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SUSTAINABLE ENERGY SOURCES: THE IMPACT OF SOLAR PV INSTALLATION IN ETHEKWINI, KWAZULU-NATAL

By B. Moosa

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ABSTRACT

This study examines the impact of solar photovoltaic (PV) installations in the eThekwini Metropolitan Municipality, focusing on economic and environmental benefits, implementation challenges, and policy recommendations. The primary objective is to evaluate solar PV as a sustainable alternative to coal-powered and diesel-generated electricity. A quantitative research approach was adopted, utilising the eThekwini Municipality – GIS Department's solar map viewer to calculate potential annual savings from solar energy adoption. Six locations with mixed property uses—including commercial, residential, industrial, and special-use properties—were analysed to visualize potential cost savings and energy efficiency gains. The findings indicate that switching from coal-generated power to solar power can lead to significant economic savings, with electricity cost reductions of 20–30% for businesses and households. The municipality's feed-in tariff program has further incentivized adoption, and over 5,000 participants now contribute excess energy to the grid. Additionally, the solar sector has created approximately 1,500 local jobs in installation, maintenance, and manufacturing. From an environmental perspective, solar PV adoption has resulted in a 15% reduction in municipal carbon emissions, aiding in climate change mitigation. However, challenges such as high upfront installation costs and a lack of awareness persist, limiting widespread adoption. Solar PV systems offer significant economic and environmental benefits, but financial and educational barriers must be addressed. The study recommends expanding financial incentives, enhancing public awareness campaigns, and streamlining regulations to facilitate increased adoption. These efforts will contribute to a more sustainable and energy-efficient future for eThekwini.

KEY WORDS Solar PV, eThekwini, KwaZulu-Natal, Sustainable energy, feed-in tariff, Climate change, Renewable energy

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1. INTRODUCTION

The urban environmental landscape in South Africa presents a critical challenge requiring urgent attention. Over the past three decades, rapid municipal and governmental development has largely overlooked environmental sustainability and green practices, exacerbating the situationAccording to The World Bank (2016), rapid urban growth and climate change have significant impact on the environmental resources and ecosystem services provided by the city of eThekwini, with heavily polluted rivers and terrestrial plants on the verge of becoming endangered. The significance of creating a blueprint for sustainable energy solutions has grown on the African urban environment since the technological boom. Even after significant urbanization, eThekwini is endowed with abundant natural resources it is one of the world's 35 biodiversity hotspots, home to a high percentage of endemic plant and animal species with 3 terrestrial biomes: savanna, forest and grassland, supporting more than 2,000 plant species, 97 km of coastline, 18 rivers, 16 estuaries and 4,000 km of riverbanks (Global Ocean Forum, 2010).

In 2015, the eThekwini municipal council approved the Durban Climate Change Strategy (DCCS) revolving around thematic areas to improve the environmental intergrity of eThekwini, with energy objectives directing a 40% shift of the metropolitan area to renewable energy 2023 (eThekwini Municipality, 2020). Solar energy is a clean and renewable energy source that has the potential to greatly reduce our dependence on fossil fuels. It is generated by converting the energy from the sun into electricity or heat. In recent years, the use of solar energy has been on the rise around the world, as more and more countries are recognizing the benefits of this clean energy source. One of the main advantages of solar energy is that it is a clean and sustainable energy source. Unlike fossil fuels, solar energy does not produce harmful emissions or contribute to climate change. This makes it an attractive option for countries that are looking to reduce their carbon footprint and meet their climate change targets.

Another advantage of solar energy is that it is widely available. The sun is a constant source of energy that can be harnessed all over the world. This means that countries that may not have access to other forms of energy, such as fossil fuels, can still benefit from solar energy (Climate Action Tracker, 2023).

In addition, solar energy is becoming increasingly cost-competitive with fossil fuels. The cost of solar panels and other solar technology has been decreasing in recent years, making it more affordable for individuals and businesses to install solar systems. This has led to a significant increase in the number of solar installations around the world (Dociu & Dunarintu, 2012). Currently, China and the United States are the top solar energy producers, followed by Japan, Germany, and India. These countries have implemented policies and programs to promote the use of solar energy, including government incentives and subsidies for solar projects, and have seen significant growth in their solar energy industries as a result (China Organization, 2020). However, despite the growth in solar energy usage, it still only accounts for a small percentage of the world's energy mix. The cost of energy storage is still relatively high, making it difficult for solar energy to compete with fossil fuels on a large scale. However, as technology continues to improve and costs continue to decrease, it is likely that the use of solar energy will continue to increase in the coming years. In South Africa, loadshedding has had a significant impact on the economy and daily life of citizens. Loadshedding is a term used to describe the intentional power cuts that are implemented by utility companies in order to manage and balance supply and demand for electricity (Gubangxa, 2021).

One of the main impacts of loadshedding in South Africa has been on the economy. Businesses have been forced to shut down or reduce production during power cuts, leading to losses in revenue and productivity. This has had a ripple effect on the economy, as decreased production has led to job losses and reduced economic growth. Additionally, loadshedding has also had a significant impact on daily life for citizens. Power cuts can last for several hours at a time and can occur at any time of day, making it difficult for people to carry out their daily activities and maintain their livelihoods. This has particularly affected those who rely on electricity for essential services such as healthcare and education. Loadshedding has also had an impact on the country's infrastructure. Power cuts can cause damage to equipment and appliances, and have also led to increased wear and tear on generators and other backup power sources.The main cause of loadshedding in South Africa is the lack of sufficient electricity generation capacity to meet the growing demand. The state-owned utility company, Eskom, which is responsible for the majority of electricity generation in the country, has been facing financial and operational challenges, leading to a lack of maintenance and investment in new power plants. This has resulted in a shortage of electricity and the need for load shedding (Development Bank of South Africa, 2023).

