A FEASIBILITY STUDY EXPLORING ENERGY ACCESS THROUGH COMMUNITY-LED SOCIALLY OWNED RENEWABLE ENERGY DEVELOPMENT IN SOUTH AFRICA

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A feasibility study exploring energy access through community-led socially owned renewable energy development in South Africa

Project: *"Mobilising Social Movements for Energy Democracy and Sovereignty in South Africa: Towards socially owned renewable energy solutions". This project is led by groundWork and conducted in a partnership of organisations, namely South Durban Community Environmental Alliance (SDCEA), Vukani Environmental Movement (VEM), Abahlali baseMjondolo (AbM) and Sustainable Energy Africa. The project aims to empower communities to develop champions that will engage effectively with local government, and other actors, towards a just transition which promotes and enables community-led, renewable energy solutions"*

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Glossary

Affordability	the ability to pay the cost
Capacity	The combination of strengths, attributes, and resources available to an individual, community, society, or organization, which can be used to achieve established goals.
Climate versus weather	Weather is the day-to-day change of the atmosphere, e.g. it is sunny/rainy/windy today. Climate is the average weather that an area experiences over a long time, e.g. a place has a tropical (warm and wet) climate, or a Mediterranean climate (cold, wet winters and warm, dry summers), etc.
Climate change	Climate change refers to the long-term shift in weather patterns. It may involve a change in the average weather patterns (e.g. more or less rainfall) or in the frequency and/or intensity of events (e.g. more or fewer storms). Climate change can be caused by natural causes, such as volcanic eruptions, or human causes, such as greenhouse gas emissions from the burning of petrol. Global warming, which is the general increase in temperature caused by human-related greenhouse gas emissions, is one type of climate change.
Community energy	This involves the economic and operational participation and ownership by citizens or members of a defined community – be it at the village, city or regional level – in a renewable energy project, regardless of the size and scope of the project (IRENA, 2020).
Climate Action Plan	This plan provides an integrated, evidence-based picture and a detailed pathway for what a city or province for example needs to do to meet its low carbon goals. It aims to transition a city towards carbon neutrality and climate resilience while also ensuring the benefits of this transition are distributed equitably. Such a plan integrates both mitigation and adaptation actions and prioritises the need to ensure that the City and its people are resilient to climate-related hazards and extreme weather events.
Climate change impacts	Climate change impacts are the consequences of climate change on a human or natural system. For example, climate change could cause less rain in an area, but climate change impacts in this area, as a result, would involve droughts, crop failure, famine, etc.
Resilience	A resilient system is one that is better able to cope with change and can recover quickly. Building resilience looks to making systems, places and people more robust, both in being able to 'bounce back' after a stress, but also in being able to 'bounce forward' – adapting to long term changes in trends.
Electricity distribution	Electrical power distribution is the final stage of an electrical power system (or the electricity grid). Electricity is distributed via electric distribution substation. At the substation, the high voltage electricity from the high-voltage transmission lines is passed through step-down transformers that lower the voltage. The electricity is then carried through a network of local electric distribution lines and delivered to consumers.
Electrical grid	An electrical grid is an interconnected network for electricity delivery from producers to consumers. Electrical grids consist of: • power stations: often located near energy and away from heavily populated areas • electrical substations to step voltage up or down

	• electric power transmission to carry power long distances • electric power distribution to individual customers, where voltage is stepped down again to the required service voltage(s).
Electricity tariffs	The electricity tariff is defined as the rate at which the electrical energy is sold to a consumer. It includes the cost of producing and supplying electrical energy.
Energy	Electrical energy is energy derived as a result of movement of electrically charged particles. The basic unit of electrical energy is the joule or watt-second
Energy transition	This refers to the shift from fossil-based systems of energy production and consumption — including oil, natural gas and coal — to renewable energy sources like wind and solar, as well as lithium-ion batteries. It involves the transformation of the energy model from a centralized fossil fuel-based system to a decentralized renewable-based system. It entails a convergence of technology, infrastructure, institutions and people. It is enabled by new technologies and has resulted in new social practices and governance methods. Renewable energy, with its adaptability and decentralised nature, encourages increased citizen participation in the energy transition.
Energy system	A system showing a connection and the flow between energy sources and their final usage. This includes all the related technologies
Grid-tied system	A solar photovoltaic system for example that is connected to the municipal electrical grid. The export/transfer of energy onto the municipal electrical grid is possible when generation of electricity from the system exceeds consumption at any point in time and no grid-limiting is applied.
Greenhouse gases	Greenhouse gases (GHG) contribute to the phenomenon of global warming. GHG emissions are mostly made up of carbon dioxide and methane. Emissions are measured in terms of carbon dioxide equivalent (CO_2e). For example, methane, which is a powerful global warming gas, with a global warming potential 21 times that of CO_2 (in trapping heat in the atmosphere). The majority of GHG emissions come from the burning of fossil fuels to generate energy for the purposes of lighting, cooking, warming, appliances, computers, industrial motors, air conditioning, and transportation. Our solid waste also results in the emission of methane gases.
Independent Power Producer (IPP)	An IPP refers to a producer of electrical energy (power plant) that is not a public utility, but which makes electricity available for sale to utilities or the general public.
Investment cost	Cost attached to setting up a new energy generation system or any related technology required in power generation.
Mitigation (of climate change)	Climate change mitigation involves reducing the amount of GHG emissions that are being released into the atmosphere to stabilise and ultimately reduce global GHG levels. For example, switching from coal to solar as a source of energy will significantly reduce the amount of GHG emissions being released into the atmosphere. This results in additional benefit of cleaner, more breathable air.
Municipality	A government organisation classified under the local government sphere. This organisation is responsible for the administration of towns (local) and districts (regional centres)

Off-grid system	A solar system that generates electricity from the sun and operates completely without the electricity grid. The system may rely on a battery to store access power that is generated which can be used at night.
Nationally Determined Contribution	Nationally Determined Contribution (NDC) is a non-binding national plan highlighting climate change mitigation, including climate-related targets for greenhouse gas emission reductions, policies and measures that the government aims to implement in response to climate change as well as the contribution to achieve the global targets set out.
Photo-voltaic system	A system composed of solar panels attached to the roof or mounted on any surface, which is used to convert sunlight into electrical energy.
Power (electrical)	Power is the rate at which electrical energy is transferred by an electrical circuit per unit of time.
Renewable energy	Electrical energy that is generated or comes from natural sources that cannot be depleted. These can be sunlight (solar energy), wind (wind energy) or water (ocean and hydropower) or plants (bioenergy).
Small Scale Embedded generation	Small-Scale Embedded Generation (SSEG) refers to power generation facilities, located at residential, commercial or industrial sites, where electricity is generally also consumed. It is an electrical generator interconnected with the municipal network. The generator operates in parallel with the network and should be synchronised with the grid supply. These are mainly solar photovoltaic (PV) systems but include also other technologies such as wind and biogas.
Subsidization	The act by a government, organization, or other group of paying part of the cost of something.
Wheeling	Wheeling is the delivery of electricity generated by a private generator in one location to a buyer or off-taker in another location via a third-party network (Eskom or municipality).

1. Introduction

1.1. Purpose of this feasibility study

A major energy transition is underway globally with the transformation of the energy model from a centralized fossil fuel-based system to a decentralized renewable-based system. This transition involves a convergence of technology, infrastructure, institutions and people. It is enabled by new technologies and has resulted in new social practices and governance methods. It provides fertile ground for the emergence of new solutions with an enormous potential to stimulate local economies, create social cohesion, and increase the overall resilience of cities and countries. Renewable energy, with its adaptability and decentralised nature, encourages increased citizen participation in the energy transition.

In recent years increased global investment in renewables has resulted in declining costs of renewable technologies. Between 2010 and 2018, the average price of solar photovoltaic (PV) systems reduced by about 77%, rendering renewables the fastest-growing part of the electricity sector. In 2020, renewable energy (RE) grew by more than 260 gigawatts (mostly in solar PV), and in 2020, a new generation from RE outpaced all other energies (IRENA 2021).

The benefits of renewable energy are numerous. These include lower energy costs (for countries, corporates and households), increased grid reliability, reduced environmental and climate impacts, improved air quality and public health, employment creation, fuelling economic development and enhancing the welfare of citizens. Municipalities and their communities are thus able to actively participate in energy supply, distribution and energy efficiency. As a result, the growing importance of the green economy presents South African municipalities (particularly cities) with the opportunity to unleash their transformative potential, by accelerating the transition towards clean, resilient energy systems and meeting energy needs. Such green energy systems are also a lever for cities and the country to stimulate post-Covid-19 economic recovery.

Access to a reliable and constant supply of electricity is key for development. Modern economic activities, new technologies and the provision of public services all depend on power. With adequate electricity, families can meet their important energy needs- lighting, heating/cooling (stoves, fridges, washing machines etc), media and communication (television, radio, Wi-Fi, cell phones). Energy systems need to be clean, safe, reliable, affordable and equitable, which means urgently scaling-up renewable energy interventions at the local level and empowering cities and their citizenry.

Against this backdrop, this study sets out to explore the feasibility of community-led socially owned renewable energy development in South Africa, with a focus on eThekwini Metro (KwaZulu-Natal Province) and Emalahleni Local Municipality (Mpumalanga Province).

The study is undertaken as part of the broader project: "Mobilising Social Movements for Energy Democracy and Sovereignty in South Africa: Towards socially owned[1] renewable energy solutions"

[1] This includes options of state ownership, employee ownership, co-operative ownership, citizen ownership of equity in private companies, individual ownership, and collective ownership.

supported by the Urban Movement Incubator (UMI) fund. The project is conducted in a partnership of leading community-based and non-governmental organisations, namely South Durban Community Environmental Alliance (SDCEA), Vukani Environmental Movement (VEM), Abahlali baseMjondolo (AbM), Sustainable Energy Africa and coordinated through groundWork. The project aims to empower communities to engage effectively with local government, and other relevant actors to access clean, safe, reliable and affordable energy through pursuing community-led socially owned renewable energy solutions.

This report follows the format of first introducing the national and local energy development landscape as a background context for the study. It then deepens its focus on energy use in municipalities, covering the energy service delivery status of the 2 study municipalities (technical and policy elements), household energy use patterns of low-income households in these municipalities, followed by a brief review of lessons from international and local community energy projects. Against this context locally appropriate models for community-led energy projects in South Africa are explored, focussing on technical, financial, social and environmental considerations and their replicability and scalability. The report concludes with a suggested project technical design and implementation plan.

2. Background

2.1. National context

The recent United Nations Intergovernmental Panel on Climate Change (IPCC) report (2021) by the world's leading climate scientists warns 'a code red for humanity'. The report alerts that the pace of global warming is rapidly increasing, and Sub-Saharan Africa has been experiencing temperature increases well above the global average. The climate crisis grows in intensity with each year. This has been reaffirmed over the last 2 decades by numerous global reports from international scientific institutions.

Climate change presents serious health, environmental and economic risks for our country. Such risks have damaging effects on human health, water availability, food production, infrastructure and migration. South Africans are already feeling the effects of climate change through drought and flooding, which have impacted livelihoods. Moreover, communities in the Mpumalanga Province, for example, are affected by high levels of pollution, leading to incidences of respiratory illnesses and other diseases, increasing morbidity and mortality. Those who are dependent on the ocean for a living have already seen depleted fish stocks amid changing weather patterns and changes in ocean temperature. All these emerging trends mean that we need to act with urgency and ambition to reduce our greenhouse gas emissions (gases that contribute to global warming and climate change) and undertake a transition to a low-carbon economy. South Africa has a raft of key national climate response policy commitments in place and a dedicated Presidential Climate Change Coordinating Commission to build an environmentally sustainable, climate change resilient, low-carbon economy and a just society. More recently to signal the country's increased climate ambition, Cabinet approved our updated Nationally Determined Contribution (NDC), which sets out our greenhouse gas emissions (GHG) targets towards net-zero carbon emissions by 2050.

While South Africa is vulnerable to climate change impacts, it is also one of the most carbon-intensive economies in the world, contributing more than one per cent of global GHG emissions despite its comparatively smaller population and gross domestic product (GDP) (TIPS, 2019). The energy sector accounts for most of these emissions. More than 80% of the sector's emissions arise from the production of coal-fired power (coal-fired plants generate 92% of the electricity) and coal liquefication from Sasol, the country's coal to liquid fuel plant (TIPS, 2019). South Africa is the highest GHG emitter on the African continent and the 14th highest global emitter due to its high dependency on coal for energy and the high emissions from the mining and industrial sectors (Carbon Brief, 2018). South Africa's economy, for the past century, has been built around a mineral-energy complex that has dwarfed all other areas of economic activity (Fine & Rustomjee, 1997). The mining and industrial sectors accounting for 82% of national GHG emissions, are major players in the national economy and dominate some local economies such as that of Emalahleni Local Municipality, in Mpumalanga Province (TIPS, 2019). Energy demands are also increasing with growing urban populations. Projections point to 70% of South Africa's population expected to live in cities by 2030 and 80% by 2050 (Wolpe & Reddy, 2018).

At the same time, South Africa wrestles with the deep-rooted historical challenges of inequality and poverty, highly exposing the country to the impacts of climate change, which disproportionately affect the poor. South Africa is recognised as the most unequal country in the world in terms of the income distribution (World Bank, 2018). Approximately half the population live below the poverty line. Unemployment stood at 34.9% in the 3rd quarter of 2021 (StatsSA, 2021), meaning people who want to work are out of employment. Moreover, unemployment according to the expanded definition, which includes people who were available for work but had given up looking for a job, rose from 44.4% to 46.4% in the 2nd quarter of 2021. With 80,000 direct jobs in the coal sector (most of which are in a single province, namely Mpumalanga) and many of the projected 100,000 jobs in renewable energy in different geographic locations throughout the country, it becomes patently clear that a just energy transition is not an option as the country moves to decarbonise the economy. It becomes imperative that the energy transition underway in South Africa must be just if political unrest and deepening economic inequality are to be avoided. However, a just transition is not exclusively about jobs, it is also crucially about addressing and engaging meaningfully with communities affected by the environmental impacts of coal power, tackling the distribution of employment in different local economies and reducing energy poverty. It also involves empowering and involving different communities which are impacted in the decision-making processes.

The global energy transition however is driving fundamental changes in South Africa ahead of national policy responses. Old and newer coal power plants will increasingly be replaced by renewable energy according to government and independent least-cost planning models. Many power plants are already reaching their decommissioning lifespans in the next 10 to 15 years. An energy transition, therefore, signals radical and accelerated changes to the energy system, associated with a shift from traditional energy resources and related technologies to cleaner and renewable sources.

Another impetus for the acceleration of the just energy transition in South Africa is the unprecedented, financial, operational and governance crisis experienced by the electricity sector. This crisis of several years is now reaching a point of collapse. The impacts of which are severely experienced across the economy and society, in the rotational nation-wide load shedding or rolling blackouts since 2018 (up to 6 hours per day); announcements of large financial bail-outs and the restructuring unbundling plans for debt-ridden state-owned, vertically integrated and monopolistic power utility, Eskom; approved tariff increases contributing to the quadrupling of electricity prices over the past ten years and the onset of progressive decommissioning at Eskom's ageing coal power stations. The electricity crisis presents the single largest threat to the South African economy and the national fiscus. Bailouts for Eskom accounted for half of the budget deficit in 2019 which severely impacted the country's sovereign's credit rating. Energy insecurity has contributed to job losses and economic decline. Hence a 'just transition' in the energy sector requires top and immediate political priority. This will require meaningful engagement with the historical legacies and realities of poverty and inequality that prevail in the sector[2], placing community participation and engagement at the forefront and ensuring the most vulnerable are represented and involved in the decision making in shaping sustainable energy provision.

As a result, the focus of this study on decarbonising the economy and democratising energy through exploring community-led socially owned renewable energy development becomes very significant.

2.1.1. Policy and regulatory shifts supporting a low carbon development path

In response to the energy transition underway and the country's pursuit of a low carbon development path, South Africa has seen some significant policy shifts over the last 2 years supporting low carbon development and to this end promoting the uptake of renewable energy.
Highlighted below are some of these key shifts that provide the impetus for community-led socially owned renewable energy development in South Africa.

- In 2019, Cabinet approved the updated Integrated Resource Plan (IRP), which is the 20-year electricity master plan for the country. For the first time, the IRP signalled a substantial shift away from fossil fuels to renewable sources, predominantly wind and solar PV, for the bulk of new generation capacity. South Africa pledged to peak its carbon emissions between 2020 and 2025, allowing them to plateau for roughly a decade before they start to fall. The IRP also points to greater contributions from medium-scale plants and embedded generators directly connected to municipal distribution networks.

- In his State of the Nation address 2020, the President announced that the national government will *"put in place measures to enable municipalities in good financial standing to procure their power from Independent Power Producer (IPPs)"*. Subsequent regulatory amendments allowed 2000 MW to be procured from a range of energy technologies, from 2019 to 2022. In October 2020, the Minister of Minerals Resources and Energy gazetted a new directive that provides a framework for electricity generation: Section 34 of the Electricity Amendment Act allows municipalities to source their power instead of being solely reliant on Eskom; no licence is required for small-scale distributed generation for own use up to 1 MW (megawatt), while

[2] Addressing issues of ownership and participation (private sector vs the state or communities), inequality, employment and social development, access and affordability, environmental impacts and other externalities, and the equitable distribution of the costs and benefits of an energy transition in a highly unequal context.

municipalities may develop additional grid capacity from renewable energy, natural gas, hydropower, battery storage and coal.

- More recently on 20 August 2021, Schedule 2 of the Electricity Regulation Act was amended to lift the generation facility licensing threshold from 1MW to 100MW. The main implications for municipal electricity distributors are that they can expect more applications for generation facilities above 1MW which require detailed grid impact studies, and municipalities will need to develop the capacity to evaluate these studies. Secondly, since the Amendment explicitly allows for wheeling of electricity through the grid from generators to customers, municipalities can expect an increased number of applications for wheeling arrangements, and municipalities will need to develop the billing and metering capabilities to facilitate these transactions.

- In meeting our national and international Paris Agreement climate commitments, President Ramaphosa in his State of the Nation Address (SONA) 2019 and 2020, further committed the country towards reducing carbon emissions, building resilience, and reducing vulnerability within communities across all sectors. He appointed a 22-member inaugural Presidential Climate Change Coordinating Commission (P4C), with effect from 17 December 2020. The Commission is tasked with advising on South Africa's mitigation and adaptation response to climate change and its impacts. It also aims to provide independent monitoring of South Africa's progress in meeting its emissions reduction and adaptation goals (Presidency 2020). The formation of the Commission emphasises the countries' ambition for a just transition.

- To signal South Africa's increased climate ambition, Cabinet in 2021 approved our updated Nationally Determined Contribution (NDC), which sets out our emissions targets towards achieving net-zero carbon emissions by 2050. This sets a target range for emissions from restricting global warming to less than 2 degrees Celsius at the top of the range, with the bottom of the range compatible to restrict warming to less than 1.5 degrees Celsius. The NDC takes into consideration updated information on climate action response both globally and nationally, including the GHG emissions projections. The updated NDC focuses on the national and global shift to the green economy, green industrialisation and creating new opportunities for South Africa's rich mineral endowment, many of which are vital for low emission and climate-resilient development.

