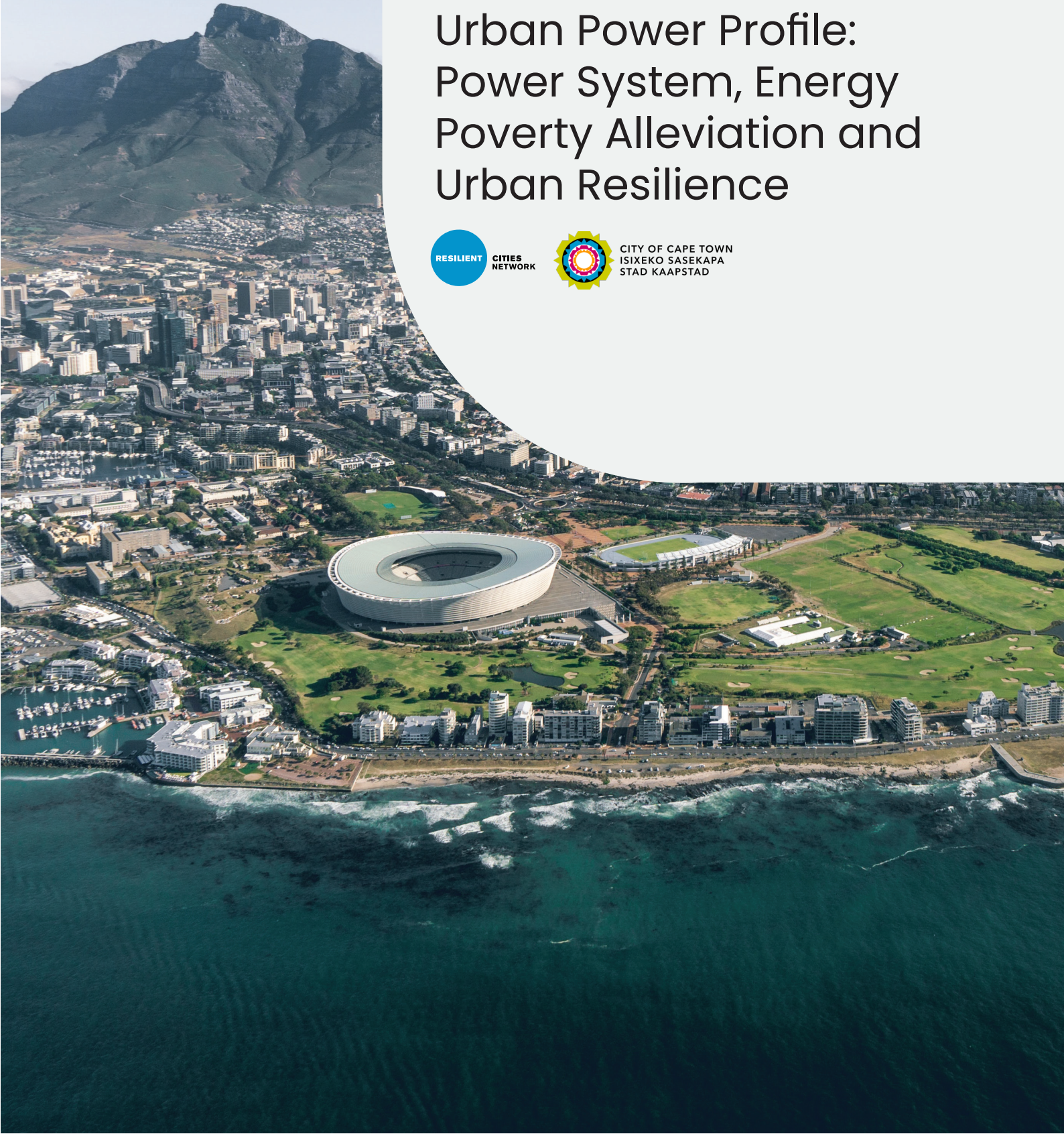
URBAN POWER

Cape Town

Urban Power Profile: Power System, Energy Poverty Alleviation and Urban Resilience

RESILIENT CITIES NETWORK

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD



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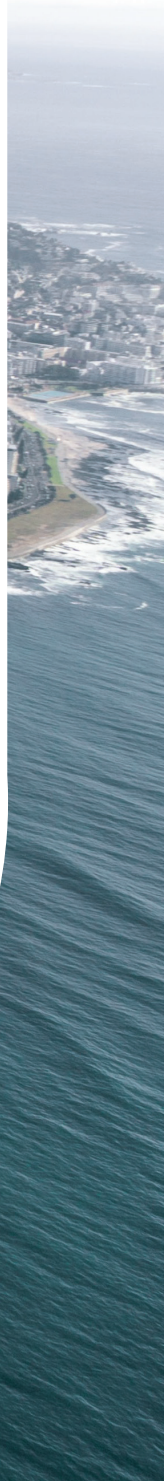

FIGURES

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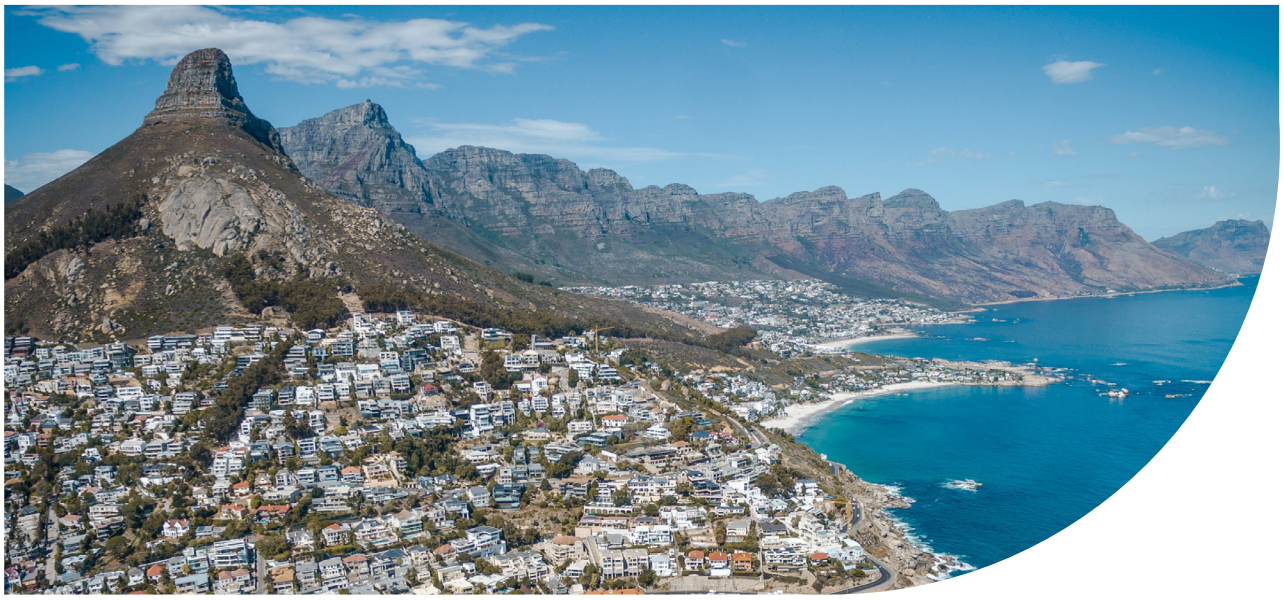
ACRONYMS AND ABBREVIATIONS

CAP	Climate Action Plan
DBSA	Development Bank of South Africa
DCOG	National Department of Cooperative Governance and Traditional Affairs
DFFE	National Department of Forestry, Fisheries and the Environment
DMRE	National Department of Mineral Resources and Energy
DOE	National Department of Energy
DPE	National Department of Public Enterprises
EGD	Electricity Generation and Distribution
ERA	Electricity Regulation Act
FBAE	Free Basic Alternative Energy
FBE	Free Basic Electricity
GDP	Gross Domestic Product
GHG	Greenhouse gas
GVA	Gross Value Add
IPP	Independent Power Producer
IPPPP	Independent Power Producer Procurement Programme
IRP	Integrated Resource Plan
NDC	Nationally Determined Contribution
NDP	National Development Plan
MFMA	Municipal Finance Management Act
NEES	National Energy Efficiency Strategy
NERSA	National Energy Regulator of South Africa
NNR	National Nuclear Regulator
PFMA	Public Finance Management Act
PV	Photovoltaic
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SALGA	South African Local Government Association
SEM	Sustainable Energy Markets
SSEG	Small-Scale Embedded Generation
tCO2e	Tonnes Carbon Dioxide Equivalent



INTRODUCTION

ENERGY AND URBAN RESILIENCE

Electric power and cities have a long and interwoven history. Cities are where electricity systems were developed and tested and, in exchange, electricity transformed cities. Since the introduction of electric power, cities have been able to build higher buildings, power large-scale public amenities and extend civic life beyond daylight hours, effectively transforming urban economies. This has resulted in denser, more populous cities that in turn consume more energy.

Today, cities consume an estimated 78% of the world's electricity, a percentage that is growing, as climate change pushes more of the global population into urban centers.[1] Cities are also responsible for over 70% of global emissions, much of which is tied to energy-intensive urban services including transportation, heating and cooling, and construction.[2]

As cities work to reduce emissions and fortify themselves against the impacts of climate change, they need to critically evaluate the energy systems on which they depend. Over the last two years, the Covid-19 pandemic, extreme climate hazards and the Russian invasion of Ukraine have highlighted the vulnerabilities of the current energy systems, while reinforcing the importance of reliable clean energy sources.

A resilient energy system is one that is able "to reduce the impact of shocks and stresses, including the capacity to anticipate, absorb, adapt to, and rapidly recover from such events and to transform where necessary".[3] Resilient energy systems cannot exist unless the gaps in urban energy access are addressed, given that over 55% of city dwellers today experience regular electricity outages or lack electricity altogether.[4]

A renewables-driven energy transition is at the core of efforts aimed at achieving the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change, and meeting emissions targets at every scale. The policy choices that governments make today, to address energy challenges, will shape the paradigm shift to low-carbon development and ensuring access to critical services in an increasingly digital world. They will determine success in building the greener, fairer, more inclusive and more resilient cities of tomorrow.

R-CITIES' URBAN POWER PROGRAM

The urgent need to address energy poverty and climate change requires new vehicles for spurring transformational change and partnerships at the city level. In 2021, with support from the Global Energy Alliance for People and Planet and the S&P Global Foundation, the Resilient Cities Network (R-Cities) launched its Urban Power program, to identify, design and accelerate energy solutions for tackling energy poverty and advancing a green and just energy transition.

Through this program, R-Cities is helping member cities to source, design and prepare projects that deliver energy solutions to the urban poor and vulnerable populations in two of its regions: Africa and Latin America and the Caribbean. The program is also developing tools that enable cities to evaluate the resilience of their energy systems. The work in each program city builds on existing resilience initiatives and aims to address issues that are barriers to building energy resilience. The program assists cities in identifying and taking up renewable energy solutions and increasing energy-related investments to address existing financing constraints in developing and emerging economies.

The Urban Power program brings together civil society actors, leading academics, financial institutions and private sector leaders to build trusted partnerships for developing, sharing and scaling resilience solutions and informing tools. This Urban Power profile is the outcome of the first of three phases that aims to:

- gather and analyze data on the existing state of an urban energy system, in order to identify gaps and opportunities for resilience,
- enable the city to co-develop energy resilience solutions alongside industry experts, and
- take these solutions to a pre-feasibility stage to accelerate their eventual implementation.

Note: The term 'the City' refers to the local government entity, while 'the city' refers to the metro area.

THE URBAN POWER PROFILE

This report was completed through a joint effort between Sustainable Energy Africa and the Resilient Cities Network, and forms a composite of the information gathered towards developing a resilience-oriented analysis of the City's Urban Power profile, including gap analysis, best practices, and an existing actions inventory. This was primarily a desk-based exercise as the city has extensive documentation on its energy sector, having undertaken energy data gathering and analysis since 2003. The primary documents drawn on were the City's spatial and development planning documents and recently published Climate Action Plan and the Cape Town State of Energy & Carbon Report, both published in 2021.

In addition to desk-based research and analysis, interviews and engagements took place with City staff from Sustainable Energy Markets, Energy Generation and Distribution and Resilience directorates. The analysis also drew on knowledge of the sector that Sustainable Energy Africa has accumulated through its role in the sector over many years and participation in policy and research work and discussions on these themes.

This profile was completed in partnership with the City of Cape Town Sustainable Energy Markets Department, City of Cape Town Energy Directorate, Sustainable Energy Africa, Arup and the Resilient Cities Network

CAPE TOWN CITY CONTEXT

Cape Town lies on the southwest coast of South Africa under the shadow of Table Mountain. The mountain has shaped the development of the city's road and rail networks, while its status as a biodiversity hotspot has restricted where houses can be built – nature reserves cover over 40% of the municipal area.[5] From the 1950s, the urban form was increasingly shaped by Apartheid's discriminatory laws and forced removals, whereby Black and Colored South Africans were moved to townships on the edge of the city (Figure 1). This legacy has resulted in a divided city, with affluent suburbs juxtaposed against poor townships on the low-lying Cape Flats, which include areas that naturally fill with water (or 'vleis') during the rainy winter months. Cape Town's unique environmental context makes it particularly vulnerable to certain natural risks, which are heightened by climate change. Over the next 30 years, the greatest climate-related risks for Cape Town will be from:[6] increased frequency of multi-year drought, increased wildfire incidents, heatwaves, flooding and gale-force winds

TABLE 1 Key facts about Cape Town

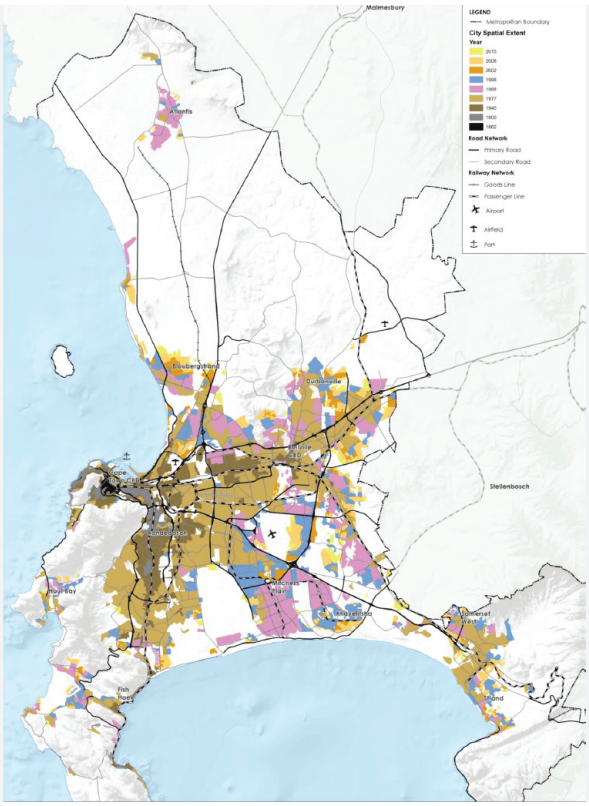
Key Facts	
Population	4.68 million (2021). Working population: 70%. Population under the age of 14 years: almost 25%.
Economy	3rd largest gross domestic product (GDP) in South Africa (9.6% of national GDP in 2020), with an average economic real growth rate of 1.2%.
Key economic sectors	Finance and business services, community services, transport and communication, trade and hospitality.