In recent years, the South African government has announced plans to address the issue of loadshedding by increasing investment in renewable energy and independent power producers. However, it will take time for these plans to come to fruition, and in the meantime, the issue of loadshedding continues to affect the country. Loadshedding has had a significant impact on the economy and daily life in South Africa. It is caused by a lack of sufficient electricity generation capacity and the financial and operational challenges faced by the state-owned utility company (Ali & Husain, 2018). While the government is making efforts to address the issue, it will take time for these efforts to have a meaningful impact. KwaZulu-Natal is a province in South Africa known for its abundant

sunshine, making it a prime location for solar energy generation. The province has a high solar insolation, which refers to the amount of solar radiation that reaches the surface of the earth, and this makes it an ideal place for solar power plants (Haywood, 2016).

Since the boom of renewable energy alternatives, the mid 2010's, there has been a growing interest in solar energy in KwaZulu-Natal, with several solar power projects being developed in the province. One of the most notable solar energy projects in South Africa is the Khi Solar One power plant, located in the Northern Cape. It is the first privately-funded solar power plant in South Africa and it provides clean energy to over 80,000 homes (eThekwini Municipality, 2020). Another notable project is the Soweto Solar Park, which is located in the heart of Soweto, Johannesburg. This project is aimed at reducing the cost of electricity for low-income households and it has been successful in reducing the electricity bills of more than 100,000 households. The government of KwaZulu-Natal has also been promoting the use of solar energy in the province through various initiatives. The Department of Economic Development, Tourism and Environmental Affairs has developed a solar energy policy that aims to increase the use of solar energy in the province. This policy includes initiatives such as the installation of solar panels on government buildings and the implementation of solar energy education programs. In addition to these projects, there are also several private companies and organizations in KwaZulu-Natal that are investing in solar energy. These companies are building and operating solar power plants, as well as providing solar energy solutions for homes and businesses.

1.1. Durban's Energy Office Solar (EOS) Project

The Energy Office Solar (EOS) project is a pilot project that actioned in the eThekwini Municipality implementing 300 kWp of rooftop Photovoltaic on 5 municipal owned rooftops. The project was undertaken to test the regulations and processes that the Municipality has put in place for the private sector to adhere to when installing Rooftop PV (Ntshalintshali, 2015), and garnered recognition as a physical means to addressing load-shedding and electricity challenges faced by the region. The municipality reported the purpose of this project as a means for progress reporting and understanding the potential of the PV systems with promises to rollout a programme that would implement PV systems to municipal owned facilities – this imagined prospect has not been confirmed as realized. To measure the success of national rollout of the Solar PV systems would create opportunity for budget relooking and redefining. The shortlisting process by the Energy Office resulted in 6 buildings being identified for installation, these buildings were uShaka Marine World, Water and Sanitation Headquarters, Metro Police Headquarters, Moses Mabhida Stadium Arch, People's Park Café and Loram House which was later removed due to structural concerns, resulting in only 5 municipal facilities being equipped with Rooftop PV. The total capital cost to the municipality was reported at R7 600 000.00 (Seven Million Six Hundred Thousand Rands) to equip 5 municipal facilities with Solar PV Systems (eThekwini Municipality, 2020).

1.2. Solar Implementation in South Africa

Sustainable development goals within the continent have been improving and progressing since 2008. The South African government published guidelines on the processes to improve the rate of achieving SDG's within the region. Sustainable development has been cited as the blueprint for enhancing human well-being and quality of life, focusing on creating access to resources and ensuring that urbanization is met with sustainable procedures and policies to control the depletion of naturally occurring resources which support life.

The country has immense solar potential, most areas in South Africa average more than 2 500 hours of sunshine per year, and average solar-radiation levels range between 4.5 and 6.5kWh/m2 in one day (Energy Office, 2016).

Solar PV (photovoltaic) technology converts sunlight into electricity and is a key technology in the adoption of solar energy in South Africa. In recent years, there has been a significant increase in the adoption of solar PV in the country, driven by a combination of government policies, private sector investment, and declining costs of solar PV technology.

One of the main drivers of solar PV adoption in South Africa has been the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). The REIPPPP is a competitive bidding process that aims to increase the use of renewable energy in the country by encouraging private sector investment in renewable energy projects. The program has been successful in attracting significant investment in solar PV projects and has helped to establish South Africa as a leader in the field of renewable energy. Additionally, the South African government has also implemented a number of policies and incentives to promote the adoption of solar PV. These include tax incentives for solar PV installations, subsidies for low-income households, and the installation of solar PV systems on government buildings.

The cost of solar PV technology has also been decreasing in recent years, making it more affordable for individuals and businesses to install solar PV systems. This has led to a significant increase in the number of solar PV installations in the country, both for residential and commercial use. Currently, majority of solar PV installations in South Africa are located in the Western Cape, Gauteng and the Northern Cape, where the majority of the population and the industrial activities are located. However, the adoption of solar PV is increasing in other provinces as well. The adoption of solar PV technology has been increasing in South Africa in recent years, driven by a combination

of government policies, private sector investment, and decreasing costs of solar PV technology. The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has been a key driver of this trend, and the country has become a leader in the field of renewable energy. The majority of the solar PV installations in the country are located in the Western Cape, Gauteng, and the Northern Cape, but the trend is spreading to other provinces as well.

1.2.1. ETHEKWINI SOLAR MAPS

Evidently, financial benefit is at the forefront of initiatives as the face of efficiency and worthiness in implementation. The eThekwini municipality, Department of Town Planning introduced a useful tool 'Solar Map Viewer' to allow GIS viewing of the cost benefit related to Solar PV installation. Resources like these map out actual costs and the benefits associated which motivate the need to allow these implementations to succeed. The Solar Maps Viewer forms the basis of this paper, where opinions of solar PV installation should become affordable and recommended as a country-wide solution to the current capacity issues faced by the national electricity supplier Eskom (eThekwini Municipality, 2020).

1.2.2. THE ESKOM-LOADSHEDDING SITUATION

A true discovery revealed that illegal electricity connections rob more than 50% of the municipal capacity as purchased from Eskom. The effect of which reveals that municipal funds are meant to be regenerated through revenue received, the gap in the revenue leaves municipal structures with a lack of financial capacity to invest in infrastructure and maintainence of existing sub-stations which over time become part of the problem to access. A holistic view of Eskom and the municipalities depending on its supply show a crumbling system with questionable recovery and ability to sustain demand over a prolonged period.