2.2. Local context

South Africa's municipalities play a vital role in addressing the country's social, economic and environmental needs. Local government is constitutionally tasked with the provision of services (water, waste removal, energy, clean air, housing, transport) sustainably and equitably, the facilitation of social and economic development and the promotion of a safe and healthy environment for all. These are clearly articulated in the Constitution, Section 152(1), which outlines the objectives of local government as:

(a) to provide a democratic and accountable government for local communities
(b) to ensure the provision of services to communities in a sustainable manner
(c) to promote social and economic development

(d) to encourage the involvement of communities and community organizations in matters of local government.

These objectives point strongly to development having a human face, and municipalities should be the site for this engagement with citizenry.

Municipalities are also major drivers of energy demand, influencing the country's energy and carbon emissions profiles and socio-economic development indicators (SEA, 2020). The latest State of Energy in South Africa's Cities Report (2020) tracks 27 cities in South Africa, comprising of metros, secondary cities and a few nodal towns, demonstrates that these cities alone accounted for 38% of the country's total energy consumption, 54% of national demand for electricity and 29% of national emissions. Cities are therefore crucial for achieving national climate commitments (Nationally Determined Contribution under the Paris Agreement), while at the same time delivering on their commitments of poverty alleviation, equality and employment. They are essential to push for more sustainable and resilient low-carbon development paths. It is the sphere of government that is closest to the people and responsible for their built and living environment. Even globally, cities have emerged as important actors, in promoting sustainable energy, low carbon development and climate change responses. This is because of a convergence of forces: population dynamics, with cities, now home to over half of the world's population; the "new energy paradigm[3]," with its emphasis on energy service; and the technology disruption, with investments in renewable and decentralized energy outstripping those in traditional fossil fuels. City activity related to climate mitigation and resilience (for example renewable energy deployment) is now firmly on the international political agenda, which allows for resources to be directed to local government.

As noted earlier in the report, a major energy transition underway; this also manifests significantly at the local government level. Following the global acceleration of renewable energy development and the decentralisation trend of renewable energy generation options, this has made a substantial impact on driving down the costs of renewable energy technologies (by 77% in 2020) both globally and in South Africa (IEA, 2020). The renewable energy transition agenda is not exclusively about technology change, but also crucially embraces equitable access to energy and economic opportunity within the energy sector. The decentralisation of energy generation is happening as a result of the shift from traditional fossil fuels to renewable energy sources (a market-driven shift arising out of climate responsive investments driving technology disruption[4]). Renewable sources are by their nature dispersed (e.g., sun and wind conditions across spaces), and renewable technologies are far more modular than traditional fossil fuels and can be efficient at very different scales. Decentralised energy systems (distributed renewables) are more dynamic and flexible, and therefore suitable to being locally managed and governed

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[3] In the early 2000s, the new energy paradigm of sustainable energy emerged that broke with the traditional, growth-oriented, supply-side model, which had failed to address inequity and environmental damage. The measure of development shifted from the magnitude of energy supply to the level of energy services, expanding the domain of energy beyond supply to the end use. In this domain, local government becomes a key governance instrument, with a mandate not only to deliver energy services, but also to take responsibility for urban form, mobility and infrastructure, including social housing delivery.

[4] The cost of renewable energy is now lower than traditional fossil fuel. According to the Independent Energy Agency's World Energy Outlook 2020, "It's official: Solar is the cheapest electricity in history", as for the first time, solar per megawatt cost is below that of fossil fuels. (https://www.popularmechanics.com/science/a34372005/solar-cheapest-energy-ever/)

and including a range of public and private investors, owners, and operators, right down to the household level (SEA, 2020).

Distributed renewables are small-scale power generation systems located near the point of use in the form of solar home systems, micro- or mini grids. These systems generate, store and distribute energy from renewable sources independently of, or to enhance, the traditional, centralised national electricity grid. Battery storage technology may be used to store power in the absence of a grid, helping to balance demand with power supply. They may provide energy to communities where the grid is absent or where the power supply is unreliable and unaffordable and are increasingly a part of the global trend towards sustainable power systems. As global demand rises, the cost of distributed renewables and battery storage technology is rapidly decreasing. Together with energy efficiency, distributed renewables are a key lever for cities to achieve a wide range of objectives such as reducing air pollution (and so improving public health), mitigating climate change, supporting the local economy, creating more liveable urban areas and enabling a better quality of life.

This technology disruption (distributed generation) enables municipalities to play an active role in shaping energy supply ensuring energy security within their jurisdiction and extending citizen participation in energy planning and investment. Communities are energy consumers and their role in this new energy model may be in planning energy systems and owning energy infrastructure appropriate to the local contexts. Local governments need to enable the participation of “ordinary citizens” in energy policy, planning, ownership, and use. This should include transparency and engagement of the public in key policy developments, sharing of benefits from a local energy economy and innovative private-public ownership models. Local government also has a role to play in educating the community through awareness campaigns about distributed renewables work, and training workshops with community organisations and local entrepreneurs (SEA, 2020).

While this technology disruption opens the opportunity for municipalities to play a key role in shaping energy supply and bringing citizen participation into the energy planning and investment, there are some prevailing constraints facing municipalities with decentralised energy generation. Given the size of the power economy (it is big business), substantial forces are ranged against such “municipalisation”. Further, real constraints to decentralised energy include grid configuration and safety, and the need to ensure the security of supply through a “supplier of last resort” (due to the intermittency of renewable power). The costs of changing the system, particularly in South Africa where much of the municipal revenue is tied up in electricity, may not fall fairly and “without an adequate policy and pricing intervention, decentralised energy can disproportionately benefit those with the capital to invest in their own or shared infrastructure.” (Hermanus, 2017). Much work is already underway with addressing these real constraints.

In providing the above local context about energy as part of the background for this feasibility study report, the context is not complete without providing the energy poverty picture that prevails at the local level. This picture is vital towards providing impetus for communities to be a crucial part of the energy transition democracy process – policy planning, development and implementation.

2.2.1. Energy poverty

Energy is central to meeting basic human needs and improving living standards. Households require energy for the essential services of cooking food, heating water, space heating, lighting and media/communication in order to satisfy basic human needs. It is widely accepted that energy is a fundamental prerequisite for development (UNDP, 2000). The global community adopted the Sustainable Development Goals (SDGs) in 2015, which include SDG #7: 'Ensure access to affordable, reliable, sustainable and modern energy for all. Lack of choice in accessing adequate, reliable, good quality, safe and environmentally benign energy services to sustain economic and human development is the way in which energy poverty manifests itself (UNDP, 2000:3).

Despite South Africa's achieving remarkable levels of electrification, 87% throughout the country and 93% in urban areas, it is estimated that 43% of South African households are energy poor, meaning they cannot meet their basic energy needs (DoE, 2013). Affordability of electricity remains a challenge. This is demonstrated by widespread electricity disconnections in poor areas, due to the non-payment of electricity accounts, high levels of illegal electricity connections and widespread protests about unaffordable electricity access (Ledger 2021). Government's intention to provide universal access to electricity has not yet been achieved and nor has affordability to safe forms of energy been attained. Poor households spend up to 20% or more of their household budget (a ratio used to express the energy burden of a household) on energy compared with the 2-3% for wealthier households (SEA, 2020). While energy is considered a basic need by government (White Paper on Energy, 1998), the poor continue to largely rely on unsafe, unhealthy and expensive fuels such as paraffin, biomass or coal (and associated appliances) as sources of energy for cooking and heating, the two primary and most energy intensive domestic activities which continue to entrap households in poverty. These fuels cause major ill health through indoor air pollution arising from their combustion in poorly ventilated spaces and the use of inefficient appliances. Indoor air pollution is estimated to result in 1,400 deaths of children each year (Ledger, 2021). Paraffin and candles are known to be the leading cause of fires and associated fatalities and burns particularly in dense informal settlements (SEA, 2015; Ledger, 2021). It is estimated that there are ten shack fires a day across South Africa (Wang et al, 2020) resulting in the destruction of thousands of homes over the past five years and loss of all possessions for poor families. Moreover, in large informal settlements in urban areas, as households attempt gaining access to basic services through harmful 'illegal connections', children become vulnerable to electrocution from poor wiring. Even when people move to formal title deed houses, households struggle to afford the metered electricity, and resort to the practice of tapping into overhead electricity – this causes both fires and death (Moodley & Erwin, 2021). Generating socially owned renewables for low-income and informal settlements would bring with it an enormous safety benefit for residents

Energy poverty is a complex and multi-faceted phenomenon and is driven by a diverse range of social and economic factors such as rising electricity prices, household incomes, energy-inefficient homes to name a few. Low-income households are burdened with a high share of energy-related costs to meet their basic energy needs which include cooking, water heating, space heating and lighting. Additionally, poor households including those living in government delivered RDP homes built before 2014 (approximately 3 million houses), lack ceilings and other forms of important thermal insulation. This lack of insulation is

linked to poor health and severe thermal discomfort due to poor thermal protection against extreme temperatures and requires space heating on extremely cold days. Thermal inefficiency adds to the household energy costs. According to the Department of Energy survey of 2013, 42% of formal houses are thermally inefficient compared to 94% of shacks and informal dwellings which were deemed thermally inefficient. The implication is that those residing in informal dwellings, often non-electrified, bear higher energy costs for space heating requirements relative to middle and high-income households.
To add to this energy burden, poor households, including the former RDP houses are typically located on the margins of cities leaving the poor far from places of work and social activities. This has resulted in high energy costs associated with travel/commuting to access these opportunities, deepening the poverty cycle.

Energy poverty is most severely experienced by those residing in the urban informal sector, due to lack of access to electricity and severe poverty (affordability). South Africa is 67%[5] urbanised and growing, as people move from rural areas to cities in search of employment and better opportunities. As subsidised housing programmes have declined, informal settlements have grown, surpassing social housing delivery (Gardener, 2018) as the government struggles to keep pace with the rapid urbanisation. According to conservative estimates in 2011, between 1.1 and 1.4 million households, or between 2.9 and 3.6 million people living in informal settlements in South Africa (Gardener, 2018). South Africa's nine largest cities alone are estimated to be home to 23% of households deemed to be without adequate shelter. Informal settlements are characterised by a lack of formal tenure, insufficient public space and facilities, inadequate access to municipal services and poor access ways. Informality also includes those households living in backyard shacks of formal properties (serviced plots) in overcrowded conditions, accommodating families who can't afford to live independently. A makeshift cable is typically run from the main house to the shack to supply electricity, however, this results in the household paying higher rates and places pressure on the infrastructure and existing services. Even when electricity is available in informal settlements, due to affordability constraints households remain reliant on a combination of polluting and unsafe fuels such as candles, paraffin, charcoal and firewood to meet their basic energy needs.

Energy poverty is also manifest among vulnerable groups such as women or child-headed households who make up a sizeable proportion of the total population, especially in urban areas (SEA, 2020). In general, energy poverty impacts women and children more severely compared to men (Barnes et al., 2000), since women are typically the primary carers of the household responsible for cooking, cleaning and childcare (Department of Women, 2015; Clancy et al., 2003). Women spend more time and energy on unpaid care tasks and domestic tasks (by a factor of six regarding caregiving, and a factor of two on domestic chores) relative to men (Department of Women, 2015). Women as a result typically tend to forego opportunities to actively engage in income-generating and livelihood enhancing activities. Moreover, in low-income households, research shows that women tend to have little control over household resources and decision-making and therefore have minimal influence on energy purchases and the choice of fuels used in the household (Clancy, 2003). Thus, women and children tend to endure increased exposure and the

[5] World Bank. 2018. United Nations Population Division – World Urbanisation Prospects. Available at: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=ZA

harmful health impacts of these unsafe fuels, rendering them more vulnerable to the impacts of energy poverty than men. Moreover, energy poverty in female-headed households is particularly severe as fewer women are employed and those that are, generally earn less than their counterparts (Department of Women, 2015).
In the urban context, crime and especially gender-based violent crime is a grave problem, particularly in unelectrified informal settlements. The lack of street lighting and indoor lighting places women at substantial risk – toilets are often located a distance from the household dwelling and open public spaces and without adequate lighting at night these are sites of high crime (Davis, 2013; SEA, 2016).

Against this energy poverty context, it is paramount that any approach for the transition towards low carbon or sustainable energy systems must be meaningful within this context and address these critical issues. Transition strategies must ensure access to affordable, reliable and sufficient clean energy, quality housing, the development of skills and new enterprises, as well as new economic or business models that unlock opportunity for a far broader proportion of the population.

2.2.2. South Africa's pro-poor energy policies and legislation

South Africa has several pro-poor policies specifically targeted at energy which began with the adoption of the White Paper on Energy Policy in 1998. Further, the duties of local government require it to prioritise the needs of the poor and participate in national programmes. The Energy White Paper inter alia articulates the policy goals of access to affordable energy services for all (Section 3.2.2.1), improved governance and a better economy. Subsequent policies and programmes have been developed to assist in the implementation of the White Paper. The major departmental programme in this regard has been the Integrated National Electrification Programme (INEP). Tasked in terms of Schedule 4B of the Constitution with electricity and gas reticulation, local government is a critical partner in the delivery of this national policy goal. Other key policies to affect the goals of the White Paper on Energy Policy include the prioritising the provision of (free) basic energy to the poorest citizens of the country.

Summarised below are some of the policies and legal frameworks developed to support the energy needs of the poor.

- The Municipal Systems Act (Act 32 of 2000) (MSA) requires that all members of the local community have access to at least the minimum level of basic municipal services. It provides for direct or indirect subsidisation of poor households so that they have access to at least basic services, and that this subsidisation can come from sources other than revenues generated from the service provided.

- The National Framework for Municipal Indigent Policies (2005) (NFMIP) identifies 'basic energy' as one of a suite of essential services falling within a 'social safety net' that the municipality is obliged to provide for free to indigent households, as a priority.

- The National Energy Act (Act 34 of 2008) (NEA) requires that the Department of Energy provide universal access to appropriate forms of energy or energy services, considering government's commitment to providing free basic electricity to poor households (Sections 5(1) & 5(2)).

- The Free Basic Electricity (FBE) Policy (2003) (Electricity Basic Services Support Tariff Policy) provides for municipalities to give 50kWh or more of free electricity to indigent residents each month.

- The Free Basic Alternative Energy (FBAE) Policy (2007) makes provision for subsidised alternative energy sources (such as cooking fuels) for indigent households that do not have access to grid electricity or off-grid solar home systems.

  Recognising that FBE and electrification will not reach unelectrified households soon, national government in its bid to close this energy poverty gap introduced policy with a wider approach covering 'free basic energy' and not just electricity. This is a subsidy intended to provide poor households with alternative energy to improve their welfare and promote a more equitable share in reliable and affordable services to the growing unelectrified poor households.

While there are many progressive pro-poor policies and strategies that have been implemented since 1994, 27 years into democracy, substantial challenges persist in effective energy service delivery to the poor. Affordable access to sustainable energy is paramount to ensure more households continue to have energy. Inconsistency in how municipalities address energy poverty, lack of strong governance and inequitable distribution of electricity influence the extent to which energy poverty persists in South Africa (Ledger, 2021). Moreover, municipalities are structured to operate along cost recovery business accounting lines[6] and at the same time constitutionally mandated to function in a developmental manner. Since they are expected to generate revenue from the sale of electricity and other service charges, the amount they receive from the national government in grants and transfers is relatively small. The revenue municipalities generate is declining, and together with a contracted economy, higher bulk electricity prices mean there is a substantial gap in their ability to provide services for all and to maintain the infrastructure required to deliver those services (SEA, 2020).

3. Overview of the 2 study municipalities

The municipalities selected for this feasibility study were determined based of varied geographies and contexts they represent in South Africa, the strong social movements working on related issues that are active in the respective municipalities and the differential municipal structures.

Emalahleni Local Municipality, located at the heart of coal mining and power generation in the country, is at high risk with the imminent decline in coal production activity and/or coal-based electricity, as the country transitions from coal to renewable-based energy. Given the municipality's high dependence on coal mining and Eskom power plants, it will be most vulnerable to rising unemployment and reduced economic activity.

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[6] Since 2000, local government underwent a massive restructuring process and reorganization of municipal delivery systems such that the municipal service delivery model is based on the corporatization of municipal services, with emphasis on a cost recovery and technocratic approach to delivery. Smaller poorer municipalities in particular do not have a large revenue base like that of metros to cross-subsidize the poor.

eThekwini Metropolitan Municipality, one of the 8 largest cities in the country with substantially more resources than a local municipality is among the leading cities in its climate response efforts. As early as 2011, the metro pioneered the process of allowing grid-connected solar PV. It has since established a Renewable Energy Roadmap which provides the strategic direction for renewable energy development in the municipality. More recently in 2021, the metro launched its decisive Climate Action Plan (CAP), in which it set ambitious renewable energy objectives to accelerate RE development in the metro.

In light of the context of the 2 study municipalities, both are readily poised for exploring how communities can participate in the energy transition through community-led renewable energy projects implemented in partnership with municipalities to accelerate the transition towards clean, resilient and inclusive energy systems for meeting energy needs affordably, creating jobs and improving health and well-being.

3.1. Snapshot of Emalahleni Local Municipality

The Emalahleni Municipal area, meaning a “place of coal” is the third-largest secondary city in the Mpumalanga Province and the main city centre within the Nkangala District Municipality. It is strategically located as a gateway town for eight of the nine provinces of South Africa. The municipality located to the northeast of the province accommodates the largest concentration of coal-fired power stations in the country and is among the most industrialized municipal area in Nkangala. Its landscape features mainly underground and opencast coal mines and is the locus of most of the coal production in the country (TIPS 2019). A disproportionate share of the country's greenhouse gas emissions, therefore, originates from within this locality. The mining industry in Emalahleni LM consists mainly of coal mines which cover approximately 334 km^2. Mining activities contribute substantially to harmful particulate matter (PM_{10}) emissions[7] – the main pollutant emitted by coal mines and other mining-related activities. In essence, the Emalahleni Local Municipality falls within the Highveld Priority Area (HPA)[8] (Emalahleni Local Municipality 2019).

[7] Studies suggest that short-term exposure to particulate matter leads to adverse health effects, even at low concentrations of exposure (below 100 µg/m3). Morbidity effects associated with short-term exposure to particulates include increases in lower respiratory symptoms, medication use and small reductions in lung function (Scapellato & Lotti 2007).

Long-term exposure to low concentrations (~10 µg/m3) of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO 2005). Those most at risk include the elderly, individuals with pre-existing heart or lung disease, asthmatics, and children.

[8] n 2007 the Minister of Forestry, Fisheries and the Environment declared the greater Emalahleni region as a national air pollution hotspot called the Highveld Priority Area (HPA) in terms of the National Environmental Management: Air Quality Act (39 of 2004). In terms of this declaration the national government is responsible for monitoring, managing, and mitigating air pollution, in conjunction with local and provincial governments (SACN, 2014)

Source: https://www.sa-venues.com/maps/mpumalanga/witbank.php

The town of eMalahleni fulfils the function of a service centre to the surrounding smaller towns and settlements, as well as farms in the district (SACN, 2014). As a Category B[9] municipality, it is mandated to provide housing, electricity, waste management, roads, transport services as well as water and sanitation. Emalahleni municipality has been experiencing high settlement growth patterns due to rapid urbanisation attributed to its location to various mining and industrial activities attracting migrant labour. Its population increased from 395 466 in 2011 to 455 228 in 2016, with a population growth rate of 3.2% per annum (ELM, 2020). An increase in population has resulted in growing informal settlements. The number of informal dwellings increased from 23 138 in 2011 to 34 845 in 2016 (which is an increase of more than 11 000 households). Almost a quarter of the households in the municipality are living in informal dwellings (ELM, 2020). Emalahleni LM accounted for 32% of the total population living within the Nkangala District Municipality in 2016 (ELM, 2020).