As South Africa's second-largest city (after Johannesburg), Cape Town is a major center of in-migration, with a population that has grown rapidly over the past decade. By 2030, Cape Town's population is expected to reach 5.1 million people (compared to 4.68 million in 2021).[7] The rapid population increase is outstripping the City's ability to provide services, such as housing. As a result, informal settlements have expanded, and in 2020 almost a fifth (19%) of Cape Town's population resided in informal shacks.[8] Cape Town has over 200 informal settlements,[9] many of which are established on land that is unsuitable for housing because

of being located close to transmission lines, covered in wetlands and prone to flooding, on land requiring environmental protection or with contested ownership.

In 2021, Cape Town's unemployment rate was 27.5%, compared to 34.9% nationally.[10] Of the workforce, 82.1% were formally employed and 11.2% were informally employed.[11] The tertiary and services sectors, which account for 80% of Cape Town's gross value add (GVA), were hard-hit by Covid-19, especially the tourism and transport sectors. The result was an increase in the already high levels of poverty and inequality: in 2018, Cape Town's GINI coefficient was 0.62, while 28% of households earned less than R3,500 per month,[12] which aligns roughly with the global poverty index of US$2.15/person/day.[i]

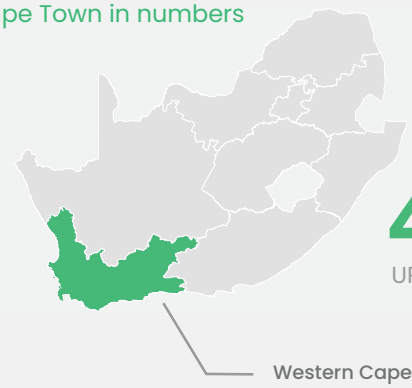
FIGURE 1
Cape Town's historic growth



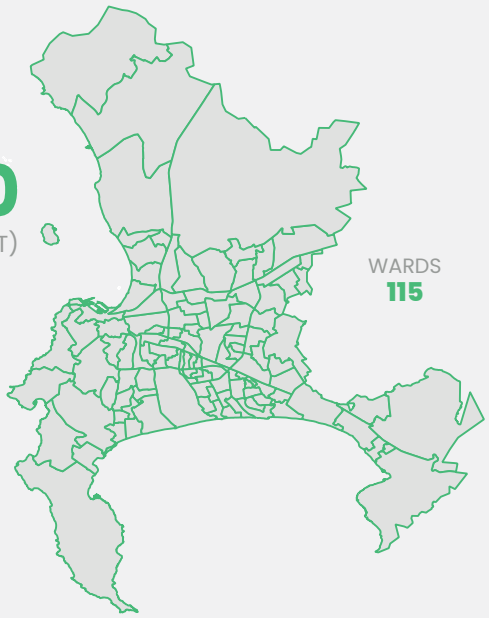
Cape Town is one of eight metropolitan (or category A) municipalities (metros) in South Africa. The city is governed by a council that is elected every five years, headed by an executive mayor. The city is divided into wards, which each elect two councilors: one directly and one on a proportional representation basis. The City is administered through executive directorates, of which there were 11 in 2022, that are overseen by members of the mayoral committee (MMCs).[ii] In 2017, the City established an Energy and Climate Change Directorate, overseen by a dedicated MMC and comprising two departments: a new Sustainable Energy Markets (SEM) Department, which absorbed the old Energy and Climate Change Unit, and the Electricity Generation and Distribution Department, which was formerly the Electricity Distribution Department. Since then, the directorate has been renamed 'Energy', and the climate change aspects have moved out of the SEM and into a new directorate called Future Planning and Resilience.

i According to Stats SA's General Household Survey of 2020. However, it should be noted that these general household surveys have become less reliable over time due to a substantive decrease in sample size. Therefore, data may not be truly representative, although indications are that the percentages are more likely to be on the higher rather than lower end.
ii The 11 directorates are: Safety and Security, Urban Mobility, Economic Growth, Human Settlements, Community Services and Health, Spatial Planning and Environment, Urban Waste Management, Future Planning and Resilience, Energy, Corporate Services, and Water and Sanitation.

FIGURE 2
Cape Town in numbers



4 678 900
URBAN POPULATION (2021 EST)



Western Cape Population

South African Population

THE ENERGY SECTOR

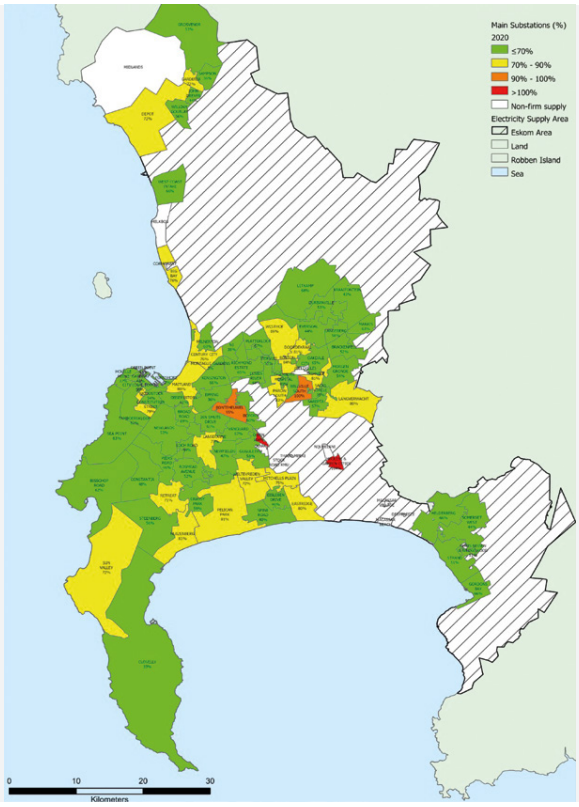
In South Africa, energy governance is centralised under national government. Eskom, the national public utility, "has an almost complete monopoly over electricity generation and transmission", but "[e]lectricity reticulation is a constitutional function of local government".[13] Although the City of Cape Town is almost 100% dependent on Eskom for the generation and transmission of electricity to its 44 bulk intake points, distribution is split between Eskom (21%) and the City of Cape Town's Energy Directorate (79%).[14]

The Energy Directorate is the heart of the City's energy services delivery work and engages vertically, with National Energy Regulator of South Africa (NERSA), National Treasury (NT) and the national Department of Forestry, Fisheries and the Environment (DFFE) and the Department of Mineral Resources and Energy (DMRE); and horizontally, with other departments in the City, such as the Department of Human Settlements.

- The Electricity Generation and Distribution (EGD) Department interacts directly with customers, including electricity consumers and embedded generation producers; and is responsible for transaction, metering and billing systems for small-scale embedded generation (SSEG) and wheeling customers; and distribution grid investments to enable renewable energy expansion.
- The SEM Department provides critical new skills, as well as research and innovation, and communication campaigns for sustainable energy and market liberalization transition; and interacts with academia and non-profit organizations on development solutions, and donor organizations that support its work.

The Energy Directorate is driving the City's work on low-income energy access, exploring how to enable a service delivery system that includes choice, is affordable and optimizes clean energy and is also researching battery storage, independent power producer (IPP) procurement and conducting grid impact studies. The main research areas are energy and climate data, generation development and municipal operational efficiency, renewable energy and energy efficiency facilitation, and energy poverty alleviation (see Appendix A).

FIGURE 3
Map of the distribution infrastructure capacity and ownership[15]



Historically a vertically integrated monopoly, Eskom is in the process of unbundling into three entities: generation, transmission and distribution. Additionally, other entities are also being established including the Independent System and Market Operator (ISMO), the CPA (Central Purchasing Authority), a Distribution System Operator company (broken into 5 geographical areas) with the municipality becoming a standalone municipal distribution system operator. The electricity generated by Eskom supplied in bulk to municipalities, including metros, and large clients, mostly commercial and industrial. Up until 2020, Eskom was the only buyer allowed to purchase electricity from Independent Power Providers.

Eskom owns most of the power plants in South Africa, with three of these plants located within the Cape Town metro area (Table 2). In addition, unlike other metros, Cape Town has its own plants, which are largely used for arbitrage[iii] and loadshedding[iv] mitigation and so not considered part of the supply sources for meeting customer demand.

TABLE 2 Power plants relevant to Cape Town

Plant	Capacity (MW)	Owner	Within metro area	Notes
Koeberg nuclear plant	1,840	Eskom	Yes	Feeds into national grid (5% of national grid mix).
Ankerlig diesel-fired peaking plant	1,327	Eskom	Yes	Feeds into national grid. It has local air pollutant impacts and is increasingly used by Eskom to mitigate loadshedding.
Acacia jet kerosene plant	171	Eskom	Yes	Serves as back-up power for Koeberg nuclear power station.

iii A cost-saving technique where electricity is purchased during off-peak times for storage (e.g., pumped storage, batteries, etc.) and then discharged during peak times.
iv Loadshedding is a controlled way of rotating the available electricity between all customers.

Plant	Capacity (MW)	Owner	Within metro area	Notes
Steenbras pumped storage	180	City	Yes	Uses more electricity than it generates. Mainly used for arbitrage and (more recently) for loadshedding mitigation.
Small-scale embedded generation (SSEG)	86	Private	Yes	Grid-tied systems, mainly rooftop photovoltaic (PV), within the City distribution area. No data is available for Eskom distribution areas.*
Athlone jet kerosene plant	36	City	Yes	Mainly used for loadshedding mitigation in recent years. It is uneconomic to run.
Roggebaai cycle gas turbine	42	City	Yes	Mainly used for loadshedding mitigation in recent years. It is uneconomic to run.
Darling Wind Farm	5.2	Private	No	The City buys a share (not all) of this plant's electricity.
Micro-hydro	2.8	City	Yes	Used to supplement electricity demand of City water treatment plants.

*Note: *At time of writing, Eskom does not offer a formal/legal process to connect PV systems to the grid in Eskom distribution areas. Therefore, residential PV systems in these areas could be considered illegal and uncounted.*

TABLE 3 Cape Town Energy System Stakeholders

Government	Non-profit	Private sector	Academia	International funding organizations
National Treasury/ City Support Programme (NT/ CSP) National DFFE National DMRE Western Cape Provincial Government City of Cape Town Energy Directorate (EGD and SEM departments)	South African Photovoltaic Industry Association (SAPVIA) Green Building Council South Africa (GBCSA) GreenCape Western Cape Economic Development Partnership (WCEDP) Sustainable Energy Africa (SEA) Community Organisation Resource Centre (CORC) Slum Dwellers International (SDI)	Consultants, e.g., Global Carbon Exchange (GCX) and Ecolution Renewable energy project developers Aggregators/ traders, e.g., PowerX or Energy Exchange	University of Cape Town (UCT) Stellenbosch University (SU) University of the Western Cape (UWC)	GIZ, German Development Agency C40 Cities United States Agency for International Development (USAID) International Finance Corporation (IFC)

CAPE TOWN'S RESILIENCE JOURNEY

In 2016, the City of Cape Town joined the 100 Resilient Cities (100RC) program[v] and, in 2017, appointed its first Chief Resilience Officer. With the support of the 100RC program and in the aftermath of the 2015-2018 drought, the City developed its first Resilience Strategy, which was approved in 2019. The strategy was produced following extensive engagement with stakeholders, including business, academia and civil

