costing Tool) in savings which is equivalent to 2 829 992 kWh/year. The financial evaluation for the initiative is summarised in Table 4.4

*Table 4.4: Pump Efficiency Optimisation.*

| Description | Quantity |
|---|---|
| Screw Pump Motor, Wash water pump motor, Unit 3 Bio 3 Screw Pump Motor, Effluent Electric Fire Pump, Dilutional pump motor, Compressor pump motor (Installation & Specialised Study) | R 30 299 723.00 |
| NPV & IRR Calculation period | 12 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 4 726 087.00 |
| Eskom price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 1 200/month | R 14 400.00 |
| Net Present Value (NPV) | R 383 719.00 |
| Internal Rate of Return (IRR) | 11.3% |
| Pay Back Period | 6.41 years |

### 4.3.7 Summary of energy savings

Table 4.5 summarises the anticipated energy savings that could be realised from EE and RE initiatives at Olifantsvlei WWTP. The figures presented in this section are based on the information gathered onsite.

*Table 4.5: Summary of Energy Savings*

| Summary of energy savings/ gains | Contribution to EE &RE outcome | SPC Before kW/m3 | SPC After kW/m3 | Payback years | Saving/gain kWh/a | Feasibility of EE measure | Saving/gain R/a | Investment Rand (excl) | CO2 eq saving kg/a |
|---|---|---|---|---|---|---|---|---|---|
| Aeration saving | 9% | 0.206 | 0.178 | 7.2 | 1 904 199.52 | High | 3 180 013.19 | 22 983 062.51 | 1 961 325.50 |
| Pump Efficiency | 13% | 0.206 | 0.166 | 6.4 | 2 829 992.43 | High | 4 726 087.38 | 30 299 722.98 | 2 914 892.20 |
| EE motors | 3% | | - 0.011 | 6.1 | 727 890.65 | High | 1 215 577.38 | 7 395 271.65 | 749 727.37 |
| P/F correction (only demand charge) | 0% | | 0.000 | 0.3 | - | Very High | - | 400 000.00 | - |
| **Total EE saving** | **26%** | **0.414** | **0.333** | | **5 462 082.59** | | **9 121 677.92** | **61 078 057.15** | **5 625 945.07** |
| Solar PV | 35% | | -0.111 | 5.5 | 7 539 467.98 | High | 12 633 223.83 | 62 499 400.00 | 7 791 748.83 |
| CHP | 39% | | -0.025 | 5.6 | 8 359 595.00 | High | 13 960 523.65 | 51 666 667.00 | 1 753 126.95 |
| **Total RE gain** | **74%** | **0.000** | **-0.136** | | **15 899 062.98** | | **26 583 747.48** | **62 400 000.00** | **9 544 875.78** |
| **Grand Total** | **100%** | **0.414** | **-0.197** | | **21 361 145.57** | | **35 715 425.40** | **123 478 057.15** | **15 170 820.85** |

# 5 POTCHEFSTROOM WASTEWATER TREATMENT PLANT

## 5.1 PLANT OVERVIEW

The Potchefstroom WWTP is in Potchefstroom south of the city in the Dr Kenneth Kaunda District. The WWTP treats both domestic and industrial wastewater and has a capacity of 45 ML/day. The capacity challenges are encountered mostly when there is rain which creates overflows. The plant starts at the inlet, from there they are split to the new works and old works. The difference is in the size of the equipment and a few modifications on the sections as compared to the old works process.

## 5.2 PLANT TREATMENT PROCESS DESCRIPTION

The inlet works consist of two mechanical fine screens as well as a standby manual bar screen, grit classifier, grit removal, Screw conveyor, Compactor and the lifting pump station which consists of seven (7) pumps in total. The raw sewage(influent) flows directly through two mechanical fine screens (20 mm to 50 mm) which operates alternately with a timer basis, but during high inflows, both mechanical fine screens operate at the same time. The manual screen (20mm – 50mm) does not require power and is used as an emergency screen. A manual bar screen is designed to be used when both mechanical fine screens are not operating. The lifting pump station is divided into two stations. The raw sewage is pumped into the aeration tank where the organic constituents are biologically oxidised by the micro-organism population present in the activated sludge and the treated effluent to chlorine dosing.

### 5.2.1 Overall plant control system

The control system for the Plant is mainly a basic stop and start mechanism, this is controlled at the Control Office. Some of the equipment is manually operated through stop and start buttons in the area they are based and are not controlled from the Control Office. The plant has the three (3) main pumps coupled to VSDs.

### 5.2.2 Influent data

The inflow readings taken over the period of four (4) years indicate that Potchefstroom WWTP has an average daily flow of 41.93 ML/day. The estimated yearly inflow is 15 306.46ML.

## 5.3 ENERGY DATA ANALYSIS

### 5.3.1 Energy sources

Electricity is the main source of energy at Potchefstroom WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by Eskom. The electrical reticulation diagram for the plant was not supplied.

### 5.3.2 Energy tariff

Historical observations of 2018/2019 tariffs for Potchefstroom WWTP are that cost of energy differs from the time of use during a 24-hour cycle and per season of the year.

### 5.3.3 Baseline energy use and cost

#### *5.3.3.1 Energy use*

Electricity bills for July 2019 to June 2020 and July 2020 to June 2021 were made available. It should be noted that the billing information provided by the JB Marks Municipality only indicated the total cost per month though the energy consumption was split into off-peak, standard, and peak TOU.

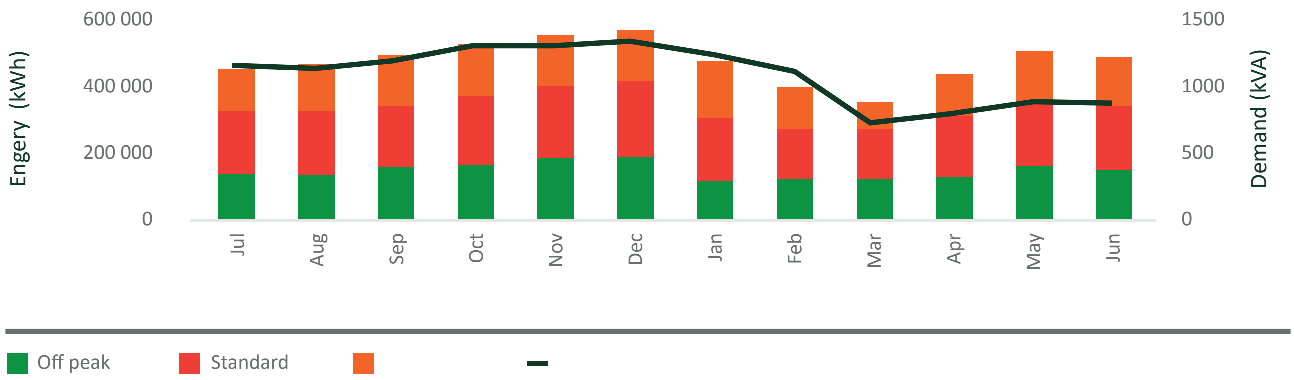



*Figure 5.1: Monthly electricity consumption at Potchefstroom WWTP (2020/2021).*

#### 5.3.3.2 *Energy cost*

In 2019/20 and 2020/21 the plant was billed about R 71 505 920.96 and R 13 279 332.47, respectively for electricity usage.

### 5.3.4 Energy split

During the site audit, 58 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings, are summarised in Table 5.6 below.

*Table 5.1: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerators | 56.73% |
| 2 | Pumps | 23.40% |
| 3 | Mixer | 11.26% |
| | **TOTAL** | **91.39%** |

As expected, the bulk of power consumption occurs in aeration, pumping and mixing applications (biological treatment and pumping sections), representing 91.39% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

Onsite energy production opportunities exist in the form of a solar PV system. Based on the simulation, a 1 039 kWp PV system could be implemented and the simulation results are highlighted in this section. The estimated solar PV system in form of a grid-tied option will assist to off-set consumption during daytime which will lead to reduction in energy consumption. The use of battery bank has not been explored as it makes the system expensive.

#### *5.3.4.1 Anticipated energy savings*

A simulation of the grid-tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 5.11.

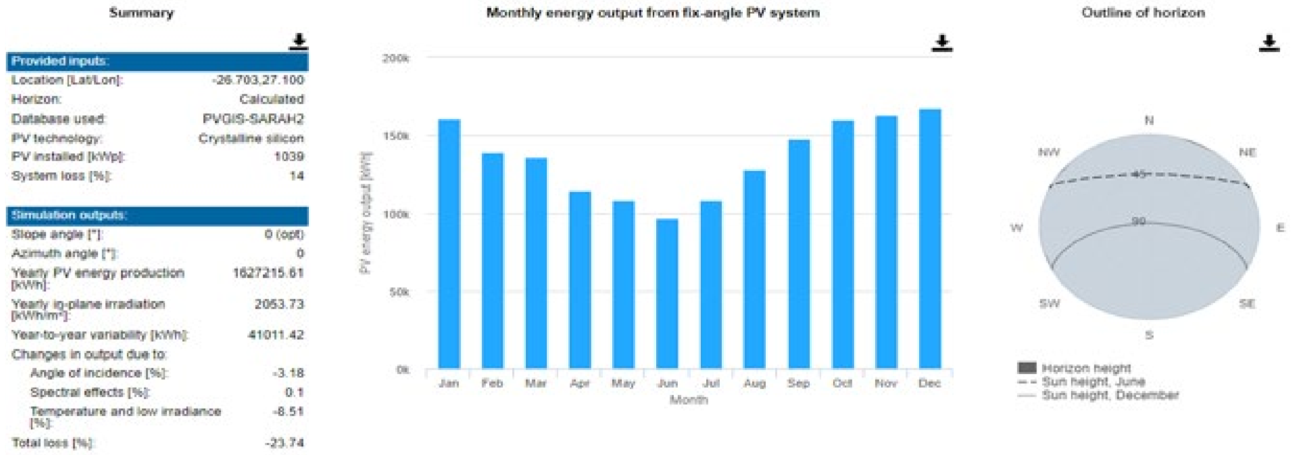



*Figure 5.2: Performance of Grid Tied PV System at Potchefstroom WWTP.*

The estimated energy production will be 1 627.22 MWh/year and corresponds to the energy savings that can be realised by the plant. About 21% in potential energy savings per year could be realised from the Solar PV installation.

### 5.3.5 Aeration

Based on some historic data and the current study, aeration forms a significant part of consumption at Potchefstroom WWTP 56.73% which amounts to approximately 4 304 050.64 kWh/year. At Potchefstroom WWTP the existing extent of DO control was estimated to be 50% for the purposes of this study. With these assumptions and estimates the aerators present significant opportunities for energy savings of up to 13.2% through the implementation of VSD. These savings translate to about 1 001 471.33 kWh/year, making the feasibility of the initiative very high.

*Table 5.2: Aeration Optimisation*

| Description | Quantity |
|---|---|
| VSD, DO loggers and Installation & Specialised Study | R 4 827 675 |
| NPV & IRR Calculation period | 5 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 1 672 457 |
| Eskom price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 2 500/month | R 30 000 |
| Net Present Value (NPV) | R 2 309 553 |
| Internal Rate of Return (IRR) | 26.8% |
| Pay Back Period | 2.73 years |

### 5.3.6 Pump efficiency

There two pumps of 22 kW and 37 kW which contribute 6.6% to the total energy consumptions. Benchmark of between 0.150 kWh/m$^3$ and 0.226 kWh/m$^3$ were considered. Improving the efficiency of these pumps will result in 2% in savings which is equivalent to 48 094 kW/year.

*Table 5.3:Pump Optimisation.*

| Description | Quantity |
|---|---|
| Feed Pumps, RAS Pump, Settled sewage pump (Installation & Specialised Study) | R 914 368.00 |
| NPV & IRR Calculation period | 5 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 245 854.00 |
| ESKO price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 1 200/month | R 14 400.00 |
| Net Present Value (NPV) | R 134 817.00 |
| Internal Rate of Return (IRR) | 14.4% |
| Pay Back Period | 3.54 years |

# 6 SEBOKENG WASTEWATER TREATMENT PLANT

## 6.1 PLANT OVERVIEW

Sebokeng Wastewater Treatment Plant is located in Sebokeng, a class A works that has been registered in terms of section 36 of the National Water Act (Act No. 36 of 1998) for the operation of water care works used for purification, treatment or disposal of effluent. The plant is currently treating domestic wastewater. The plant has recently been upgraded from 100 to 150 ML/day. Raw sewage divisions receive the sewer from four main channels, namely: Eastern Sewer, Southern Sewer, Northern Sewer A, and Northern Sewer B. The raw wastewater is screened and degritted and is split between modules which consist of primary settlement tanks, activated sludge aerators and biological reactors, secondary settling tanks and the final stage which is disinfection.