1.2.3. KHI SOLAR ONE PROJECT

Khi Solar One is a concentrated solar power (CSP) plant located in the Northern Cape province of South Africa. It is the first privately-funded solar power plant in South Africa and it provides clean energy to over 80,000 homes.

The Khi Solar One plant uses parabolic trough technology to generate electricity. It consists of a field of parabolic mirrors that concentrate sunlight onto a fluid-filled pipe, which runs along the focal line of the parabolas. The fluid in the pipe is heated to a high temperature, and this heat is then used to generate steam, which drives a turbine to produce electricity. The plant has a total capacity of 50 megawatts (MW) and it can generate enough electricity to power around 80,000 homes. It is also equipped with thermal energy storage, which allows it to continue generating electricity even when the sun is not shining. This makes it a reliable source of clean energy and it helps to reduce the dependence on fossil fuels.

Khi Solar One was developed by Abengoa, a Spanish multinational corporation that specializes in the design, construction and operation of sustainable energy projects. The project was completed in 2014 and it was the first privately-funded solar power plant in South Africa. The project was supported by the South African government, which provided funding through the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). The REIPPPP is a competitive bidding process that aims to increase the use of renewable energy in South Africa and to reduce the country's dependence on fossil fuels. Khi Solar One is an important milestone for the development of renewable energy in South Africa, as it has helped to establish the country as a leader in the field of concentrated solar power. The plant has been successful in providing clean energy to over 80,000 homes, reducing the dependence on fossil fuels and contributing to the country's renewable energy goals.

2. MATERIALS AND METHODS

This paper justifies solar powered systems as a replacement for coal-powered and diesel-generated electricity supply, using quantitative methods to calculate the annual savings as per the solar map viewer created by the eThekwini Municipality – GIS Department. Switching from coal-generated power to solar power can result in significant savings for both individuals and businesses. One of the main savings from using solar power instead of coal-generated power is the cost of electricity. Solar power is a clean, renewable energy source that does not require fuel, so the cost of electricity is relatively stable and predictable. In contrast, the cost of electricity from coal-generated power can fluctuate depending on the price of coal. As a result, solar power can provide long-term savings on electricity costs for individuals and businesses.

Another savings from using solar power is the reduced need for expensive and polluting coal-fired power plants. Solar power is generated at the point of use, which means that there is no need for the high transmission costs associated with coal-fired power plants. This can result in significant savings for both individuals and businesses.

Additionally, solar power does not produce harmful emissions or contribute to climate change, unlike coal-generated power. This means that there are no costs associated with mitigating the negative environmental impact of coal-generated power. Solar power can also provide savings in terms of job creation and economic development. The solar power industry is growing rapidly and has the potential to create a significant number of jobs in the areas of installation, maintenance, and manufacturing. Switching from coal-generated power to solar power can result in significant savings for both individuals and businesses. These savings include lower electricity costs, reduced need for expensive and polluting coal-fired power

plants, reduced environmental costs, and increased job creation and economic development. This study evaluates the financial and environmental benefits of transitioning from coal-powered electricity to solar energy by analyzing six selected locations within the **eThekwini Municipality**. The research employs **quantitative methods** to estimate potential cost savings using data from the **eThekwini Municipality – GIS Department's Solar Map Viewer**.

The **data collection process** involved several key steps. First, six locations representing different property types—commercial, residential, industrial, and special-use properties—were selected to ensure a diverse analysis. Using the **Solar Map Viewer**, the solar energy potential of each location was assessed based on irradiance levels and estimated energy output. These estimates were then compared to the current costs of coal-generated electricity to determine possible annual savings. Additionally, secondary data from municipal reports, energy tariff structures, and industry studies were reviewed to validate the findings.

For data analysis, a comparative cost analysis approach was used. Electricity tariffs for coal-generated power were compared with projected solar power costs to determine financial viability. Return on investment (ROI) calculations were performed to estimate the payback period for solar installations.

The study utilized several **analytical tools and instruments**. The **Solar Map Viewer (a GIS-based tool)** was the primary resource for evaluating solar energy potential at different sites. Additionally, **energy cost models** were employed to estimate savings based on municipal electricity tariffs and projected solar power generation. Finally, **statistical software such as Excel** was used for data processing, visualization, and comparative analysis.

By incorporating these methodologies, the study provides a structured and data-driven approach to assessing the feasibility of solar energy as an alternative to coal-generated electricity in the **eThekwini Municipality**.

The solar map viewer created by the eThekwini Municipality – GIS Department tool. A cadastral map view appears and the area can be zoomed into and pinned for an accurate view of a specific location. 6 points in different demographic areas have been identified and pinned to create a visualization of the eThekwini municipality's potential savings. These locations are chosen based on mixed property uses to display the outlay and savings that can be opportuned by various stakeholders.

eThekwini covers an area of 2,297 square kilometres stretching from Umkomaas in the south to Tongaat in the north and Cato Ridge in the West, including Umbumbulu and Ndwedwe. Spatial planning in KwaZulu-Natal, like in any other region, involves the coordination and management of land use and development in order to achieve sustainable and equitable outcomes. This includes identifying and allocating land for different uses such as housing, industry, agriculture, and recreation, as well as ensuring the provision of infrastructure and services such as transportation, water, and waste management. The KwaZulu-Natal province has several spatial plans, such as the KwaZulu-Natal Spatial Development Framework (KSDF) which serves as a blueprint for the spatial development of the province. The KSDF provides a comprehensive approach to land use management, and is intended to guide the sustainable development of the province by promoting balanced regional development, protecting natural resources and heritage sites, and addressing social issues such as poverty and inequality.

In addition, the province has Spatial Development Initiative (SDI) which focuses on creating economic opportunities in the rural areas and townships, and the Integrated Development Plan (IDP) which aims to coordinate the efforts of the different levels of government and the private sector to achieve development objectives.

Overall, spatial planning in KwaZulu-Natal is aimed at promoting sustainable and equitable development in the province, through the coordination of land use and the provision of infrastructure and services.