Emalahleni's economy is heavily reliant on coal mining and accounts for 44% of the municipal GVA (TIPS, 2019). Manufacturing is the second-largest economic sector with a contribution of 9% followed by trade (9%) and finance (8%) respectively (ELM, 2020). Coal mining accounts for 26% of employment in the municipality. The immediate impacts of a decline in coal production and/or coal-based electricity will be hardest felt by the Municipality given its high dependence on coal mining and Eskom power plants, therefore rendering it most vulnerable to rising unemployment and reduced economic activity.

[9] A municipality that shares municipal executive and legislative authority in its area with the District Municipality in which it is located.

3.2. Snapshot of eThekwini Metropolitan Municipality

eThekwini Metropolitan Municipality (Durban), in the KwaZulu-Natal province of South Africa, is the third-largest city in South Africa with the busiest port in the African continent. The Municipality covers 2 297 km^2, which includes urban and rural landscapes and is home to an estimated 3.7 million people. Durban is among the few metros in the country with active and robust social movements that have been in existence for well over 3 decades. These movements have worked relentlessly to bring the community voice and perspective firmly onto the developmental agenda of the national government giving rise to the formation of key developmental policies that have benefitted South African communities concerning improved health and well-being.

Durban is an economic hub that is home to South Africa's sugar industry and is a centre for diversified commercial activity (financial, manufacturing, agriculture etc). While it is a thriving city, it is also faced with several complex challenges. The City's industrial sector is predominantly concentrated in the South Durban Industrial Basin. South Durban has the largest concentration of petrochemical industries in the country, including the two biggest oil refineries that refine approximately 60% of South Africa's petroleum. Moreover, there remains the challenge of apartheid spatial planning that relegated historically disadvantaged communities to the edges of the city and around the South Durban Basin industrial complex, compounding inequalities and affecting health. There is also an increasing rate of migration to the city due to the high levels of poverty in outlying rural areas. These challenges will be further compounded and exacerbated by the effects of climate change.

More recently in 2021, the metro being an industrial port city containing large rural areas with high levels of inequality and vulnerability, released its ambitious climate action plan (CAP) in which it sets out several climate and development objectives. For the purposes of this report, we will focus only on the renewable energy objective of the CAP which sets the following targets: 1) 40% of electricity to be supplied by RE by 2030; 2) ensure 70% of public and private electricity demand is provided by self-generated renewable energy by 2050 and 3) ensure that 100% of electricity purchased by the metro for resale is from renewable energy sources by 2050. (eThekwini, 2021)

To meet its CAP objective to "Ensure 100% of electricity purchased by the Municipality for resale is produced from Renewable Energy sources by 2050", eThekwini has developed a Strategic Renewable Energy Roadmap to guide the city in achieving this objective. This requires 22% of future electricity demand to be met from renewable resources within the city, and the remaining 78% to come from independent power producers (IPPs) (eThekwini, 2019). To this end, the municipality is launching a Municipal Independent Power Producer (MIPP) programme and has issued a Request for Information, with the main objective of procuring 400MW of new generation capacity by 2025 in order to mitigate the impact of load-shedding on the local economy.

eThekwini, to achieve a transition to 100% renewables will require a transformative change in the way that electricity is generated, transmitted and distributed. Globally, the trend in the electricity sector is to move away from centralised electricity generation and monopolistic distribution towards more localised and integrated electricity systems. A future electricity system is envisaged to be a smart grid that enables bidirectional power flow and includes large-scale renewables from national and locally produced small-scale embedded generation (SSEG) (See Figure 1). In support of this, the National Energy Regulator of South Africa (NERSA) has permitted eThekwini Municipality to facilitate SSEG via a bidirectional tariff structure to enable credits where power is exported onto the grid. Driving SSEG in Durban as a component of a decentralised grid currently faces numerous barriers. These include the lack of clear policy and regulatory frameworks, municipal capacity to evaluate applications and technical constraints relating to SSEG technology. However, recent studies have shown that the Levelized cost of electricity (LCOE)[10] generated from solar photovoltaic (PV) systems is expected to be lower than Eskom's tariffs in the long run, with a payback of fewer than seven years. Short payback periods are primarily linked to the low capital cost, free energy resources and the rising cost of Eskom's coal-based electricity (Dippenaar et al, 2020).

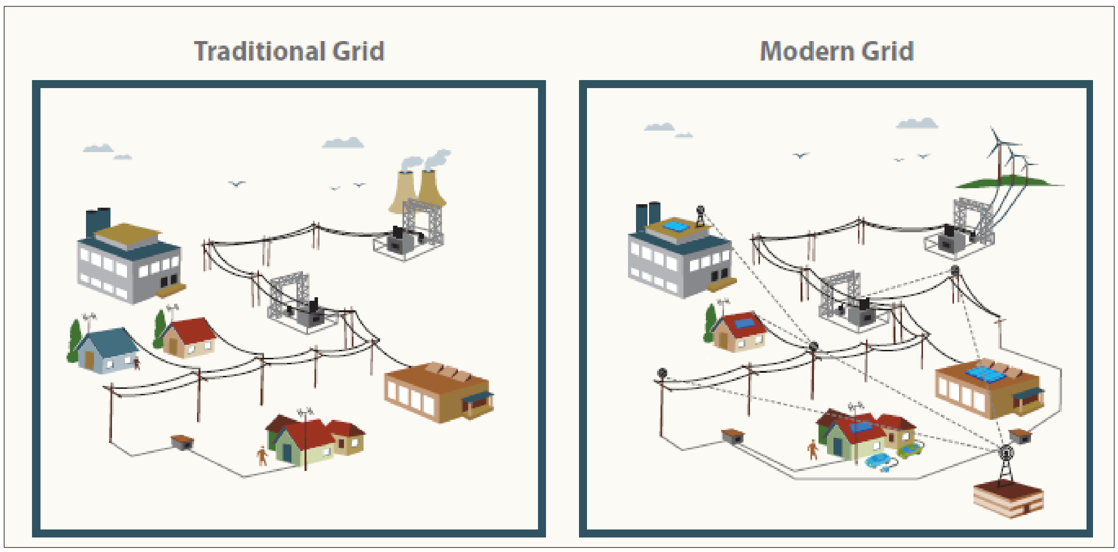


Figure 1: Transformation of the electricity grid towards smart, distributed systems
(Source: eThekwini, 2021)

This backdrop of renewable energy development and ambition set out by the city provides many opportunities for community-led socially owned renewable energy development to be explored and take root.

4. Municipal electricity supply status quo in the 2 study municipalities

This section explores the status quo of electricity supply in the two municipalities in consideration: eThekwini Metropolitan Municipality in KwaZulu-Natal Province and Emalahleni Local Municipality in Mpumalanga Province.

[10] LCOE "represents the average revenue per unit of electricity generated that would be required to recover the costs of building and operating a generating plant during an assumed financial life and duty cycle" and is calculated as the ratio between all the discounted costs over the lifetime of an electricity generating plant divided by a discounted sum of the actual energy amounts delivered.

4.1. Mandate as electricity distributors

South Africa's Constitution empowers municipalities with responsibility for the distribution of electricity. As such, municipalities are the key distributors of electricity (alongside Eskom) to households and businesses. One of the Government's key objectives is the electrification of all households and the provision of free basic electricity to poor households. Electricity distribution is central to local government operations; revenue from electricity sales accounts for roughly a quarter of a typical municipality's total income and is key to funding service delivery.

4.2. Household energy service delivery status

Electricity is the safest and cleanest source of energy for households to use for cooking, heating and lighting. While South Africa's electrification programme has been successful in expanding the grid to increase access to electricity, thousands of households still do not have a formal connection to the grid.

eThekwini Metro is actively expanding its electricity network to connect more households to the grid. The municipality has a backlog of over 300 thousand households awaiting a formal grid connection. eThekwini Metro has a target of electrifying 10 thousand households each year.

Emalahleni's Local Municipality is having challenges connecting new customers as the grid capacity of their Eskom intake points has been reached. Accommodating new connections will require expensive infrastructure upgrades and the municipality is currently encouraging off-grid alternatives to minimise grid congestion.

4.3. Status of municipal renewable energy uptake

The massive global investment in renewable energy over recent years has made a substantial impact on driving down the costs of these technologies, both globally and in South Africa. Renewable energy lends itself well to modular, scalable design – ranging from large megawatt-sized renewable energy plants to as little as kilowatt-sized rooftop PV panels suitable for the residential sector, thus making it suitable for the private sector participation at all levels.

Renewable energy generators are typically either large-scale utility generators connected to Eskom's transmission network or embedded generation (typically solar PV) connected directly to a customer's load. Utility-scale renewables are typically procured via national government and these generators tend to sell directly to Eskom who then on-sell to municipalities. South Africa's Integrated Resource Plan (IRP, 2019) describes a massive renewable energy build program through the 2020s, and most of this capacity will be added in the form of utility-scale generators. As such, the carbon intensity of municipal electricity supply will steadily decrease as the national grid sees more renewable energy connecting.

An alternative renewable energy arrangement is when the systems are connected "behind-the-meter" directly to a customer's load. These systems are referred to as small-scale embedded generation (SSEG). South Africa has seen an exponential uptake of SSEG since 2017 (SALGA, 2020; SEA, 2021). SSEG systems are typically privately owned, and the business case is built off reducing the customer's municipal (or Eskom) electricity bill. Municipalities have a key role to play in enabling the uptake of SSEG in their jurisdictions. A functional municipal SSEG process involves an application process for customers to connect their systems to the grid, a policy that describes what is allowed and not allowed, tariffs that compensate SSEG customers for feeding into the grid, and staff capacity to manage the grid connection applications. eThekwini Metro has a comprehensive SSEG process and has connected several megawatts of solar PV to their grid. Despite being a far smaller municipality, Emalahleni Local Municipality has made good progress in getting their SSEG process running, and they too have connected many solar PV systems to their grid.

4.4. Tariffs and subsidization mechanisms

Municipalities set their tariffs following the guidelines provided by the National Energy Regulator of South Africa (NERSA). Municipal tariffs need to consider the cost of bulk electricity purchases based on the Eskom tariff increases, as well as the increases in wages, repairs and maintenance, and other municipal operating costs. While electricity remains unaffordable for many South Africans, municipalities face the very real challenge of recovering sufficient revenue for business sustainability.

Cities use municipal surcharges, high-income household tariffs and commercial tariffs to cross-subsidise low-income household tariffs and for FBE (Free Basic Electricity) allocations. Progressive cross-subsidisation is assisted through electricity tariff structures that have low connection fees, no fixed charges (i.e., a set daily charge for the use of the grid, regardless of whether electricity is being consumed) and inclining block tariffs, where the cost per unit of electricity increases, as the customer uses more. Substantial pro-poor subsidies exist within the electricity industry and were estimated to be at least R8 billion per annum in 2010 (Eberhard, 2018). Therefore, it can be argued that indigent tariffs for services are the most fiscally efficient form of social transfer and one of the best ways citizens can help each other.

While tariff cross-subsidisation has been reasonably successful for the last decade, the continued sustainability of this tariff structure is being questioned. While municipalities continue to do the brilliant work of electrifying households, the number of commercial and high consuming customers – those that fund the cross-subsidisation – remains unchanged. Municipal officials are therefore pleading for an increase in the Local Government Equitable Share[11] grant from National Treasury. This dilemma is most pronounced in poor, rural municipalities with only a few commercial and industrial customers.

5. Status quo of household energy use in low-income households in the 2 study municipalities

5.1. Introduction

A small survey exploring household energy use patterns focusing on energy access, affordability and renewable energy knowledge, was conducted in 2 selected communities in eThekwini Metro (KwaZulu-Natal) and 1 community in eMalahleni Local Municipality (Mpumalange Province). The purpose of the survey was to gain a broad insight into the current household energy use patterns, needs and perceptions prevalent among households to better inform this broader study that explores locally appropriate

[11] In order to provide basic services to poor households and as a substitute for own revenues, local municipalities are accorded an 'equitable share' of tax revenues raised at national level by the South African Revenue Service in terms of section 214 of the Constitution.

community energy system options. While the survey sample size is not statistically representative, for the purposes of this study, a small sample size is adequate to provide broad insights into the energy use dynamics that prevail in households.

5.2. Methodology

The household energy survey consisted of a combination of qualitative and quantitative questions. The intention was to survey 10 households from each of the 3 selected communities, amounting to a total sample of 30 households. The survey was administered digitally with the assistance of the project partners (Community Based Organisations) who are active in the communities. Data on energy use patterns were collected through face-to-face interviews from informal and formal households within the selected communities in KwaZulu-Natal and Mpumalanga provinces. The data collected entailed 1) fuels used to meet primary household energy requirements; (2) household energy access and affordability; (3) perceptions of household fuel use and (4) energy awareness. This data was captured using the Google survey platform, collated and then analysed using Microsoft Excel software, the findings of which are presented in this report.

5.3. Community selection

The survey was conducted in two selected communities in the eThekwini Metropolitan Municipality (KwaZulu-Natal) and one community in Emalahleni Local Municipality (Mpumalanga Province). Surveyed households in the community of Empumelelweni, kwaGuqa in eMalahleni, comprised electrified households living in government delivered subsidised RDP housing. In eThewkini, surveyed households comprised a formal electrified apartment block in Austerville, Wentworth and informal, non-electrified households in Ekhenana, Cato Manor. These communities were selected by the partner organisations of this broader project, as representative of the low income formal electrified and un-electrified communities in the participating municipalities (eThekwini and Emalahleni) with respect to the energy poverty challenges that confront them.

5.3.1. Community Background

Background to the 2 surveyed communities in the eThekwini Metro Area (KwaZulu-Natal Province)

1) **Ekhenana** (eThekwini Metro) is an informal settlement located in Cato Manor, part of Chesterville, northeast of Durban. The Cato Manor area established in the mid-1800s was named after the first Mayor of Durban, George Cato. The area has consistently experienced informal growth and sprawl. Through various developmental interventions over time, it is currently registered as a semi-developed township,

Dialogue meeting held with the Ekhenana community in November 2021 with some access to water and sanitation services and remains a hotspot and a gateway for new informal settlements to develop.

2) **Austerville** (eThekwini Metro), is part of the greater Wentworth area, located south of Durban. The Wentworth area arose in the 1930s as a military base and was later converted into a township for the coloured population, under the Group Areas Act. Over time it evolved into an industrial area, home to oil refineries, paper mills, landfill sites and water treatment sites. As result of its large industrial presence, Wentworth contributes to the larger share of Durban's greenhouse gas emissions and harmful public health conditions arising from high levels of air and water pollution.

Dialogue meeting held with Austerville community members in February 2021

Background to the surveyed community in Emalahleni Local Municipality (Mpumalanga Province)

3) **kwaGuqa Ext 18** (Emalahleni Local Municipality) is in Ward 7, located in the west of the Municipality. It is part of two larger communities in the municipality which is home to approximately 8 400 residents and 2 113 households (StatsSA 2016). The community has mainly formal houses, comprising government delivered RDP homes and privately built housing including backyard rentals. The average combined annual household income in 2016 was R57 300. The area is located near the coal mines and is directly affected by the harmful emissions and pollution arising from the mining activity.

Dialogue meeting with the KwaGuqa community in November 2021

5.4. Survey findings and analysis

This section presents the survey findings from the selected communities. It provides a brief insight into energy access and affordability experiences by households, the extent to which polluting and harmful fuels are used to meet household energy needs, knowledge about renewable energy and its ability to provide clean energy to households. The findings also highlight the similarities and differences in energy use patterns observed in these 3 communities. Surveys were received from Austerville (17 responses) and KwaGuqa (10 responses) and Ekhenana (Cato Manor) (8 responses), totalling 35 surveyed households.

5.4.1. Household demographic profile

This section provides a brief overview of the socio-economic status of the surveyed households through examining household size, composition and economic status.

Household type and size

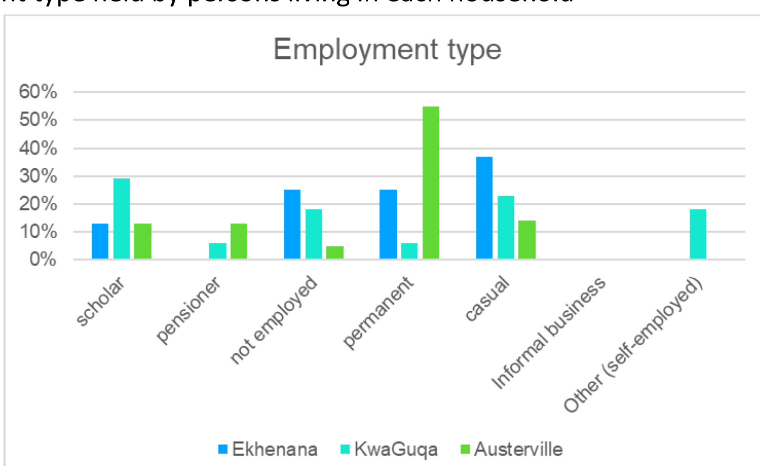
Responses from surveyed households reflected the type of built form of the communities in which they were located. Ekhenana households were informal shack dwellings, whilst those in KwaGuqa (Empumelelweni) were formal stand-alone houses. Households in Austerville were part of a block of flats (See Figure 2).

The household typology and the number of persons per household indicate levels of inequality and poverty. Household size in Ekhenana was mainly 5 -9 persons per household with limited access to services. Households in kwaGuqa were mainly 4 (50%) and 6 (30%) person households and respondents in Austerville indicated a maximum of 2 (24%) and 4 persons per household (24%). This trend should also be held in mind in the following sections that explore energy access, affordability and access to information on renewable energy.

Employment

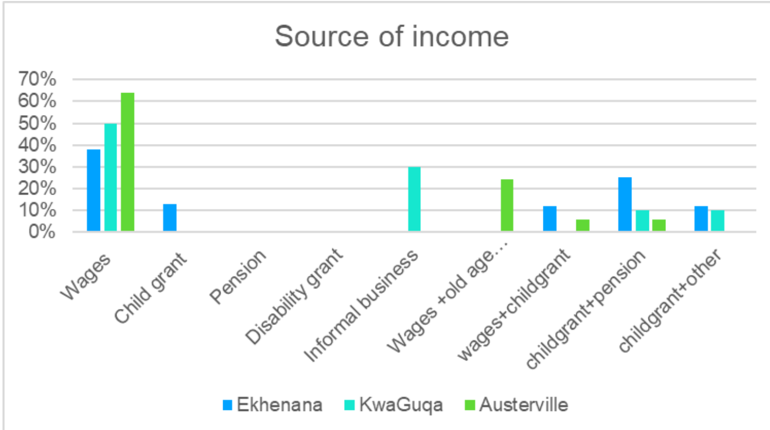
Among the small sample of households surveyed in this study, Ekhenana reported a quarter of households engaged in permanent employment, with just over two thirds engaged in casual employment (37%) and 25% were unemployed. kwaGuqa showed a slightly different picture with majority of households having scholars (29%), 23% engaged in casual employment, close to 20% were self-employed and 18% were unemployed. Surveyed households in Austerville in contrast displayed 55% permanent employment with 14% engaged in casual employment (14%), while 13% were pensioners (13%) and 13% were scholars.