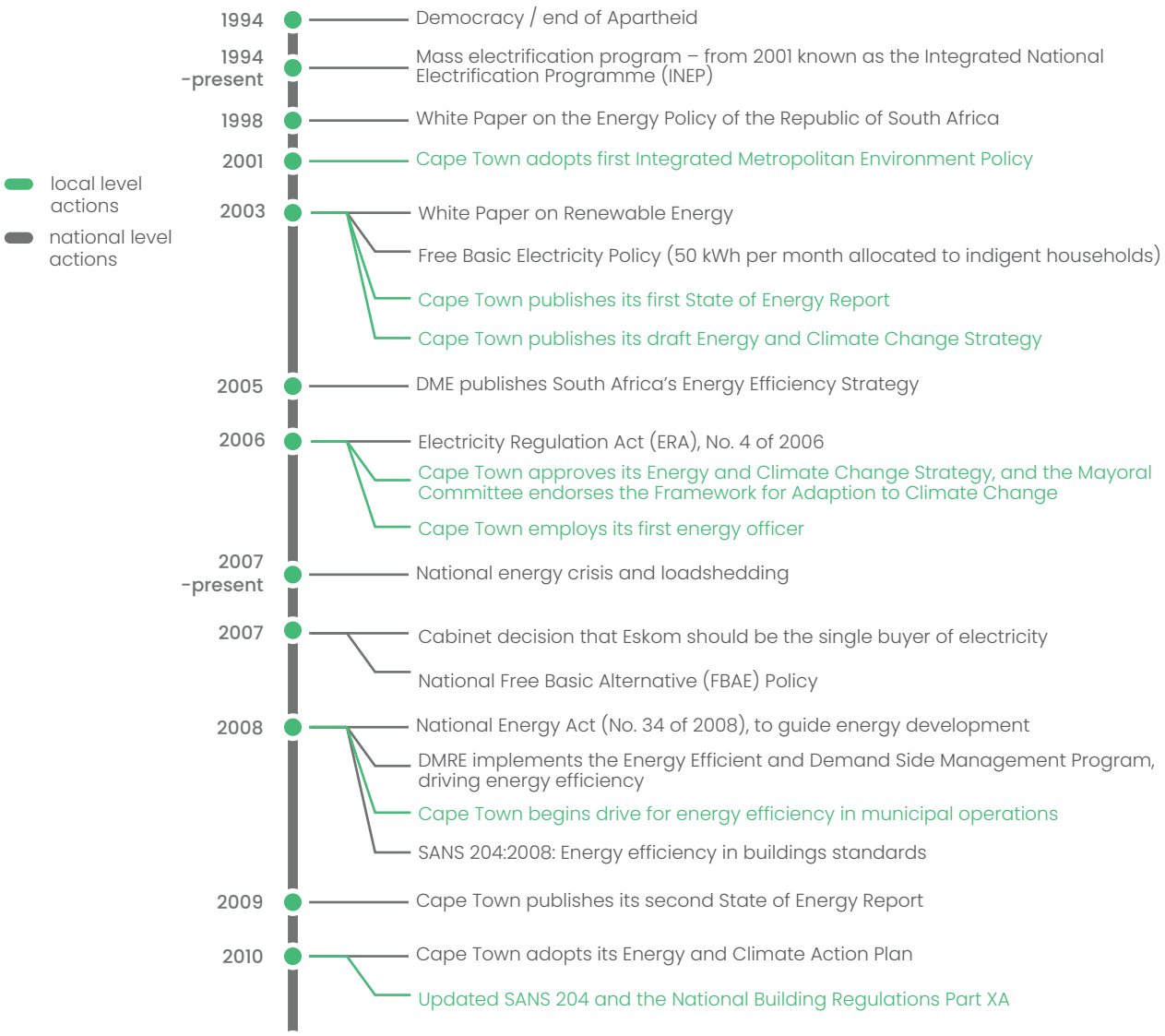
v Cape Town is one of 10 African cities in the network. The other cities are Accra, Addis Ababa, Dakar, Durban, Kigali, Lagos, Luxor, Paynesville and Nairobi.

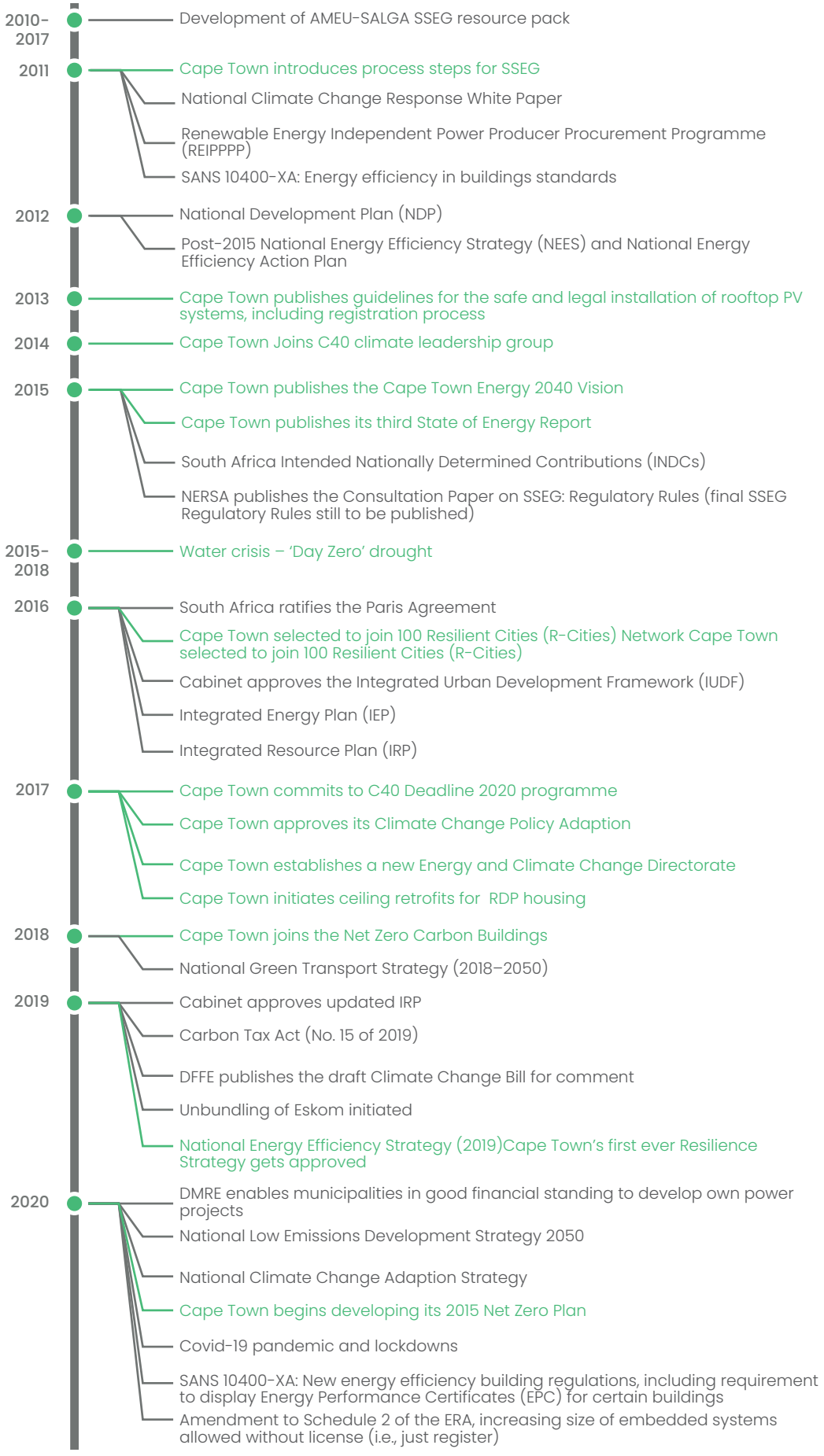
society, and household surveys conducted across the city. Resilience is a guiding principle of the City's Integrated Development Plan (IDP).

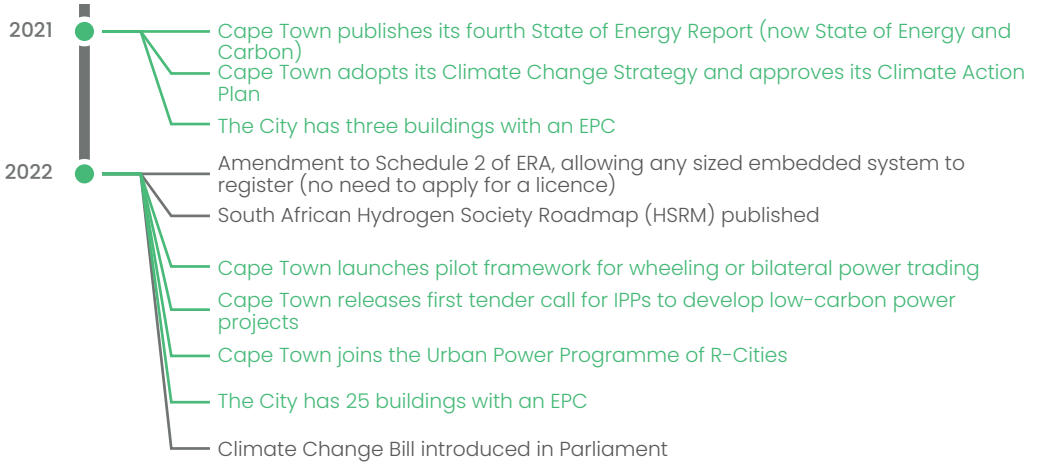
The Strategy comprises five pillars, 20 goals and 75 actions, of which 24 have implications for the power sector or are directly managed by the Energy Directorate. The shocks and stresses to which the Strategy responds are:

- Prioritised shocks: infrastructure failure, gale-force winds, civil unrest, financial/economic crisis, cyber-attack, power outage, fire, drought, rainfall flooding and heatwaves.
- Prioritised stresses: climate change, informal settlements, substance abuse, crime and violence, lack of social cohesion, traffic congestion, food insecurity, poverty and inequality, trauma, insecure municipal finances, rapid urbanisation and unemployment.

FORMATIVE EVENTS IN CAPE TOWN'S HISTORY DRIVING RESILIENCE AND CLIMATE ACTION




2010-2017
Development of AMEU-SALGA SSEG resource pack
2011
Cape Town introduces process steps for SSEG
National Climate Change Response White Paper
Renewable Energy Independent Power Producer Procurement Programme (REIPPPP)
SANS 10400-XA: Energy efficiency in buildings standards
2012
National Development Plan (NDP)
Post-2015 National Energy Efficiency Strategy (NEES) and National Energy Efficiency Action Plan
2013
Cape Town publishes guidelines for the safe and legal installation of rooftop PV systems, including registration process
2014
Cape Town Joins C40 climate leadership group
2015
Cape Town publishes the Cape Town Energy 2040 Vision
Cape Town publishes its third State of Energy Report
South Africa Intended Nationally Determined Contributions (INDCs)
NERSA publishes the Consultation Paper on SSEG: Regulatory Rules (final SSEG Regulatory Rules still to be published)
2015-2018
Water crisis – 'Day Zero' drought
2016
South Africa ratifies the Paris Agreement
Cape Town selected to join 100 Resilient Cities (R-Cities) Network Cape Town selected to join 100 Resilient Cities (R-Cities)
Cabinet approves the Integrated Urban Development Framework (IUDF)
Integrated Energy Plan (IEP)
Integrated Resource Plan (IRP)
2017
Cape Town commits to C40 Deadline 2020 programme
Cape Town approves its Climate Change Policy Adaption
Cape Town establishes a new Energy and Climate Change Directorate
Cape Town initiates ceiling retrofits for RDP housing
2018
Cape Town joins the Net Zero Carbon Buildings
National Green Transport Strategy (2018–2050)
2019
Cabinet approves updated IRP
Carbon Tax Act (No. 15 of 2019)
DFFE publishes the draft Climate Change Bill for comment
Unbundling of Eskom initiated
National Energy Efficiency Strategy (2019)Cape Town's first ever Resilience Strategy gets approved
2020
DMRE enables municipalities in good financial standing to develop own power projects
National Low Emissions Development Strategy 2050
National Climate Change Adaption Strategy
Cape Town begins developing its 2015 Net Zero Plan
Covid-19 pandemic and lockdowns
SANS 10400-XA: New energy efficiency building regulations, including requirement to display Energy Performance Certificates (EPC) for certain buildings
Amendment to Schedule 2 of the ERA, increasing size of embedded systems allowed without license (i.e., just register)


2021
Cape Town publishes its fourth State of Energy Report (now State of Energy and Carbon)
Cape Town adopts its Climate Change Strategy and approves its Climate Action Plan
The City has three buildings with an EPC
2022
Amendment to Schedule 2 of ERA, allowing any sized embedded system to register (no need to apply for a licence)
South African Hydrogen Society Roadmap (HSRM) published
Cape Town launches pilot framework for wheeling or bilateral power trading
Cape Town releases first tender call for IPPs to develop low-carbon power projects
Cape Town joins the Urban Power Programme of R-Cities
The City has 25 buildings with an EPC
Climate Change Bill introduced in Parliament

SNAPSHOT: CAPE TOWN'S ENERGY SYSTEM

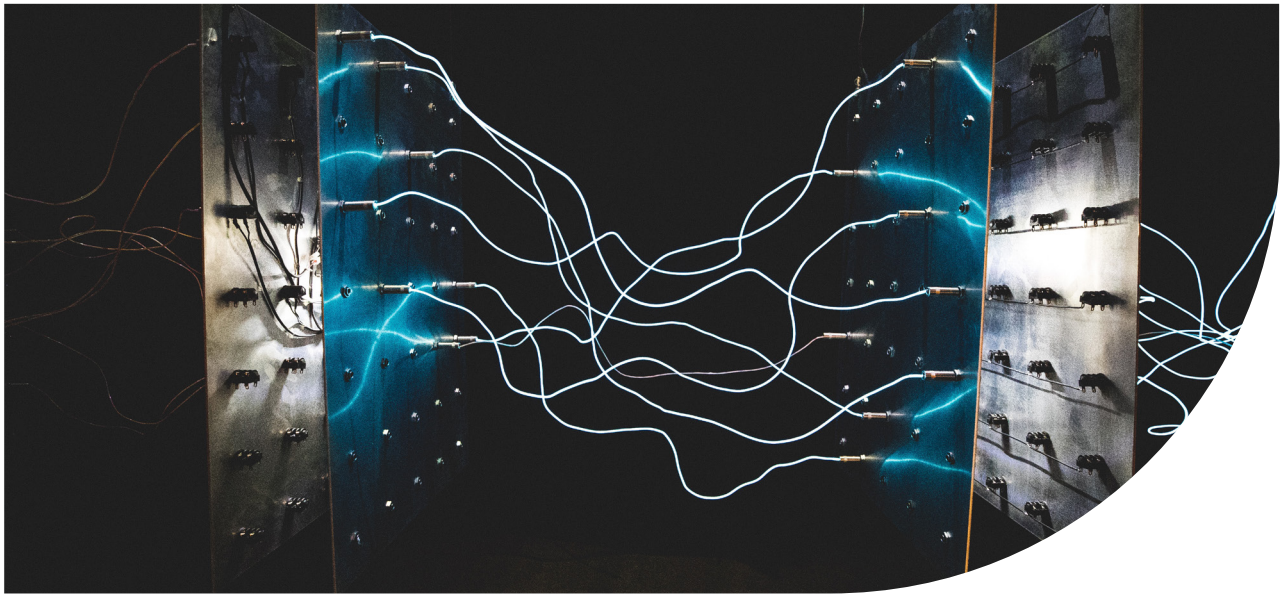
Less than 0.5% of the metro's electricity demand is sourced from IPPs and SSEG (Table 4).Energy System Vulnerability

TABLE 4 Cape Town's energy system

City Energy Sector Statistics	
Annual electricity supply (2018)	12,050 GWh
From electricity utility	12,040 GWh
From RE independent power producers	5 GWh
From SSEG (total generated)	43 GWh
Energy system losses (2018)	10.5% (9.2% national)
Residential consumption (2018)	2,828 GWh/month
Commercial consumption (2018)	4,249 GWh/month
Industrial + special consumption (2018)	1,095 GWh/month
Official + (street lighting) PL consumption (2018)	355 GWh/month
Electricity access (2020)*	
City**	98% (91% informal dwellings)
National	94% (74% informal dwellings)
System Average Interruption Duration Index (SAIDI)	3.11 (36.9 national)
System Average Interruption Frequency Index (SAIFI)	0.74 (14.4 national)

Goals and Targets
City RE target: Net zero carbon by 2050
National RE target: 27,464 MW by 2030
National Determined Contributions (NDCs): By 2025: 398-510 MtCO2e By 2030: 350-420 MtCO2e By 2050: net zero emissions
Climate Change Bill [B9-2022]: in Parliament

*Notes: *Derived from Stats SA (2020) General Household Survey, using "electricity used as main energy source for lighting" as proxy for electrification, whether legal or illegal. **Includes households that access the main grid regardless of whether the connection is legal or not.*



ENERGY SYSTEM VULNERABILITY

The City of Cape Town's energy system is inextricably linked to local, national and global systems, and the energy sector is often called the 'lifeblood' of a city due to the numerous interdependencies with other services (Figure 4).