## 6.2 PLANT TREATMENT PROCESS DESCRIPTION

### 6.2.1 Overall plant control system

The overall plant control system of Sebokeng WWTP is done automatically and manually. Supervisory control and data acquisition (SCADA), is used to monitor the whole plant. Most of the pumps use direct online drives while the aerators and big pumps use variable speed drives (VSDs). The plant uses a portable dissolved oxygen (DO) meter to regulate the levels of DO in wastewater.

### 6.2.2 Influent data

The Sebokeng WWTP previously had a capacity of 100 ML/day and has been upgraded to 150 ML/day. Figure 6.1 illustrates the variation of inflow at the plant.

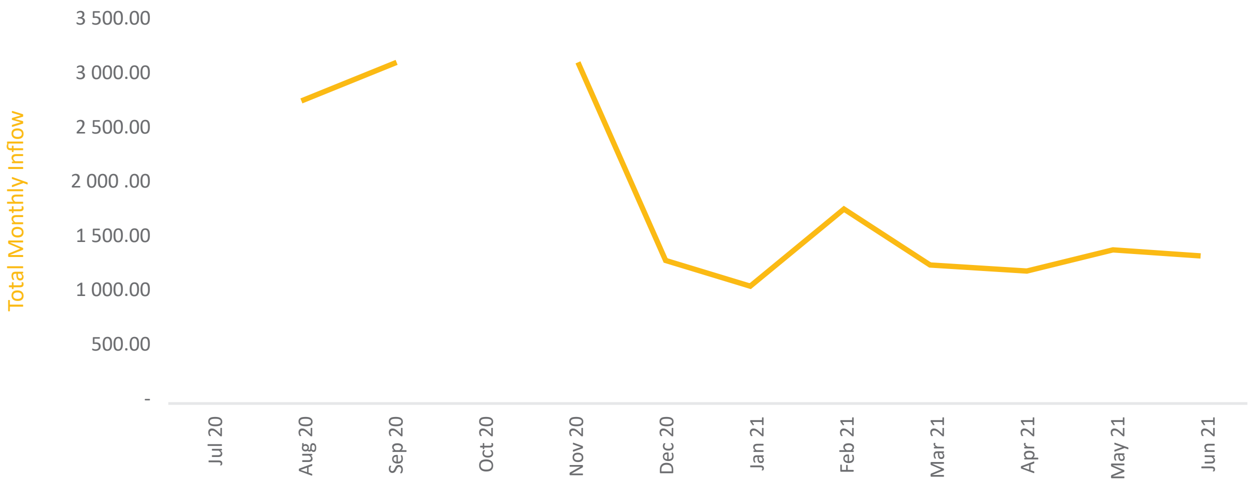



*Figure 6.1 Daily influent at Sebokeng WWTP.*

## 6.3 ENERGY DATA ANALYSIS

### 6.3.1 Energy sources

Electricity is the main source of energy at Sebokeng WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by Eskom.

### 6.3.2 Energy tariff

Electricity at Sebokeng WWTP is supplied by Eskom and the municipality is using a block tariff structure to bill the plant.

### 6.3.3 Baseline energy use and cost

#### *6.3.3.1 Energy use*

Energy consumption and cost for 2020 and 2021 was used for this analysis. Since electricity at Sebokeng WWTP is supplied by Eskom, peak and off-peak rates do not apply for Sebokeng WWTP hence a block tariff structure is used. The monthly energy consumption used for Sebokeng indicates that consumption generally varied between 241 983 and 920 611 kWh. The total and average annual energy consumption were evaluated as 6 758 934.00 kWh and 4 299 537 kWh respectively for 2020 and 2021. Figure 6.2 and Figure 6.3 show the percentage of energy consumption per season during the years 2020 and 2021.

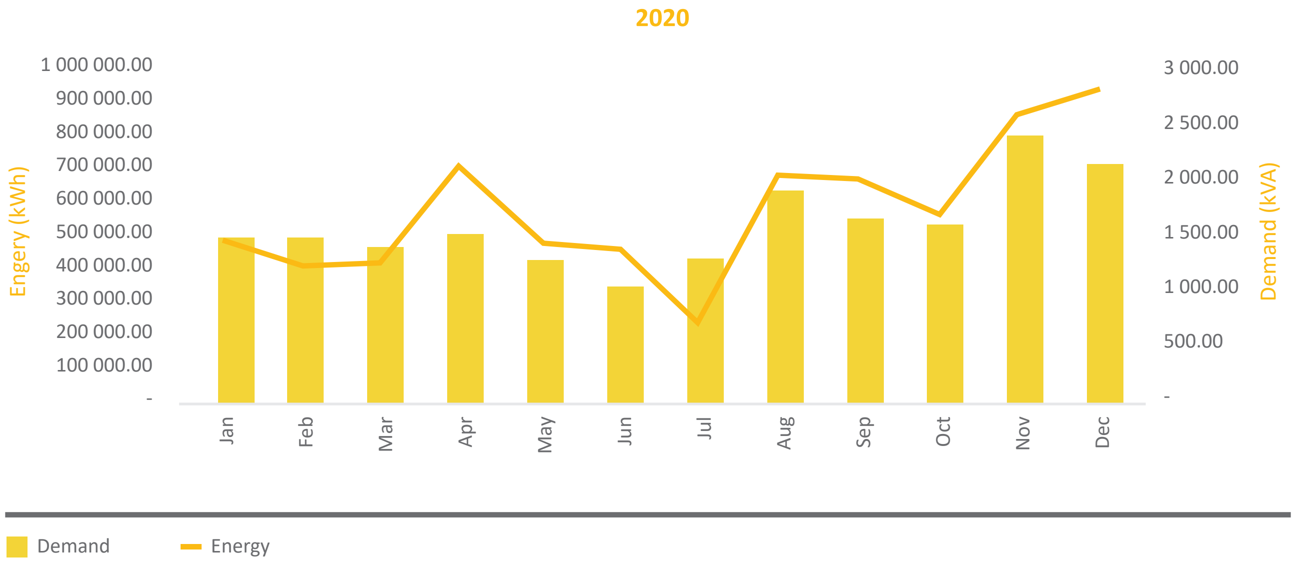



*Figure 6.2: Energy Consumption Profile for Sebokeng WWTP in 2020.*

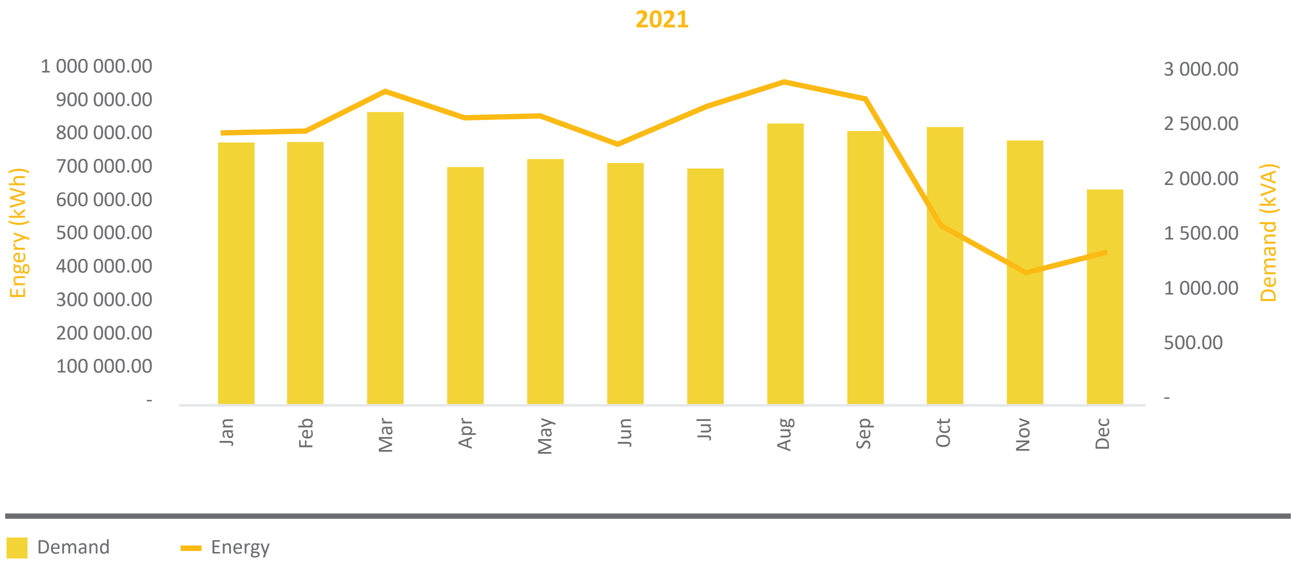



*Figure 6.3: Energy Consumption Profile for Sebokeng WWTP in 2021.*

#### *6.3.3.2 Energy cost*

Figure 6.2 and 6.3 give the breakdown of the monthly electricity costs for Sebokeng WWTP. In 2020 and 2021, the plant was billed about R 7 774 227.45 and R 11 718 729.04, respectively, for electricity usage. On average, during the assessed period the electricity bills received did not split the cost into the different components. The total cost depicts that for 2020 and 2021 the low season period accounted for 63% and 52% respectively, while high season period constituted 37% (2020) and 48% (2021). High season consumption increased by 11% and the low season billing decreased by the same magnitude as from 2020 to 2021. This could be attributed by the increase in the plant's design capacity.

### 6.3.4 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 6.5. Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and/or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

During the site audit, 240 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings are summarised in Table 6.1 below.

*Table 6.1: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerators | 65.42% |
| 2 | Pumps | 26.51% |
| 3 | Mixers | 5.03% |
| | TOTAL | 96.96% |

As expected, the bulk of power consumption occurs in aeration, pumping and other applications (biological treatment, pumping sections), representing 96.96% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

In terms of equipment, the aerators form the highest energy consumer with 65.42%, followed by pumps (26.51%), mixers (5.03%), blowers (1.32%), press (0.56%), clarifier bridge (0.13%) and screens (0.12%). The top three (3) energy consumers constitute 96.96% of the total plant's consumption. All the other equipment at the plant accounts for 3.04% of the total energy use excluding buildings. Figure 6.10 shows the demand distribution according to process sections within the plant.

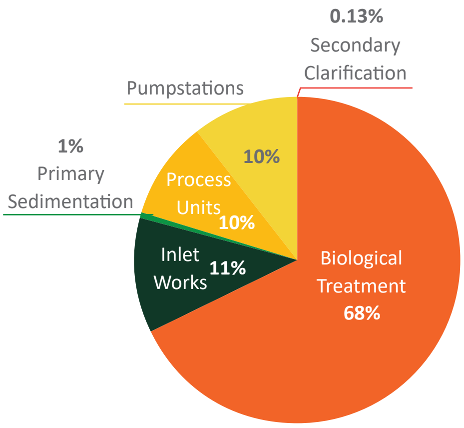



*Figure 6.4: Energy Distribution According to Process Sections within the Plant.*

Onsite Renewable Energy Production Opportunities exist in the form of a solar PV system. This was mainly based on the available area and the power consumption collected onsite as there was no information on the consumption profile for the plant. Based on the simulation a 905 kWp PV system could be implemented and the simulation results are highlighted in this section.

#### 6.3.4.1 *Anticipated energy savings*

A simulation of the grid-tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 6.5.