Figure 2: Employment type held by persons living in each household



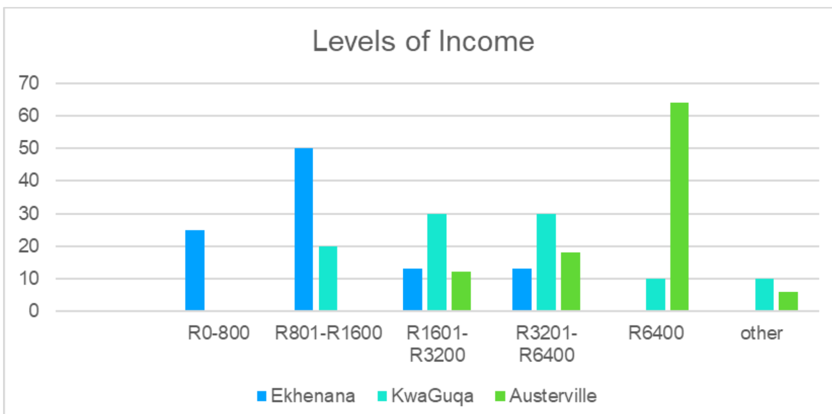
Household Income

Figure 3: Sources of household income



In regard to household income, (Figure 5 and 6) surveyed households in all communities reported wages as the main source of income - with 38% of households in Ekhenana and kwaGuqa respectively and Austerville at 64% households. Child grants, pensions and informal businesses featured as the second most common source of income in these surveyed households across all 3 communities.

Figure 4: Total monthly household income coming from all sources



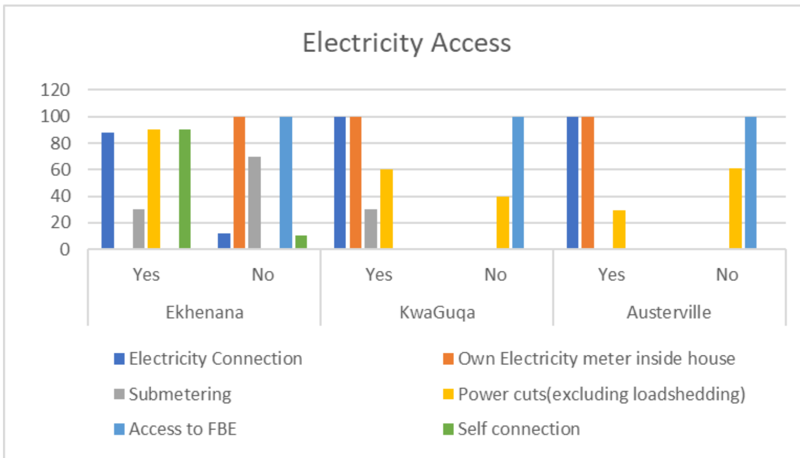
Regarding income levels, half of the surveyed households in Ekhenana (Figure 6) reported an income range of R801-R1600, and a quarter reported R0-R800. While 13% of surveyed households earned between R1601-R3200 and a further 13% earned R3201-R6400. In kwaGuqa, close to a third of surveyed households earned between R1601-R3200 (30%), a third between R3201-R6400 (30%) and a fifth earned between R801-R1600. In Austerville, majority of the surveyed households earned R6400 (60%) followed by households that earned R3201-R6400 (18%) and R1601-R3200 (12%). Surveyed households in Ekhenana reported the lowest income levels and by default were most impacted by energy poverty.

When looking at the monthly income variations (Figure 6) and sources (Figure 5) in each community, it was evident that a significant proportion of the surveyed households (albeit a small sample) reported employment to varying extents and reliance on government grants (child and pension grants). Regarding income levels particularly for Ekhenana and kwaGuqa, majority of the surveyed households in this study would be classified as indigent as per poverty line benchmarks[12],. This means that most households in 2 of the 3 communities that participated in this survey live below the South African minimum wage levels and are on the border of the poverty line.

Household energy use patterns

This section provides broad insight into energy access and use experienced by surveyed households in the 3 different communities.

Figure 5: Electricity access

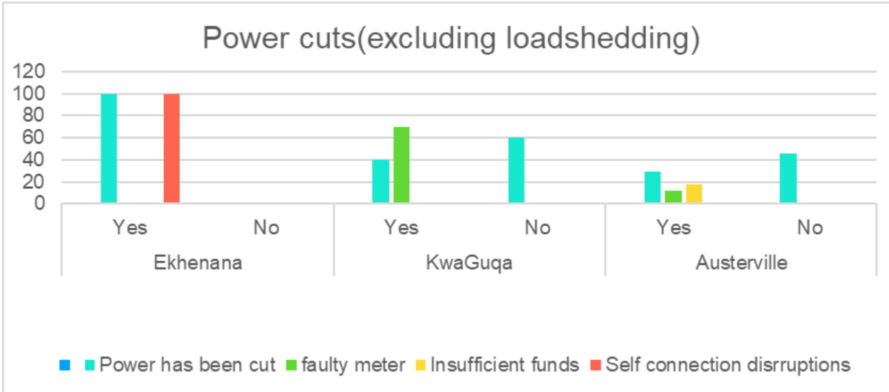


Surveyed households in all 3 communities reported having an electricity connection (Figure 7). kwaGuqa and Austerville indicated having an electricity meter inside their homes, whilst in Ekhenana, households have self-connected access. Households in Ekhenana experienced the highest incidence of power cuts, followed by kwaGuqa and Austerville. kwaGuqa indicated having electricity meters inside the house with some level of submetering (30%) taking place. Households in Austerville also reported an electricity meter inside the house. All surveyed communities indicated no knowledge about or receiving Free Basic Electricity.

Self-connected electricity access is highly unstable and has led to ongoing power cuts (Figure 8) for Ekhenana. Households in Austerville experienced power cuts due to faulty meters and in a few cases, due to insufficient funds to purchase electricity units. Households in kwaGuqa also experienced power cuts mainly due to insufficient funds to purchase electricity.

Figure 6: Power failure occurrences

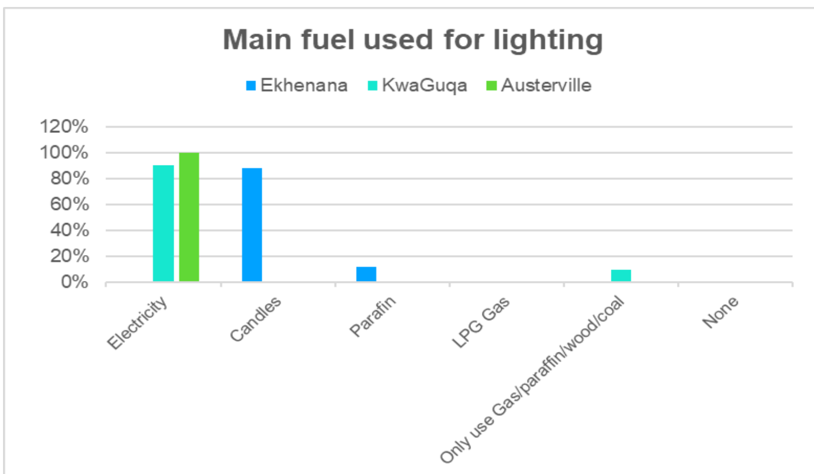
[12] The poverty line marks the point in income or consumption below which an individual or household is defined as poor. In South Africa, numerous poverty lines have been calculated. The two lines used of households earning less than R1600 per month and less than R3200 are widely accepted poverty thresholds used in South Africa and defined by Leibbrandt et al (leading poverty and development economists of South Africa) in line with internationally recognized poverty line measures. Poor households are defined according to an upper bound poverty line of a monthly R3200 (amounting to R949 per capita in 2008 Rand values) and a lower bound poverty line of R1600 (amounting to R515 per capita in 2008 Rand values).



5.4.2. *Lighting*

Surveyed households in kwaGuqa and Austerville indicated using electricity as the main energy source for lighting. Households in Ekhenana used candles and paraffin as the main energy sources for lighting.

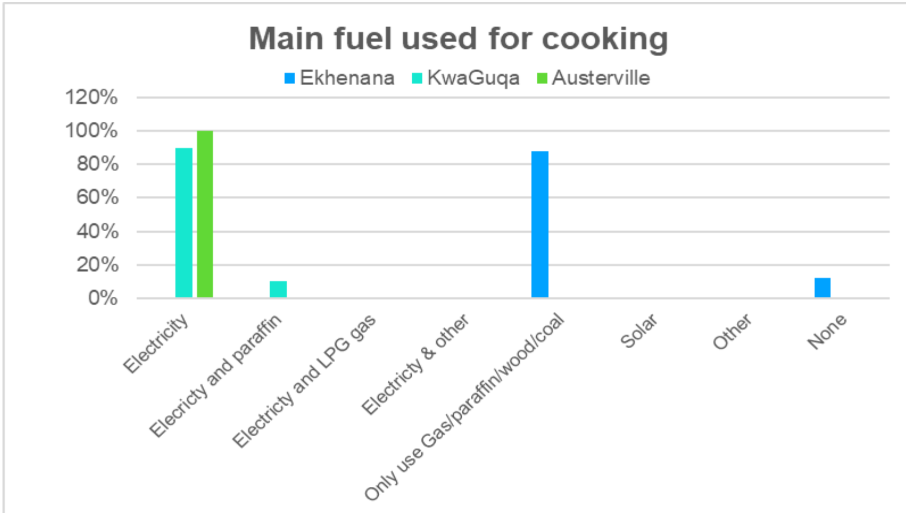
Figure 7: Fuel source for lighting



5.4.3. *Fuel used for cooking*

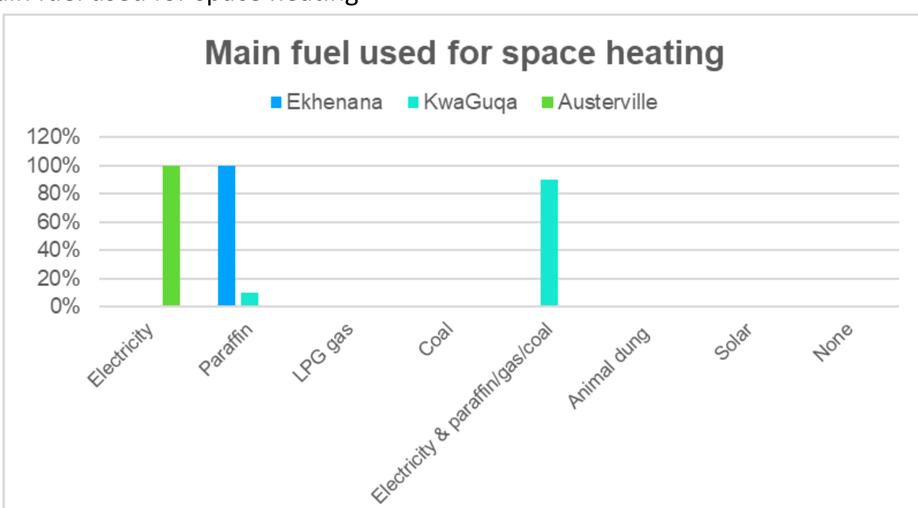
Surveyed households in Austerville and kwaGuqa reported the use of electricity to meet their cooking needs whilst in Ekhenana, a range of fuels (multiple fuel use) were used to meet cooking needs (Figure 10). Multiple fuel use refers to the practice of households utilising a range of fuels and appliances at the same time, or interchangeably because of their availability, accessibility and affordability.

Figure 8: Main fuel used for cooking and water heating (electrified households)



All households in Ekhenana used paraffin (Figure 11) for space heating, whilst in kwaGuqa, households used a combination of paraffin, gas, electricity and charcoal. In Austerville, households indicated the use of electricity for space heating. Paraffin along with a range of fuels (multiple fuels) emerged as the main fuels used for space heating in households with lower income levels. Paraffin and charcoal were also used as supplementary fuels during the cold season when electricity prices are noted to peak. Multiple fuel use also increases during winter months as space heating requirements are greatest in cases where homes are not fitted with ceilings, as was the case for about half of the surveyed households in all surveyed communities.

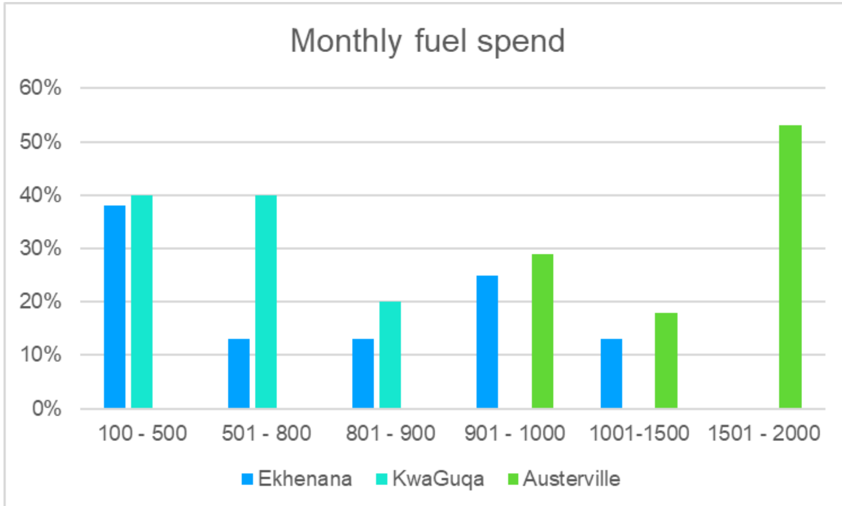
Figure 11: Main fuel used for space heating



Household energy expenditure

Energy expenditure features prominently in the economy of low-income households and generally constitutes a significant proportion of monthly household expenditure (SEA 2015). It has been widely documented that low-income households spend a larger share of their income on energy than wealthier households, often over 10% of their income compared to wealthier households, who typically spend 2-3% (SEA 2015).

Figure 9: Monthly household energy expenditure (electrified and non-electrified households)



Households spend a substantial portion of their monthly income on energy (Figure 12). Households in KwaGuqa and Ekhenana spend between R100-R1000 on fuel monthly, an average of R550 monthly for all households. This monthly cost accounts for multiple fuels that these households use, as access to electricity is limited or highly unstable (self-connection). This is closely followed by KwaGuqa, where households spend between R100 and R900 on fuel monthly, with an average of R500. For KwaGuqa, households split their fuel spend on electricity and additional fuels used for space heating and cooking. In Austerville, the amount spent was mainly for electricity, with households spending at most R2000 a month on energy (53%). Household energy expenditure is high and may account for 50% of household income when noting the average income earned per household (Figure 6) as well as the source of income.

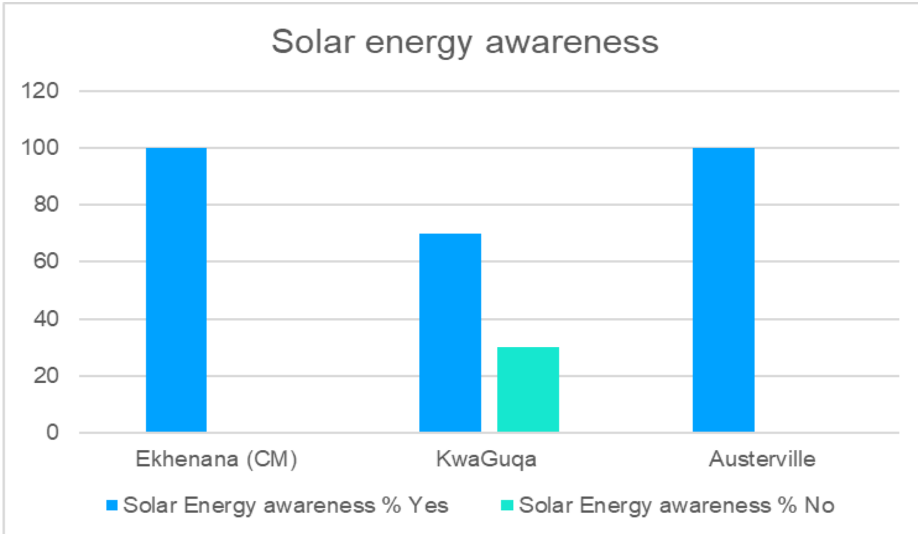
Renewable energy knowledge

This section explores the awareness and perception of renewable energy among surveyed households. The main renewable energy source households were aware of was solar energy, which also forms the basis of this feasibility study, in its exploration into the community-led socially owned renewable energy development in these participating communities.

5.4.4. Awareness of clean energy and technology

Majority of households in all 3 communities were aware of solar energy as an alternative energy source. Households were mostly positive about solar energy and were interested in the larger solar home systems that support many end-uses – such as powering lights, radio and cell phones – although affordability was mentioned as a constraint. Households perceived these larger solar systems as too expensive.

Figure 10: Awareness of clean energy



Several households conveyed some knowledge about electricity tariffs (Table 3) and expressed their concerns about electricity pricing. They attributed their limited knowledge about electricity tariffs to the lack of communication from the municipality. Overall responses directly relating to solar energy, its functionality, quality of service and reliability were captured as follows:

Table 3: **Community household responses**

Survey question	Responses Yes/No/Maybe	Detailed descriptive responses
Do you think solar energy can meet household energy needs such as lighting, cooking and heating?	88% - Yes 12% - Maybe	"because we have used it before in our house, it was working fine, able to watch tv and lighting the house, but the battery was too small to add more appliances" "Never gets wasted since it generated from the sun" "it is useful to have in a poverty-stricken community" "better and more reliable to the current power failures" "in the long run, it is better the cost of coal, gas or paraffin" "they've already inverted some of the household appliances that are easy to use with solar, that's why I'm saying yes to solar" "It will provide the power we need during emergencies." "The more quality the panel is the more power it generates"

Survey question	Responses Yes/No/Maybe	Detailed descriptive responses
		"depends on how much electricity we use "We have never experienced load shedding in this area so we do not understand how powerful it is, however, we have seen it on TV."
Would you use solar energy for your household energy needs?	95.8% - Yes 4.2% - No	"it will be very helpful to our community since our electricity is unreliable. Because I will save and my children will be safe from electro-cuts" "Durban/KZN has a good climate for solar panels" "it can power the whole house" "There won't be a rise in the light bill every month with solar unlike regular coal electricity" "We won't need to save lights as much as we do at the moment" Many communities have solar powering their entire household, therefore it will work as well in our community" "with solar you just have to be disciplined when using it, the current energy you don't plan anything, they just switch it off without informing us, they just switch it off without even informing us and can be off for a couple of days" "it will save costs from the current energy I am using and be able to save for other needs" "solar energy will not only supply power for my basic needs like cooking, cleaning and heating but it will also keep our household appliances from wearing out as fast as when there is a sudden power outage" "We can increase our use of electricity without load shedding" "it would since you are not restricted as you are with the current electricity" "it will be as reliable as our electricity at the moment but with solar, you will have power during load shedding"

Survey question	Responses Yes/No/Maybe	Detailed descriptive responses
		“no-load shedding and free of paying the ridiculous light bill” “you only pay once to install the solar power and after you become off the grid and free of Eskom's load shedding and massive electricity bills” “In our house, we rely on boiling pots of water since load shedding damaged our geyser, with solar we won't have these issues and we won't need to pay electricity bills that we can't even afford” “Solar is giving you an option on using it and saving on your own, but electricity is switch off anytime without even informed, we don’t have control or say over it” “Although it's natural we are not assured that there will always be sunny days”
Do you understand how you are charged for electricity? (Determining knowledge about electricity tariffs)	54% - Yes 43% - No 3% - Did not respond	“Based on the total amount of units used” “the municipality estimates and charges per k/w used” “they check our meter box or they estimate depending on the municipality's records” “the municipality collect information from the electricity meter box” “All we know is the estimate because we have not seen the municipality checking our meter box”

Survey question	Responses Yes/No/Maybe	Detailed descriptive responses
Have you ever heard or seen any communication about electricity billing and tariffs from the municipality? (poster/ newspaper advert/ social media/ community meeting)	54% - Yes 43% - No 3.6% - did not respond	"We are unsure because we do not see the guys coming to check the meter, but we receive a huge bill month-end" "municipality charges us according to tariffs, and often estimate the number of lights been used" "they charge according to the tariffs per unit" "When you buy the electricity, you don't get what you purchased for" "I have prepaid electricity but when I buy for R100 I don't get what I purchased for the units are far less to 42kwh units" "I don't know, and I don't understand because I don't get what I paid for and no explanation from the municipality" "because when you buy R100 you get 46.8 and I don't know where the other units are going" "because we have used it before in our house, it was working fine, able to watch TV and lighting the house, but the battery was too small to add more appliances"

Participants were open and appreciative of the survey, as well as the study and its objectives. Households expressed a keen interest in community-led energy ownership, however, many respondents did not know how it would be implemented or operated. Respondents conveyed their disapproval of the lack of communication and engagement from the municipality regarding alternative clean energy options, particularly solar energy. Households felt that communication would ease their energy security anxiety, particularly those who were willing to purchase and install solar systems in their homes. Some of their views are captured as follows:

"Thank you for these questions you have asked, they leave me with homework and really, we need to know everything about the service we get from the municipalities. I wish it was them doing these interviews so we can tell them what we want

"As you explained to me about solar, I wish the municipality can do the same but never does, I don't think so because they are after profits, and they don't even look for our needs like me as old as I am it is very hard"

"It is a good interview, but we wish to have solar in our households because the current energy is very expensive, now the load shedding that sometimes is not announced is killing us and we can be out of electricity for days without being informed without alternatives"

5.4.5. Overall analysis and conclusion

This survey provided a snapshot of household energy use patterns of low-income households in the surveyed communities within the eThekwini Metro and Emalahleni Local municipality. These households were from the formal electrified community of Austerville and kwaGuqa as well as the informal mostly unelectrified community of Cato Manor.