SHOCKS	Description	Impact on system	Potential impacts on city
Drought	The frequency and severity of droughts are expected to increase.	Reduction in energy capacity, hydro storage capacity and city's ability to mitigate loadshedding	Blackouts (loadshedding) unfavorable public opinion.
Fire, gale-force winds, flooding	Cape Town is vulnerable to increased frequency and severity of these climate-related shocks.	Damage to infrastructure (e.g., power lines).	Increased costs for maintaining and upgrading distribution systems, reduced ability to cross-subsidize tariffs.
Power outage	Almost 100% of electricity is from the national utility, Eskom, which is struggling to meet the country's energy demand, resulting in loadshedding.	Damage to distribution infrastructure because of shutting down/starting up the system, theft of copper cables when system is off.	Reduced service quality, reduced demand (economic shock), unfavourable public opinion. Consumers that can afford it, go partially off the system affecting the financial and cross subsidization model. Downturn in economic growth and jobs due to lack of power.

STRESSES

 **Technology and generation risk**	Koeberg Nuclear Power Station, which is located within the city's boundaries but is managed by Eskom and falls under the Nuclear Regulator, licence expires in 2024.	Loss of power generation capacity during major refurbishments to extend lifespan by 20 years.	Service interruption, risk of nuclear incident.
 **Poverty and inequality**	Almost a third (28.2%) of households live in poverty, with inadequate/insecure income, poor health, a low living standard and disempowerment.	Historically, the City has relied on electricity sales to high-use, wealthier households, and small businesses to cross-subsidize basic services, such as energy, sanitation and water, to poor households.	Municipal business model is affected, as the City's capacity for cross-subsidizing services for the poor is reduced if high-use households and commercial sector users increase energy efficiency and move to renewable energy option
 **Rapid urbanization and in-migration**	Increased in-migration to the city puts additional strain on the ability of people to access services, jobs and housing opportunities.	In-migration (mostly poor people) results in an increased share of the population living in low-income and informal settlements and unable to pay for services.	Financial and technical challenges in meeting the energy service needs of a significant share of the city population, resulting in service backlogs.
 **Informal settlements**	Illegal connections to the local grid are common in informal settlements where people cannot afford to pay for services.	Damage to local infrastructure, loss of income, human safety risks.	Reduced service quality, increased tariff to recoup the cost of non-technical losses.
 **Insecure municipal finances**	Higher-income consumers move off the grid and embrace RE solutions, including solar PV.	Lost revenue, lack of maintenance of the grid.	Reduced ability to cross-subsidize services to low-income households and less income to maintain the grid unless tariffs are not restructured.
 **Vandalism and Theft**	Vandalism and theft of electricity infrastructure is on the increase, influenced by the impacts of poverty and apartheid spatial planning	No public lighting, making areas more unsafe; theft of infrastructure, especially copper wire.	Service disruption, higher costs, unsafe communities. Need for alternative public lighting options for informal settlements not connected to the grid.

TABLE 5 Critical interdependencies with other urban systems

Transport
The move towards a future all-electric transport system will be critically dependent on electricity services. Currently, loadshedding affects both rail and road transport. • Services on Cape Town's extensive electric rail system are suspended when loadshedding results in the malfunctioning of substations that feed power to move trains. • Cold-chain storage and refrigeration are vulnerable to power outages, which could lead to problems with food quality, especially for food imports from outside Cape Town that are transported in electric vehicles. • The appetite for switching to electric vehicles is affected by the concern over the grid capacity constraints and cost of EVs due to 100% importation.
Water and sanitation
Electricity is used to run the pumps that treat and distribute water. The City of Cape Town has 26 wastewater treatment plants and 17 water treatment plants. Power failures could lead to plants being shut down or infrastructure being damaged, resulting in sewage leaks, water cuts or water-quality problems. In a recent incident, residents were told to boil their water before drinking it.[16]
Housing and health
Energy-inefficient buildings represent a financial drain on households and the economy. Many of the older government-delivered housing units have no ceilings, increasing the tuberculosis health burden due to condensation on the inside of the roof. Residents in informal dwellings made of aluminium/steel materials are vulnerable to extreme weather due to lack of insulation. Measures to improve thermal comfort are required. More stringent energy efficiency requirements would reduce utility costs and improve health, but could mean higher costs, resulting in fewer low-cost housing units being provided due to the limited housing budget.
Waste
Cape Town needs an improved waste management system that meets its growing demand. With less than 10 years of landfill space left in the city, Cape Town has been exploring opportunities for alternative waste disposal systems.[17] The City has been looking into the feasibility of complimenting its existing energy sources through waste to energy conversion, which can help lessen the burden on current waste management and disposal options while supporting the city's capacity to generate alternative, and clean, energy resources.

CASE STUDIES: OVERCOMING CHALLENGES

ALTERNATIVE PUBLIC LIGHTING SCHEME

Safety and security

Loadshedding/ power outage

Informality and access to energy

CONTEXT

Crime and violence are key stresses on the city of Cape Town. In many townships and informal settlements, particularly those not connected to the grid where streetlights are not possible, high-mast lighting is used. However, these lights offer a poor level of lighting, equivalent to a full moon and often do not cover the full area. As a result, high-mast areas become crime hotspots, with criminals finding it easy to rob people blinded by the brightness as they emerged from darker pathways. Residents are often afraid to leave their houses at night to use the shared toilets located in the area, and instead use buckets inside their homes, but many must leave home in the dark to undertake long commutes to work. The high-mast lights are also difficult to maintain, as they are targets of vandalism (such as being shot out) and informal shacks are built around their bases.

THE SOLUTION

In informal areas or areas serviced by high-mast lighting, solar powered lighting offer an alternative. The lights are installed above the front doors of households and provide adequate lighting, improving visibility and safety for residents.

- The **PJS Informal Solar Projec**t in Khayelitsha has provided 750 solar powered lighting devices for outdoor lighting.
- The community was involved in installing and maintaining the lights, which resulted in low levels of theft and vandalism.
- The pilot project experienced technical challenges with the lighting devices that were overcome.
- The City of Cape Town is undertaking a evaluation and cost-benefit analysis, to motivate for the City to adopt solar powered lighting alternatives as a formal approach to public lighting.

A short video on the PJS project can be found here:

RESILIENCE QUALITIES

- The solar lighting improves the safety and security of residents, as well as offering entrepreneurial opportunity, contributing to more **resilient** communities.
- The solar lighting approach is **integrated**, with community involvement and ownership of the infrastructure.
- Using solar energy makes the public lighting **resilient** in the face of power outages.
- Rooftop-mounted solar lighting is **robust** and has a relatively low capital cost. However, careful financial planning is required to ensure its long-term inclusion into the City's procurement practices and maintenance procedures, especially as entrepreneurial and community-ownership opportunities are often challenging to integrate into the public procurement procedures.

CASE STUDIES: OVERCOMING CHALLENGES

'MAYPOLE' ELECTRIFICATION IN INFORMAL SETTLEMENTSE

Rapid urbanization and health

Poverty and inequality

Informality and access to energy

CONTEXT

Informal urban settlements are the fastest-growing type of household in Cape Town, tend to be much more dynamic than formal settlements and will likely require re-planning, network modifications and new connections. Providing electricity services into these unplanned, crowded and non-linear developments raises issues of legality, financial viability and technical feasibility. Twenty-five years ago, the City's Electricity Department was charged with implementing informal settlement electrification, which was initially done using underground copper cabling. However, this approach was too cumbersome and costly for fast-changing settlements where cable theft and illegal 'on-selling' were common.

THE SOLUTION

Blanket electrification of informal settlements through aerial reticulation ('maypole') provides a flexible and cost-effective approach with simple household service connections. Nine-meter-tall maypoles provide enough elevation to connect up to 27 households and can accommodate up to three pole boxes, each with nine connection points. The supply goes into a distribution board, with sockets and a light, which satisfies the regulatory safety requirements and allows the owner to extend the network inside the dwelling with extension leads.

- Prepayment split-type meters are used, with active units mounted on the pole and just the keypad in the house to reduce tampering.
- Area or 'blanket' coverage, with no upfront connection charge (charges are recovered over time) ensures economies of scale and enables even the poorest households to get access to electricity.
- Good community liaison is a vital part of the successful electrification of informal communities. For instance, a demonstration truck was driven around the communities in the early days to demonstrate the benefits and safe use of electricity

RESILIENCE QUALITIES

- Households with a formal electricity connection who qualify can receive free basic electricity subsidy or cross-subsidized units, boosting household budgets.
- Households are healthier, with fewer incidences of fire or poisoning from dirty and dangerous fuels.
- Community safety is improved through better outdoor lighting.
- The maypole approach is reduces illegal connections, as most communities respect a clear demarcation of areas that will / will not be electrified.
- Fewer illegal connections result in optimal use of the infrastructure, generating a greater return on investment.

LEGAL AND INSTITUTIONAL ENVIRONMENT

South Africa has a cooperative system of governance, with "three distinctive, interdependent and interrelated spheres of government (national, provincial and local) that operate according to the principles of cooperative government and intergovernmental relations".[18] The Constitution confers powers and functions on the three spheres – local government's functional areas are listed in Schedules 4B and 5B and include electricity reticulation, while other functions are assigned to local government by legislation. Municipalities are constitutionally mandated to pursue the provision of sustainable and equitable services for all, in a way that promotes socio-economic development and environmental protection. Their powers and functions include building codes, air quality regulation, disaster management, and the provision of infrastructure and related services, such as electricity, water, sanitation and waste management.

Although municipalities exercise considerable authority over urban functions, they are subject to national and/or provincial legislation and regulations, which are often poorly aligned. This is the case in the energy sector. For instance, the policies include national energy efficiency and renewable energy targets but do not clearly identify the municipal mandate and associated resources, or how these translate into performance measures.[19]

In the energy sector, national government sets policies and develops plans, and oversight lies with the DMRE. Municipalities may "develop policy and legislate on energy efficiency, renewable energy and waste management".[20] Recent shifts in policy and regulations have opened up opportunities for metros to procure energy from independent power producers who mainly support renewable energy.

In addition, although not a direct stakeholder in the energy value chain, the South African Local Government Association (SALGA) is constitutionally mandated to represent the interests of local government. It coordinates local government comments on various national policies, regulation and strategies, and supports local government transformation.

TABLE 6 Governance of the energy sector

Institution	Role
	Oversight, policy-setting and planning
Department of Minerals Resources and Energy (DMRE)	• Custodian of all energy policies and energy security. • Drafts power sector legislation, policies, plans and strategies (e.g., NEES). • Produces the IRP for national electricity production to which all new electricity generation needs to align. • Oversees the Independent Power Producer** Procurement Programme (IPPPP) office, a joint venture of DMRE, National Treasury and the Development Bank of Southern Africa (DBSA) that offers procurement and contract management services and monitors progress of REIPPPP.
Department of Public Enterprises (DPE)	• Oversees efficiency and financial sustainability of all state-owned enterprises including Eskom.
Department of Forestry, Fisheries and the Environment (DFFE)	• Drafts climate policy and legislation on air quality, promotes clean, efficient energy in line with international obligations.
National Treasury	• Provides economic policy and sets national budget. • Manages public spending in accordance with Public Finance Management Act (PFMA) and Municipal Finance Management Act (MFMA), which govern financial management within government. • Equitably distributes nationally raised revenue among all spheres of government. • The City Support Programme supports metros through enabling policy environment fiscal frameworks.
Department of Cooperative Governance and Traditional Affairs (DCOG)	• Coordinates communication and cooperation among all spheres of government: national, provincial and local. • Supports municipalities to deliver core services of electricity supply.
Department of Trade, Industry and Competition (dtic)	• Drafts commercial and industrial policy to promote inclusive and equitable economic development.
National Planning Commission (NPC)	• Drafts, promotes and monitors implementation of the NDP. • Consults public on pathways for a just transition in line with the NDP.
Just Energy Transition Partnership	• Mobilize Resources to accelerate the decarbonisation of South Africa's economy to help it achieve the ambitious goals set out in South Africa's updated Nationally Determined COntribution emissions goals
Presidential Climate Change Coordination Commission	• Advise on South Africa's climate change response, including mitigation and adaptation efforts to climate change and its associated impacts. Provide independent monitoring and review of South Africa's progress in meeting its emissions reduction and adaptation goals.
	Regulatory agencies
National Energy Regulator of South Africa (NERSA)	• Regulates the electricity, piped gas and petroleum industries. • Grants licences for electricity generation, transmission, distribution, trade and import/export. • Regulates electricity tariffs of sellers and resellers. • Provides rules for policy implementation. • Enforces performance and compliance requirements.
National Nuclear Regulator (NNR)	• Regulator of nuclear industry, around safety and authorization related to construction, operation and decommissioning of nuclear plants.
	Generation and Distribution
Eskom	• State-owned utility that generates the vast majority of electricity in the country. • Until 2020, the only buyer allowed to purchase electricity generated from IPPs.
Local or district municipalities	• May be electricity distributors.
Development Bank of South Africa (DBSA)	• Finance institution owned by national government. • Implements/manages energy infrastructure programmes, including the REIPPPP, the Climate Finance Facility, and the Embedded Generation Investment Programme.