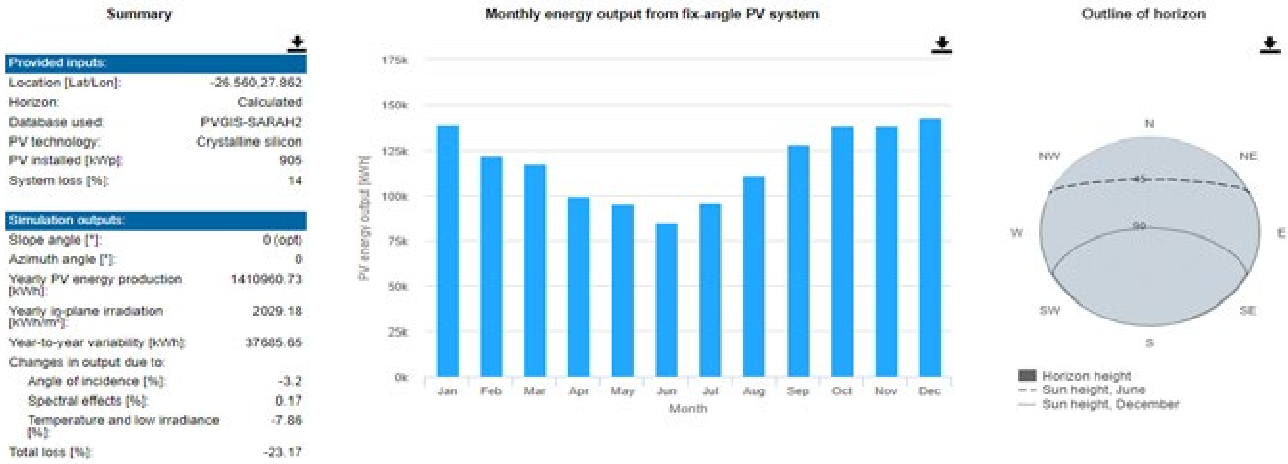



*Figure 6.5: Performance of Grid-Tied PV System at Sebokeng WWTP.*

The estimated energy production will be 1 410.96 MWh/year and corresponds to the energy savings that can be realised by the plant. About 24% in potential energy savings per year could be realised from the solar PV installation. The potential economic justification of the solar system is shown in Table 6.10.

*Table 6.2: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 11 765 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 2 116 441.10 |
| Eskom price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 15 580 369.00 |
| Internal Rate of Return (IRR) | 23.2% |
| Pay Back Period | 5.07 years |

#### 6.3.4.2 *Aeration*

Based on the collected data, aeration forms a significant part of consumption at Sebokeng WWTP 67.91% which amounts to approximately 5 189 452.95 kWh/year. Data collected from the plant revealed that aerators are coupled to VSDs hence limited opportunities can be presented.

#### 6.3.4.3 *Pump efficiency*

The two 184 kW screw pumps, three 37KW waste activated sludge (WAS) pump and six 18.5 kW RAS pumps are VDS controlled, and the drives are IE3 motors. All the big pumps are VSD controlled.

# 7 SOUTHERN WASTEWATER TREATMENT PLANT

## 7.1 PLANT OVERVIEW

The Southern Wastewater Treatment Works has a design capacity of 230 ML. It has two head of works with incoming raw sewage. The raw sewage from the Chatsworth line is treated and sold to Veolia Water. Sewage is screened and degritted before entering two primary settling tanks. The primary effluent from here is sent to the Veolia Water Plant. The raw sludge produced is discharged at sea.

Incoming raw sewage from the Jacobs Line, Badulla Line, Tanker Discharge and Refinery Road Pump Station discharge is received at the second head of works. Sewage is screened and degritted using vortex degritters. This is then discharged at sea.

## 7.2 PLANT TREATMENT PROCESS DESCRIPTION

### 7.2.1 Overall plant control system

Most of the processes on the plant are control with the panels which use the PLC (Programmable Logic Controller) which is programmed to switch off any unnecessary machinery at a specific time.

### 7.2.2 Influent data

The inflow readings taken over the period of June 2020 to May 2021 indicate that Southern WWTP has an average daily flow of 124.71 ML/day. The estimated yearly inflow is 45 520.41 Mℓ. Figure 7.1 illustrates the variation of inflow at the plant.

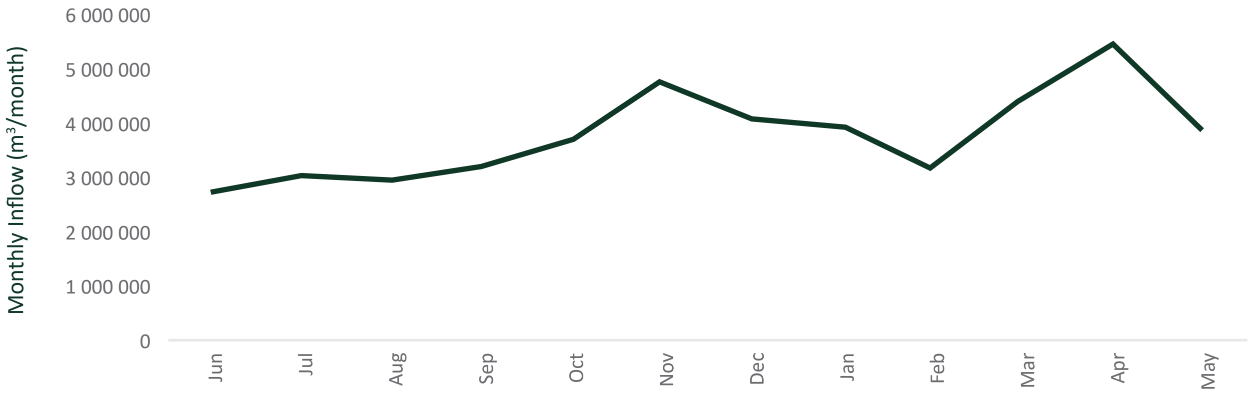



*Figure 7.1: Wastewater Inflow.*

## 7.3 ENERGY DATA ANALYSIS

### 7.3.1 Energy sources

Electricity is the main source of energy at Southern WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by the eThekwini Municipality. The plant is equipped with generators which are supposed to keep the critical processes operational during loadshedding.

### 7.3.2 Energy tariff

Tariffs for Southern WWTP are that cost of energy differs from time of use during a 24-hour cycle and per season of the year.

### 7.3.3 Baseline Energy Use and Cost

#### *7.3.3.1 Energy use*

Electricity bills for 2020 and 2021 were analysed. A summary of the monthly consumption and demand is given in Figure 7.2. During 2020, the monthly consumption generally varies between 343 440.00 and 490 965.40 kWh.

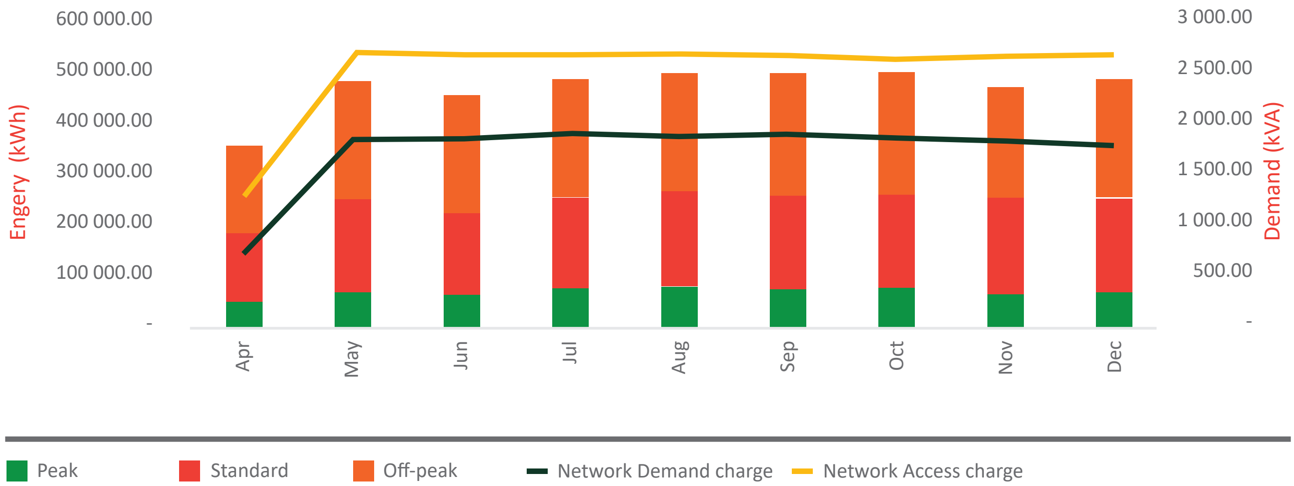



*Figure 7.2: Energy and Demand Profile (2020).*

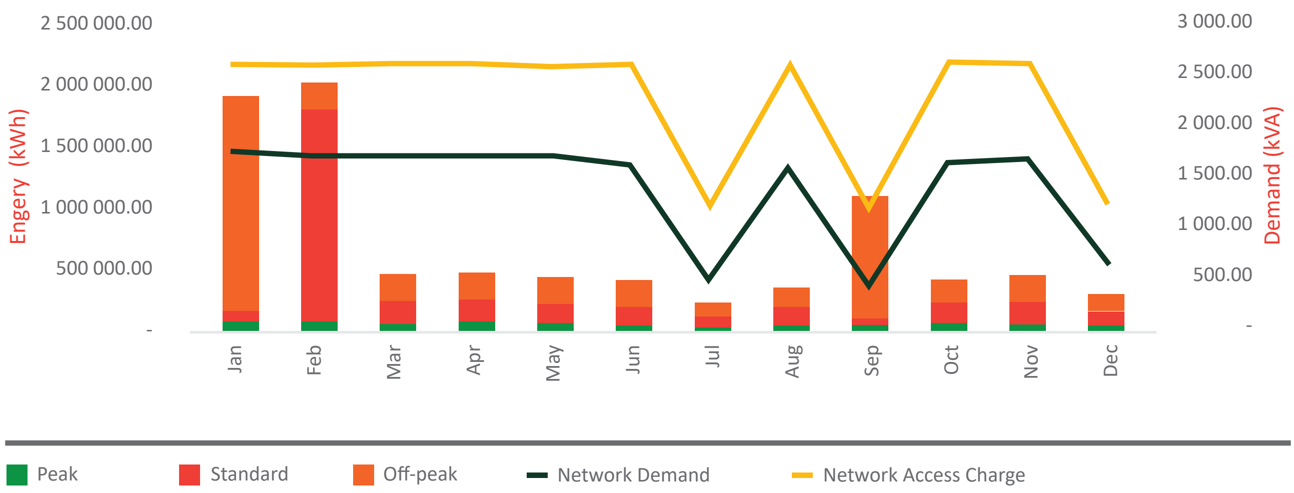



*Figure 7.3: Energy and Demand Profile (2021).*

#### 7.3.3.2 ***Energy cost***

In 2020 and 2021, the plant was billed about R 31 821 461.70 and R 31 082 038.49 respectively for electricity usage. There is a noticeable reduction of R 739 423.21 (2.32%).

On average, the high demand season (June-September) peak, standard, and off-peak period charges accounted for 22.36%, 21.16% and 16.24% of the energy cost respectively while the low demand season peak, standard, and off-peak period charges accounted for 8.28%, 21.61% and 13.53%. On average energy consumption cost constitutes 48.72% of the total electricity cost. It can be observed that during the high demand season peak charges were higher.

#### ***7.3.3.3 Energy split***

The plant demand distribution by section of the treatment plant is shown in Table 7.3. Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and/or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

During the site audit, 93 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings are summarised in Table 7.1 below.

*Table 7.1: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerators | 48.26% |
| 2 | Pumps | 36.97% |
| 3 | Other Drives | 12.47% |
| | **TOTAL** | **97.71%** |

As expected, the bulk of power consumption occurs in aeration, pumping and other applications (biological treatment, pumping sections), representing 97.71% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

In terms of equipment, the aerators form the highest energy consumer with 52.67%, followed by pumps (31.05%), and other drives (8.73%). The top three energy consumers constitute 97.71% of the total plant's consumption.

Onsite Energy Production Opportunities exist in the form of a solar PV system. A high-level sizing of the solar PV system and economic analysis was conducted. This was mainly based on the available area and the power consumption collected onsite as there was no information on the consumption profile for the plant. Based on the simulation a 900kWp PV system could be implemented and the simulation results are highlighted in this section.

## 7.4 ANTICIPATED ENERGY SAVINGS

### 7.4.1 Solar PV system

A simulation of the grid ties solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 7.3.