Multiple fuel use and why it persists

Multiple fuel use was prevalent in surveyed households, particularly among the un-electrified informal households. Due to the informality, the socio-economic status of households and the lack of adequate energy service delivery in Ekhenana, households are reliant on a range of polluting fuels such as candles, paraffin and firewood to meet primary household energy needs. These fuels result in harmful levels of indoor and outdoor pollution. Multiple fuel use among households prevails for several reasons; 1) households are accustomed to these fuels, 2) majority of households are still not grid-connected, 3) lack of affordability of electricity compel poor households to use cheap and unsafe fuels which are easily accessible and affordable.

In kwaGuqa and Austerville, multiple fuel use was apparent to some extent, as households primarily use electricity. Multiple fuel use was particularly evident for cooking and space heating, where households supplement electricity with paraffin and gas. The reason for multiple fuel use in both these communities is largely attributed to lack of affordability of electricity; households expressed that they cannot afford energy sometimes.

The energy use patterns demonstrated in surveyed households indicate the prevalence of energy poverty in low-income households, both formal electrified households in kwaGuqa and Austerville and informal unelectrified households in Ekhenana. This was reflected by 1) prevailing multiple fuel use in settlements, and 2) the high proportion of household income spent on energy per month. This small survey showed that both the lack of access to modern forms of energy such as electricity and affordability constraints compel households to use a range of polluting and unsafe fuels (paraffin, candles, wood). Furthermore, all surveyed households with electricity access did not receive free basic energy from the municipalities as they lack the knowledge on how to access it. This places them at a disadvantage in minimising their monthly energy costs. In addition, energy poverty is exacerbated by disconnections, particularly in Ekhenana, where electricity connections were unstable, while in both Austerville and kwaGuqa electricity faults were experienced.

Households' awareness of modern energy technologies was fairly good however the majority were not able to access such technologies. Low-income households tend to be more aware of the traditional inefficient energy technologies and/or fuels such as paraffin/ gas stoves and heaters, paraffin lights, candles etc. As a result, this is one of the key barriers in the adoption of domestic energy-saving measures through the use of energy-efficient technologies (Vassileva and Campillo, 2014). Households showed interest and knowledge in solar energy. Particularly because solar is much cleaner and safer, and likely more reliable than the current – ever load shed – coal-fired power that the country uses. There was more interest in solar as a cheaper alternative in the long run than paraffin or gas.

Conclusion
The survey findings broadly revealed the extent of energy poverty experienced by the different settlements as well as similarities in energy use by households. A lack of information and engagement about renewable energy and electricity tariffs from the municipality was also evident. This gives rise to a substantially limited understanding held by households regarding the real costs associated with electricity provision and accessing solar energy. Awareness raising of modern energy choices and developing community capacity towards community-led socially owned renewable energy is critical. The municipality has a significant role to play in tariff education and renewable energy access in these communities i.e. engaging communities about renewable energy options, as well as energy efficiency actions that can be taken, to save on electricity costs.

6. Community energy development

6.1. The rationale for community energy

Globally, energy systems have largely been centralized, with one source of generation and with municipalities acting as distributors and resellers of electricity. The primary energy sources are coal, natural gas, oil and uranium which come with additional costs to transform them into electricity for use by the end user. This transformation process has led to increased carbon emissions globally and increased cost of household electricity. Communities in the global south still form part of the 759 million people that live without electricity and the 2.6 billion without access to clean cooking (IEA et al., 2021). The energy used by households in developing countries continue to be traditional biomass-based polluting fuels such as wood, dung, and charcoal – which still form a predominant part of the fuels used in many African homes to date.

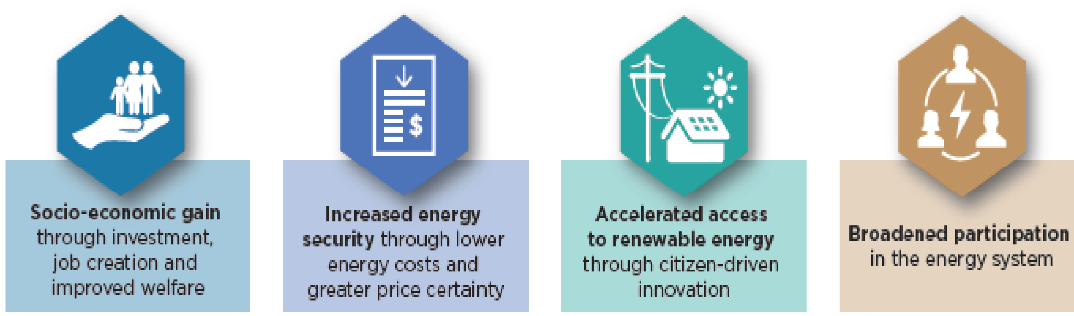
As the world commits to transitioning to cleaner sources of energy, developing countries remain with the challenge of balancing reducing emissions and meeting their economic, social, and environmental objectives. Countries in the global south have experienced severe energy supply challenges mainly due to the fluctuating oil prices, often imported, that results in increasingly high energy prices. For many developing countries, escalating oil prices have led to food prices increases, creating economic and political instability – further placing a heightened need for diversification of domestic energy resources which will rely less on imported oil whilst reducing long term exposure to financial, social, and environmental crises.

Renewable energy, given its adaptability and decentralised nature, enables the development of more equitable, inclusive and resilient economies and at the same time encourages increased citizen participation in the energy transition (IRENA, 2020). Decentralised renewable energy systems (distributed renewables) are more dynamic and flexible, and therefore suitable to being locally managed and governed and including a range of public and private investors, owners, and operators, right down to household.
Such renewable energy systems offer a rapid and efficient way to meet energy deficits in cities. Because they are scalable, renewable energy systems can unlock finance through multiple smaller investments where many central utilities are unable to take on further debt. From a community perspective, community-led renewable energy development, referred to in the energy sector as “community energy”

is widely recognised to play an important role in the post COVID recovery by stimulating local social and economic prosperity while helping to achieve climate and sustainability objectives. The International Renewable Energy Agency (IRENA) Coalition for Action defines community energy as the *"economic and operational participation and ownership by citizens or members of a defined community – be it at the village, city or regional level – in a renewable energy project, regardless of the size and scope of the project"* (IRENA, 2020).

International literature reveals a diverse range of approaches to community energy development applied around the world. It also shows that community energy projects can bring about substantial benefits to communities involved - direct social and economic benefits from the creation of revenues and employment from renewable energy generation - as well as its broader benefits to a society brought about through the expansion of access to electricity. The literature highlights however that investment is one of the key factors required to realise community energy's full potential. The International Renewable Energy Agency (IRENA) Coalition for Action informs that with the removal of regulatory, financial and institutional barriers that limit investments, more communities can contribute to the energy transition. Community energy projects involve citizens and communities as producers, distributors and sellers of electricity – and as consumers. Such projects can benefit communities socially, economically, environmentally and institutionally (Figure 13 below). The extent to which communities can derive benefits from community energy will be dependent on local political frameworks, ownership models and other factors.

Figure 11: Potential benefits of community energy



Source: (IRENA, 2020)

Literature shows that community energy supports an inclusive energy transition through the following potential ways (IRENA 2020):

Community energy contributes to local socio-economic development through investment, job creation and improved welfare

The transition to a renewable energy system can play an important role in the economic recovery from the COVID-19 pandemic. Community-owned renewable energy projects in particular have the potential to employ local contractors and re-invest in local enterprises, services and goods thus supporting local resilience (Gancheva et al., 2018). Furthermore, successful community energy projects have shown to often invest in capacity building and skill development enabling communities to maintain and operate installations, thereby creating jobs along the entire renewable energy value chain (Callaghan & Williams, 2014). In some cases, the financial returns from projects were re-invested in public facilities such as hospitals, used to retrofit buildings or channelled into other renewable energy and energy efficiency projects (IRENA, 2020). Lastly, community energy projects also have the ability to improve health and well-being through reduced air, water and land pollution and greenhouse gas emissions.

Community energy improves energy security and helps to lower energy costs
Renewable generation, when locally owned and managed, helps communities to increase energy independence from external energy suppliers often reliant on fossil fuels (such as Eskom), reduces exposure to increasing energy prices and saves on costs. Community energy projects may also be able to generate long-term income through the sale of (excess) renewable energy.

Community energy enables access to renewable energy through community-led innovation
Literature has shown community energy projects to have resulted in innovative business models and technological solutions that expand access, improve reliability of service and help build climate resilience, increase possibilities for new productive activities and improve livelihoods (IRENA, 2020).

Community energy fosters increased participation in the energy system and expands awareness and acceptance of renewable energy.
Engaging communities in shared decision-making processes can lead to increased transparency and inclusiveness in the planning, construction and management of installations. Making collective decisions about the use and distribution of investments and generated income enable communities to achieve greater autonomy and self-governance. Such shared and inclusive participation can increase community sense of ownership and community unity, as well as raise awareness, acceptance and active support for the energy transition (IRENA, 2020).

As renewable energy becomes more accessible, with consumers choosing to generate their own energy at small scale, more alternative renewable energy generation approaches are emerging. Decentralised and community energy access is explored in this section from the perspectives of policies that enable a government to innovate its energy resources, highlighting the economic, social and environmental development benefits and outlining the financial resources required to roll out the required capacity. The rationale for community energy systems within this context is to explore the possibility of availing clean sustainable energy to households in the developing world, that meet the social, economic, and environmental development goals and needs, whilst not compromising the quality of the technology used and the cost for generation, transmission, and distribution all within limited financial resources.

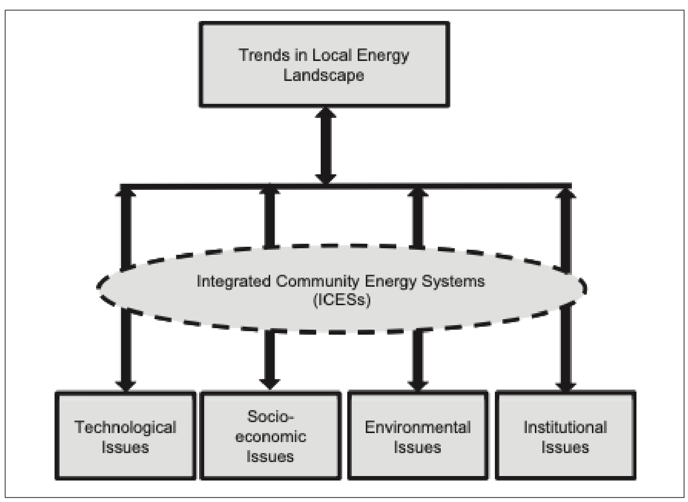
6.2. Global community energy ownership overview

Globally energy generation, transmission and distribution are typically central monopolized systems that are either government owned entities or private organizations that have the mandate from governments to provide large scale electricity. This is how the energy business has developed over centuries, built solely on non- renewable sources that were either mined or imported. This top-down system was designed around economies of scale where large scale production offers cheaper kilowatt per hour sales. However, as technology evolved, so have economies, opening opportunities for small scale energy generation from various renewable sources as well as at scale opportunities – cutting off some of the input costs that have formed part of the energy generation space for decades and thus offering far cheaper prices per kilowatt hours.

Community ownership structures, in the context of the global energy transition and the decentralisation of power systems, refer to the collective ownership and management of energy-related assets, usually distributed energy resources (DERs). Through cost sharing, community ownership models enable individual participants to own assets with lower levels of investment. Community ownership projects vary in size but are often between 5 kilowatts (kW) and 5 megawatts (MW) in size, depending on where they are being implemented (IRENA, 2020).

As a result of technological advances and socio-political acknowledgment, the potential for community owned energy systems is now at the forefront of exploration with a key role in transitioning energy systems (IRENA, 2020). Integrated Community Energy Systems (ICES) is an approach coined around sustainable communities that involves a shift of energy use from fossil fuel to renewable, taking over the technical aspects necessary to generate such energy from a decentralized point, servicing communities whilst interchangeably also connecting them. Furthermore, ICESs also exemplify planning, design, implementation, and governance of energy systems at a community level, to maximize energy performance while cutting costs and reducing environmental impact (Koirala et al., 2016).

Figure 12: Analytical framework considering issues and trends in changing local energy landscape.



(Source: Koirala et al., 2016)

6.2.1. Key levers that support the development of Community owned generated renewable energy

Economic lever: Renewable energy projects generally generate revenue from the return on investment and land rents or taxes. Other additional economic benefits include employment opportunities and job trainings for residents – those involved in the project and surrounding communities (The British Academy, 2016). To fully realize and capture the economic benefits that can be derived from decentralized community owned energy systems, one must factor in storage into the discussion. Broadly, two economic approaches that can be used to evaluate the optimal level of storage in an electrical network (in particular – intermittent generation such as that of solar PV). The first one relates to evaluating the social benefits and costs of storage, secondly, to examine the private benefits and costs of the operation. Though there are benefits that can be derived directly from storage, they can also be captured arbitrage[13]. The three key benefits that can be derived from an economic lever to advance a CES include:

- Saving on the capital expenditure required to install peaking plants (although these costs should be compared to the capital costs for the construction of storage facilities).
- Reduced expenditure on transmission and distribution grid reinforcement, thereby saving the end-user electricity usage costs.
- The renewable system becomes an avenue for wealth creation, as an asset as an income generator from the sale of electricity units or savings from expensive electricity costs (The British Academy, 2016).

In order to understand the context within which these systems can be developed, and successfully, the economic developmental aspect needs to be explored in-depth, looking at how local economies can benefit from decentralised, community energy systems and what the macro-economic benefit is. The inputs required from a global level, to support developing nations in-order to enable such developments to occur need to be identified.

Social lever: Community-owned energy systems (CES) are not only an opportunity for decentralised energy ownership, achieved through bottom–up solutions, it is also the epitome of decentralized governance – symbolising what is often spoken about by large national utilities when they decentralise generation, transmission, and distribution. Literature points to the importance of more deliberative and inclusive participation of consumers in the energy production process. These systems are also motivated by increased climate awareness and willingness to become autonomous among pro-active communities. In addition, community mobilisation has a very important role in initiating and sustaining CES. Collective community identity and the quest for autonomy play a critical role in community engagement for the larger context of energy systems. The push from local government entities as well as local business and residents will have a larger impact and a greater probability of success (Koirala et al., 2016).

Community renewable schemes have an ability to provide a range of social and economic benefits for local communities such as increased autonomy, local economic empowerment, and resilience by providing sustainable long-term income and local control over finances, often in areas where there are few options for generating wealth. Other benefits include opportunities for education, a strengthened sense of place and an increase in visitors to the area (DEA, 2012). The three key benefits that can be derived from a social lever to advance a CES include:

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[13] Energy Arbitrage is simply **purchasing more electricity during Off-peak periods**, storing that electricity and discharging it during peak periods. For example, using a storage solution, we have bought more electricity at off peak rates, stored that electricity and then used it during peak periods.

- Communities get to be empowered by gaining insight in project development, governance and operation (DEA, 2012)
- There is education that emanates from business trading for social and environmental purposes (The British Academy, 2016)
- Social cohesion that develops from good governance processes required to successfully operate a CES.