KEY REGULATORY RESPONSIBILITIES OF NERSA

The Electricity Regulation Act states that the Minister of the DMRE may make regulations regarding:

- Activities that need to be licensed or only registered (the latter is less onerous), based on certain cut-off points, such as power plant size.
- Standards and norms on electricity quality of supply, as well as health, safety and the environment.
- New electricity generation and its source (e.g., renewable), as well as shares of total electricity to be generated by different sources.
- Private sector participation in electricity generation.

Any changes to existing, or the creation of new, electricity-related regulations, must be done in consultation with NERSA, and be published in the Government Gazette for public consultation. The Regulator's (NERSA) key responsibilities include:

- Licensing of electricity generation, transmissions, distribution, trade, and import or export.
- Regulating electricity tariffs of electricity sellers/resellers such as Eskom and local municipalities.
- Providing rules for the implementation of national policy and plans, such as the IRP.
- Establishing a national electricity-related information and monitoring system, which integrates with other national information systems. This system includes data on the number, capacity, technology type and output of all licensed power plants.
- Enforcing performance and compliance requirements, as specified in license conditions.
- Mediating disputes among electricity stakeholders (generators, transmitters, distributors and customers).

STAKEHOLDER ENGAGEMENT AND PARTICIPATORY DECISION-MAKING

The City engages with the RE industry on an ongoing basis and has a wealth of data and resources that are available to the public.

- The Climate Action Plan had an extensive engagement process supported by independent facilitators from the WC Economic Development Partnership.
- The City led an SSEG registration campaign, and its website includes sections on SSEG guidelines[21] and on IPPs.[22]
- The City's Energy, Waste and Water Forum is a platform for businesses to gain access to information and to learn from each other.
- The City's open data portal includes a Maps Viewer that has maps with 'layers' of network detail on distribution network capacity and the grid's ability to support embedded generation.[23] The city also has available State of Energy & Carbon Reports and associated data sets.
- The City has run communication campaigns on energy efficiency, sustainable living and building guides, and developed a 'Smart Kids' TV show. The City Transversal Education Forum is an internal department that consolidates all City department communications.

*Notes for table on previous page: *Competitive tender process designed to facilitate private sector investment into grid-connected renewable energy generation **Independent Power Producer (IPP): A consortium, typically including black industrialists, shareholders (local and foreign) and a community trust (representing local communities where the project is located), that owns and manages privately-owned power plant(s).*

NATIONAL POLICY FRAMEWORK

- **The Electricity Regulatory Amendment Act** (ERA, 2006) governs electricity, including the reticulation authority assigned to municipalities/distribution utilities.
- The **National Climate Change Response Policy White Paper** (2011) contains South Africa's vision for the long-term, just transition to a climate-resilient and lower-carbon economy and society. It is guided by the principles set out in the Constitution, the Bill of Rights, the National Environmental Management Act, the Millennium Declaration and the UN Framework Convention on Climate Change.
- **South Africa's Low Emission Development Strategy 2050 (2018)** outlines the research, technology development and transfer needs as the country transits to low carbon emissions development.
- The **National Energy Efficiency Strategy (2019)** is based on the White Paper on Energy Policy (1998) and determines how to improve energy utilisation, mainly through improvements in energy intensity and decoupling economic growth from energy demand.
- The **National Climate Change Adaptation Strategy (2020)** provides a common vision of climate change adaptation and climate resilience for South Africa, and outlines priority areas for achieving this vision.
- The **Carbon Tax Act (2019)** provides for the imposition of a tax on the carbon dioxide equivalent of greenhouse gas (GHG) emissions. This Act, together with taxation law amendments means that the City will be liable to pay carbon tax through Certified Emission Reductions via Carbon Offsetting Regulations (2019).
- The **Climate Change Bill**, which is currently being finalized, requires local governments to prepare climate change needs, response assessments and associated climate action plans.

LOCAL POLICY FRAMEWORK

- In 2021, the City updated its integrated **Climate Change Strategy** and launched its **Climate Change Action Plan (CCAP)**, which recognizes the need for resilience, and equitable access to essential services, alongside ambitious mitigation actions in order to reach a goal of net zero carbon by 2050.[vi]
- The City's **IDP** recognizes resilience, through resource efficiency, climate responsiveness and poverty reduction, as foundational to future prosperity and inclusivity.
- The City has drafted an **Energy Strategy** to ensure a cost-effective and cohesive approach to the energy transition, with commitments to energy security, power utility reform and sustainability, grid investment, energy efficiency and poverty alleviation.

KEY REGULATIONS AND INCENTIVES

- In 2011 the **New Generation Regulations** were added to enable the establishment of the REIPPPP under the Single Buyer (assigned to Eskom) model.
- In 2013, in the absence of national standards for solar PV on buildings, the City of Cape Town published guidelines promoting the safe and legal installation of distributed renewables in commercial and residential settings.
- In 2020, **ERA was amended to allow municipalities to buy from IPPs**, if aligned with the national electricity build plan, and Schedule 2 of ERA clarified that systems above 100 MW need a generation license from NERSA and those between 1 MW and 100 MW need to register with NERSA.
- In 2022, **the Second Amendment Bill of ERA** was published for public comment and included the lifting of

vi Please see Cape Town's CAP for an in-depth explanation of the climate goals and actions that the City is implementing.

the licensing requirements for embedded generators wheeling through the network.

- The **Municipal Finance Management Act and Electricity Pricing Policy** determine that SSEG exports are offset against electricity consumption, i.e., there is net consumption only at this stage, unless the full IPP procurement process is engaged.
- National government introduced a **12L tax incentive** to incentivize energy efficiency that allows for a tax deduction of 95c/kWh saved on energy consumption. This incentive has been very successful in catalyzing efficiency within the industrial sector.
- The City offers an **SSEG export-credit incentive** that is valid to 2025. This incentive of 25c/kWh is on top of the base rate of R0.7551/kWh. As noted above, in terms of regulation, customers must be net consumers, but the City has requested an exemption from this requirement from National Treasury.
- The City is a signatory to the **C40 Net-Zero Carbon (NZC) Buildings Declaration** and is developing by-laws that align with the net zero carbon policy goals listed in the CAP (see Table 7).
- The City **electricity bylaw of 2010** allows for third-party access to the grid for retail wheeling of power (financial transaction) and grid access. This is a pilot introduction of a parallel market environment (embryonic) and will only be allowed, initially, at medium to high voltage connection levels – 11–132 kVA.[vii] The City's wheeling framework (to be rolled out in 2023) will allow private electricity generators to wheel across City's grid.

ENERGY SECTOR TARGETS

The National Energy Efficiency Strategy has a target of 29% reduction in consumption by 2030 (off a 2015 baseline of 12%). In 2019, an energy efficiency target of 21% was achieved, exceeding expectations and driven by the industrial, mining and residential sectors, as a result of national energy efficiency campaigns and increasing electricity prices.[24]

In recent years, the DMRE's REIPPP has resulted in the rapid deployment of renewable energy. By June 2021, 6,422 MW of electricity had been procured from 112 RE IPPs, while 5,250 MW of electricity generation capacity from 81 IPP projects had been connected to the national grid (against a target of 27,000 MW by 2030 in the IRP). Since 2013, a total of 62,949 GWh of energy has been generated by RE sources procured under the REIPPPP.[25]

CAPE TOWN ENERGY AND CLIMATE TARGETS

Table 7 provides an overview of the City of Cape Town's RE, energy efficiency and decarbonization targets

TABLE 7 City energy targets

Area	Target	Progress to date
	100-200 MW utility wind and solar by 2030	First IPP procurement RFP out (Feb 2022) – aim for 200 MW from low-carbon sources. Further planned RFP for 300-500 MW of dispatchable power (storage, gas). 10 MW City-owned solar PV under development in Atlantis and feasibility study underway for 25-60 MW in Paardevlei. The City is planning to install an additional 14 PV systems with a total capacity of about 10-15 MWp.

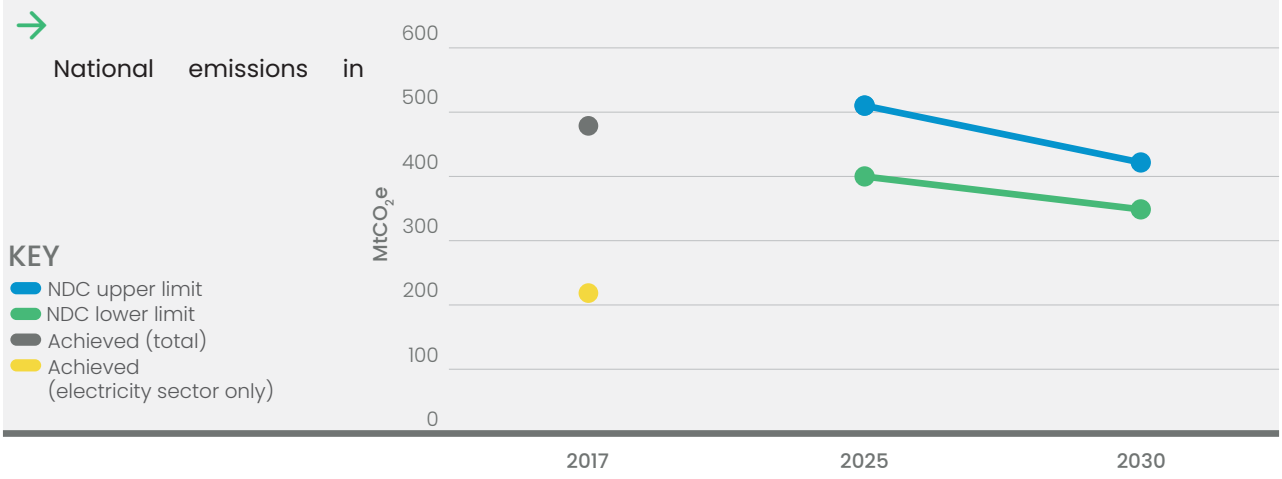
vii There are substantial complexities of energy balancing in an emerging market – in full market, surplus energy is cheap, deficit energy expensive. In the pilot phase, the City will take surplus energy from third party at R0 (i.e., will not pay for it or give credit for it) but will provide deficit energy at the regulated tariff rate.

Area	Target	Progress to date
Decarbonized grid supply	100% clean energy supply by 2050 (indicative quantity: 1,650 MW of RE capacity to reach 80% 'clean' grid supply)	See Table 9 for detail on actions by the City to drive renewable energy uptake.
Municipal buildings	100% net zero carbon municipal buildings by 2030	The target requires that the 100 GWh annual demand from the municipal building portfolio used for administration and services (excludes industrial plants) is reduced and offset by energy efficiency programs and renewable energy generation on City sites by 2030. Municipal efficiency projects across all sectors (street lighting, buildings, wastewater, etc.) projects reduced demand for electricity by 265 GWh (2010–2021). Rooftop PV (0.6 MW is offsetting 749,138 kWh or 0.7 GWh). The municipal utility scale solar mentioned above (e.g., Atlantis and Paardevlei) will be considered for 'own' consumption by the municipality.
Electrification	100% of households	98% electrified, with unelectrified households largely being in Eskom distribution areas (not City mandate) and on land that cannot be electrified (e.g., privately-owned, in a flood plain or under high-voltage transmission lines). The City is investigating the possibility of providing an alternative energy subsidy to residents in informal settlements that are not connected to the grid.

*Notes: *Climate Action Plan, pg. 65*

EMISSIONS REDUCTIONS TARGETS

Since 2008/09, national emissions have stabilized[26] and in 2017 were within the upper and lower bounds required by the NDC by 2025. (Figure 5).