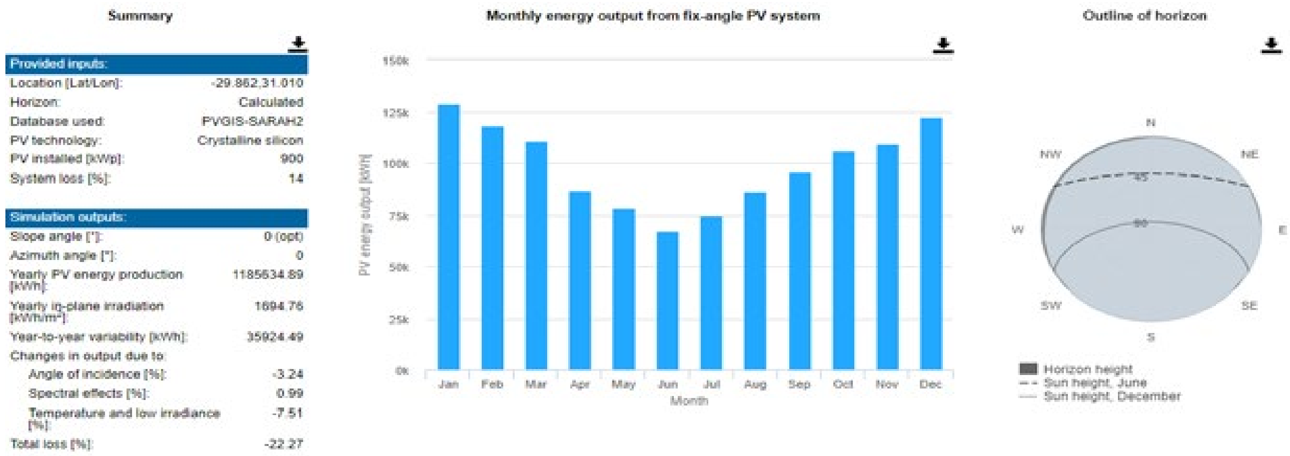



*Figure 7.4: Performance of Grid-Tied PV System at Southern WWTP*

The estimated energy production will be 1 185.63 MWh/year and corresponds to the energy savings that can be realised by the plant. About 13.98% in potential energy savings per year could be realised from the solar PV installation these could go up to 24% depending on adequate space. The potential economic justification of the solar system is shown in Table 7.2.

*Table 7.2: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 17 700 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 2 629 883.25 |
| ESKOM price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 11 278 403.00 |
| Internal Rate of Return (IRR) | 12.7% |
| Pay Back Period | 9.48 years |

### 7.4.2 Aeration

Based on the collected data, aeration forms a significant part of consumption at Southern WWTP (52.67%) which amounts to approximately 4 467 627.05 kWh/year.

### 7.4.3 Pump efficiency

With reference to the Energy Assessment template, the total contribution of the pump was calculated (see Table 7.5). There are about four big pumps of 37 kW and, 75 kW which contribute 26.57% to the total energy consumptions. Benchmark of between 0.150 kWh/m$^3$ and 0.226 kWh/m$^3$ were considered. Improving the efficiency of these pumps will result in 4.8% in savings which is equivalent to 406 568 kWh/year.

*Table 7.3: Pump Optimisation.*

| Description | Quantity |
|---|---|
| Screw pumps, Submersible pumps (Installation & Specialised Study) | R 660 171 |
| NPV & IRR Calculation period | 5 years |
| Year 1 energy savings (assuming conservative energy charges @ 1.67/kWh) | R 609 852.50 |
| ESKOM price escalation (conservative) | 8% |
| Interest Rate | 11% |
| Yearly Maintenance Cost (estimated @R 1 200/month | R 14 400.00 |
| Net Present Value (NPV) | R 1 892 252.00 |
| Internal Rate of Return (IRR) | 92.5% |
| Pay Back Period | 1.1 years |

*Note there are other pumps within the plant which are not included in this analysis

### 7.4.4 Summary of energy savings

Table 7.4 summarises the anticipated energy savings that could be realised from EE and RE initiatives at Southern WWTP. The figures presented in this section are based on the information gathered onsite.

*Table 7.4: Summary of Energy Savings.*

| Summary of energy savings/gains | Contribution to EE & RE outcome | SPC Before kW/m$^3$ | SPC After kW/m$^3$ | Payback years | Saving/gain kWh/a | Feasibility of EE measure | Saving/gain R/a | Investment Rand (excl) |
|---|---|---|---|---|---|---|---|---|
| Pump efficiency | 3% | 0.06 | 0.05 | 0.97 | 406 568.33 | Very High | 678 969.11 | 660 171.31 |
| EE motors | 1% | - | - | 0.00 | 7.89 | 125 055.69 | High | 208 843.01 | 1 647 539.45 |
| P/F correction (only demand charge) | 0% | - | - | 1.31 | - | Very High | - | 400 000.00 |
| **Total EE saving** | **4%** | **0.06** | **0.05** | | **531 624.02** | **-** | **887 812.12** | **2 707 710.76** |
| Solar PV | 9% | - | - | 0.04 | 9.48 | 1 185 634.89 | Very High | 1 778 452.34 | 11 700 000.00 |
| CHP | 87% | - | - | 0.04 | 5.55 | 11 661 312.00 | High | 19 474 391.04 | 70 587 733.33 |
| **Total RE gain** | **96%** | **0.19** | **0.10** | | **12 846 946.89** | | **21 252 843.38** | **82 287 733.33** |
| **Grand Total** | **100%** | **0.25** | **0.15** | **-** | **13 378 570.91** | **-** | **22 140 655.50** | **84 995 444.10** |

The findings from the study reveal that implementation of EE initiatives at Southern WWTP present attractive payback period and the feasibility is high with a total anticipated savings of 13 378 570.91 kWh/year, which will offset the plant's energy requirements. However, it should be noted that for the success of the implementation, specialised studies should be conducted to accurately determine the viability of such initiatives.

# 8 STANGER WASTEWATER TREATMENT PLANT

## 8.1 PLANT OVERVIEW

Stanger Wastewater Treatment Plant (WWTP) is the largest of the four iLembe District Municipality-owned WWTPs. The facility is located en route to Stanger a few kilometres from the N2. Stanger WWTP is a registered Class C plant, located on the Mbozamo River and is the main sewage works for Stanger. The plant treats a combination of domestic and industrial wastewater of Stanger. The plant is designed to receive and treat 10 ML/day, with its current flow being 4,98 ML/day. The technology incorporated at the plant is activated sludge for the liquid streams which consists of three primary settling tanks, two aerobic reactors with two aerators each, two secondary settling tanks, three chlorine tanks and an emergency tank, thirty drying beds and three anaerobic digesters for the sludge streams.

## 8.2 PLANT TREATMENT PROCESS DESCRIPTION

The schematic process flow of Stanger WWTP is illustrated in Figure 8.1

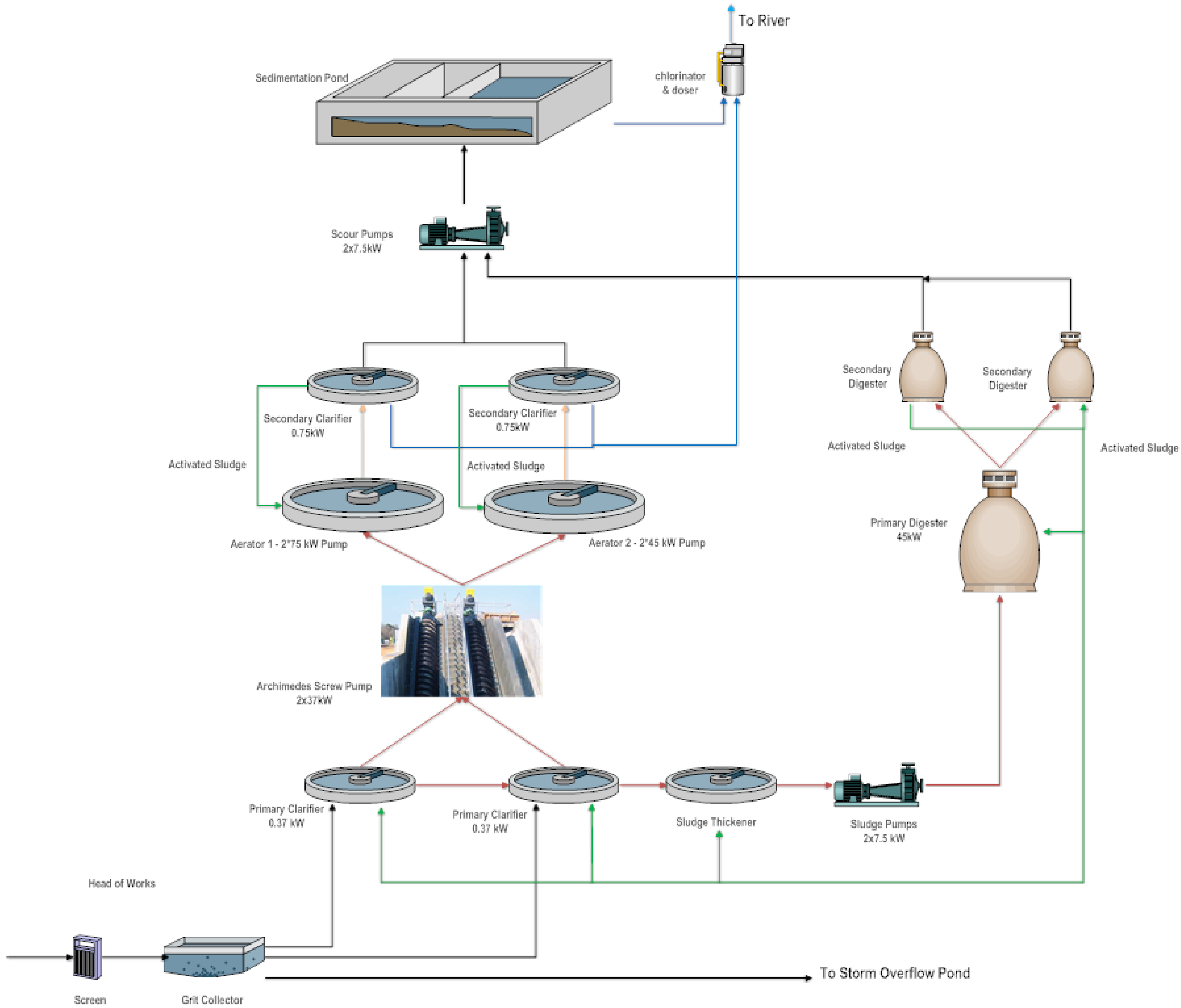



*Figure 8.1: Process Flow Schematic.*

### 8.2.1 Influent data

The inflow readings taken over the period of September 2019 to May 2020 indicate that Stanger WWTP has an average daily flow of 6.23 ML/day. The estimated yearly inflow is 67 814 ML. Figure 8.2 illustrates the variation of inflow at the plant.

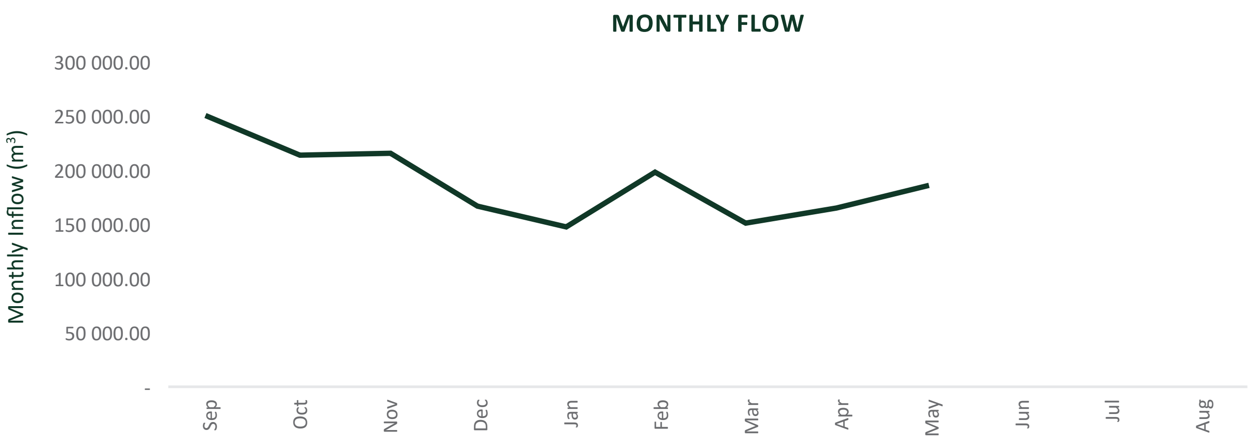



*Figure 8.2: Monthly Inflow.*

## 8.3 ENERGY DATA ANALYSIS

### 8.3.1 Energy sources

Electricity is the main source of energy at Stanger WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by the Municipality.