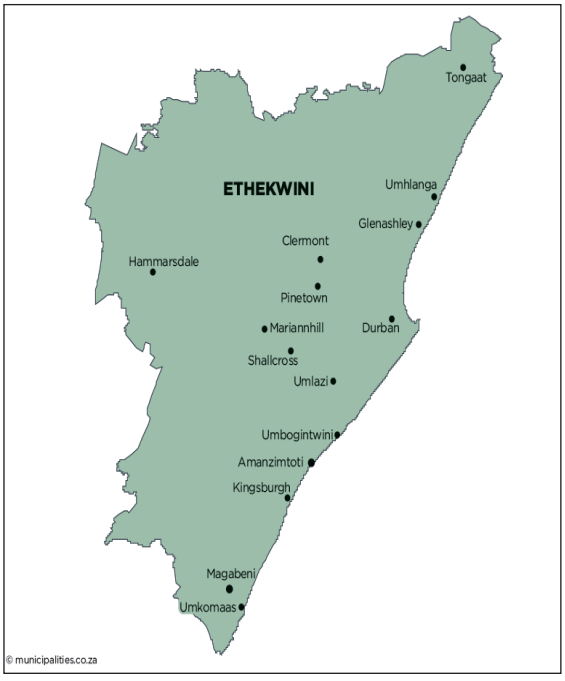


Image: Map of eThekwini
Source: municipalities.co.za

The 6 chosen locations for this study are listed below:

- Commercial Property (Shopping): La Lucia Mall
- Residential Property (Estate): Zimbali Eco Estate
- Vacant Land: South Beach Rd, La Mercy
- Industrial Property: Toyota Manufacturing Plant
- Special Use Property: Tongaat Primary School
- Residential Property: Stand Alone House Morningside

For the precautionary safety and protection of information, no physical addresses will be supplied, but can be made available upon request, ethical distribution and attainment of information has been adhered to in the retrieval of the below results.

3. RESULTS

The results obtained in this paper intend to recommend changes to renewable energy sources for the chosen subjects of the study, however also reflect an overall recommendation to nation-wide rates payers that are anticipating failure of the electricity services as currently offered in South Africa.

The 6 chosen locations are assessed based on the usable area, the system size required for that usable area, the system cost, the current city tariff, the annual energy generated by the intended system and an annual savings amount all as per the tool SolarMapsViewer.

The study focuses on six locations within the **eThekwini Municipality** selected based on their property type and energy consumption patterns. These locations represent a mix of commercial, residential, industrial, vacant land, and special-use properties. They include:

- **La Lucia Mall** (Commercial Property)
- **Zimbali Lifestyle Estate** (Residential Estate)
- **South Beach Road, La Mercy** (Vacant Land)
- **Toyota Manufacturing Plant** (Industrial Property)
- **Tongaat Primary School** (Special Use Property)
- **Stand-Alone Residential Property, Morningside**

The municipality spans **2,297 square kilometers**, covering **Umkomaas to Tongaat** and extending inland to **Cato Ridge, Umbumbulu, and Ndwedwe**. Each selected location contributes uniquely to the region's energy consumption patterns, making them ideal candidates for assessing the feasibility of solar power as a replacement for coal-based electricity.

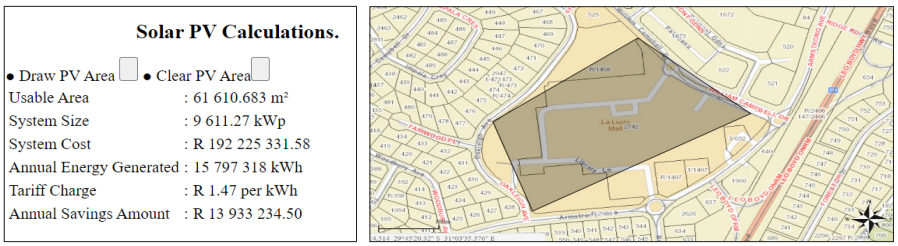
3.1. La Lucia Mall

La Lucia is a suburb located in the city of Durban, in the KwaZulu-Natal province of South Africa. It is known for its affluent neighbourhoods and upscale amenities. The area is home to several large shopping centres, including the La Lucia Mall, as well as a variety of restaurants, cafes, and bars. La Lucia is also home to several schools and universities, making it a popular destination for families and students. The area is considered to be one of the most desirable neighbourhoods in Durban, known for its safety, cleanliness, and high standard of living.

La Lucia Mall is a shopping mall located in the city of Durban, in the KwaZulu-Natal province of South Africa. La Lucia Mall first opened its doors in 1974 and currently boasts over 130 retailers. Attracting a footfall of approximately 4 million shoppers annually, La Lucia Mall provides an upmarket shopping destination for the local Durban North, La Lucia and Umhlanga communities and tourists. The shopping centre offers 1000 free open parking bays and over 600 undercover parking bays, as well as design with attention to creating ample access to facilities for disabled shoppers.

This location formed part of the case study weighing as a good point of reference for the city since the province is home to more than 15 shopping malls and hundreds of shopping centres, strip malls and retail parks. These areas require a continuous feed of electricity to support business processes and financial sustainability of the provincial economy. The mall features a variety of stores, including fashion retailers, electronics shops, and restaurants. It also has a cinema and a fitness centre. It is one of the most popular and biggest malls in the region, and is known for its wide range of shops and amenities, as well as its convenient location.

3.1.1. THE GIS SOLAR MAPS VIEWER TOOL PROJECTIONS FOR LA LUCIA MALL:



Map: La Lucia Mall | Accessed through: durban.gis

The Solar Maps Viewer tool identified a usable area of 61 610.683m2 for the purpose of identifying the system size for Solar PV installation. The system size is based on the usable area for installation as an approximation of the required consumption. The Photovoltaic system size approximates at 9611.27kWp, costing R192 225 331.58,

which will produce an annual savings of R13 933 234.50.

3.1.2. ZIMBALI LIFESTYLE ESTATE

Zimbali Lifestyle Estate is a luxury residential development located on the North Coast of KwaZulu-Natal, South Africa. The estate is situated between Ballito and Umhlanga, and is renowned for its natural beauty and exclusive living experience.