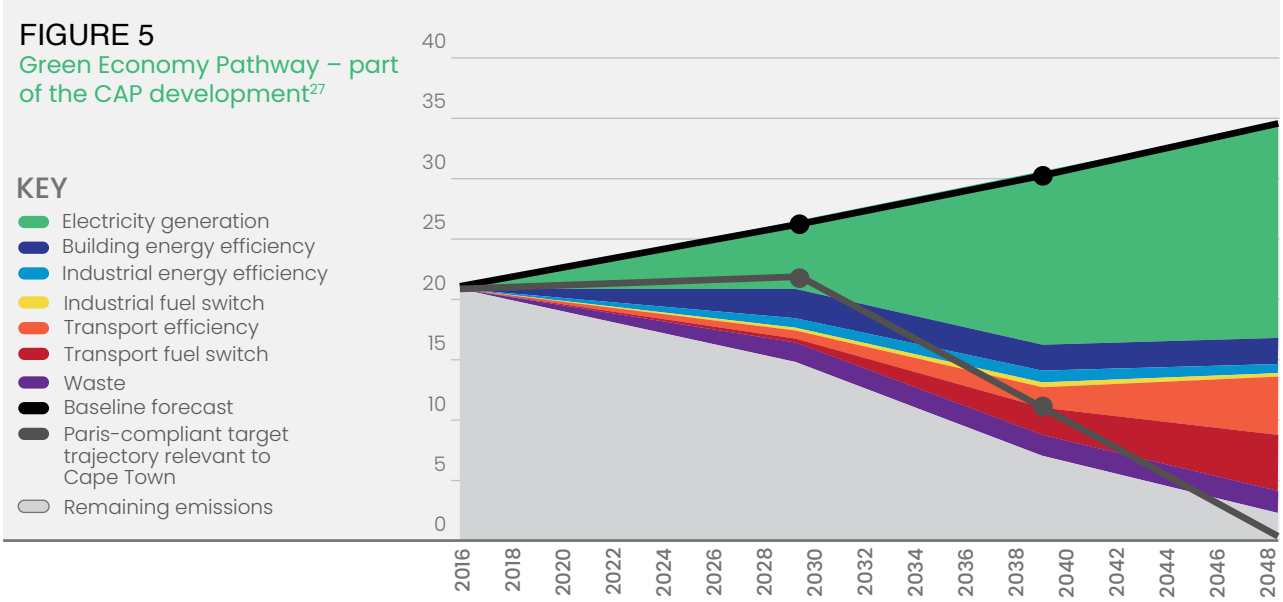
Cape Town has committed to a 9.6% absolute cut in GHG emissions by 2030 (30% reduction in per-capita emissions at current population growth rates) and reaching near carbon neutrality by 2050.

TABLE 8 City emissions targets

Commitment	Target	Progress to date
Climate Change Action Plan (CCAP) / C40 Global Cities Declaration	Aim for net-zero carbon emissions by 2050 across all sectors	This commitment is as a result of being a signatory of the C40 Net-Zero Carbon Buildings declaration and is aligned with national policy goals as per the NDP. City-wide emissions have stabilized and appear to be decreasing.
CCAP / C40 Global NZC Buildings Declaration	All new buildings added from 2030 onwards are net-zero carbon. All existing buildings are net-zero carbon by 2050	This commitment is incorporated within the CAP and Strategy, which includes specific action areas that speak to this goal
	All new and existing municipal buildings to be net-zero carbon by 2030	Between 2009/10 and 2020/21, municipal efficiency projects across all sectors (street lighting, buildings, wastewater, etc.) projects reduced demand for electricity by 265 GWh, saved over 262,735 tCO2e in GHG emissions.

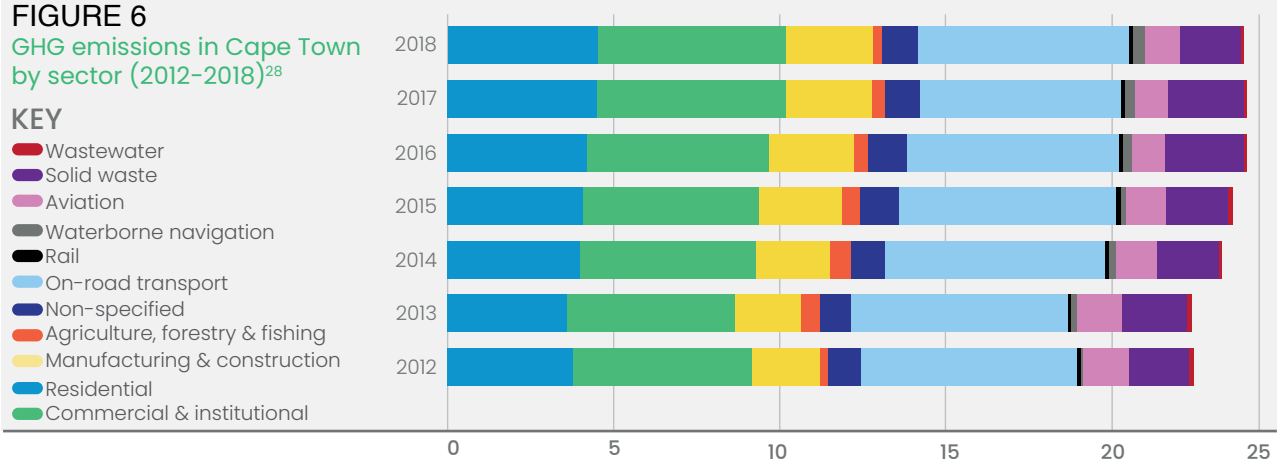
The City does not specify sector targets, but its Green Economy or Net Zero scenario model provides an indication of the sector contributions and main technological disruptions that make this target possible (Figure 6). These include renewable electricity technologies (now competitive), building efficiency (design and technology), battery storage (needed for grid stability) and electric vehicles (dropping prices).[27]

FIGURE 5
Green Economy Pathway – part of the CAP development[27]



As Figure 7 shows, in 2018, the biggest contributor to GHG emissions was the built environment, comprising commercial and institutional and residential sectors that rely on grid electricity, which is mainly coal-fired. The next contributor was the transport sector, reflecting the city's sprawling urban design, which results in long travel distances and a reliance on private vehicles.

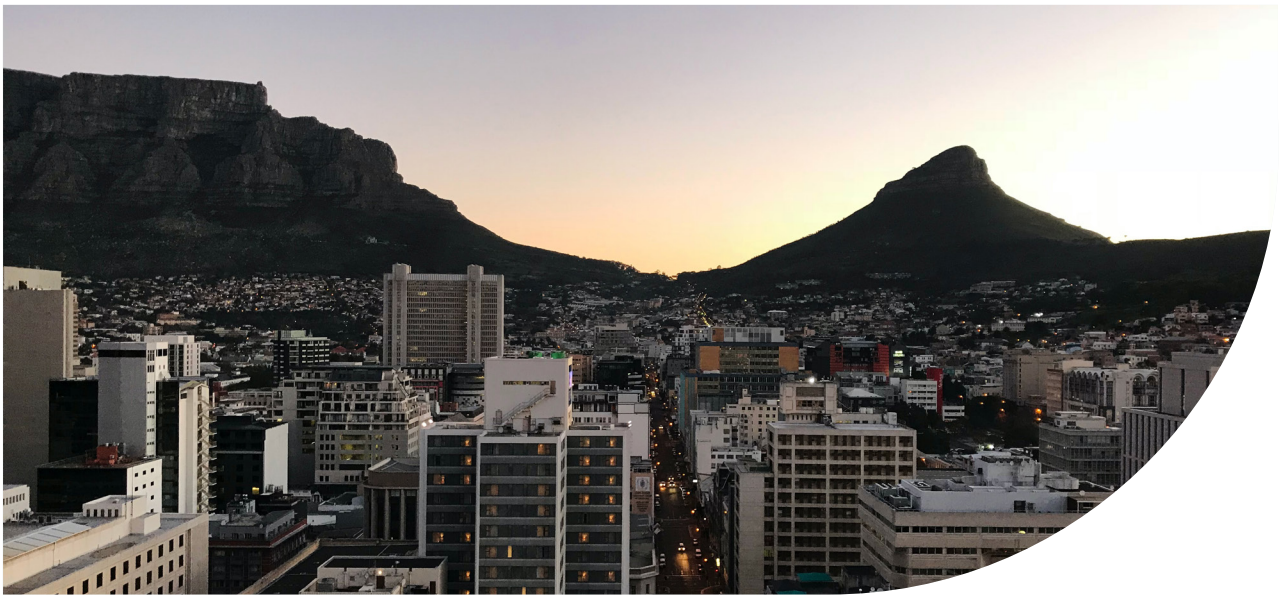
FIGURE 6
GHG emissions in Cape Town by sector (2012-2018)[28]



Note: Data appendices spreadsheet behind this report, available on the City's Open Data portal

In 2018, total energy-related GHG emissions for the City of Cape Town was approximately 21.77 million tCO2e, a decrease of 1.51 million tCO2e since 2012 levels (or 6.5%). This decrease in total emissions reflects in a decrease in per capita emissions from 5.98 tCO2e in 2012 to 4.92 tCO2e in 2018.[29] The residential sector had the largest decrease in emissions compared to the other sectors. Emissions have stabilized, which is likely due to greater energy efficiency and lower electricity demand and economic growth.[30]

The City has been undertaking a substantial retrofit of its buildings since 2008. As a result, between 2009 and 2021, the City reduced demand for electricity by 265 GWh, saving over 262,735 tC02e in GHG emissions.

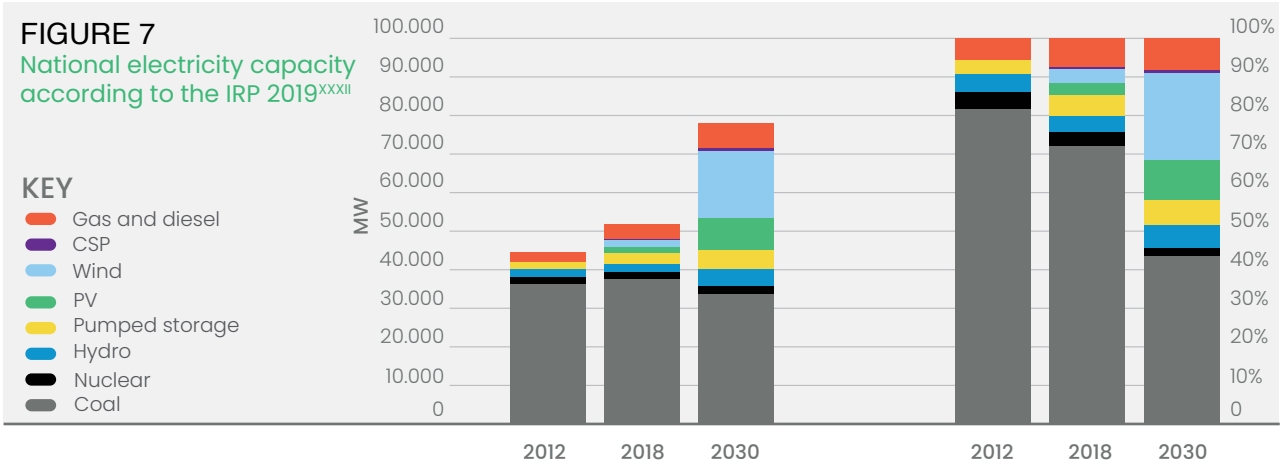


ENERGY SUPPLY AND MARKET

GENERATION CAPACITY

The Integrated Resource Plan 2019[31] is South Africa's long-term plan for electricity generation and includes a national power plant build plan, with a shift towards renewable energy, increasing from 8% (4% wind and solar, and 4% hydro) in 2020 to 33.5% (25% wind and solar, and 8.5% hydro) in 2030 (Figure 8). The City is committed to a local and regional electricity transition in a framework of mutual support with national program.

FIGURE 7
National electricity capacity according to the IRP 2019[XXXII]



In 2022, approximately 86MW of installed SSEG was registered in the city, excluding Eskom supply areas. In total, between 2011 and 2020, Cape Town approved the installation of nearly 42 MW of rooftop solar PV and installed 0.6 MW on City buildings through its rooftop PV programme. In 2018, approximately 850 MWh were generated from 10 rooftop PV systems with a total capacity of 563 kWp installed on municipal buildings. The City has retrofitted all traffic lights with LED lighting and is in the process of retrofitting all high-intensity discharge streetlights with LED fittings.

TABLE 9 RE installed and under development in Cape Town (2022)

Type of RE	Capacity	Under development
On-site generation (registered rooftop solar PV installed within the city boundaries)	86 MW (approx.)*	
Landfill gas		2 MW
Wastewater biogas		4 MW
Solar plant		7-10 MW (in Atlantis)

*Notes: *If unregistered systems were included, this capacity would be higher.*

TABLE 10 CAP actions that are driving RE generation capacity[XXXIII]

Actions	Sub-actions
Promote SSEG uptake among residential, commercial and industrial sectors	Encourage registration through awareness campaigns; establish the network's technical readiness; allow and compensate net generation; consider residential SSEG time-of-use tariffs and fairly compensate customers; investigate and implement cheaper residential advanced metering infrastructure (AMI) costs
Finalize and implement a framework and tariffs for the wheeling of renewable electricity	Implement the wheeling framework (in pilot phase in 2022); explore special wheeling tariffs for green SEZs; clarify accounting rules among City entities to allow for wheeling between entities
Develop a renewable energy roadmap and implement as and when economically viable	Finalise the City's Renewable Energy Roadmap (maximise local supply); identify electricity decarbonization pathways in SSEG, ground-mounted SSEG and IPP Programme; investigate potential of floating solar PV
Invest in transitioning to grid of future	Upgrade control systems for supervisory control and data acquisition (SCADA) and outage management to the advanced distribution management system with integrated distributed energy resources management system
Investigate, prepare, and implement a new utility business model	Aggregate renewable-powered electricity for the industrial sector; design innovative tariffs; unbundle EGD into separate generation, wires and retail businesses, with network cost recovery protected in a cost-reflective network tariff
Focus on customer relations for liberalizing market	Develop a retail trading platform and digital apps; improve communications around tariff-setting methodology

DISTRIBUTION INFRASTRUCTURE AND RE

Before a REIPPPP bid window, Eskom releases a Generation Connection Capacity Assessment that indicates the capacity available to connect new generation to the existing transmission grid. The latest assessment, released before bid window 6, indicated a capacity of 1,820 MW for the Western Cape. This tallies with a Stellenbosch University study, which noted that the installed transformer capacity, at high voltage level, could allow installations of up to 1,329 MWp.[34] The installed transformer capacity, at high voltage level, could allow installations up to 1,329 MWp, but the stability of the grid may be compromised at this level.[35]

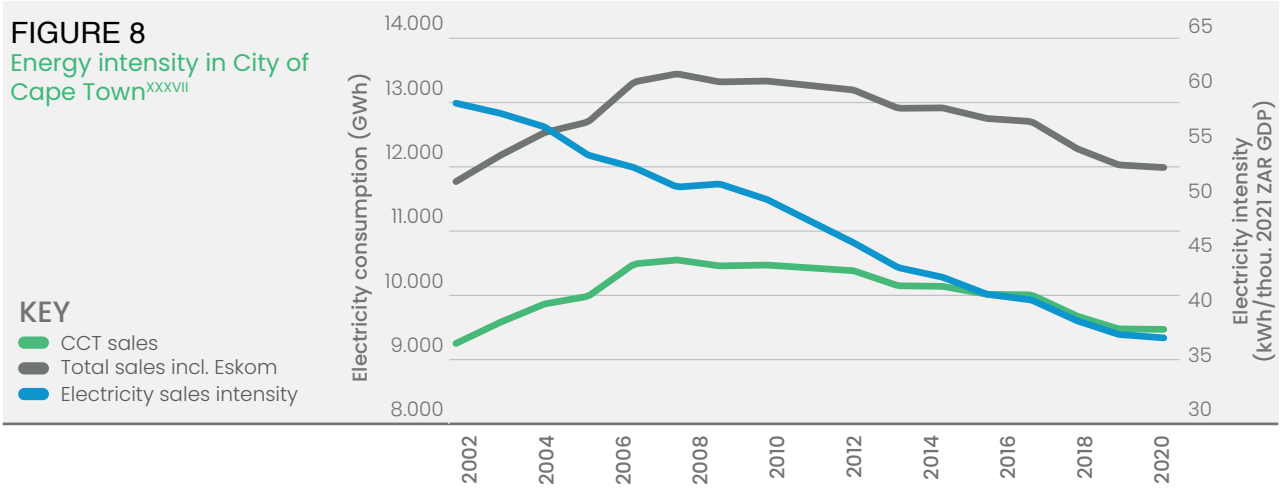
Cape Town's distribution grid is well managed but designed originally for uni-directional flow. Although RE is feasible, any installations above 5 MW will require detailed grid impact studies to be undertaken to know what grid strengthening is required. The City's open-data portal provides access to maps that detail distribution characteristics in support of embedded generation.