### 8.3.2 Energy tariff

As per the billing records and due to its location, the Stanger WWTP falls under the KwaDukuza Local Municipality Tariff 1: Industrial, which does not differentiate between "peak", "off-peak" and "standard" rates. Typical KwaDukuza Local Municipality Tariff 1: Industrial tariffs as per the 2019/20 Tariff 1 Structure which includes for a season change, are:

- standard time low and high season: R 1.5550/kWh (June-August)
- standard time low and high season: R 1.3760/kWh (September-May).

### 8.3.3 Baseline energy use and cost

#### *8.3.3.1 Energy use*

Electricity bills for 2019/20 were analysed. A summary of the monthly consumption and demand is given in Table 8.3 and graphical representations of the values are given in Figure 8.4. The monthly consumption generally varies between 24 234.23 and 56 226.70 kWh.

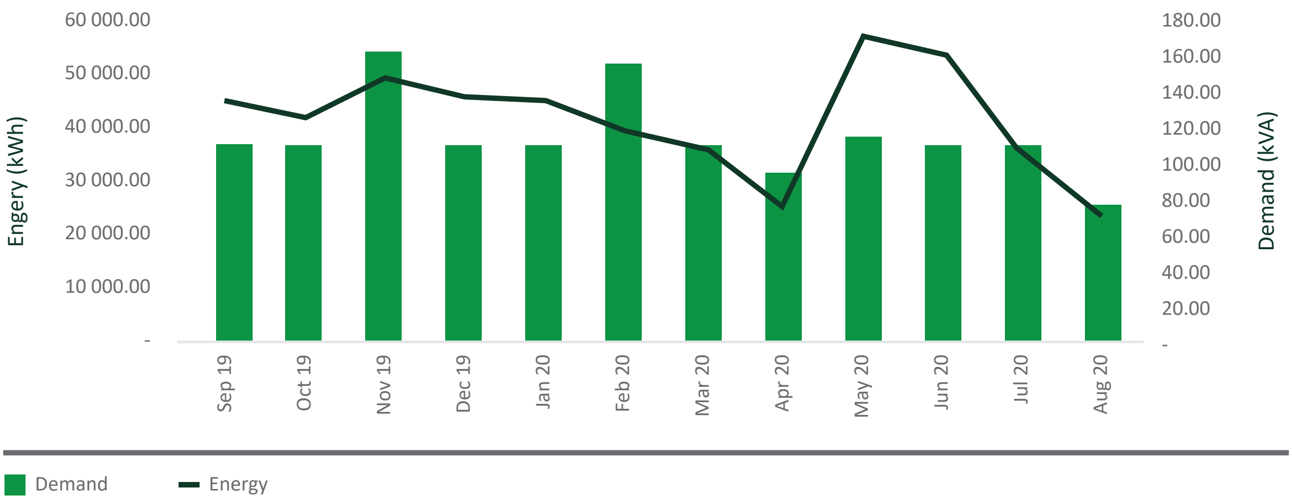



*Figure 8.3: Energy Consumption and Demand Profile.*

#### *8.3.3.2 Energy cost*

In 2019/2020, the plant was billed R 912 167.21 with energy consumption accounting for R 761 714.40 (i.e., 83.51%).

### 8.3.4 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 8.1. Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and/or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

During the site audit and using historical data, 15 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings are summarised in Table 8.1 below.

*Table 8.1: Demand Distribution by Equipment*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerator | 61.34% |
| 2 | Pump | 26.58% |
| 3 | Mixer | 11.50% |
| | **TOTAL** | **99.42%** |

As expected, the bulk of power consumption occurs in aeration, pumping and other applications (biological treatment, pumping sections), representing 99.42% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

In terms of equipment, the aerators form the highest energy consumer with 64.34%, followed by pumps (26.58%), mixers (11.50%), and clarifier bridge (0.57%). The top three energy consumers constitute 99.42% of the total plant's consumption. All the other equipment at the plant accounts for 0.58% of the total energy use excluding buildings. Figure 8.4 shows the demand distribution according to process sections within the plant.

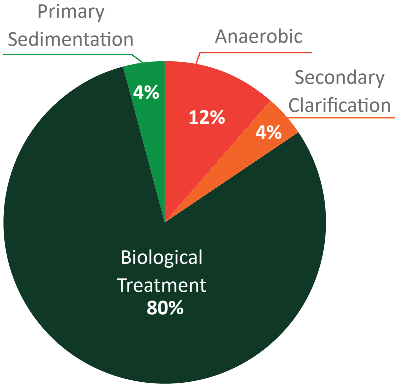



*Figure 8.4: Demand Distribution According to Process Sections*

## 8.4 ONSITE ENERGY PRODUCTION OPPORTUNITIES

### 8.4.1 Solar PV system

A high-level sizing of the solar PV system and economic analysis was conducted. This was mainly based on the available area and the power consumption collected onsite as there was no information on the consumption profile for the plant. Based on the simulation a 300 kWp PV system could be implemented and the simulation results are highlighted in this section.

#### *8.4.1.1 Anticipated energy savings*

A simulation of the grid-tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 8.5.

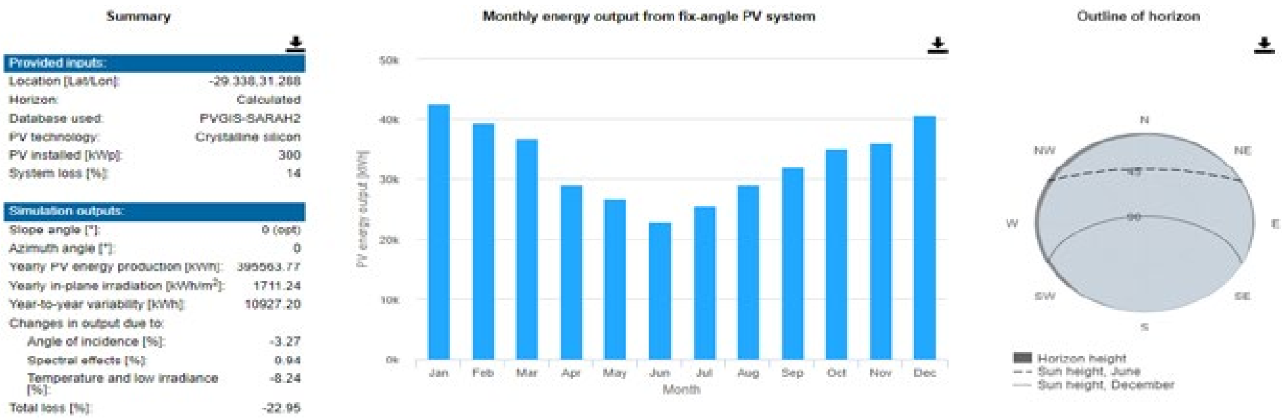



*Figure 8.5: Performance of Grid-Tied PV System at Stanger WWTP.*

The estimated energy production will be 395.564 MWh/year and corresponds to the energy savings that can be realised by the plant. About 79.51% in potential energy savings per year could be realised from the Solar PV installation. The potential economic justification of the solar system is shown in Table 8.2.

*Table 8.2: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 3 900 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 593 345.66 |
| ESKOM price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 3 766 292.00 |
| Internal Rate of Return (IRR) | 12.7% |
| Pay Back Period | 9.47 years |

### 8.4.2 Aeration

Based on the collected data, aeration forms a significant part of consumption at Stanger WWTP 61.34% which amounts to approximately 305 158.53 kWh/year. Due to the requirements to meet the effluent discharge standards the aerators are timer operated.

At Stanger WWTP the existing extent of DO control was estimated to be 50%. With these assumptions and estimates the aerators present significant opportunities for energy savings of up to 3.3% through the implementation of VSD on five aerators. These savings translate to about 16 311 kWh/year. The payback for the VSDs on the aerators is approximately 32.3 years making the feasibility not attractive.

### 8.4.3 Pump efficiency

With reference to the Energy Assessment template, the total contribution of the pump was calculated. There about six pumps of 7.5 kW - 37 kW which contribute 26.58% to the total energy consumptions and approximately 132 231.61 kWh/year. The various flows rate for the different pumps could not be verified during the audit. It is therefore recommended that long term monitoring of the flow rates and pump operating data be considered for pump efficiency adjustments. According to some literature, incorporating VSDs on the pumps will save up to 20%, however this is subject to further investigation using the pump curves (which were not available during the time of the audit).

# 9 DE AAR WASTEWATER TREATMENT PLANT

## 9.1 PLANT OVERVIEW

The De Aar WWTP is designed to treat 20 ML/d with a current flow of 3.16 ML/d. The treatment technology comprises of a combination of physical, chemical, and microbiological processes to meet the required effluent limits and biosolids specifications as set by the Department of Water and Sanitation. De Aar WWTP uses electricity purchased from Eskom as the main energy source on the site.

## 9.2 PLANT TREATMENT PROCESS DESCRIPTION

The sewage is pumped to the plants and flows into the inlet works were manual screening and degritting takes place the screened raw sewage gravitates into the anaerobic ponds. The inflow into the anaerobic ponds is pumped into the anoxic reactor where the mixed liquor overflows into the aeration reactor after which it flows to the clarifiers. The final effluent from the disinfection channel gravitates to the maturation ponds. During the time of the study the plant was not functional due to machine component failure.

### 9.2.1 Influent data

Historical information gathered shows the following:

- Capacity ML/day: Average Wet Weather Capacity – 3.16 ML
- Operational Capacity ML/day: Average Dry Weather Capacity (Based on organic load) - 20
- Design Loading (BOD kg/day) – 1098

## 9.3 ENERGY DATA ANALYSIS

### 9.3.1 Energy sources

Electricity is the main source of energy at De Aar WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by the Eskom.

### 9.3.2 Baseline energy use and cost

Electricity bills for 2020 and 2021 were analysed. A summary of the monthly consumption and demand and graphical representations of the values are given in Figure 9.1. The monthly consumption generally varies between 1 kWh and 381 kWh, which was too low since all sections of the plant were not working.

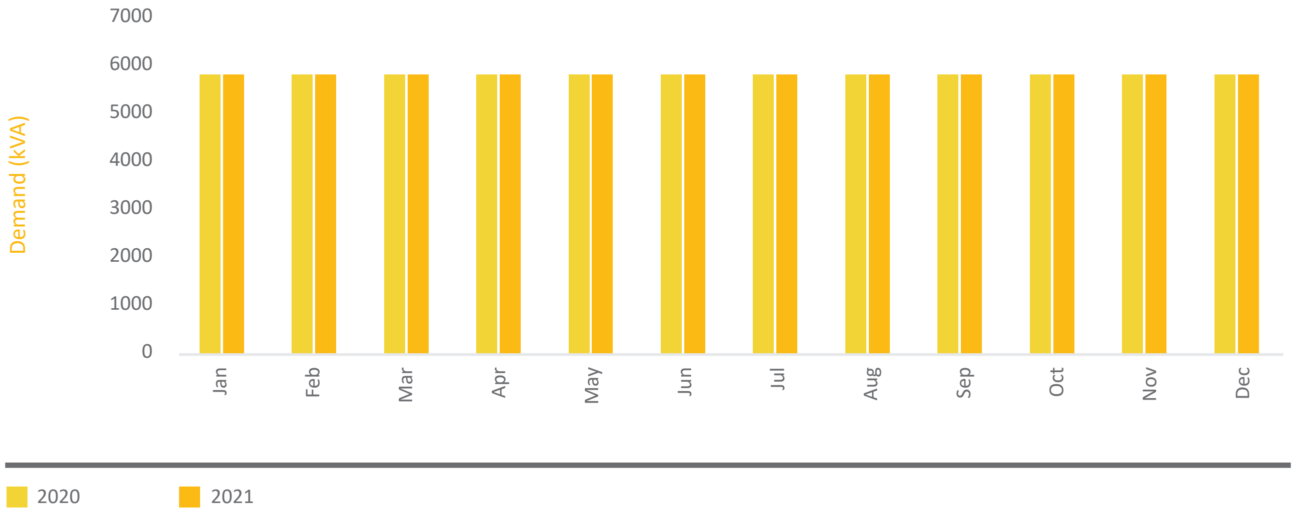



*Figure 9.1: Energy Demand for De Aar WWTP (2020 – 2021).*

### 9.3.3 Energy cost

In 2020 - 2021, the plant was billed about R2 910 600.96 for electricity usage. The energy consumption accounted for about R929.88 (0.032%) with demand charges accounting for R2 909 671.08 (99.968%). On average about R66.24 and R121 236.30 was billed for consumption and demand charges respectively.