Environmental Lever: Environmental activism by community-based organisations that has gained a widespread momentum over the last decade, particularly around the high carbon emitting coal-based energy, that is also expensive for the poorest consumer – has created a driving force behind the rise in the implementation CES's in the developed and developing world. Encompassed in the energy democracy phenomena, as well as improvement in efficiency and reliability of new technologies, CES's are increasingly becoming a more viable option environmentally, offering a strong contending alternative to the centralized power supply system. Being local, these systems have higher social acceptance than their giant counterparts (Koirala et al., 2016). Some clear environmental benefits that can be derived from CES in summary include:

- Reduction of greenhouse gas emissions per capita for the benefit of the municipal jurisdiction
- Potential for electric mobility to be introduced, further reducing carbon emissions in the transportation sector
- Opportunity to expand into other sectors that can be run communally such as farming, communal sources of water and greening of communities providing an overall improvement in health and the well-being of citizens

Financial Lever: At the inception stage of an energy utility, the financial viability and revenue potential of the system, regardless of the scale and size of the system, is important. This is based on the business case, source and methodology of funding used to determine the size, scale and viability of the utility. Financial costs need to include the capital costs to install the system coupled with the operating and maintenance costs as well as technical performance elements of the system – which needs to be of good quality and recent technology for users to trust that it will deliver, including to some extent, storage capacity (The British Academy, 2016). Some systems are connected to the grid and often do not require storage, however, there are costs involved in conversion of the solar energy into electric energy as well as wheeling costs to connect the system onto the grid. Some key financial aspects to consider include:

- Sourcing of financial capital may be simplified by pulling resources from the community which will own the system
- Pricing of electricity from the system may be done in an equitable manner ensuring that each customer is charged according to their affordability or by providing a cheaper flat rate for all

Some clear economic benefits that can be derived from such a system include (Netherlands Enterprise agency, 2020):

- The overall cost for electricity is significantly cheaper (solar panels in combination with net-metering).
- The type of metering used contributes towards economic savings or losses
- Generated power in comparison to consumption is a key economic aspect (wheeling or battery storage options should be explored)

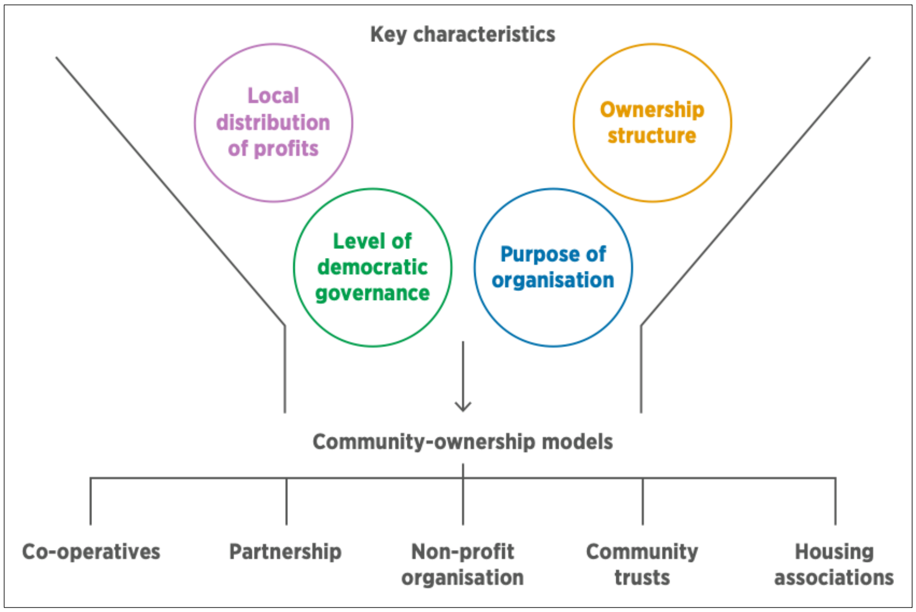
Technological lever: The architecture of CESs depends on available technologies and the corresponding political, market and regulatory frameworks as well as technical standards adopted. Furthermore, the system needs to be in-line with the local municipal regulations with regards to off-grid or embedded generation systems. The size of the system needs to also be within the approved scale by the national regulator for licencing (both generation and distribution).
Each country, city and community has its own set of codes and regulations to be followed when installing a small renewable energy system in a home or small business. These regulations can affect the type of renewable energy system that can be installed and who installs it. These can also affect whether the system can be connected to the electricity grid or it can operate as an off-grid system. The available technology is also impacted by the cost of the infrastructure as well as the labour required to install. The main elements for consideration when looking at technological requirements include:

- The availability of the type of technology that will used as well as its costs play a vital role to the type of system that is installed (solar PV vs wind turbines etc)
- Grid considerations in the area of development, to inform the decision to install a battery or to enter into a wheeling agreement with the municipality (or to do both)
- Smart metering options to ensure proper tariff considerations for both the end-users and the local authority (for wheeling or buying back access energy).

6.2.2. The legal structure for a community energy system
Community owned energy requires some structure, likely legalised, in order for it to operate seamlessly. Many CES's in the developed world are established as energy co-operatives that enable citizens to invest in generation units and energy efficiency measures (IRENA, 2020). It is apparent that the USA model of co-operative ownership can be easily scaled and marketed. However, the European model where these co-operatives are well embedded in the society and part of their culture is more suited for the development of CES's. Renewable energy and other forms of local generation are suitable for co-operatives in light of high initial costs and local availability. Currently, energy co-operatives in Germany are facing difficulties to develop new business models, leading to stagnation in their growth. Innovative business models such as self-consumption and energy services can be enabled through the development of CES's (Koirala et al., 2016).

The involvement of the local municipality as a co-owner or public partner can assist in providing democratic accountability and legitimacy to the establishment of the system and the running of the project. The involvement of the municipality also adds value and legitimises the system as well as the resale of energy from the system. The locally based commitment, along with cooperation between the co-operative, the local utilities, and the municipality constitutes a significant precondition for the management of a CES (The British Academy, 2016).

Figure 13: Characteristics and common community-ownership models



Source: IRENA, 2020

6.2.3. Barriers to entry

The four main levers necessary to ensure the success of an ICES could also lead to their demise if not well planned and carried out. The key benefit that ICES stand to provide is energy autonomy, which presents numerous social and technical challenges due to the shift towards a more distributed energy generation system. In a decentralized system, the degree and scale of energy autonomy; matching of demand with supply; importance of socio-economic and political factors and energy autonomy need to be determined, often with no existing legal framework or universal plan to work from. Some of the key barriers include:

i. **Land access barriers**: raising capital to acquire private land or leasing land long term, obtaining a distribution licence coupled with obtaining a plan approval from the municipality, present barriers to community renewable projects. This is often accompanied by a lack of clarity and inconsistency in national government policy which poses a significant concern. The role of the national and local government is to support own energy generation by consumers, even if it is in the form of community renewable projects. At a local level this might include providing access to land and signposting useful sources of support and funding. Municipalities can also use their own experience of installing renewables to help communities navigate the complexities of the process and lend credibility to projects they partner with (British Academy, 2016).

ii. **Financial barriers:** Embarking on developing a community owned energy system in a developing country context where such systems are a relatively new phenomenon and where grid electricity remains dominant, it can be a costly exercise. Coupled with the lack of existing business cases backed by bank loans, with minimal government funding, the process may seem a challenge to accomplish. Whilst there are sources of grant funding which can support such systems, high up-front capital costs compared to the existing national grid alternative make their availability patchy (The British Academy, 2016). Once the viability of the scheme has been assessed and planning permission has been granted, schemes could potentially seek commercial loan finance from a range of providers. Policy incentives to persuade local households to enable self-financing model is also necessary. Moreover, the cost of distributed energy resource technologies is reducing constantly. For instance, storage and fuel cell technologies are continuously improving in term of investment cost (IRENA, 2020). Though there are studies that attempt to understand the costs and benefits associated with the renewable energy technologies in the context of modern electricity system, they have not yet explored CES. Furthermore, loan packages in many countries, risk aversion of banks concerning loans for communities is a major barrier to financing.

iii. **Regulatory barriers:** include registering the system with the national regulator whose purpose is to balance the competition between centralized and decentralized resources and the design of prices for services based on markets (such as energy markets, capacity markets, balancing markets) (Rodríguez et al., 2018). Access to a distribution grid for the local transfer of locally generated energy is of crucial importance which includes additional costs and regulatory conditions associated with the use of distribution grid for local consumption. Community energy labelling and different tariff design for the energy produced from CES's might help in local consumption of the energy. Another challenge is that community owned energy systems are sometimes seen as wanting to operate separately from the national grid, taking customers away and as such may experience more challenges with obtaining licencing from the national regulator or development permits from the municipality. Yet they offer an opportunity both nationally and locally, for additional capacity and an avenue for additional revenue for the local municipality (Hewitt et al., 2019).

6.3. International Case studies

The above section has provided insight into the community energy development globally, drawing from the developed world experience and highlighting some considerations for the developing world. The international case studies presented below showcasing practical examples of community energy projects from the both the developing and developed world serve to deepen some of these insights and show the similarities and differences. Such case studies help to gain better insights into what a community energy system within the South African context could possibly look like.

Table 1: International case studies

Project details	**Technical aspects**	**Financial aspects**	**Environmental aspects/benefits**	**Social development**	**Legal context**	**Policy/regulatory context**
Case studies from developed nations						
Cwm Arian Renewable Energy (CARE)[14] *West Wales – United Kingdom*	Consisted of two 1.2MW wind turbines, while the second, proposal consisted of a single 500kW turbine.	The idea was that money for the construction of each project would be raised through a combination of bank loans and a co-operative share offer, initially restricted to those living locally to the developments but then extended to the rest of Wales. For local people unable to afford the minimum £250 investment there was an option to join via the local credit union. Profits from the electricity	No direct environmental benefit infused into the project development objectives. However, the systems are renewable and therefore respond to the clean energy objectives and reduction of carbon emissions.	The introduction of Feed-in Tariffs (FiTs) was important in making both proposed projects financially viable, enabling a secure rate of return on electricity sold and ensuring significant funds would be available for local projects.	CARE is a renewable energy co-operative that has been pursuing community wind energy schemes since 2010.	The early seeds of the project were planted during the development of a Community Action Plan that took place in 2004-05, which was funded by PLANED (Pembrokeshire Local Action Network for Enterprise and Development).

[14] Netherlands Enterprise agency. 2020. New strategies for Smart Integrated Decentralised Energy Systems, Amsterdam, Metabolic. available at: https://www.metabolic.nl/publication/new-strategies-for-smart-integrated-decentralised-energy-systems/

Project details	Technical aspects	Financial aspects	Environmental aspects/benefits	Social development	Legal context	Policy/regulatory context
		generated would first be distributed to members, and then the remainder would help fund collective projects in the local community.				
Feldheim, *Germany*[15]	The energy system consisted of a 81.1 MW wind farm, a 2.25 MW_p solar farm and a 500 kW_e/ 500 kW_t biomass-plant for district heating and storage.	The project was funded by Energiequelle (a renewable energy company in Germany that provides project development, planning, and operational management services for wind power, biogas, and photovoltaic plants), EU subsidies, capital loans and individual contributions. It sells 99% of the generated electricity to the community first and the surplus is fed back into the central grid.	No direct environmental benefit infused into the project development objectives. However, the system is renewable and therefore responds to the clean energy objectives and reduction of carbon emissions.	The project resulted in lower energy prices which are set independently by the co-operative irrespective of the wholesale market.	A local energy co-operative and is run by the local renewable energy company, Energiequelle.	Feldheim is self-sufficient in terms of energy and is dependent on the national grid only for exporting electricity and providing system services.
Case studies from the developing world						

[15] Netherlands Enterprise agency. 2020. New strategies for Smart Integrated Decentralised Energy Systems, Amsterdam, Metabolic. available at: https://www.metabolic.nl/publication/new-strategies-for-smart-integrated-decentralised-energy-systems/

Project details	Technical aspects	Financial aspects	Environmental aspects/benefits	Social development	Legal context	Policy/regulatory context
Off-Grid Electric Company (OGE) *Tanzania*[16]	An off-grid solar home system providing small individually connected systems.	The company has raised capital from traditional venture funds, as well as funding from development finance sources. A mobile payment system is used for customers to load credits (like the meter system) and costs $5 (R75) a month to unelectrified households.	No direct environmental benefit was infused into the project development objectives. However, the system is renewable and therefore responds to the clean energy objectives and reduction of carbon emissions.	The system is off-grid and since its establishment in 2012, it has provided energy to 50 000 households.	The system is established and run as a private company that provides solar home systems on a fee-for-service basis.	Since its establishment, it has inspired the Tanzanian government to alter policy towards supporting solar home system initiatives.
IDCOL (Infrastructure Development Company Limited), *Bangladesh* [17]	A solar programme that installs mini-grid (solar home systems) and provides households with micro-credit needed to pay for the system.	The systems were initially part subsidized, although this has been largely phased out (except for the smallest systems). The market has matured to the extent that customers do not perceive an investment in a SHS as a risk, and so the role of the subsidy has changed from being	Bangladesh experiences high emissions from vehicles, industries and poor infrastructure roll out to minimise these challenges. As such, these systems have been a good	The project improved knowledge on solar home systems, built local technical capacity and overall improved the local economy such that the systems now finance themselves. Government	IDCOL is a parastatal institution in Bangladesh aiming to ensure economic development and improving the standard of living of the people of	With long-term commitment from the government with policy interest steadily increasing over the years, IDCOL specifically sought to shield the SHS programme from political interference by limiting direct government involvement.

[16] SANEDI. DEA. 2012. Sustainability of decentralised renewable energy systems report. Department of environmental Affairs. Pretoria. Available at https://www.dffe.gov.za/sites/default/files/reports/decentralised_renewableenergysystems_report.pdf

[17] SANEDI. DEA. 2012. Sustainability of decentralised renewable energy systems report. Department of environmental Affairs. Pretoria. Available at https://www.dffe.gov.za/sites/default/files/reports/decentralised_renewableenergysystems_report.pdf

Project details	**Technical aspects**	**Financial aspects**	**Environmental aspects/benefits**	**Social development**	**Legal context**	**Policy/regulatory context**
		largely a risk-reducing measure to being an access-enabling measure. The smallest systems are being subsidized to make them affordable to the poorest sections of society.	environmental initiative for Bangladesh	subsidies the provision of the SHS to poor households.	Bangladesh through sustainable and environmentally friendly investments. It IDCOL promotes financing in the private sector since its inception in 1997, focusing on infrastructure, renewable energy and energy efficiency projects.	
Ghana Energy and Development Access Project (GEDAP), *Ghana*[18]	The project included five pilot mini grids supplying isolated communities in Volta Lake islands and the Volta River. Different technologies that were	The project was Bank financed and focused on inclusive access to renewable energy through off-grid solar services and products. The project included subsidies to help make	The project aimed at using solar energy as a renewable and carbon-free alternative energy, as it has unquantifiable potential to decrease	Since the project kicked off the communities have used off-grid solar electricity for public lighting of parks and recreation, small	Government parastatal	the legal and regulatory framework was established for a nascent renewable energy sector. The enactment of the Renewable Energy Law supported the

[18] SANEDI. DEA. 2012. Sustainability of decentralised renewable energy systems report. Department of environmental Affairs. Pretoria. Available at https://www.dffe.gov.za/sites/default/files/reports/decentralised_renewableenergysystems_report.pdf

Project details	Technical aspects	Financial aspects	Environmental aspects/benefits	Social development	Legal context	Policy/regulatory context
	sustainable and affordable were considered, including hydroelectric and wind technologies, but identified solar as the best option. Solar energy panels are relatively simple, making the transformation both affordable and resilient. .	energy more affordable and supported access to financing with local financiers, including rural banks.	greenhouse gas emissions.	businesses, and lighting for schools.		activities of the Bank and other donors in this sector. The project also supports regional policy makers as they address ongoing barriers to a regional market for stand-alone solar systems.
The Mokoloki Community mini-grid Project – Nigeria[19]	Mokoloki is a rural community of about 1,000 inhabitants in Ogun State, Nigeria that struggled with intermittent and low-quality electricity, which was available for an average of four hours per day. In 2017. The Mokoloki project demonstrates the potential to increase			Within the first three months, the project resulted in: • Reduced carbon dioxide emissions by 15,000 kg • Cost savings for the Ibadan Electricity Distribution Company, which before the project had commercial and	The Mokoloki mini-grid project involved a cooperative tripartite contract agreement between Nayo Tropica Technology (a private developer), the Ibadan Electricity Distribution Company (IBEDC)	The Nigerian Electricity Regulatory Commission (NERC) ratified the regulation for mini-grids, which opened up a window of opportunities for the private sector. The Mokoloki mini-grid project shows how simple, straightforward regulations can open up opportunities for the private sector to

[19] RMI 2020, Nigeria's First Commercial Undergrid Minigrid Project, https://rmi.org/insight/mokoloki/

Project details	Technical aspects	Financial aspects	Environmental aspects/benefits	Social development	Legal context	Policy/regulatory context
	energy access in 'underserved' urban communities through "underground" mini-grids, which leverage existing distribution infrastructure to achieve lower system costs than isolated mini-grids while improving service reliability from the status quo. The solar hybrid mini-grid provided 100kw of generation, with additional loads to be added, supplying 230 households and 48 commercial, 11 public, and 1 anchor customer.[20]			technical losses of up to 70% in Mokoloki. • Lower electricity costs for customers, by on average 0.06USD/kWh • Project participants believe that this model can be replicated and scaled to help serve millions of Nigerians living in underserved communities.	and the local community, with advisory support from the Rocky Mountain Institute in the USA (RMI – USA) The Mokoloki mini-grid project shows how simple, straight-forward regulations can open up opportunities for the private sector to participate in innovative joint ventures that benefit all parties.	participate in innovative joint ventures that benefit all parties.

[20] RMI 2018. Under the Grid: Improving the Economics and Reliability of Rural Electricity Service with Undergrid Minigrids, www.rmi.org/ insight/under-the-grid/

7. Local community energy ownership overview

In South Africa, distributed renewable energy could offer the opportunity to be shielded to some extent from above-inflation electricity tariff hikes as well as lead to socio-economic developmental benefits such as green economy growth and the creation of jobs in low and middle-income communities. Low and middle-income households have not engaged in the increasing uptake of renewable energy such as small-scale embedded generation (SSEG [21]) systems in South Africa for various reasons, key among them are affordability and access to finance. Although there are several examples of innovative approaches to deploy grid-connected solar PV technologies on low-income households globally, most are reliant on full or partial subsidisation. In South Africa, such initiatives where PV is implemented, the target is predominantly unelectrified households. Currently, the financial case for solar PV SSEG system implementation is not strong for households and for municipalities without subsidisation. At the same time, the business case for subsidies is weak given the social and economic benefits of alternative social investments programmes. However, with constantly decreasing PV prices and rising electricity tariffs, the financial case is rapidly changing and PV industry players are also interested in further developing this area. This includes piloting initiatives to find solutions that could be scaled up to benefit lower-income households. Coordination and sharing the lessons among these players is important going forward. Decentralised PV installations with battery storage for low-income areas that are located at distributor depots, hold potential benefits for communities and municipalities. Much research is still required in this area.

7.1. National (Local) Case Studies

The following case studies demonstrate different approaches to community energy access form renewable energy sources. They also highlight the varied and nuanced levels of community agency and engagement and ownership in accessing energy services. A crucial thread inherent in all these examples is the significance of partnerships in varied combinations between community, private and public sector that have enabled implementation and financial sustainability. Each case study presents interesting and significant lessons, to valuably inform the implementation community-led socially owned renewable energy projects in the future.

7.1.1. Sun Exchange, Cape Town South Africa

Sun Exchange is a private company, whose purpose is to unlock the scaling potential of crowdsourcing to fund mid-sized (15-100kWp) grid-tied or off-grid Solar PV installations. Their target group is typically schools, villages, businesses, off-grid conservation and tourism initiatives. The approach of Sun Exchange is that of an intermediary linking private investors (from contributing R100.00 and upwards) with organisations that need fixed-price long-term electricity supply. Investors purchase solar panels (15-100Wp) and lease them to the end-user over a 20-year period. They aim to ensure a reasonable rate of return to the lessor and fixed prices of electricity to end-user (10% savings).

In this case study, Sun Exchange demonstrates how government may enable innovative financing for distributed renewables. Sun Exchange is a South African company that crowdfunds the upfront capital cost and installs and maintains solar power systems on schools and other organisations. They

[21] Small Scale Embedded Generation (SSEG) is a solar PV system that is usually installed on the rooftop of a home or building. These systems are classified as small scale because they generate energy of between 1MW up to 10MW, mostly for personal consumption at home or commercial buildings.

recognise themselves to be "the world's first peer-to-peer solar leasing platform"[22]. Any investor is eligible to purchase solar cells for as little as US$5 per cell. Once the solar installation is connected and in operation, the school or organisation pays for the solar-generated electricity, which is cheaper than traditional grid electricity. Investors receive this money (excluding insurance and servicing fees) as monthly lease payments paid either in local currency or in Bitcoin. One of their projects is Wynberg Girls High School in Cape Town, where an 84 kWp[23] solar PV system was installed and funded by 368 investors from all over the world. Investors will receive rental income over 20 years at an expected internal rate of return[24] of 12%.

Western Cape Provincial Government played a key role in enabling Sun Exchange's business model. In South Africa, provincial governments have executive responsibility for the administration of schools. Sun Exchange worked with the Province to approve their business model and develop standardised contracts and agreements for each school, giving schools the assurance to enter into power purchase agreements. This model involving government, communities and the private sector could also be considered for clinics, libraries and other public services to enable the rollout of distributed renewables.