The estate is set within a nature reserve and boasts of an 18-hole golf course, which is considered one of the best in the country. The Zimbali Coastal Resort, located within the estate, offers residents access to a range of amenities, including a spa, fitness center, tennis and squash courts, and several swimming pools. In addition, the estate has a range of restaurants and shops, as well as a conference center and business facilities.

One of the key features of Zimbali Lifestyle Estate is its emphasis on preserving the natural environment. The estate has been designed to minimize its impact on the surrounding ecosystem, and residents are encouraged to adopt eco-friendly practices. This includes the use of water-saving systems and the use of renewable energy sources.

The estate comprises of different types of properties, such as apartments, townhouses, and freehold homes. All of which are designed with the latest modern finishes and are spacious, providing residents with ample living space and privacy. The properties are surrounded by lush gardens and natural vegetation, which provide a sense of tranquility and seclusion.

Living in Zimbali Lifestyle Estate is an experience like no other. The natural beauty of the area, combined with the exclusive amenities and eco-friendly environment, make it an ideal place to call home. The estate is a gated community, providing residents with a sense of security and privacy. With the combination of natural beauty, luxury living, and eco-friendly practices, Zimbali Lifestyle Estate provides residents with a truly unique lifestyle experience.

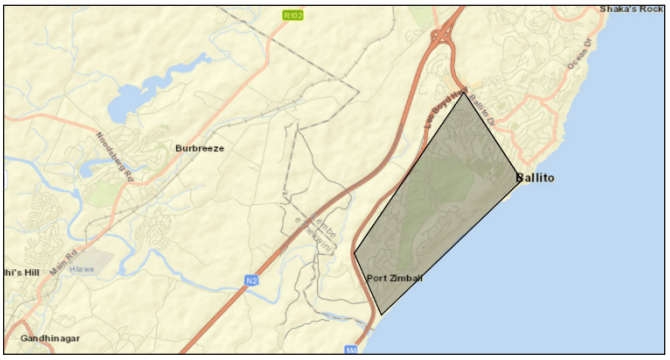
Zimbali Lifestyle Estate is an exclusive and luxurious residential development that offers residents an unparalleled living experience. The estate's natural beauty, combined with its eco-friendly practices and access to a range of amenities, make it an ideal place to call home. The properties are spacious and modern, and the gated community provides residents with a sense of security and privacy. Overall, Zimbali Lifestyle Estate is a truly unique and desirable place to live.

3.1.3. THE GIS SOLAR MAPS VIEWER TOOL PROJECTIONS FOR LA LUCIA MALL:

Solar PV Calculations.

● Draw PV Area ● Clear PV Area

Usable Area	: 4 917 039.033 m²
System Size	: 767 058.09 kWp
System Cost	: R 15 341 161 782.34
Annual Energy Generated	: 1 260 755 852 kWh
Tariff Charge	: R 1.47 per kWh
Annual Savings Amount	: R 1 111 986 661.22



Map: Zimbali Lifestyle Estate | Accessed through: durban.gis

The Solar Maps Viewer tool identified a usable area of 4 917 039.033m2 for the purpose of identifying the system size for Solar PV installation. The system size is based on the usable area for installation as an approximation of the required consumption. The Photovoltaic system size approximates at 767 058.09kWp, costing R15 341 161 782.34, which will produce an annual savings of R1 111 986 661.22.

3.2. South Beach Road, La Mercy

La Mercy is a town located in KwaZulu Natal, South Africa. It is situated on the coast of the Indian Ocean and is part of the eThekwini Metropolitan Municipality, which includes the city of Durban. Despite its small size, La Mercy has seen significant growth and development in recent years, making it a popular destination for both residents and tourists.

One of the main attractions of La Mercy is its natural beauty. The town is surrounded by rolling hills, lush vegetation, and pristine beaches. The warm climate and clear waters make it a popular spot for swimming, sunbathing, and water sports. Visitors to the area can also take part in various outdoor activities such as hiking, fishing, and bird watching.

La Mercy is also home to a number of tourist attractions, such as the La Mercy Beach, which offers a variety of beach activities and is a popular spot for swimming,

sunbathing, and water sports. Other notable attractions include the La Mercy Lighthouse, which offers a panoramic view of the town and surrounding area, and the La Mercy Nature Reserve, which is home to a wide variety of plant and animal species.

Despite its small size, La Mercy has a growing economy and is home to a number of businesses and services. The town is home to several small businesses such as restaurants, shops, and accommodation. The town is also home to a number of residential developments, making it an attractive location for those looking to relocate or invest in property.

La Mercy is a small but growing town located in KwaZulu Natal, South Africa. It offers a variety of natural attractions, tourist destinations, and business opportunities. The town's proximity to Durban and the Indian Ocean, along with its natural beauty and growing economy, make it an attractive location for both residents and tourists.

3.2.1. THE GIS SOLAR MAPS VIEWER TOOL PROJECTIONS FOR SOUTH BEACH ROAD:

Solar PV Calculations.

• Draw PV Area • Clear PV Area

Usable Area	: 2 457.818 m²
System Size	: 383.42 kWp
System Cost	: R 7 668 390.91
Annual Energy Generated	: 630 198 kWh
Tariff Charge	: R 1.47 per kWh
Annual Savings Amount	: R 555 834.59

Map: 184 South Beach Rd, La Mercy | Accessed through: durban.gis

The Solar Maps Viewer tool identified a usable area of 2 4 57.818m2 for the purpose of identifying the system size for Solar PV installation. The system size is based on the usable area for installation as an approximation of the required consumption. The Photovoltaic system size approximates at 383.42kWp, costing R7 668 390.91, which will produce an annual savings of R555 834.59.

3.3. Toyota Manufacturing Plant

Toyota South Africa operates a manufacturing plant in Durban, KwaZulu-Natal. The plant, which is situated in Prospecton, south of Durban, was opened in 1974 and has since produced over one million vehicles. The plant covers an area of 220,000 square meters and employs over 4,000 people. It has the capacity to produce up to 200 vehicles per day, including the Corolla, Fortuner, Hilux, Quantum, and Dyna models.