### 9.3.4 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 9.1.

Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

During the site audit, 11 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings are summarised in Table 9.1 below.

*Table 9.1: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerator/Blowers | 73.32% |
| 2 | Pumps | 24.44% |
| 3 | Mixer | 2.04% |
| | **TOTAL** | **99.80%** |

As expected, the bulk of power consumption occurs in aeration, pumping and mixing applications (biological treatment, pumping sections), representing 95.62% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

## 9.4 ONSITE ENERGY PRODUCTION OPPORTUNITIES

### 9.4.1 Solar PV system

A high-level sizing of the solar PV system and economic analysis was conducted. This was mainly based on the available area and the power consumption collected onsite as there was no information on the consumption profile for the plant. Based on the simulation a 600kWp PV system could be implemented and the simulation results are highlighted in this section.

### 9.4.2 Anticipated energy savings

A simulation of the grid-tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 9.2.

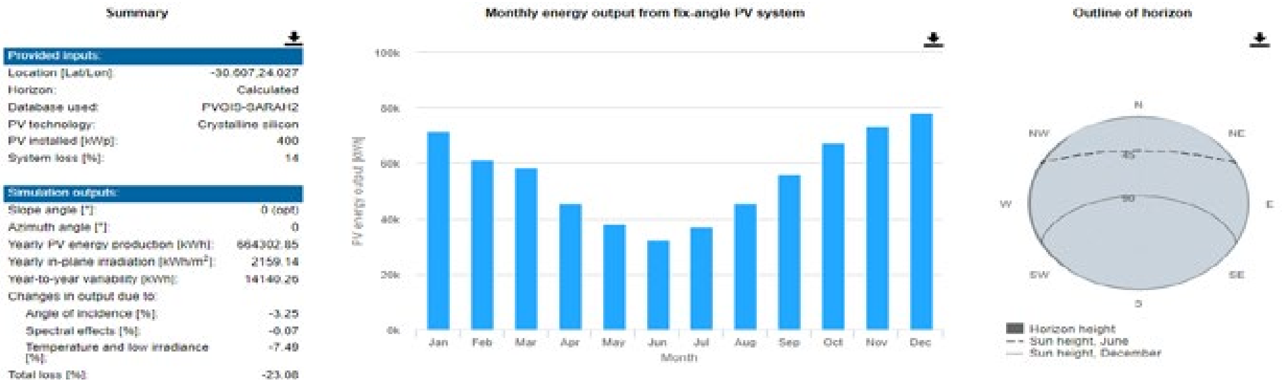



*Figure 9.2: Performance of Grid-Tied PV System at De Aar WWTP.*

# 10 ENNERDALE WASTEWATER TREATMENT PLANT

## 10.1 PLANT OVERVIEW

The catchment area for Ennerdale WWTP is Orange Farm, Poortjie and parts of Ennerdale. The Ennerdale WWTP is designed to treat 8 ML/d (2013) with a current flow of 6.8 ML/d (as ADWF - 2013). The treatment technology comprises of a combination of physical, chemical, and microbiological processes to meet the required effluent limits and biosolids specifications as set by the Department of Water and Sanitation. The plant incorporates a combination of septage, gravity-fed and pumped wastewater to the inlet works, screening, gravitated grit removal, activated sludge and BNR processes and chlorination. The treated effluent is discharged to a local river. The waste sludge undergoes gravity thickening and is dried before removal from site for agricultural use.

## 10.2 PLANT TREATMENT PROCESS DESCRIPTION

### 10.2.1 Overall plant control system

The system at Ennerdale is controlled using SCADA (Supervisory Control and Data Acquisition). However, manual checks on the equipment are required since the SCADA might not be always accurate due to not being updated. Inlet is entirely operated manually with no involvement of SCADA. SCADA is mainly used in the balancing tank and bioreactor sections. In the balancing tank the SCADA monitor the level, activation speed in the mixers and outlet flow rate. SCADA selection of balancing tank pumps on the balancing tank monitor daily inflow bioreactor.

### 10.2.2 Influent data

Historical information shows the following:

- Capacity Ml/day: Average Wet Weather Capacity - 9
- Operational Capacity Ml/day: Average Dry Weather Capacity (Based on organic load) - 8
- % Hydraulic capacity in use - 85
- Design Loading (COD kg/day) – 4 230
- % of Loading capacity in use – 96%
- Current WWTP utilisation as % of capacity -96%
- Sludge produced (dry tons per day) - 1
- Solid waste disposal (m3/day) – 0.06
- Total influent received (Ml/day) – 7
- Operating hours per day – 24.

## 10.3 ENERGY DATA ANALYSIS

### 10.3.1 Energy sources

Electricity is the main source of energy at Ennerdale WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by the City of Johannesburg Municipality.

### 10.3.2 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 10.1.

Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

During the site audit, 38 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings are summarised in Table 10.1 below.

*Table 10.1: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerator/Blowers | 74.23% |
| 2 | Pump | 16.58% |
| 3 | Mixer | 8.44% |
| | **TOTAL** | **99.24%** |

As expected, the bulk of power consumption occurs in aeration, pumping and mixing applications (biological treatment, pumping sections), representing 99.24% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

## 10.4 ONSITE ENERGY PRODUCTION OPPORTUNITIES

### 10.4.1 Solar PV System

A high-level sizing of the solar PV system and economic analysis was conducted. This was mainly based on the available area and the power consumption collected onsite as there was no information on the consumption profile for the plant. Based on the simulation a 400kWp PV system could be implemented and the simulation results are highlighted in this section.

### 10.4.2 Anticipated energy savings

A simulation of the grid-tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 10.1.

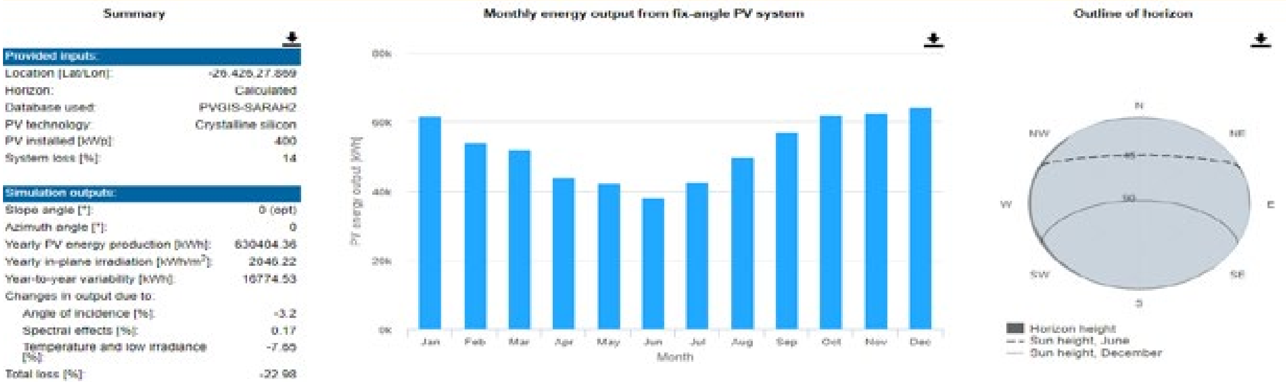



*Figure 10.1: Performance of Grid-Tied PV System at Ennerdale WWTP.*

The estimated energy production will be 630.404 MWh/year and corresponds to the energy savings that can be realised by the plant. About 24.28% in potential energy savings per year could be realised from the solar PV installation. The potential economic justification of the solar system is shown in Table 10.5.

*Table 10.2: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 5 200 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 945 606.54 |
| ESKOM price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 7 017 661.00 |
| Internal Rate of Return (IRR) | 23.4% |
| Pay Back Period | 5.02 years |

Based on the estimates the returns on a project of this nature shows that this option is economically viable for the plant and can be considered.

# 11 KLERKSDORP WASTEWATER TREATMENT PLANT

## 11.1 PLANT OVERVIEW

The Klerksdorp WWTP is designed to treat 36 ML/day with a current flow of 25 ML/day (as ADWF - 2015). The treatment technology comprises of a combination of physical, chemical and microbiological processes to meet the required effluent limits and biosolids specifications as set by the Department of Water and Sanitation. The plant is classified as a Class A plant, consisting of activated sludge process for liquid treatment and anaerobic digestion for sludge treatment.

Klerksdorp WWTP uses electricity purchased from the City of Matlosana as the main energy source on the site. A 110 kVA generator is also available to provide back-up power during power failures.

## 11.2 PLANT TREATMENT PROCESS DESCRIPTION

Sewage enters the plant at a main inlet works and at a night soil handling facility. From the main inlet works the solids are separated from the sewage and are split between two primary sedimentation tanks. After pre-sedimentation, the flow gravitates to two activated sludge plants namely Module 2 and Module 3. The settled sludge from the primary clarifiers is pumped to the anaerobic digester (sludge lagoon). After pre-sedimentation the overflows from each sedimentation tank (Primary Sedimentation Tank 1 and Primary Sedimentation Tank 2) gravitate to a biological reactor (Module 2 and Module 3) respectively. From the Module 3 biological reactor, some sludge is waste activated sludge (WAS) tank where settling takes place. The overflow from this tank will go to the chlorination facility and the underflow or the waste activated sludge will be sent to the first anaerobic sludge lagoon. The rest of the flow from Module 3 will enter two secondary sedimentation tanks from where the overflow will be sent to the chlorination facility. The underflow from these two secondary sedimentation tanks will be recycled to the Module 3 biological reactor and the scum will be combined with the scum from the first primary sedimentation tank to the first sludge lagoon. During the time of the study the plant was not functional due to machine component failure and cable theft.

### 11.2.1 Influent data

Historical information shows the following:

- Capacity Ml/day: Average Wet Weather Capacity - 36
- Operational Capacity Ml/day: Average Dry Weather Capacity (Based on organic load) - 36
- % Hydraulic capacity in use – 62%
- Design Loading (COD kg/day) – 23.4
- % of Loading capacity in use – 93%
- Current WWTP utilisation as % of capacity - 93%
- Sludge produced (dry tonnes per day) – 0.07
- Solid waste disposal (M3/day) – 0.67
- Total influent received (Ml/day) – 25
- Operating hours per day – 24.

## 11.3 ENERGY DATA ANALYSIS

### 11.3.1 Energy sources

Electricity is the main source of energy at Klerksdorp WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by the Eskom.

### 11.3.2 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 11.1.

Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

During the site audit, 70 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings are summarised in Table 11.1 below.

*Table 11.1: Demand Distribution by Equipment*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerator/Blowers | 72.68% |
| 2 | Mixer | 12.95% |
| 3 | Pumps | 10.59% |
| | **TOTAL** | **96.21%** |

As expected, the bulk of power consumption occurs in aeration, pumping and mixing applications (biological treatment, pumping sections), representing 96.21% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

In terms of equipment, the aerators form the highest energy consumer with 72.68 %, followed by mixers (12.95%), pumps (10.59%), other equipment (1.93%), clarifier bridge (0.71%) and lastly screens and press (0.57%). The top three energy consumers constitute 96.21% of the total plant's consumption. All the other equipment at the plant accounts for 3.79% of the total energy use excluding buildings.