7.1.2. Electrifying informal settlements in Johannesburg[25][26]

The City of Johannesburg (CoJ), the economic hub of South Africa, attracts approximately 12,000 new immigrants (local and international) on a monthly basis. This has led to a rapid growth of informal settlements, home to an estimated 180 000 households, resulting in service delivery backlogs in electricity, water and refuse removal. Residents in these settlements typically access electricity via illegal and often rudimentary means, accounting for 13% of power losses in the City and frequent cases of fatal electrocutions, hazardous fires and damage to transmission infrastructure. The households are also reliant on the use of unclean fuels for cooking notably paraffin, wood and coal. To reduce the high risks associated with energy use in these settlements and minimize loss of revenue caused by illegal connections, CoJ embarked on an ambitious electrification programme. Where the extension of the electricity grid was not possible, due to prohibitive network upgrade costs or challenging land tenure issues, the City looked to deploy a combination of grid and distributed renewables and/or alternative energy sources. This included the installation of independent power grids powered by renewable energy. In 2018, CoJ reported that 12,850 homes in informal settlements had been electrified of which 1,600 are from the Setjwetla informal settlement. The electrification of Setjwetla is an example of how a mix of solar power (grid enhancing PV system) and gas stoves was successfully utilised to stop electrocutions, regularise power supply and prevent the loss of revenue caused by illegal connections. This intervention also significantly reduced devastating fires caused by hazardous cooking and heating appliances.

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[22] https://thesunexchange.com/about-us

[23] The 84.40 kWp rooftop solar system at Wynberg Girls High school comprises 18 072 solar cells mounted in modules of 72 cells or 251 X 335 W solar modules.
https://d1tsx6lhcafpu4.cloudfront.net/production/6f499ca7b629406e9a7c571c02eabba5.pdf

[24] Internal Rate of Return (IRR) refers to the annual rate of growth that an investment is expected to generate.

[25] City of Joburg, 2018. More informal settlements in Joburg get electricity.
https://www.joburg.org.za/media_/Newsroom/Pages/2016%20&%202015%20Articles/More-informal-settlements-in-Joburg-get-electricity.aspx

[26] C40, 2018. Johannesburg: Benefits of the electrification of informal settlements

7.1.3. Zonke Energy[27]

Zonke Energy is a company whose mission is to deliver clean, affordable and reliable energy to informal settlements in South Africa that are not connected to the grid. They deliver power (install, operate and partially own) through modular mini-grids which serve up to 16 households with affordable, reliable, safe and clean energy. These power lights, mobile phones, TVs, refrigerators and more from a central power hub. Their pre-paid metering platform enables payments to be made.

Ownership of infrastructure involves investors, Zonke Energy and communities. The capital cost entails R8,000 per household. Households rent a portion of the PV generator for a pre-paid monthly rental fee. Rental fee includes power and installation. Power is available day and night, summer and winter.

Zonke Energy implemented a pilot community energy project in the form of a solar micro-grid in Jabula informal settlement in Cape Town. This settlement in its 30 years of existence has never had access to grid electricity. Seed capital financing for this project was derived from UK development institutions. Zonke installed a single mini grid system connecting 54 households, which provided lighting, cell phone charging, radio and optional appliances (television, and DVD players) at a cost of $0.07 (R1) per hour. The other primary available energy sources in the community are petrol generators. Power from this source costs $1.43 (R20) per hour. The households pay a fixed weekly or monthly price to get access to the system. Zonke has managed to raise capital to expand to an additional 90 households in this settlement to demonstrate that the commercial model is viable at a large scale.

Households expressed great satisfaction since subscribing to Zonke Energy for their energy services. They noted cash flow improvements in savings accrued from avoided use of paraffin, candles and petrol to power their generators. Households not only have access to reliable energy but also have savings at the end of the month to meet other household needs. Zonke Energy also experience 100% payment compliance and no tampering of the system. Central to Zonke's Energy approach is close community engagement and inclusive decision making to ensure community understanding and acceptance of the technology, its operation and value. A key challenge for Zonke Energy to scale up efforts is financing and an enabling government policy framework for off-grid energy service delivery to informal settlements.

7.1.4. The Upper Blinkwater smart renewable community grid project, Eastern Cape

Although this case study refers to a rural context, there are important lessons to be learnt from such a community renewable energy project.

The Upper Blinkwater smart, renewable minigrid pilot project is based on a trilateral agreement between the Eastern Cape Provincial government, the federal state of Lower Saxony in Germany and GIZ Germany. The latter acted on behalf of the Federal Ministry for Economic Cooperation and Development (BMZ) of Germany. Upper Blinkwater is a small rural village of sparsely scattered

[27] Zonke Energy. Available at: http://www.zonkeenergy.com/

settlements, located within the Raymond Mhlaba Local Municipality. The rough and hilly terrain, low electricity demand, low population density, high cost of grid extension, and remote location of the village hinders the electrification of the village. The aim of the project is to demonstrate a service delivery solution for an economically and ecologically sustainable energy supply to non-electrified rural communities. It involved implementing a renewable energy hybrid minigrid consisting of PV panels and batteries.

Open communication and transparency were key from the start of the project with everyone involved from the community in order to gain acceptance of the initiative. The biggest threats to mini-grids are theft (due to economic constraints) and vandalism of the system due to resentment or the perception of discrimination. Lack of understanding of technology often leads to lasting damage to infrastructure in case of small defects. Therefore, at the beginning of the project a facilitation manager was appointed to ensure a constant dialogue throughout the project. Facilitation activities helped to identify concerns, needs and prospects as well as the demand for workshops and education activities. From conception until commissioning, every step was clearly explained with room for questions and comments to ensure full transparency and avoid any misunderstanding.
A structure was created to formalize the communication stream to consider everyone's interests and allowing a platform to raise issues or challenges from different perspectives. A Community Project Steering Committee (CPSC) was set up as the main social body that represented the community of Upper Blinkwater during the construction of the minigrid. This CPSC was organized with presence of community leaders, the community liaison officer, the social facilitator and the ward councillor, where every member of the CPSC represented an important stakeholder.

The project implementation benefited from the strong partnership and will for cooperation. Partners included Eastern Cape Provincial government, Raymond Mahlaba Municipality, the community of Upper Blinkwater, GIZ, CSIR, University of Fort Hare and Nelson Mandela University. There was good cooperation and close coordination of the main project partners between Germany (GIZ and DLR) and South Africa (Eastern Cape Department of Environment Affairs and Tourism - DEDEAT). The partners showed a great flexibility to adjust to changes.
The facilitation process set up in the pilot village guaranteed continuous involvement of and good information flow to and from the community, which was very important for the project implementation. The sustainability of minigrid is secured through ownership of the municipality. For the communication within the project team, the initial workshops in Germany and South Africa provided a good basis to bring all partners together and share ideas and results.
At the end of the project, especially due to its pilot character, a conclusion was drawn from the lessons learnt. Lessons learnt looked at successes and failings, traced causes and effects as well as strengths and weaknesses encountered by the project.
Among some of the lessons learnt was the need to understand if the municipality has the capacity to pay for operations and maintenance – and if not, how to build and develop this. Work was also required to ensure productive use of energy.

Achievements were:

- Minigrid up and running and people purchasing electricity

- Understanding that community engagement is key
- Understanding that energy load and demand is key
- Community trust was strong
- Community awareness: at each stage the community understood what was happening and why
- Comprehension of electricity services
- Community ownership - not owning the project in material / asset terms, but having a sense of ownership
- Keen and interested municipality
- Institutional lead (DEDEAT) and time (18 months) to work on the policy and institutional and productive use of energy
- Implementing a service delivery project through government support
- Cooperating with various funding, regulatory, institutional and developmental partners that each play a critical role.
- Costing/financial model developed from the start ((how much cost and how much to sell electricity for)
- Policy work with NERSA/DMRE related to pricing for mini-grids and where the capital/operational subsidies come from.
- Paving the way for future minigrid development and defining the much needed policies, licensing processes and public-private partnership to open up the minigrid space in South Africa.

Best practices were:

- Money and time for stakeholder process.
- Community engagement from early stage
- Important to have a social facilitator that has both social and engineering capabilities.
- Consistency/constant social facilitator with engineering qualifications
- Important to have a campaign awareness in the community.
- Technical, social, community leadership were all added in the communication
- Local employment - inclusion of women
- To look at energy demand for all types of energy and not just electricity (e.g., Strategy for cooking).
- Optimization study before buying of components

Further work:

Institutional exploration – there is a need to clarify the ongoing costs of the mini grid and where the sources of revenue/funding to cover this cost will come from; once costing is clear, the institution to manage the mini grid service must be established i.e., on a viable financial basis. In South Africa the Municipality is key – but they must not be set up for failure; how to make this viable.

Productive use of energy – starts to make the energy use an economic stimulus and considering additional levers that are required to make this happen (DEDEAT, 2020).

7.1.5. iShack Project



The iShack Project was launched in 2013 in Enkanini settlement, Stellenbosch, Cape Town. It is established as a not-for-profit social enterprise owned by the Sustainability Institute Innovation Lab (SIIL). The objective of the project is to develop and demonstrate a model for underserviced communities through building local enterprising capacity, developing skills, creating green jobs and contributing to the resilience of the communities. The project approach is one of learning-while-doing with a view to scalability and replication. The project's operating model is a long-term commitment to maintaining the energy utility (for as long as it is needed), rather than a purely technical, drop-and-go intervention. The operations team includes a group of 'iShack Agents' who all live in the community where they work. Weekly training is provided at the Sustainability Institute, during which the Agents are given the skills necessary to deliver a high quality, durable solar energy service. iShack has the goal of upgrading existing informal urban and peri-urban communities by installing off-grid 50-70Wp solar systems to power lights, cell phones and a TV, while these communities wait for electrification.

To date, more than 1,600 households within the settlement are now using the iShack solar service as an interim free basic electricity (FBE) provision while they wait for grid electrification. The systems have largely been installed, with the capital expenditure provided by the Bill and Melinda Gates Foundation and the SA Green Fund. The iShack approach works on a pay-for-service model dedicated to cover operational costs, without ownership. End-users who voluntary opt for the system, pay a modest deposit and installation fee to start, and then formally contract with the project where they go onto a pay-as-you-go system for usage. They then have free use of a standalone solar home system (SHS), installed in their dwelling which can generate adequate daily electricity to power lights and energy efficient media devices such as LED televisions, radios, tablets and smartphones. A full month of power on the largest system is $10.70 (R150). The iShack Project secured the payment for the Free Basic Electricity (FBE) subsidy from Stellenbosch municipality, which is paid directly to them. The municipality covers overhead costs through FBE (equivalent to 100kWh). Clients only make co-payments toward maintenance or system upgrades if and when required. These arrangements render the service financially sustainable.

A small team of iShack 'agents', from the community, run the daily operations of the utility in Enkanini. Their work involves marketing and client contracting, to installing and maintaining hardware, and ongoing client management. Supported by a small management team, the iShack agents help to co-produce systems and policies as part of the project's continuous improvement strategy. Customised client management systems and databases have evolved over the years. The increasingly sophisticated SHS technology together with these operating systems create rich data that have enabled an efficient and fit-for-purpose utility management programme.

In the early years acceptance for the project by communities was initially very low, but it has grown substantially. The project notes that crucially a structured engagement process is required to secure community buy-in.

It is acknowledged that while the iShack solar service amounts to a durable energy service, the energy capacity of an affordable off-grid SHS is limited and excludes the ability to meeting cooking and water heating needs. The SHS could be 'bundled' together with an affordable gas service for cooking and a solar water heater. Such a technology bundle, together with other energy efficiency solutions (such as dwelling insulation and energy saving cooking methods) could meet the threshold for a 'basic energy' – enough for lighting, access to media and cooking. However, until such time as this idea of energy bundles is seriously considered, the provision of a SHS will remain a temporary intervention prior to grid electrification.

The iShack project notes that more widespread adoption of an interim services approach (replication) in other off-grid settlements would require communities to be actively involved and widely supportive from the beginning. It is the communities that should decide whether they are prepared to accept a temporary SHS while they await a more substantial energy service (grid electricity or solar infrastructure with substantially more capacity). It is the municipalities that would need to allocate the capital and operational funding required for such a service (Conway, 2021).

7.1.6. Interim off-grid free basic energy service piloted in Siqalo, Cape Town

Siqalo is community of approximately 2 000 families living on private land in Philippi, Cape Town, with no access to electricity, and limited supply of water and basic sanitation services. Siqalo is regularly in the news for volatile and disruptive service delivery protests. This community has explored alternatives for improving their lives, and alternative ways of making their voices heard. In 2016, a group of Siqalo residents visited the iShack utility in Enkanini, Stellenbosch, Cape Town and subsequently asked the project to bring the solar service to Siqalo. Without a subsidy from the City of Cape Town, a small pilot was implemented to provide residents with opportunity to experience the technology, as part of a process of engagement that might lead to some form of democratic decision making. One hundred households joined the pilot with each paying off the cost of a solar home system (and a television) over 24 months. Each pilot client is a member of one of five 'solar teams', headed up by 'solar captains', who communicate to their teams via WhatsApp user groups. The captains mediate between the project and team members when clients default on their payments or require support with any aspect of the service.

While the organisation of the solar teams supports the project with resolving transactional issues and information dissemination, it also arose in an emerging social process which serves a promising example of innovative energy democracy. After the pilot had been running for a year, the solar teams organised a community-wide petition and obtained 1 800 signatures, addressed to the Mayor of Cape Town, asking the city to subsidise a temporary solar service for the whole settlement while they continue to wait for permanent services.

The cost of fully subsidising an off-grid SHS service is substantially lower than the maintenance costs of a household grid connection (which is what the municipality is constitutionally required to provide). The solar service itself reduces both the risks of devastating shack fires and financial constraints on the city's stretched emergency relief capacity and budget. The municipal benefits however extend beyond the financial. By agreeing to Siqalo's request, the City would help to establish a template for a workable social contract that sets out a feasible plan for further services in future and provides the City with some allowance to plan for a more phased service delivery programme. This could potentially serve as a framework for constructive engagement for other communities to follow, one in which they can give expression to their democratic demands.

The community of Siqalo has extended an invitation for such a social contract to the City of Cape Town. They have shown a willingness to compromise and suspend (temporarily) their more disruptive style of demand of violence and destruction. They have organised a peaceful, pragmatic, and democratic request. Currently, they are waiting for the decision-makers in local government – both the politicians and the officials – to accept the invitation. (Conway, 2021)

7.1.7. A community-led alternative service delivery approach to informal communities on private land - the case of Freedom Farm and Malawi Camp, Cape Town

Freedom Farm and Malawi Camp are communities in Cape Town, located on land belonging to the Airports Company of South Africa (ACSA) and the City of Cape Town Metropolitan Municipality. These communities have been prioritised for relocation to a formal housing development starting in 2023. Freedom Farm is home to close to 2000 people while Malawi camp has just over 1000 residents. Residents from both communities have been living in the area for as long as 30 years and have no formal access to electricity and limited communal water points. The unemployment rate in Freedom Park and Malawi is close to 65% and 55% respectively and more than 50% of children (0-18 years) are not in school in both communities. The leadership of Freedom Farm community is newly formed and has been stable since their formation

GreenCape's Alternative Service Delivery Unit (ASDU)[28] has been working in these two areas since 2019 to create a strong social foundation for community-led alternative service delivery. This involved building an inclusive platform for local community members to express infrastructure preferences and understanding the communities' propensity to pay for infrastructure services while also mapping existing infrastructure assets. GreenCape applied 3 vital lenses to holistic community-led service delivery which included: 1) social inclusion and mobilisation of the affected community, 2) customised technical design (right technology for the context and the need) and 3) financial sustainability and affordability of the interventions. GreenCape notes there is no one solution fits all. Each community is different and an approach to participation must be an adaptable process of participation, mobilisation and enumeration and community-led co-design. This helps to ensure the best, most context appropriate, outcome is reached. This process helps create the early foundations for trust,

[28] GreenCape's ASDU as a support to government and in some cases private landowners was established to promote underserviced and unserviceable areas as spaces for innovation through the provision of basic services, empower communities through co-design and social choice and support local municipalities and landowners to explore new approaches to providing innovative and inclusive service delivery

commitment and community buy-in and also allows for a co-design process that is informed by real-world data.

The community-led co-design process involved working with the community to ensure that they 1) agree with the information about their community (data, demographics and dynamics of communities), 2) understand what kind of interventions are available and which could be suitable; and 3) determine their greatest challenges and needs in order to help the team to design a customised intervention covering the appropriate technical mix, social diffusion and financial model.

Through this process the communities of Malawi Camp and Freedom Farm prioritised, home level lighting and connectivity (TV, radio etc.). They also highlighted that cooking and food storage was a high priority in the local area. Through the process, a home-solar system was selected which is paid for on a monthly basis by individual households.

The capital for the infrastructure was donated by the landowner but the monthly fees are sufficient to create and maintain a local company employing community members to install and maintain the systems. The project noted that manoeuvring through difficult community engagements, dealing with diverse stakeholders and supporting communities that have been without services for 30 years is a daunting task. The outcomes in these two areas have been greatly supported by the project drivers that led the engagement, facilitation and management of the process.

An important lesson in this case study, is again the strong partnerships that were forged among the stakeholders and close community co-design of the process from the start of the project. Another significant element is that the financing was leveraged through the private company whose land on which the communities were located. This is particularly worth noting, given that under-served communities in South Africa are often located at the edges of our cities, which is often where industry is located. Using these industries to leverage financing to support renewable energy development particularly for communities living in close proximity to industry is an important consideration.

8. Scalable community ownership in South Africa

Community energy projects can be designed in a range of arrangements – solar home systems, grid-tied solar PV systems, or mini-grids. Community-ownership projects are typically focused on generating benefits to the community (economic, social, environmental) in addition to financial profits. The main purpose of a community-ownership project influences its implementation, as different models may be better suited to different objectives.

8.1. Types of renewable energy systems

Community energy projects should vary according to the specific needs of the local community. Renewable energy systems, either in combination with the electricity grid or as standalone off-grid systems, can provide a range of electricity services depending on their configuration. Costs also vary significantly depending on the configuration. **Error! Reference source not found.** shows the types of renewable energy systems and describes their attributes.

Table 2: Types of community energy systems

Source: A simple model was built to investigate the feasibility of various community energy alternatives. The spreadsheet model accompanies this report.

Types of energy systems	Solar home system	Rooftop solar	Wheeling
Image			
System configuration	Off-grid system	Onsite grid-tied system	Offsite grid-tied system
Energy services	Basic energy services (lighting, Wi-Fi) while awaiting grid connection.	Grid provides full modern energy services including cooking.	Grid provides full modern energy services including cooking.
Value proposition	Allows households to use electric devices in the absence of the grid.	Solar reduces the electricity bill since solar energy is consumed during the day.	Solar reduces the electricity bill since solar energy is consumed during the day.
Typical system size (power output)	100 – 500 watts	1 – 5 kilowatts	50 kilowatts and upwards
Cost per unit installed	R40 000/kW and upwards (including basic storage[29])	R20 000/kW	R12 000/kW
Cost per household	R5 000 – R20 000	R50 000 – R80 000 or R1 – R1,30/kWh	R30 000 – R60 000 or R0,70 – R0,90/kWh
Payback period when compared to municipal grid electricity	Never – grid is cheaper than off grid solar	13 years	5 years
Suitable ownership models	Homeowners typically rent the systems from the developer for a daily or monthly fee.	Financed by a bank with monthly repayments or financed by a developer with a power purchase agreement.	Facilitated by a developer who will arrange a power purchase agreement to cover the bank's monthly load repayments.
Air quality improvements	Solar home systems can significantly improve air quality when they replace paraffin lights	Reduce consumption of grid electricity and reduce coal burn in Mpumalanga leading to considerable air quality improvements.	Reduce consumption of grid electricity and reduce coal burn in Mpumalanga leading to considerable air quality improvements.
Socio-economic co-benefits	Installation and maintenance of solar home systems is an employment opportunity	Installation and maintenance of the grid-tied solar system is a considerable employment	A solar farm is a massive socio-economic opportunity for local communities, depending on where the solar farm is located.