LIVELIHOOD AND ECONOMY

The City of Cape Town, in line with the national direction, has seen a substantial improvement in energy intensity, which was about 37 kWh/GDP in 2021, a dramatic decrease from nearly 60 kWh/GDP in 2003. A similar situation is unfolding across all the country's metros, where economic growth may be higher, but electricity demand is reducing at a higher rate than in other local municipalities.[36] This efficiency is largely due to above-inflation electricity price increases.

Detailed information about employment and investment in the energy service market in Cape Town is not available. However, investigations have been undertaken at national level to assess the potential job creation and investment from renewable energy generation.

FIGURE 8
Energy intensity in City of Cape Town[XXXVII]



- **Renewable energy IPPs.** By December 2021, the REIPPP build had resulted in 63,291 job years for South African citizens (48,110 in construction, 15,182 in operations),[38] of which local jobs represented 91-96%. These figures indicate an average of 1.7-2.6 job years per MW for operations (depending on technology) and 7.1-10.6 job years per MW for construction of REIPPPP projects.
- **Embedded generation.** By 2035, embedded generation is expected to reach a total capacity of 7.5 GW, with an estimated value of R75 billion and a potential to create 1,250 permanent jobs.[39]
- **Energy storage.** With the increased risk of loadshedding, there was a surge in demand for energy storage from the commercial and agricultural sectors. The energy storage market is expected to rise to R31 billion with 6.5 GWh installed energy capacity by 2030.
- **Climate mitigation and adaptation.** By 2030, climate mitigation and adaptation could result in 1.1 million and 700,000 job opportunities respectively across South African cities.[40] Of the mitigation jobs, 78% will be from retrofitting buildings and rooftop solar and 11% from power and transport.

RENEWABLE ENERGY POTENTIAL

The City of Cape Town's CAP Low Carbon Pathway model indicates that the equivalent of 1650 MW of additional renewable capacity would need to be added locally or nationally on a proportional basis to achieve 80% carbon neutral by 2050. The City plans include:[41]

- Installing an additional 14 City-owned PV systems, amounting to 10-15 MWp, at its facilities. The systems will be a combination of rooftop, at its offices and depots, and ground-mounted, at its wastewater treatment plants.

- Generating 7-10 MW from landfill gas to energy (partially under development).
- Generating 6-10 MW from biogas from wastewater treatment plants (partially under development).
- Exploring the feasibility of a utility scale (25-60 MW) solar PV plant in Paardevlei and a total potential of 10 MW from hydro.

Rooftops in Cape Town's city center alone have a potential capacity of 46 MW, generating 278 MWh/day, which would reduce energy consumption by 5%. Industrial warehousing areas offer greater potential than the city center, due to the rooftop space available (90% compared to 17% in the city center). The Epping industrial zone has a potential capacity of 51 MWp, generating 303 MWh/day.[42]

The average specific energy yield for PV systems in Cape Town is about 1,600 kWh per kWp per year.[43] In comparison, Germany's yield is between 1,000 and 1,200 kWh per kWp per year.[44] Cape Town experiences long bouts of winter rain periods, which mean that consumers remain very dependent on the grid connection and seasonal 'duck curve'[viii] demand will place stress on the grid during winter months.

Utility-scale wind generation is better suited to the hinterland rather than the city of Cape Town. Although Cape Town has a high annual mean wind speed of 16 km/h, it also has relatively high land prices and gusty wind conditions.

OPERATIONAL AND FINANCIAL SUSTAINABILITY OF THE ELECTRIC UTILITY

TABLE 11 Key regulatory, operational and performance indicators

Independent regulator	• NERSA regulates license conditions and tariff setting. Cost of supply studies are required every five years.
Government-mandated performance standards	• Tariff methodology is based on a regulated rate of return on required revenue. • Performance standards are not explicitly set, but tariff increases are evaluated against benchmarks set by NERSA and/or an approved cost of supply study. • At the City level, the Executive Director key performance indicators track utility performance standards ranging from technical (e.g., customer average interruption duration and frequency indices) to social (e.g., numbers of new connections, streetlighting installed).
Structure	• Eskom is a vertically integrated power utility monopoly, which is being unbundled into transmission, generation and distribution to allow for a competitive electricity market. • The City utility (EGD Department) is a regulated, bundled public entity that buys electricity from Eskom to on-sell to customers. It is responsible for all public lighting within the city's boundaries, whether inside or outside its distribution area.
Organizational structure and capacity	• The City utility is very well managed with good technical capacity. It has an in-service/ apprentice training program and an in-house technical training center for developing skills, although resource constraints are a constant.
Tariff-setting methodology	• Tariffs are based on the cost-to-serve method, including the wholesale price – NERSA regulates the wholesale tariffs. • The City's average tariff is cost reflective, but the system has built-in cross subsidies to ensure affordability. • Any tariff restructuring, such as the SSEG feed-in tariff, must be motivated for and based on a cost-of-supply study – in 2008, Cape Town produced its first cost-of-supply study which is updated annually.

viii The duck curve is a graph of power production over the course of a day that shows the timing imbalance between peak demand and renewable energy production.

Revenue protection	• The City has rolled out prepaid meters to most of its customers, as a means of protecting revenues. In 2018, roughly 75% of customers across all sectors and 80% of residential customers were on prepaid meters. Losses are relatively low in Cape Town. • AMI/smart metering systems are used by industrial and large commercial customers and required for customers who install SSEG. The City also has smart metering across many of its own facilities.
Management information systems and business processes	• City has two control center systems, for supervisory control and data acquisition (SCADA) and outage management. • Billing is done from within the City, using the SAP system.

INFORMAL ELECTRICITY MARKET

Between 2008 and 2018, the City's energy losses increased from 8% to 11% and was likely due to the steep increase in the Eskom wholesale electricity price since 2008, which made energy unaffordable and thereby encouraged electricity theft. Between 2007 and 2021, inflation grew by 134%, whereas Eskom's tariff increased by 753%. The residential sector is responsible for the largest number of cases of electricity theft, while the business sector has the highest volume of electricity theft due to its higher consumption. Off a high consumption base, even a small percentage decrease in purchases, through meter tampering, can equate to high volumes.

By July 2022, the City had registered 85.7 MVA of approved, installed grid-tied, embedded generation, with a further 80.9 MVA in the process of application, installation or legalization. This compares to 45 MW approved and 41 MW in process in 2020.[45] The City has worked hard to bring these systems within the formal system, as many were initially installed without being registered or abiding by the required standards. About 1,800 of the 2,289 registered systems are in the residential sector, but commercial installations account for the most of the capacity.

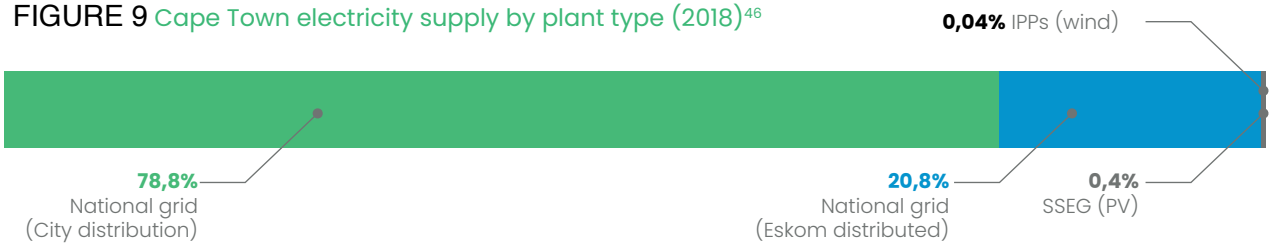
The City distribution grid does not yet include registered IPPs. The City procures a nominal amount of wind power from the Darling Wind Farm, which was initially done as a pilot 'wheeling agreement'[ix] with the intention to on-sell to willing buyers. In February 2022, the City advertised a request for proposals for the procurement of 200 MW of power generated from low-carbon sources from IPPs.

ix Financial agreement which enables the transportation of third-party electrical energy over the City's/Eskom's distribution / transmission network.

ENERGY DEMAND AND EQUITABLE ACCESS TO ELECTRICITY

The share of the City's electricity that is renewable mirrors the national grid mix (Figure 10), due to the high reliance on national grid electricity. The grid emission factor of power supply in Cape Town is 0.94 kg CO2e/kWh, due to the large share of coal-fired power within the national grid.

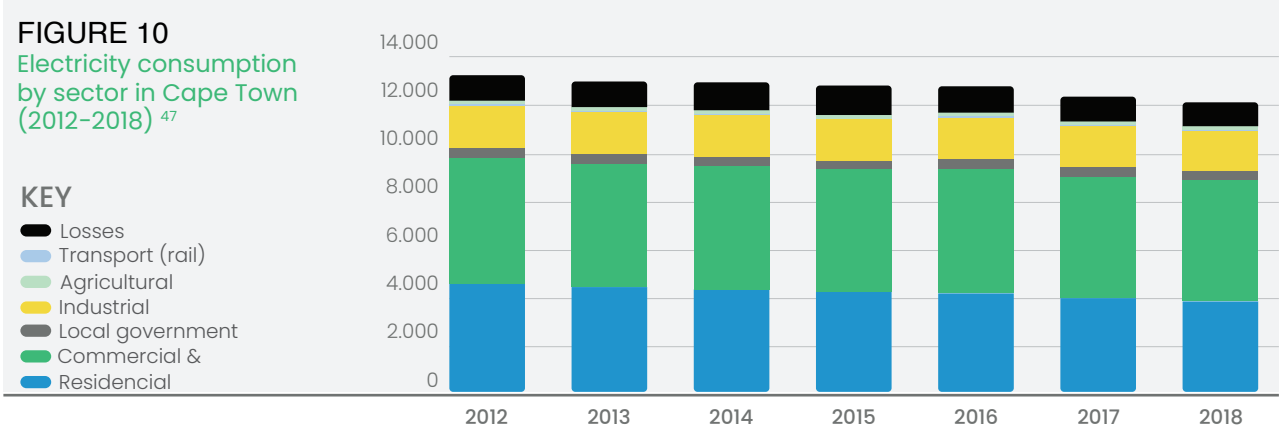
FIGURE 9 Cape Town electricity supply by plant type (2018)[46]



Note: The other category includes distributed generation, co-generation, biomass and landfill gas that feeds into the national grid. As with almost all power plants feeding into the national grid, these plants are situated outside city boundaries.

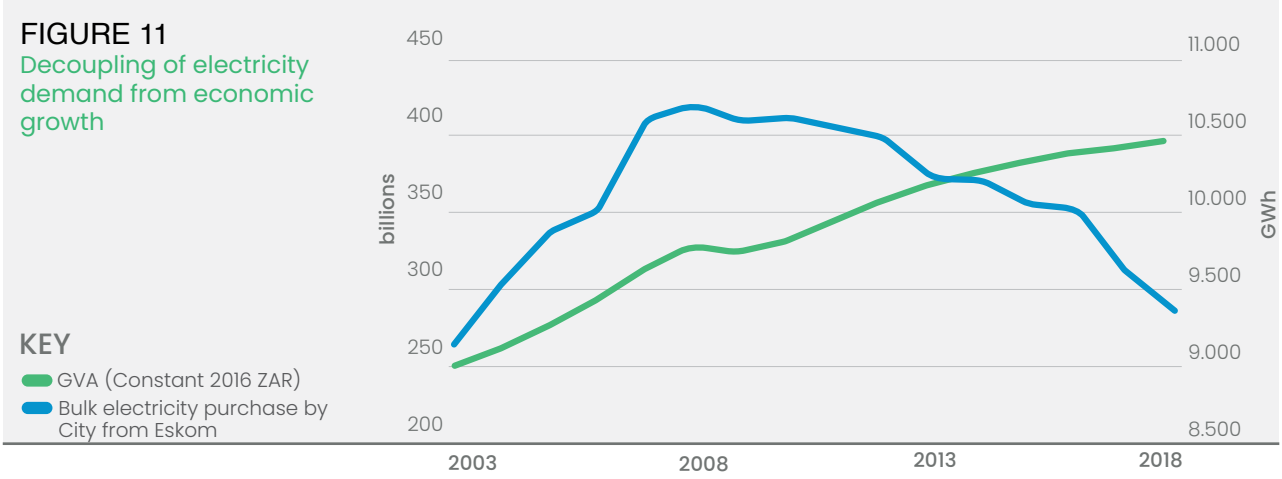
The commercial sector consumes the most electricity in Cape Town, followed by the residential sector (Figure 11).