## 11.4 ONSITE ENERGY PRODUCTION OPPORTUNITIES

### 11.4.1 Solar PV system

A high-level sizing of the solar PV system and economic analysis was conducted. This was mainly based on the available area and the power consumption collected onsite as there was no information on the consumption profile for the plant. Based on the simulation a 1 000kWp PV system could be implemented and the simulation results are highlighted in this section.

#### *11.4.1.1 Anticipated energy savings*

A simulation of the grid-tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 11.1.

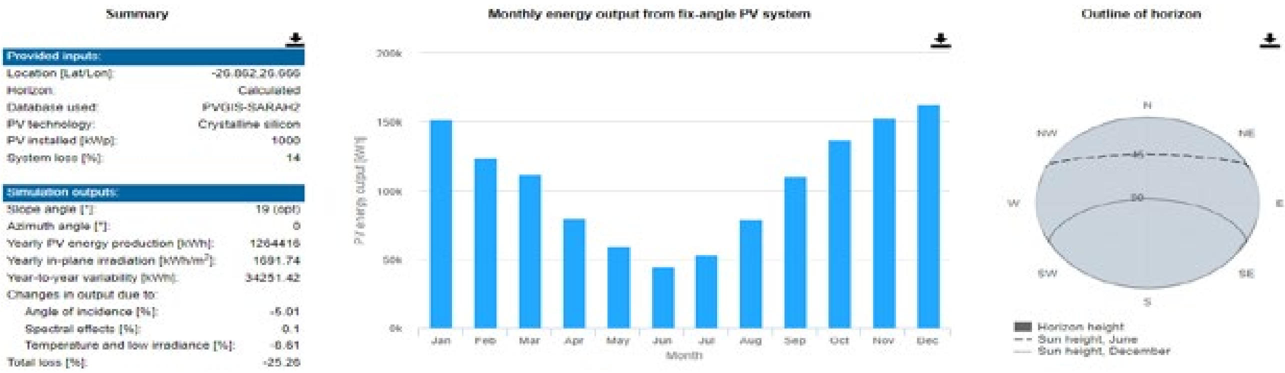



*Figure 11.1: Performance of Grid-Tied PV System at Klerksdorp WWTP.*

The estimated energy production will be 1 264.42 MWh/year and corresponds to the energy savings that can be realised by the plant. About 13.17% in potential energy savings per year could be realised from the solar PV installation. The potential economic justification of the solar system is shown in Table 11.2.

*Table 11.2: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 13 000 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 1 896 624.00 |
| ESKOM price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 11 505 234.00 |
| Internal Rate of Return (IRR) | 19.2% |
| Pay Back Period | 6.09 years |

Based on the estimates the returns on a project of this nature shows that this option is economically viable for the plant and can be considered.

# 12 ORKNEY WASTEWATER TREATMENT PLANT

## 12.1 PLANT OVERVIEW

The Orkney WWTP is designed to treat 20 ML/day with a current flow of 16 ML/day ( ADWF, 2015). The treatment technology comprises of a combination of physical, chemical, and microbiological processes to meet the required effluent limits and biosolids specifications as set by the Department of Water and Sanitation. Orkney WWTP uses electricity purchased from the City of Matlosana as the main energy source on the site.

## 12.2 PLANT TREATMENT PROCESS DESCRIPTION

Sewage enters the plant at a main inlet works and at a night soil handling facility. From the main inlet works the solids are separated from the sewage and are split between two primary sedimentation tanks. After pre-sedimentation, the flow gravitates to two activated sludge plants namely Module 2 and Module 3. The settled sludge from the primary clarifiers is pumped to the anaerobic digester (sludge lagoon). After pre-sedimentation the overflows from each sedimentation tank (Primary Sedimentation Tank 1 and Primary Sedimentation Tank 2) gravitate to a biological reactor (Module 2 and Module 3) respectively. From the Module 3 biological reactor, some sludge is waste activated sludge (WAS) tank where settling takes place. The overflow from this tank will go to the chlorination facility and the underflow or the waste activated sludge will be sent to the first anaerobic sludge lagoon. The rest of the flow from Module 3 will enter two secondary sedimentation tanks from where the overflow will be sent to the chlorination facility. The underflow from these two secondary sedimentation tanks will be recycled to the Module 3 biological reactor and the scum will be combined with the scum from the first primary sedimentation tank to the first sludge lagoon. During the time of the study the plant was not functional due to machine component failure and cable theft.

### 12.2.1 Influent data

Historical information shows the following:

- Capacity Ml/day: Average Wet Weather Capacity - 36
- Operational Capacity Ml/day: Average Dry Weather Capacity (Based on organic load) - 36
- % Hydraulic capacity in use – 62%
- Design Loading (COD kg/day) – 23.4
- % of Loading capacity in use – 93%
- Current WWTP utilisation as % of capacity - 93%
- Sludge produced (dry tonnes per day) – 0.07
- Solid waste disposal (M3/day) – 0.67
- Total influent received (Ml/day) – 25
- Operating hours per day – 24.

## 12.3 ENERGY DATA ANALYSIS

### 12.3.1 Energy sources

Electricity is the main source of energy at Orkney WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by Eskom.

### 12.3.2 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 12.1.

Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

During the site audit, 70 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings are summarised in Table 12.1 below.

*Table 12.1: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerators | 89.21% |
| 2 | Pumps | 9.15% |
| | **TOTAL** | **98.36%** |

As expected, the bulk of power consumption occurs in aeration, pumping and mixing applications (biological treatment, pumping sections), representing 98.36% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

In terms of equipment, the aerators form the highest energy consumer with 89.21 %, followed by pumps (9.15%), clarifier bridge (1.80%), mixers (1.47%), screen (0.16%), and lastly other drives (0.01%). The top two energy consumers constitute 98.36% of the total plant’s consumption. All the other equipment at the plant accounts for 1.64% of the total energy use excluding buildings.

## 12.4 ONSITE ENERGY PRODUCTION OPPORTUNITIES

### 12.4.1 Solar PV system

A high-level sizing of the solar PV system and economic analysis was conducted. This was mainly based on the available area and the power consumption collected onsite as there was no information on the consumption profile for the plant. Based on the simulation a 600kWp PV system could be implemented and the simulation results are highlighted in this section.

#### *12.4.1.1 Anticipated energy savings*

A simulation of the grid-tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 12.1.

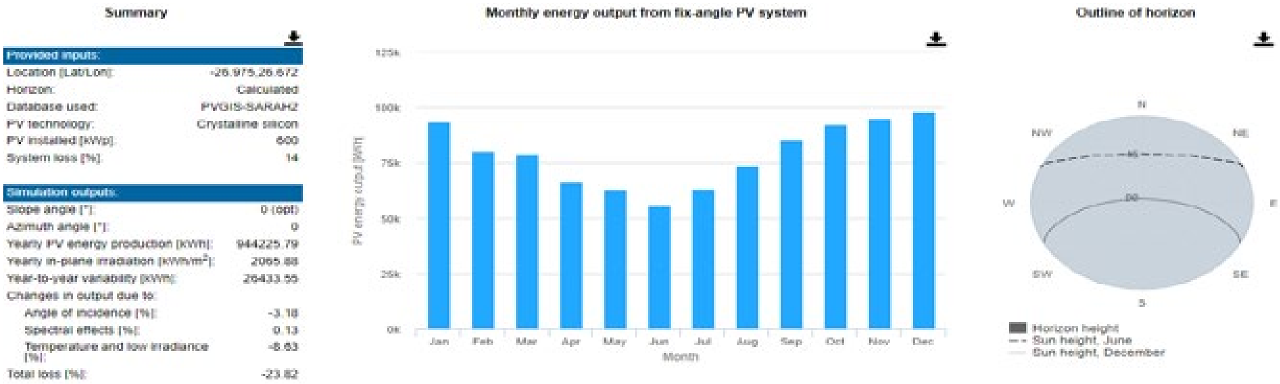



*Figure 12.1: Performance of Grid Tied PV System at Orkney WWTP.*

The estimated energy production will be 944. 23 MWh/year and corresponds to the energy savings that can be realised by the plant. About 23.25% in potential energy savings per year could be realised from the solar PV installation. The potential economic justification of the solar system is shown in Table 12.2.

*Table 12.2: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 7 800 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/ kWh) | R 1 137 974.40 |
| ESKOM price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 6 903 140.00 |
| Internal Rate of Return (IRR) | 19.2% |
| Pay Back Period | 6.09 years |

Based on the estimates the returns on a project of this nature shows that this option is economically viable for the plant and can be considered.

# 13 RANDFONTEIN WASTEWATER TREATMENT PLANT

## 13.1 PLANT OVERVIEW

Randfontein WWTP is in the rand-west city local municipality of Gauteng province. A total refurbishment of the plant was carried out in 2020. Presently it is serving a population of approximately 90 000 which is estimated to grow to 104 526 by the year 2027 and its maximum capacity is 19.5ML., It receives 11ML/day from both domestic and industrial sources alongside the municipality. The plant is classified as class A which is registered in terms of section 36 of the National Water Act (Act No. 36 of 1998) for the operation of water care works. Raw wastewater is screened, degritted and transported to the primary settling tanks (PSTs), biological reactors, secondary settling tanks and then the final effluent which is disinfection.

## 13.2 ENERGY DATA ANALYSIS

### 13.2.1 Energy sources

Electricity is the main source of energy at Randfontein WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by the Municipality (Randwest Municipality).

### 13.2.2 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 13.1.

Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

During the site audit, 45 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings are summarised in Table 13.1 below.

Table 13.1: Demand Distribution by Equipment.

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerators | 80.46% |
| 2 | Pumps | 14.46% |
| 3 | Mixers | 3.91% |
| | **TOTAL** | **98.83%** |

As expected, the bulk of power consumption occurs in aeration, pumping and mixing applications (biological treatment, pumping sections), representing 98.83% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

## 13.3 ONSITE ENERGY PRODUCTION OPPORTUNITIES

### 13.3.1 Solar PV system

A high-level sizing of the solar PV system and economic analysis was conducted. This was mainly based on the available area and the power consumption collected onsite as there was no information on the consumption profile for the plant. Based on the simulation a 600kWp PV system could be implemented and the simulation results are highlighted in this section.

#### *13.3.1.1 Anticipated energy savings*

A simulation of the grid-tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 13.1.

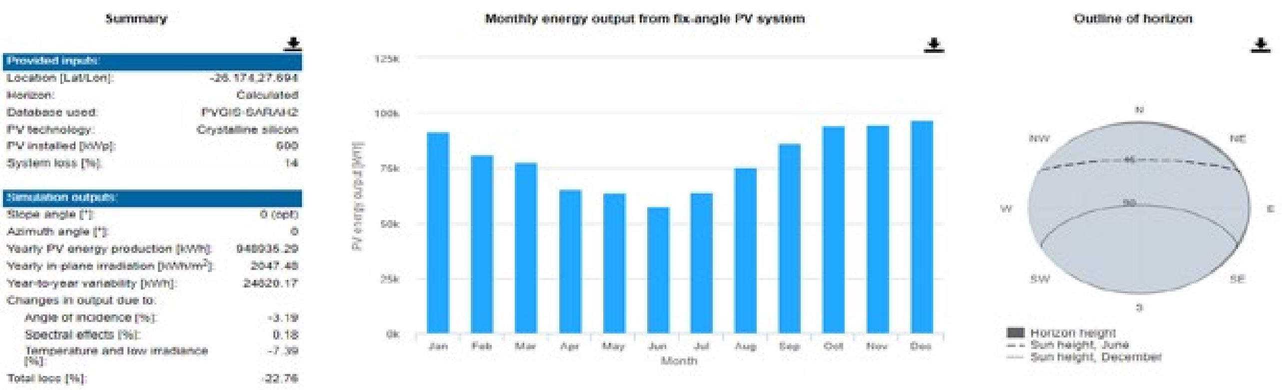



*Figure 13.1: Performance of Grid-Tied PV System at Randfontein WWTP.*

The estimated energy production will be 948.935 MWh/year and corresponds to the energy savings that can be realised by the plant. About 17.95% in potential energy savings per year could be realised from the solar PV installation. The potential economic justification of the solar system is shown in Table 13.2.

Table 13.2: Solar Power Installation Evaluation.