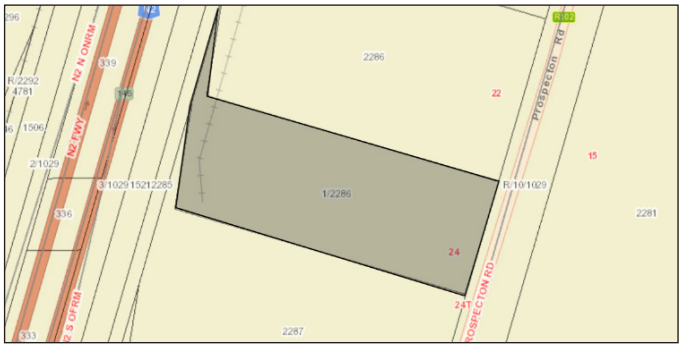
The plant has been recognized for its commitment to sustainability and has implemented several environmental initiatives. For example, it has a water recycling plant that treats and recycles over 3 million liters of water per day, which is then reused in production processes and has received several awards for its safety record, including the National Safety Award from the South African Society for Occupational Health and Safety. It has also been recognized for its efforts to promote skills development and employment opportunities in the region.

3.3.1. THE GIS SOLAR MAPS VIEWER TOOL PROJECTIONS FOR TOYOTA MANUFACTURING PLANT:

Solar PV Calculations.

• Draw PV Area • Clear PV Area

Usable Area	: 10 208.770 m²
System Size	: 1 592.57 kWp
System Cost	: R 31 851 363.65
Annual Energy Generated	: 2 617 585 kWh
Tariff Charge	: R 1.47 per kWh
Annual Savings Amount	: R 2 308 709.86



Map: 24 Prospecton Rd, Durban | Accessed through: durban.gis

The Solar Maps Viewer tool identified a usable area of 10 208.770m2 for the purpose of identifying the system size for Solar PV installation. The system size is based on the usable area for installation as an approximation of the required consumption. The Photovoltaic system size approximates at 1592.57kWp, costing R31 851 363.65, which will produce an annual savings of R2 308 709.86.

3.4. Tongaat Primary School

Tongaat Primary School is a government school located in the town of Tongaat, which is situated in the KwaZulu-Natal province of South Africa. It caters to students from Grade R to Grade 7 and follows the South African national curriculum.

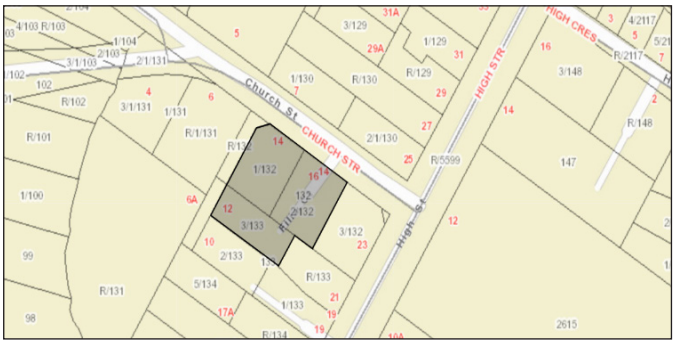
The school has a long history, having been established in 1916. Today, it is a large school with over 1,000 students and 45 teachers. The school has a reputation for academic excellence, with a strong focus on both traditional academic subjects as well as extracurricular activities such as sports, music, and drama. Tongaat Primary School also places a strong emphasis on community involvement and outreach programs. The school is actively involved in various initiatives aimed at improving the lives of disadvantaged communities in the area.

3.4.1. THE GIS SOLAR MAPS VIEWER TOOL PROJECTIONS FOR TONGAAT PRIMARY SCHOOL:

Solar PV Calculations.

● Draw PV Area ● Clear PV Area

Usable Area	: 2 717.372 m²
System Size	: 423.91 kWp
System Cost	: R 8 478 200.64
Annual Energy Generated	: 696 749 kWh
Tariff Charge	: R 1.47 per kWh
Annual Savings Amount	: R 614 532.73



Map: Tongaat Primary School 12,14,16 Church Street, Tongaat | Accessed through: durban.gis

The Solar Maps Viewer tool identified a usable area of 2 717.372m2 for the purpose of identifying the system size for Solar PV installation. The system size is based on the usable area for installation as an approximation of the required consumption. The Photovoltaic system size approximates at 423.91kWp, costing R8 478 200.64, which will produce an annual savings of R614 532.73.

3.5. Stand-Alone Residential Property

Morningside is an affluent suburb located in the city of Durban, which is situated in the Kwa-Zulu Natal province of South Africa. It is situated to the north of Durban's city centre and is bordered by the suburbs of Musgrave, Berea, and Essenwood.

Morningside is known for its beautiful tree-lined streets, large homes, and luxurious apartments. The area is a popular choice for professionals, families, and retirees due to its convenient location, access to good schools and amenities, and its relatively peaceful atmosphere. There are many attractions in and around Morningside, including the Mitchell Park Zoo, the Jameson Park Botanic Garden, and the Durban Country Club, which is one of South Africa's most prestigious golf courses. The area is also home to a number of popular shopping centres, including the Windermere Shopping Center and the Florida Road Shopping District, which offers a range of boutique stores, restaurants, and cafes.

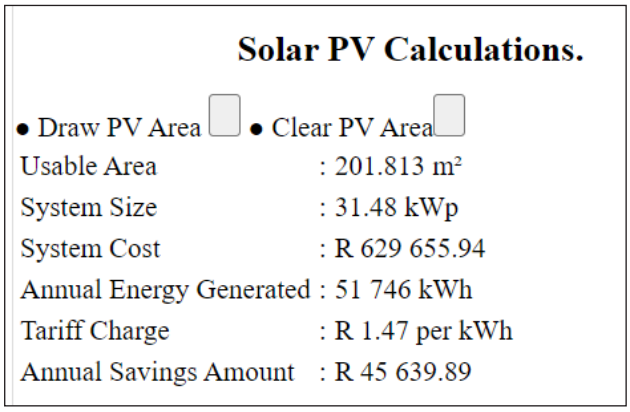
Affluent suburbs across South Africa tend to pioneer sustainable solutions in urban management, akin to Morningside pioneering the following sustainability initiatives and practices in the area:

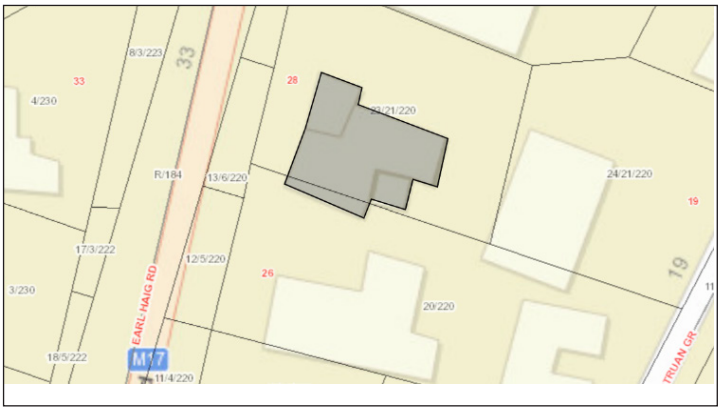
- Recycling: The eThekwini Municipality, which governs Durban and its surrounding areas, has a comprehensive recycling program that collects recyclable materials from households and businesses. This helps to reduce the amount of waste that ends up in landfills and helps to conserve natural resources.
- Sustainable transport: The Durban Green Corridors initiative is working to promote sustainable transport options in the area, including bike lanes, pedestrian walkways, and public transportation. This helps to reduce carbon emissions and improve air quality.
- Water conservation: South Africa is a water-scarce country, and Morningside has implemented various water conservation

measures to help reduce water usage. For example, many homes and businesses have installed water-efficient fixtures such as low-flow toilets and showerheads.

- Sustainable energy: Many homes and businesses in Morningside have installed solar panels to generate renewable energy and reduce reliance on fossil fuels. In addition, the eThekwini Municipality has invested in a number of renewable energy projects, including wind and solar farms.
- Sustainable agriculture: The Durban Botanic Gardens, located in Morningside, is home to a number of sustainable agriculture initiatives, including a food garden that grows organic produce and educates visitors about sustainable farming practices.
- Dense urban areas tend to overshadow the efforts of lower-income informal areas through formal structures of initiating recycling, sustainable transportation, energy and agriculture, as well as water management.

3.5.1. THE GIS SOLAR MAPS VIEWER TOOL PROJECTIONS FOR STAND-ALONE RESIDENTIAL PROPERTY:





Map: 26 Earl Haig Rd, Morningside | Accessed through: durban.gis

The Solar Maps Viewer tool identified a usable area of 201.813m2 for the purpose of identifying the system size for Solar PV installation. The system size is based on the usable area for installation as an approximation of the required consumption. The Photovoltaic system size approximates at 31.48kWp, costing R629 655.94, which will produce an annual savings of R45 639.89.

The results demonstrate that solar PV installation can yield significant savings across different property types. Large commercial and industrial properties, such as La Lucia Mall and Toyota Manufacturing Plant, stand to benefit the most due to their extensive roof space and high electricity consumption. Similarly, high-end residential estates like Zimbali Lifestyle Estate exhibit massive solar potential due to their large land area and sustainability-driven initiatives. Smaller properties, such as stand-alone residential homes, show lower savings potential but still contribute to long-term sustainability and cost reduction. Public institutions like Tongaat Primary School can also benefit from solar installations, reducing operational costs and promoting green energy adoption in the education sector. The overall findings support a strong recommendation for transitioning from coal-generated electricity to solar power within the eThekwini Municipality, benefiting both private and public stakeholders.

3.6. System Cost Analysis

The installation cost varies greatly based on the system size and the location's energy needs. Larger installations naturally come with higher costs.

- **La Lucia Mall:** R192,225,331.58 for 9,611.27 kWp → **Cost per kWp**: R20,000.00
- **Zimbali Lifestyle Estate:** R15,341,161,782.34 for 767,058.09 kWp → **Cost per kWp**: R20,000.00
- **South Beach Road, La Mercy:** R7,668,390.91 for 383.42 kWp → **Cost per kWp**: R20,000.00
- **Toyota Manufacturing Plant:** R31,851,363.65 for 1,592.57 kWp → **Cost per kWp**: R20,000.00
- **Tongaat Primary School:** R8,478,200.64 for 423.91 kWp → **Cost per kWp**: R20,000.00
- **Stand-Alone Residential Property, Morningside:** R629,655.94 for 31.48 kWp → **Cost per kWp**: R20,000.00

Interestingly, the **cost per kWp** is constant across all locations, which simplifies the cost analysis and shows a consistent pricing model regardless of system size or location.

3.7. Annual Savings vs. System Size

Annual savings are influenced by system size, but it's also dependent on energy consumption, local electricity rates, and the efficiency of the system.

- **La Lucia Mall:** R13,933,234.50 in annual savings from 9,611.27 kWp → **Savings per kWp**: R1,449.16
- **Zimbali Lifestyle Estate:** R1,111,986,661.22 in annual savings from 767,058.09 kWp → **Savings per kWp**: R1,449.16
- **South Beach Road, La Mercy:** R555,834.59 in annual savings from 383.42 kWp → **Savings per kWp**: R1,449.16
- **Toyota Manufacturing Plant:** R2,308,709.86 in annual savings from 1,592.57 kWp → **Savings per kWp**: R1,449.16
- **Tongaat Primary School:** R614,532.73 in annual savings from 423.91 kWp → **Savings per kWp**: R1,449.16
- **Stand-Alone Residential Property, Morningside:** R45,639.89 in annual savings from 31.48 kWp → **Savings per kWp**: R1,449.16

The savings per kWp are consistent across all locations, which suggests the system performance and energy savings scale directly with system size.

4. DISCUSSIONS

The electricity demand in the province has proven a challenge to the municipal structures and local government. The design and implementation of renewable energy systems and energy harvesting is the solution to reducing the provinces' greenhouse gas emissions and rapid climate change (Mutombo & Numbi, 2019). According to Elum Energy (Gubangxa, 2021), energy crises is a global challenge, proving that the curtailing of electricity is an ongoing and global occurrence, the map below represents key economic players that experience loadshedding.