[29] Because solar home systems do not have the grid as back up, they require battery storage in combination with a solar panel to store the energy so that it can be used at night when the sun is not shining. This battery storage drives the cost of the systems up significantly. The grid is a far cheaper back up power source, but for households without grid connection this is the only option.

Types of energy systems	Solar home system	Rooftop solar	Wheeling
	for a few community members.	opportunity for local community members.	
Hurdles to overcome	Systems are typically on an individual household level making community participation challenging. Could be suitable for a community hall or similar shared space.	Could work on an apartment block but submetering will be a major hurdle to determine which household consumed the energy during the day.	Requires the municipality to have a wheeling tariff and upgrade metering and billing systems to measure the amount of solar energy consumed by each household.

Each of the above community energy systems (or a variation thereof) would be suitable in a specific community.

8.2. The challenges with low-income household rooftop solar PV

While many industry stakeholders are passionate about the idea of putting solar PV on every household rooftop, the feasibility study shows that due to economies of scale the financial feasibility of large solar farms far outweigh that of rooftop solar PV. This is especially the case in lower income communities where household energy consumption is low, meaning that these rooftop solar PV systems need to be even smaller, and are thus further challenged by economies of scale. An oversized solar PV system would generate more energy than a household can consume. If the solar PV system is grid-tied, this surplus energy can be fed into the grid. Many municipalities in South Africa now compensate customers for surplus energy fed into the grid, including eThekwini and Emalahleni, however, the model has shown that the compensation rates, or "export credits", are insufficient to create a business case for low-income solar PV. This is because the compensation remains a credit, meaning that households still need to consume enough power to have their monthly bill credited for these export credits. The municipality may not, due to the limitations of the Municipal Finance Management Act (MFMA), take a customer's bank details and pay them money for the energy fed into the grid. The regulations for power generators are far more complex, and there is a need for solar PV customers to remain *customers.* As such, the business case for rooftop solar PV needs to be built on self-consumption of the energy generated, meaning that rooftop solar PV generally only makes sense for customers who have a substantial daytime energy demand, which most households do not have. Batteries can be used to store the energy for consumption in the evening, but storage systems are still very expensive and further diminish the financial viability of the systems for low-income households.

There are several alternative arrangements that enhance the financial viability of renewable energy. These are typically via larger installations coupled with aggregated demand profiles of a group of low-income households, for example in social housing projects or apartment blocks. Transporting the power from the larger solar farm to the households requires use of the municipal power grid, otherwise known as "wheeling". The above table illustrates that the financial viability of a wheeling system far outweighs the other alternatives.

9. Envisioning a scalable community energy model for South Africa

9.1. Emerging community energy enablers

In the South African context, the primary purpose of introducing collective ownership of a renewable energy system would be to overcome the challenges community members have in accessing capital to install their systems. Collectively, however, these community members could generate a far more attractive case for finance.

Many communities in South Africa are still not connected to the electricity grid meaning that addressing their immediate energy needs is most critical. Off-grid systems and solar home systems would provide these basic services. In the long term, the government's intention is for all households to receive a connection to the grid; the challenge of energy access then becomes ensuring electricity is affordable. This is already a challenge for the many South African households that are grid-connected but struggling to fund their monthly electricity needs. Grid-tied renewable energy systems can reduce the costs of grid electricity and form the basis of what we feel may be scalable community energy projects in the long term.

Until now grid-tied solar systems have typically been in the form of rooftop solar PV. These systems are viable for large commercial customers that consume significant amounts of electricity during daytime hours. When installing a rooftop solar system, these customers consume solar electricity to reduce their consumption of grid electricity. Their business case for solar is therefore built upon the savings they realise on their municipal electricity bill. The challenge with residential – especially low-consuming households – is that they do not consume enough electricity during the daytime hours to warrant the installation of a rooftop solar system. The generation of energy during daytime does not coincide with the time of typical household energy needs i.e., in the morning before work and in the evening after work. When households are pooled together, their collective electricity demand does have a substantial daytime load, and this collective load is far better suited to that of solar energy generation.

9.1.1. Why wheeling?

South Africa's energy regulatory environment has developed to allow more private sector participation in the generating of electricity. Specifically, recent amendments to Schedule 2 of the Electricity Regulation Act mean that larger generators (up to 100MW) can connect to the grid without needing to obtain a generation license. In addition, the amendment explicitly allows for the wheeling of electricity between willing sellers and willing buyers.

> Wheeling is the delivery of electricity generated by a private generator in one location to a buyer or off-taker in another location via a third-party network (Eskom or municipality).

By utilising the grid to transport electricity, wheeling allows customers to procure energy directly from large energy generation facilities offering several benefits over smaller rooftop systems:

- Due to economies of scale, large generation facilities are cheaper on a per-unit basis (R/kW) than smaller rooftop solar systems.

- Larger solar farms can be located in areas where the solar resource is the highest meaning that the solar panels generate more electricity.
- Wheeling may also allow for the aggregation of household loads into a single community energy customer meaning that the load profile matches that of solar far better than a single household. This load aggregation is key to the community energy model and municipalities will need to be engaged to determine the required metering arrangement.
- Cleaning and maintenance costs are lower for larger systems.
- Safety concerns and the risk of theft of panels is reduced when solar farms are fenced off and located outside of cities.

As such, wheeling represents the ideal technical configuration for community participation in renewable energy generation. The envisioned community energy model for South Africa relies on the collective energy load of a community of households. These households would need to form an organisation that procures energy from a willing generator via a wheeling agreement through the municipal grid. The generator would be reimbursed monthly for the energy delivered to the community, as shown in Figure 16.

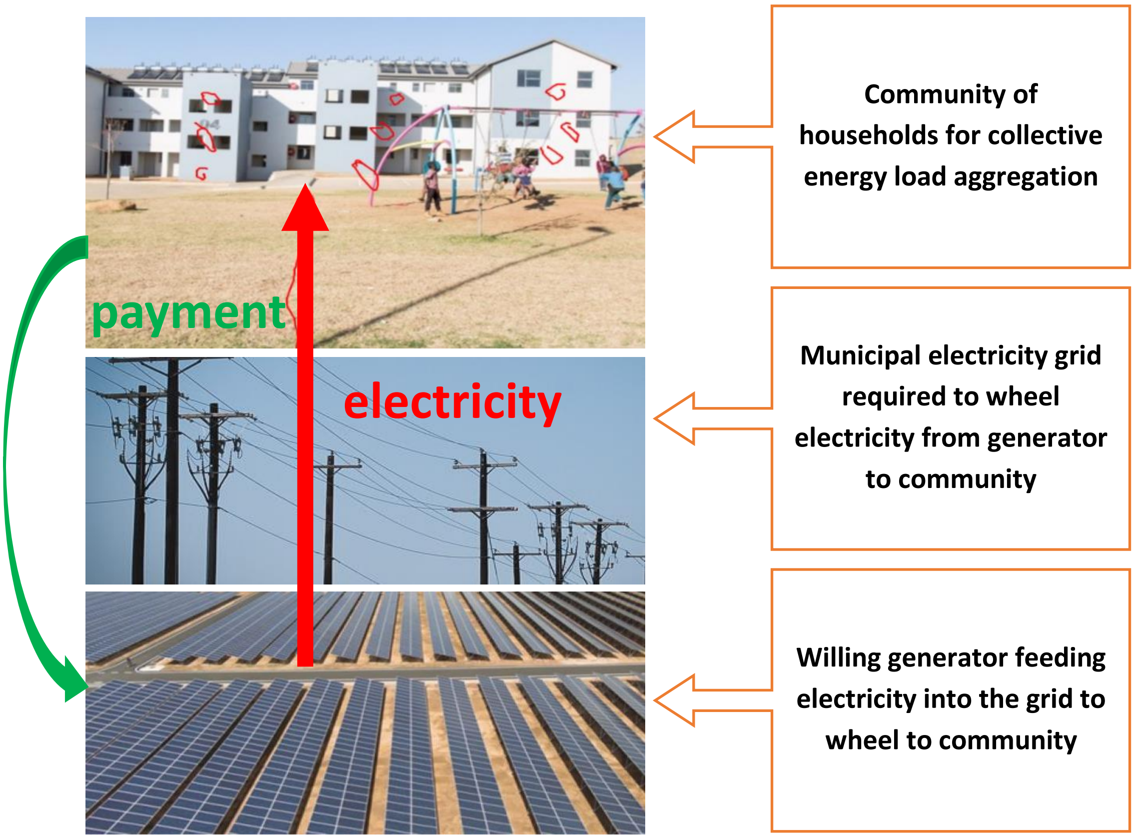

Figure 14: Envisioned community energy wheeling project

When communities consume electricity from solar, they reduce their consumption of South Africa's highly polluting grid electricity. This reduces carbon emissions arising from the burning of coal in the Mpumalanga province, leading to improved air quality for the local communities. Depending on where the solar farms are located, they also offer major socio-economic benefits for the local communities. As such, the most impactful wheeling arrangement would locate the solar farm on a vacant piece of land nearby a decommissioned coal mine to create employment opportunities for the local community members during the construction of the plant. While solar farms may yield more energy if located in the desert of the Northern Cape, the socio-economic co-benefits of a Mpumalanga solar farm are likely to outweigh the energy yield difference.

Case study: load aggregation in Austerville

Austerville is a community is South Durban where several households share a large apartment block. It is an ideal example where load aggregation could support the uptake of renewable energy. On an individual household level, the daytime load is very low, but on an aggregated level (50+ households), there is always a daytime load to consume solar energy and ultimately reduce the consumption of municipal energy.

Major hurdle to overcome:

Each household has a municipal prepaid meter. To enable either behind-the-meter self-consumption or wheeling, a bulk municipal meter would need to be installed upstream of all the houses. The community would then need to form an entity that is responsible to pay the municipal account on that bulk meter. This entity then needs to ensure that each household pays their individual account. This is a high-risk approach in the areas of non-payment. Conversely Austerville's good payment track record makes it a potentially viable case. Overall, this is complex and will require close collaboration with the municipality.

This is a potentially transformational concept and a key approach for communities to meaningfully participate in the energy transition through co-owning energy generating assets. However, it is very complex and there are a range of challenging practicalities to implementing this approach.

9.2. Practicalities of implementing community wheeling

Implementing the envisioned community wheeling energy project will require significant participation:

- from **the communities** – to aggregating (combining) their loads and forming a community energy organisation – and
- from **local municipalities** – to develop wheeling processes that facilitate the wheeling of electricity to communities.

Key steps to implementing community wheeling of energy:

1. A municipality that is keen and open to engaging with the community to walk the path towards community wheeling of energy. Ultimately, municipalities should develop a functional municipal wheeling process that includes:
    a. Technical staff with capacity to drive the wheeling process
    b. Wheeling tariffs with billing system integration
    c. A council-approved wheeling framework
    d. Upgrading of metering infrastructure to facilitate the wheeling transactions
    e. Options for community members to allocate their FBE share into wheeling projects
2. An organised community structure to democratically manage the project and engage with investors and developers on behalf of the community
3. An investor that is willing to take on the risk of this novel wheeling arrangement and build a solar/wind farm to sell energy to the community
4. Well-informed community members that understand electricity wheeling and how they can benefit from it

Implementing community energy wheeling will certainly not be a straightforward task and will require significant lobbying to get communities and municipalities to buy into this potentially transformational idea.

9.3. Practicalities of a scalable community energy model for South Africa

Collective energy ownership enables the democratisation of energy access, empowers end-users to participate in the energy value chain, provides affordable and clean energy for communities and is a catalyst for local economic development. The concept of community energy is drawn from the global north and a key contributor to its success is the aspect of property ownership – owners of the energy system often own their properties and are within the middle to high-income group. Homeowners create community energy cooperatives or trusts, through which the SSEG system is developed. The affordability level coupled with tenure, creates an attractive case for bank finance, in some instances, garnering government funding.

In South Africa however, where community energy has yet to become mainstream, accessing development capital also poses challenges. The low-income landscape, characteristic of below poverty line to minimum wage levels, lack of land tenure, and poor credit profile, makes up the lion's share of communities that make a case for collective ownership energy initiatives. Typically, the municipality is the custodian of the land wherein their homes lie. To fully explore collective energy ownership within the South African context, the following factors need to be considered:

- Access to property ownership (residential or land)
- Access to capital
- Access to technical, financial and organisational skills
- Knowledge about utility regulation (system sizes, licencing, tariff development, reticulation)
- Ability to have a legal structure for the ownership of the system,

Although an ideal model for a community-led energy generation system does not yet exist in the South African context, it does not completely exclude their participation. South Africa has a growing number of informal settlements that also require energy access, thus addressing their immediate energy need remains critical. Although grid connection is pivotal and the ultimate service level for energy access, the other concern is to ensure affordable access. Off-grid systems and solar home systems provide an alternate interim energy service (albeit offering limited energy services) for non-electrified communities at affordable rates.

9.4. The critical role of electricity distributors in community energy futures

Many communities have become intolerant of their municipalities due to lack of service delivery, constantly increasing tariffs, repeated cases of corruption, and for ignoring the voice of the community members. Despite this, electricity distributors do still have a critical role to play in enabling a transition to a just, community-led energy future. The mandate of municipalities is to equally protect the interests of all their constituents. They do this by facilitating social wealth transfers from rich to poor in the form of tariff cross-subsidies.

As discovered through this feasibility study, the notion of rooftop solar PV on every low-income household is not financially feasible. Further, engaging in power purchase agreements with private electricity generators is no simple task. Establishing a fair agreement with a private power generator requires significant legal expertise, financial security, and technical know-how. As such, most communities are not best placed to lead these engagements. While there may be certain communities who have the capacity and contacts to establish such a power purchase agreement, most communities will benefit from the municipality representing the community's interest.

By virtue of being an electricity distributor, municipalities already aggregate the loads of several thousand customers. As such, they have the ideal load profile to engage with renewable energy generators. Most municipalities also have the technical know-how and financial viability to establish these power purchase agreements. The only question remaining is whether municipalities will pass through the cost savings of these energy procurement agreements to their customers, i.e. if a municipality saves money through procuring renewable energy privately, will this mean that electricity tariffs will come down to reflect these cost savings? Some industry stakeholders feel that municipalities' finances are already so constrained that any cost savings will be absorbed by the municipal coffers. As such, the importance of ringfencing the electricity business to ensure that all renewable energy cost savings are passed through to communities in the form of reduced electricity tariffs cannot be overstated. Municipalities must perform transparent cost of supply studies to show their customers that their tariffs are fairly calculated. Municipalities must also prove that they are actively seeking ways to improve their operational efficiency to reduce electricity tariffs for their customers. Finally, municipalities must develop action plans to swiftly increase the amount of renewable energy on their local grids. These renewable energy generators should be built in the local areas to maximize the socio-economic co-benefits of these projects.

Having emphasized the critical role of electricity distributors in the energy transition, it is important to clarify that while this role is currently held by municipalities and Eskom, other institutional arrangements could still enable this social wealth transfer. The critical point is that large-scale grid electricity provision enables social wealth transfer and thus allows for a financially viable electricity grid business which far outperforms any other form of energy service provision, especially in the South African context.

10. Recommendations for the implementation of demonstration units in selected municipalities

This project includes the development of demonstration units in selected communities and municipalities. These demonstration units will be built during 2022. As such, the feasibility study concludes with recommendations for the implementation of community energy systems. The previous chapter described a scalable community energy model centring around the wheeling of electricity from a large solar farm. This should remain the long-term (5 year) vision and a campaign should be developed to lobby municipalities to develop their wheeling processes. However, for the purposes of the demonstration units, smaller off-grid solar systems installed within the communities are more suitable to build in the short term over the next 6 months.

Off grid solar systems with storage provide critical interim energy services while those customers await grid connection. To fully maximise the value of the demonstration units, the systems should be installed in public spaces on communal buildings such as community halls or schools. Electricity meters should be installed on the outside of the buildings to show the real-time solar energy generation alongside the real-time building energy generation to allow community members to learn about solar generation patterns and building energy consumption patterns. This will serve as an important learning platform allowing community members to comprehensively learn about renewable energy technology and its complexities so that they can better lobby for the community energy wheeling, which we see as foundational to socially owned renewable energy

10.1. Demonstration project technical design

Building the off-grid demonstration projects will commence in early 2022 with the primary intention of providing energy services to unelectrified communities. In addition, these systems provide an important educational opportunity. As such, the systems should be designed with these two factors in mind.

The sub-contractor should provide a system design and quotation for the following piece of work:

- Solar plus storage system design recommendation to meet the energy needs of the specific community building (preliminary discussion indicated that the intention was for the system to power a WiFi router, five phone chargers and two laptop chargers)
- Expected energy yield analysis for off-grid solar system
- Real-time electricity meter installation to allow community members to build an understanding of solar generation patterns and building energy consumption patterns
- System installation including all necessary travel
- Community engagement and training sessions

Operating manual and maintenance plan to manage the system

10.2. Implementation plan

A detailed scope of work based on the above technical outline was developed in January 2022. Potential service providers will then be required to provide quotations for this piece of work. A minimum of three quotations is recommended, and procurement will be done in line with the UMI's procurement policy. Quote evaluation criteria will then be developed to guide the assessment of bidders. Value for money is always a major consideration for quote evaluation along with relevant technical experience of designing and building off-grid solar systems and training communities to operate these systems. Successful bidders should be awarded in early 2022 for immediate commencement of the design of the demonstration units. At least two community engagements are recommended – one before installation focussing on community buy in and a second after installation focussing on system operation and maintenance.

11. Conclusions and Summary of Key Findings

While no single ideal community energy approach exists as yet, there will be a combination of approaches/models that would be adopted to adequately meet the household needs of underserved communities.

- Off-grid systems could serve as a temporary solution for interim energy service provisions while awaiting electrification.
- A grid-connected household can reduce its consumption of grid electricity by installing rooftop solar. However, this is not a financially viable option for low-income households as the solar panels are costly and only generate electricity during the daytime, when typical household energy consumption is low.
- **It is not financially viable to have solar panels on every house – grid electricity is far cheaper and far more reliable.**
- Purchasing electricity through the municipality is by far the best way to enable affordable energy service delivery to communities.

- An alternative to municipal supply is to purchase electricity directly from an independent power producer and ‘wheel’ the electricity to the community across the municipal grid. While this is technically possible, it will require the aggregation of loads i.e. a bulk municipal meter will need to be installed upstream of the community to facilitate the wheeling transaction, and the community will be sub-metered by a private entity. This approach has a high-risk profile (due to risk of non-payment) but remains a viable option in communities where payment history is good. An energy trader will need to drive this process on behalf of the community. It is complex, and therefore has not been done in South Africa, but it remains feasible, and we expect energy traders to explore this approach in the coming years.
- **Purchasing electricity from the municipality is likely to remain first prize.** The municipality has a critical role to play in the just energy future, since it represents the communities and protects the well-being of its constituents. The municipality is the custodian of the electricity grid for the public good. The electricity grid is the fabric that connects all households and enables cross subsidies from rich to poor.

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