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 7 800 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 1 423 402.94 |
| ESKOM price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 10 591 005.00 |
| Internal Rate of Return (IRR) | 23.4% |
| Pay Back Period | 5.01 years |

Based on the estimates the returns on a project of this nature shows that this option is economically viable for the plant and can be considered.

# 14 STILFONTEIN WASTEWATER TREATMENT PLANT

## 14.1 PLANT OVERVIEW

The Stilfontein WWTP is designed to treat 12 ML/day with a current flow of 8 ML/day ( ADWF, 2015). The treatment technology comprises of a combination of physical, chemical and microbiological processes to meet the required effluent limits and biosolids specifications as set by the Department of Water and Sanitation. Stilfontein WWTP uses electricity purchased from the City of Matlosana as the main energy source on the site.

## 14.2 PLANT TREATMENT PROCESS DESCRIPTION

During the time of the study the plant was not fully functional due to cable theft as well as machine vandalism, of the two aeration basins on the plant only Module 1 was in operation and information gathered from the Municipality suggested that refurbishment of the plant was in the pipeline to resuscitate the WWTP to its full functionality.

### 14.2.1 Influent data

Historical information gathered shows the following:

- Capacity ML/day: Average Wet Weather Capacity – 12.3
- Operational Capacity ML/day: Average Dry Weather Capacity (Based on organic load) - 36
- % Hydraulic capacity in use – 62%
- Design Loading (COD kg/day) – 8
- % of Loading capacity in use – 93%
- Current WWTP utilisation as % of capacity - 93%
- Sludge produced (dry tonnes per day) – 0.07
- Solid waste disposal (M3/day) – 0.67
- Total influent received (Ml/day) – 8
- Operating hours per day – 24.

## 14.3 ENERGY DATA ANALYSIS

### 14.3.1 Energy sources

Electricity is the main source of energy at Stilfontein WWTP which is used in the treatment process as well as for outside lighting and in the buildings. All the electricity used at the plant is supplied by the Municipality (City of Matlosana).

### 14.3.2 Energy split

The plant demand distribution by section of the treatment plant is shown in Table 14.1.

Power usage at the different sections of the plant was theoretically determined from the equipment ratings as per the name plates and or the plant manual. It should be noted that energy use calculation was based on the operation hours as stipulated by process controller as well as based on the plant operational manual.

During the site audit, 38 electrical equipment drives were identified. The drives were sorted based on the percentage contribution they made to the total power consumption. The highest energy consumers, excluding the low voltage power used in buildings are summarised in Table 14.1 below.

*Table 14.1: Demand Distribution by Equipment.*

| # | Equipment Description | Percentage of Power Consumed |
|---|---|---|
| 1 | Aerator | 78.10% |
| 2 | Mixer | 8.99% |
| 3 | Pump | 8.52% |
| | **TOTAL** | **95.62%** |

As expected, the bulk of power consumption occurs in aeration, pumping and mixing applications (biological treatment, pumping sections), representing 95.62% of total power consumption excluding buildings. These plant sections should be prioritised for energy efficiency interventions.

## 14.4 ONSITE ENERGY PRODUCTION OPPORTUNITIES

### 14.4.1 Solar PV system

A high-level sizing of the solar PV system and economic analysis was conducted. This was mainly based on the available area and the power consumption collected onsite as there was no information on the consumption profile for the plant. Based on the simulation a 600kWp PV system could be implemented and the simulation results are highlighted in this section.

#### *14.4.1.1 Anticipated energy savings*

A simulation of the grid-tied solar PV system was done using the information gathered onsite, the performance of the system is shown in Figure 14.1.

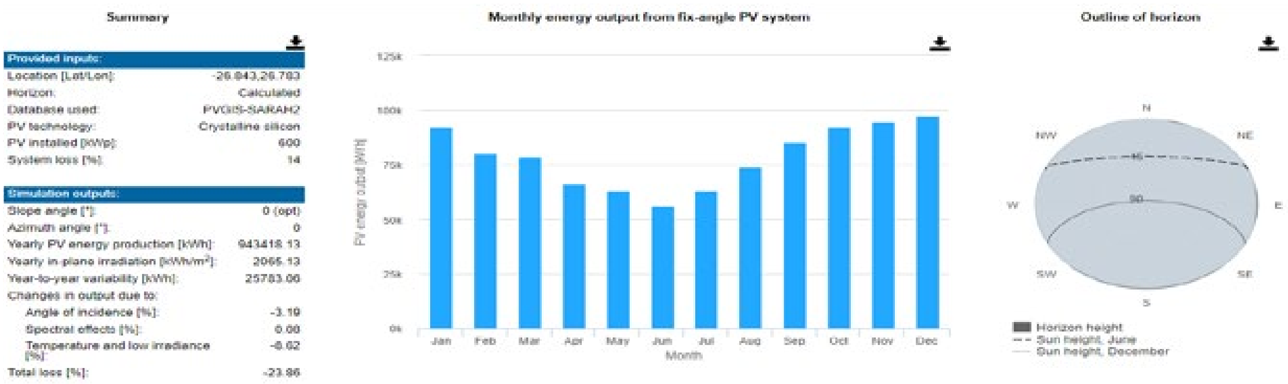



*Figure 14.1: Performance of Grid Tied PV System at Stilfontein WWTP.*

The estimated energy production will be 943.418 MWh/year and corresponds to the energy savings that can be realised by the plant. About 19.68% in potential energy savings per year could be realised from the solar PV installation. The potential economic justification of the solar system is shown in Table 14.2.

*Table 14.2: Solar Power Installation Evaluation.*

| Description | Quantity |
|---|---|
| Total Solar PV system and Installation Cost | R 7 800 000.00 |
| NPV & IRR Calculation period | 20 years |
| Year 1 energy savings (assuming energy charges @ 1.50/kWh) | R 1 415 127.20 |
| ESKOM price escalation (conservative) | 8% |
| Operations and Maintenance | 1% of project cost/year |
| Interest Rate | 11% |
| Net Present Value (NPV) | R 10 484 079.00 |
| Internal Rate of Return (IRR) | 23.3% |
| Pay Back Period | 5.03 years |

Based on the estimates the returns on a project of this nature shows that this option is economically viable for the plant and can be considered.

# PART C: KEY TAKE-AWAYS

# 1 RECOMMENDATIONS

The municipalities are recommended to firstly embark on quick fixes with low investment cost to start generating improvement and repair/refurbish the WWTP. This will assist as EE initiatives are implemented. The larger energy consumers present the largest opportunity to realise an improvement.

The following general recommendation will enable the plants to save on energy:

- Optimising on operational processes that will reduce energy consumption, e.g., operate ASP reactor at the required DO levels, operate PST optimally to divert a maximum part of CPD to the anaerobic digesters, operate RAS sump at a higher sump level without compromising proportionate TAS extraction from each clarifier, avoid throttling valves on pump delivery lines, rather run pumps for shorter times without compromising process.
- Biological treatment, pumping and secondary clarification (pumps) could be prioritised for energy efficiency innervations. Moreso, at equipment level, aerators mixers and pumps should be prioritised for EE initiatives.
- Simple operations and maintenance adjustments can be considered for existing equipment to reduce energy costs. Proper maintenance is always needed, including checking motors regularly and ensuring that all repairs are undertaken. This will, in turn enhance the largest energy gains.
- Determining the pump efficiency over the range of pumping requirements would assist for optimum energy use to improve pump efficiency. Proper studies need to be done where calculations were made on theoretical assumptions rather than data gathered.
- Where possible use the solar and/or biogas generated energy to maximise savings. All plants have the necessary space to install solar and/or biogas systems to generate energy.
- Replace inefficient lights with more efficient options such as LEDs, replace failing air conditioning units with energy efficient units, and failing geysers with solar geysers or heat pumps.
- Install check meters on the Eskom meters, record the readings daily and manage the data in the same manner as flow meter readings are coupled with effective data management.
- In line with recommended international best practices, it is recommended that municipalities should prioritise having an energy management team who will be responsible for driving the energy-related projects and develop energy efficiency policy statement documents, both at the municipal level and site level.

## HARDWARE

- The cost of converting or replacing IE1/2 class electrical motors with IE3/4 class motors will vary depending on the size of the motor.
- The remainder of the motors can be replaced as part of the normal asset replacement cycle as/when the motor has reached its end-of-life.
- Motor loadings should also be carefully investigated before considering high-efficiency replacements.
- At sites operating under peak and off-peak rates (leading to surplus charges due to peak rates), this must be minimised. Aeration during the non-peak rate hours in the early morning and then cutting back on aeration once the peak rate hours start, followed by a gradual increase in the aeration rate as the DO levels are depleted thus shifting aeration energy from peak to cheaper non-peak periods. The onsite analysis must be done to weigh the justifiable EE improvements versus potential operating risks.

# REFERENCES


- SANEDI (2021), (RFQ) – BID127RFQ227, Appointment of a Service Provider(S) to Undertake Pre-Feasibility Studies, Collect and Analyse Data, and Develop Energy Efficiency and Demand Side Management (EEDSM) Project Concepts in Fourteen (14) Wastewater Treatment Plants (WWTPS) for a Period ff Six (6) Month.
- Brandt MJ, Middleton RA and Wang S (2011). Energy Efficiency in the Water Industry: A Compendium of Best Practices and Case Studies. UK Water Industry Research Limited, Report No. 10/CL/11/3.
- Liptak BG (2006). Instrument Engineers' Handbook, Fourth Edition, Volume II: Process Control and Optimization, Edition 4. CRC Press, Florida, USA. ISBN: 9781420064001.
- Corominas L, Subiranas J, Comas J, Vanrolleghem PA, Rieger L and Poch M (2009). Using Modelling to Optimize a Full-Scale WWTP for Energy Reduction and Increased Biological Nitrogen Removal. Procs WEF Nutrient Removal Conference 2011, Washington, DC. USA.
- Corominas L, Flores-Alsina X, Muschalla D, Neumann MB and Vanrolleghem PA (2010). Verification of WWTP Design Guidelines with Activated Sludge Process Models. Procs. WEFTEC 2010, New Orleans, USA.
- Corominas LI, Rieger I, Takacs I, Ekama G, Hauduc H, Vanrolleghem PA, Oehmen A, Gernaey KV, Van Loosdrecht MCM and Comeau Y (2010). New Framework for Standardized Notation in Wastewater Treatment Modelling, Water Science & Technology. 61(2).
- Crawford G and Sandino J (2010). Energy Efficiency in Wastewater Treatment in North America: A Compendium of Best Practices and Case Studies of Novel Approaches. Water Environment Research Foundation, USA.
- Dold P, Al-Omari A, Makhayeri Y, Awobanise M, Stinson B, Bodniewicz B, Bailey W, Jones R and Murthy S (2010). Measuring Influent Heterotrophic Biomass Content for Modeling and Design. Procs., WEFTEC 2010, New Orleans, USA.
- Environment Protection Agency (2008). Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities. EPA, Report 832-R-10_005.
- Environment Protection Agency (2010). Evaluation of Energy Conservation Measures for Wastewater Treatment facilities. EPA Report 832-R-10_005.
- Frost and Sullivan (2011). Power Outages and their Impact on South Africa's Water and Wastewater Sectors. Water Research Commission, Research Report no. KV267/11, Pretoria, South Africa.
- Griborio A, Rohrbacher J, McGehee M, Pitt P, Latimer R, Gellner J (2010). Combining Stress Testing and dynamic linking of whole plant simulators and CFD for the evaluation of WWTP wet weather capacity. Water Environment Federation, Report: WEFTEC 2010.
- Jonasson M (2007). Energy benchmark for Wastewater Treatment Process: A comparison between Sweden and Austria. Department of Industrial Electrical Engineering and Automation, Lund University.
- Hill D (2010). Optimizing Bio-treatment: Integrated Process Models & Control Strategies. IWA Publishing, London, UK, ISBN: 9781843393924 (eBook).
- Gu, Y., Li, Y., Li, X., Luo, P., Wang, H., Wang, X., Wu, J. and Li, F.(2017). Energy self-sufficient wastewater treatment plants: feasibilities and challenges. Energy Procedia, 105, pp.3741-3

**South African National Energy Development Institute**
CEF House
Upper Grayston Office Park
152 Ann Crescent
Strathavon
Sandton 2196

information@sanedi.org.za
0110384700