Gubangxa, Major Countries with Load Shedding (2021), Elum Energy

South Africa has one of the highest solar radiation levels in the world, making it an ideal location for solar energy production. The country has set a target of generating 18 GW of renewable energy by 2030, with a significant portion coming from solar power. In recent years, there has been a significant increase in the deployment of solar energy in the country, with both large-scale and small-scale projects being implemented. One of the key challenges for solar energy in South Africa is the intermittency of solar power. Solar power is only generated during daylight hours and can be affected by cloud cover and other weather conditions. As a result, energy storage solutions such as batteries are required to provide a reliable and consistent energy supply. Another challenge for solar energy in South Africa is the high upfront costs associated with the installation of solar power infrastructure. While the cost of solar panels has decreased in recent years, the cost of energy storage solutions remains relatively high. This can make it difficult for small-scale projects and individuals to invest in solar energy (Dociu & Dunarintu, 2012).

Despite these challenges, there are several factors that make solar energy feasible in South Africa. The country has a well-established regulatory framework that supports renewable energy production, including a feed-in tariff program that incentivizes renewable energy production. In addition, the country has a strong renewable energy industry, with many companies specializing in the production and installation of solar power infrastructure. Furthermore, South Africa has a high demand for electricity, particularly during peak hours. This demand makes solar power an attractive option for power generation, as it can provide a reliable source of electricity during these periods of high demand. The findings of this study suggest that there is a potential for significant cost savings and improved energy security through the adoption of renewable energy sources, specifically solar PV, in South Africa (Crompton & Wu, 2005). The six locations chosen for the case study were assessed based on factors such as usable area, system size, system cost, city tariff, and annual energy generated, all of which were calculated using the GIS Solar Maps Viewer tool.

The La Lucia Mall case study is significant, as the mall is one of the most popular and biggest in the region, and the province is home to more than 15 shopping malls and hundreds of shopping centres, strip malls, and retail parks, which require a continuous feed of electricity to support business processes and financial sustainability of the provincial economy. This study recommends the installation of a Photovoltaic system size of approximately 9611.27kWp, which will cost R192 225 331.58 and produce an annual savings of R13 933 234.50. Zimbali Lifestyle Estate is a luxury residential development that offers residents an unparalleled living experience. The estate is set within a nature reserve and boasts an 18-hole golf course, a spa, fitness center, tennis and squash courts, and several swimming pools, as well as a range of restaurants and shops. This study recommends the installation of a Photovoltaic system size of approximately 767 058.09kWp, which will cost R15 341 161 782.34 and produce an annual savings of R1 111 986 661.22.

While the results of this study are specific to the six locations studied, they reflect an overall recommendation to nationwide ratepayers who anticipate failure of electricity services as currently offered in South Africa. The adoption of renewable energy sources, specifically solar PV, could lead to significant cost savings and improved energy security (Klemas, 2011). However, it is important to note that the initial installation costs may be high, and the cost savings and benefits will only be realized over the long term. Additionally, the success of renewable energy adoption will depend on several factors, including government policies and incentives, public awareness and education, and technological advancements. Elum Energy (Gubangxa, 2021) alluded that India, South Africa, Pakistan, Lebanon and Sri Lanka experience loadshedding and power generation curtailing more than other countries in the world. With South Africa being the focus of this study, the GIS Solar Maps Viewer allows residents to identify the affordability and system size requirements of installing Solar PV at their residences and places of business.

5. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, solar energy is a clean and renewable energy source with the potential to greatly reduce our dependence on fossil fuels. With the increasing availability and decreasing cost of solar technology, more and more countries are turning to solar energy as a viable alternative to fossil fuels. While it still has a way to go to fully replace fossil fuel, it has a promising future ahead. This study set out to experiment the usefulness of the municipal tool GIS Solar Maps Viewer and make recommendations on its ability to identify cost and system size which proved to be potentially consistent with expectations. These results may not prove accurate based on market prices, however the general estimation intends to provide an overview of costs and prepare the resident for Solar PV adoption (Mutombo & Numbi, 2019).

The eThekwini Metropolitan Municipality, encompassing Durban in KwaZulu-Natal, South Africa, stands as a noteworthy exemplar of progressive energy transformation. This paper sought to explore the surge in solar photovoltaic (PV) system adoption within the municipality, motivated by the drive to curtail fossil fuel reliance and embrace sustainable energy sources. The adoption of solar PV systems has yielded substantial economic advantages for eThekwini, by harnessing solar power, households and businesses have experienced marked reductions in electricity costs (WWF, 2021). A pioneering feed-in tariff initiative enables surplus solar energy to be channeled back to the grid, generating supplementary income streams. Additionally, the burgeoning solar PV sector has catalyzed local job creation, spanning installation, maintenance, and manufacturing. Solar PV systems have precipitated significant environmental dividends. By mitigating the municipality's carbon footprint, these systems tangibly contribute to the mitigation of greenhouse gas emissions. The pivotal role of solar energy in curbing dependence on fossil fuels, a key catalyst of climate change, is a cornerstone of eThekwini's sustainable future (Corbella & Stretch, 2012).

The commendable strides in solar PV integration are tempered by challenges. High upfront installation costs deter potential adopters, while a lack of awareness and education hampers the widespread embrace of solar technology. Bridging these gaps is essential for sustained growth. The municipality's commitment to solar energy should persist, fortified by well-rounded strategies. Comprehensive educational campaigns and awareness drives are pivotal in eliminating knowledge gaps. Financial incentives must be tailored to defray upfront costs, rendering solar

PV systems accessible. Regulatory frameworks should be designed to facilitate hassle-free integration. eThekwini's ascent towards solar energy marks an inspiring trajectory (Goh, et al., 2017). The embrace of solar PV systems bears testimony to the potent nexus between economic prosperity and environmental stewardship. Addressing challenges, harnessing education, and refining incentives shall propel eThekwini toward an even brighter and more sustainable energy future.

6. DATA AVAILABILITY STATEMENT

The data primarily used in this study can be found at http://gis.durban.gov.za/solarmapviewer/

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Notes