FIGURE 10
Electricity consumption by sector in Cape Town (2012-2018) [47]



Since 2007, total demand in the City has been declining, mirroring the national economy's decoupling from energy use (Figure 12).[48] Demand growth has been flat-lining at national and local level, due to increased efficiency and installation of renewables, in response to above-inflation electricity tariff increases and loadshedding by Eskom. A similar trend is occurring across the other metros.[49] The average consumption of grid electricity is not expected to grow, despite the forecasted growth in urban population, due to more efficient onsite RE development and the customer base growth being driven by low-income households that have relatively low demand.

FIGURE 11
Decoupling of electricity demand from economic growth



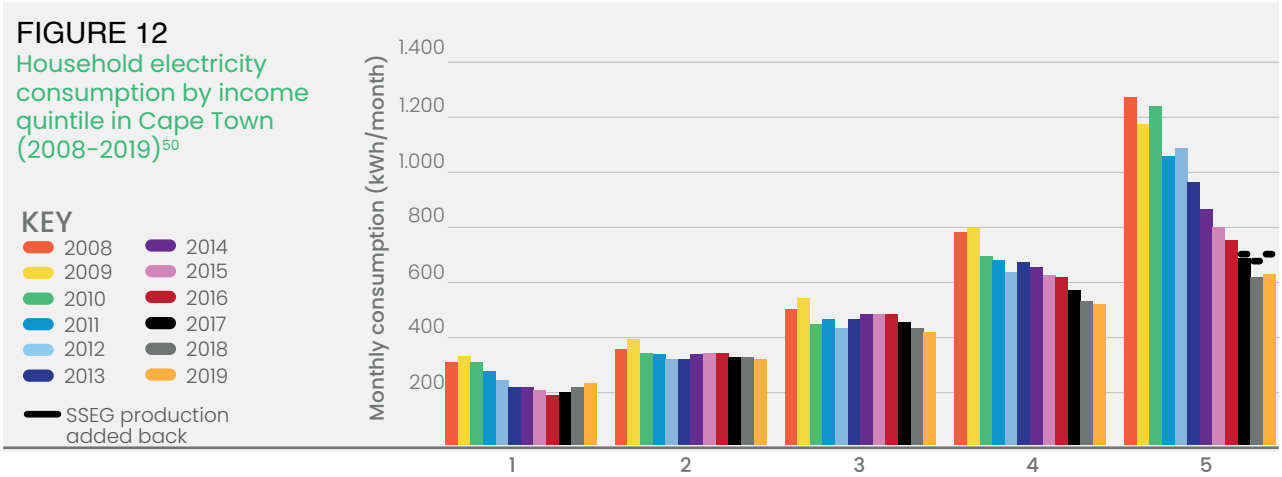
Note: Bulk electricity purchases by the City from Eskom used as a proxy for the city's total demand.

In Cape Town, the decrease in demand for electricity was largely due to the lower electricity intensity of high-income residential customers (Figure 12). Nevertheless, average monthly consumption levels for low-income households also declined, from about 300 kWh/household to 214 kWh/household between 2008 and 2018. This decline may be due to affordability factors or to the use of more efficient lighting and appliances.

ENERGY CONSUMPTION AND ACCESS

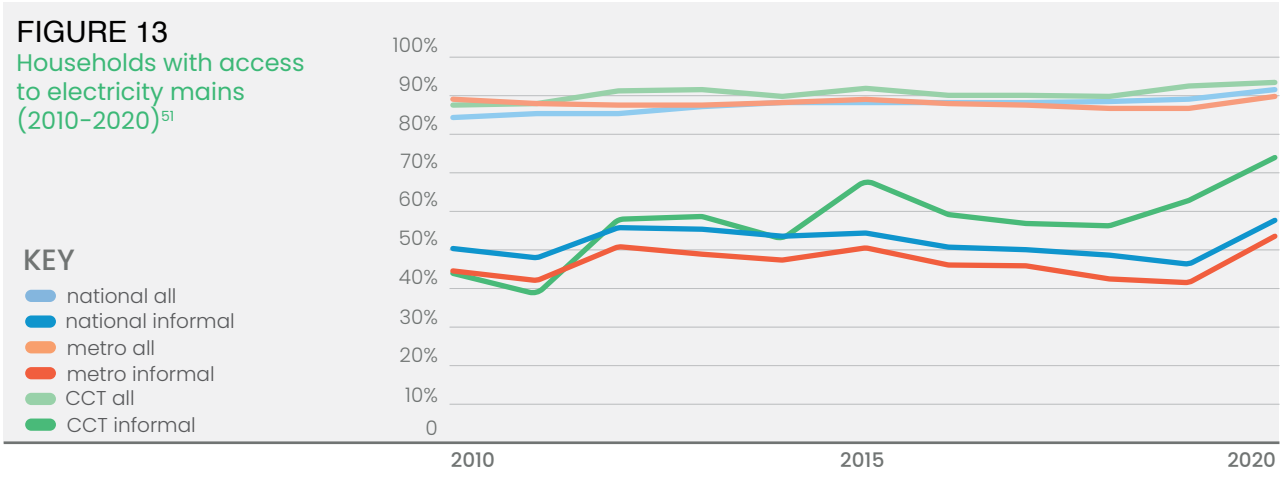
Figure 13 also shows the high disparity in consumption between low-income and mid- and high-income households. The gap has been narrowing, as a result of households improving their energy efficiency. This has implications for the City's revenue, as traditionally, the City has used revenue from mid- and high-income households to cross-subsidize low-income households.

FIGURE 12
Household electricity consumption by income quintile in Cape Town (2008-2019)[50]



Energy access in Cape Town is 100% across commercial and manufacturing sectors and 99% for all households, but 74% for households living in informal dwellings (Figure 14).

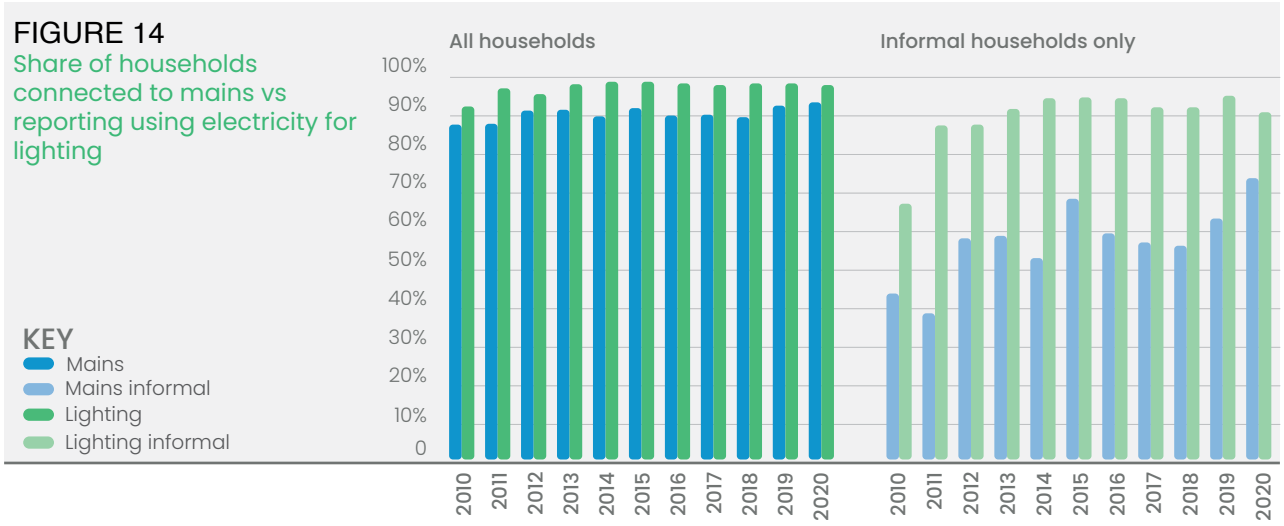
FIGURE 13
Households with access to electricity mains (2010-2020)[51]



In 2020, of the 70,000[x] unelectrified households in Cape Town, 13,000[xi] could not be electrified because they are located on land that is unsuitable or unsafe for development, is legally disputed or is reserved for infrastructure expansion. Many households in informal settlements are not connected to the mains electricity supply but still have access to electricity, either through an illegal connection[xii] or from the main dwelling, which is the case for backyard dwellers.[xiii] A proxy for access to electricity, whether legal or not, is the use of electricity as the main fuel for lighting.

An indication of illegal connections can be obtained through comparing households that report having access to electricity through a connection to mains and households that report using electricity as their main source of lighting. As Figure 15 shows, in 2020, 91% of informal households in Cape Town used electricity as their main lighting source, while only 74% had access through mains.

FIGURE 14
Share of households connected to mains vs reporting using electricity for lighting



x Internal Data, EGD, 2022
xi Internal Data, EGD, 2022
xii These households would still be considered officially unelectrified by the City.
xiii Backyard dwellers refer to households living in informal dwellings constructed on the site of a formal dwelling.

TARIFFS AND AFFORDABILITY

Both Eskom and the City distribute electricity within the city area, and both have different tariff structures and free basic electricity allocation mechanisms.

In 2010, NERSA introduced a new system of inclining block tariffs:

- Charges are divided into energy blocks, based on the amount of electricity consumed.
- Tariffs for higher-use blocks include a surplus, which is then used to cross-subsidize tariffs in the lower-use blocks.

Fixed costs (per month) relating to maintenance have historically been bundled into the electricity unit costs (R/kWh), obscuring the actual cost of service for any of the customer blocks. Today, both Eskom and the City have fixed charges for commercial, industrial, and mid- and high-income residential customers.

A challenge with inclining block tariffs is that more people tend to live in low-income households, especially when backyard dwellers are using electricity from the main household, which pushes up costs. Therefore, the City of Cape Town offers qualifying low-income households a package that comprises subsidized grid connections and a subsidized (Lifeline) tariff. Qualification for the subsidy is based on residential property value and level of electricity consumption. In 2018/19 financial year, 184,716 households received electricity at the Lifeline tariff:

- 93,109 at the Lifeline block A tariff (60 kWh free basic electricity (FBE), for customers consuming less than 250 kWh/month)
- 91,607 at Lifeline block B tariff (60 kWh FBE, for customers consuming less than 450 kWh/month).

However, the subsidy per household may be lower in cases where multiple households use the main household's connection, as it could mean that the households consume above the required 250 or 450 kWH/month required to qualify for FBE.

A significant number of households remain energy poor. The City has explored the possibility of introducing a '250 kWh/month' bundle of electricity for R100, to improve affordable access, but the detailed costing study found it to be totally unviable from a financial perspective.

From 2013/14, households using <250 kWh/month received 60 kWh free, while those using 250-450 kWh/month received 25 kWh free, provided their property valuation was less than or equal to R400,000.[xiv] Customers in City distribution suburbs qualify automatically, while those in Eskom distribution areas need to apply.

In the Eskom supply areas, a subsidised Homelight 20A[xv] electricity tariff is available to households (not necessarily low-income) whose supply is limited to a maximum of 20A without any further qualifications.

The City has taken steps to buffer low-income/low-use households from Eskom's tariff increases, as Figure 16 illustrates. The real (excluding inflation impacts) monthly electricity costs have been kept flat for households that consume 50-200 kWh of electricity per month. The dip in 2003 reflects the implementation of the national FBE programme, while the rapid real price increase from 2009 reflects the rapid increase in Eskom tariffs.

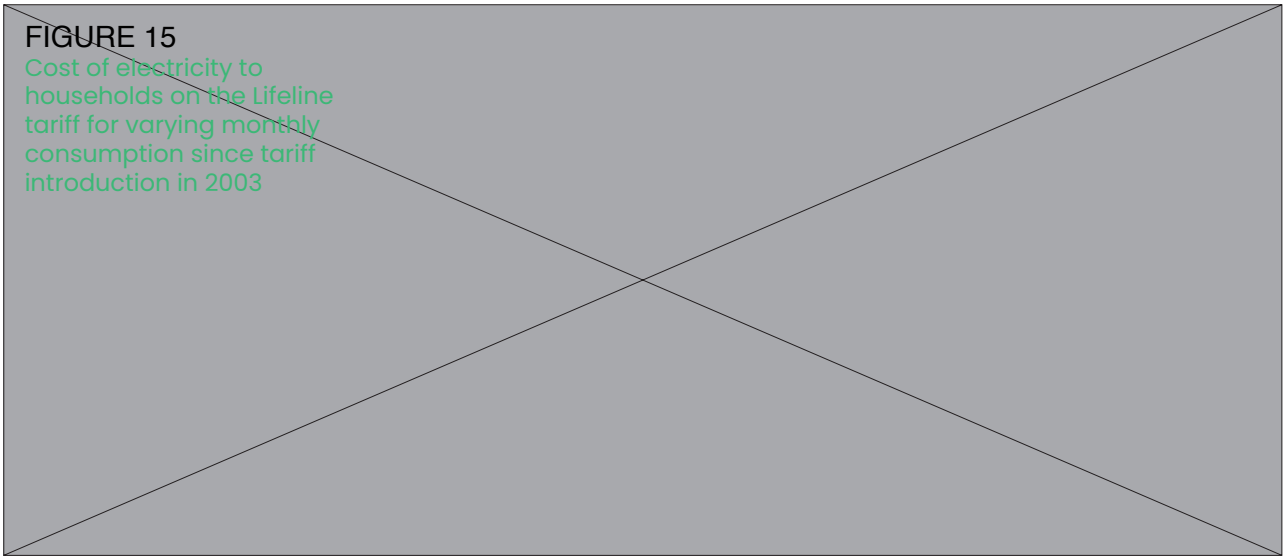
xiv In 2022, the average sales price for houses in Cape Town was R1.75 million, according to www.property24.com
xv Eskom. (2022). *Tariffs and Charges Booklet 2022/2023.*

TABLE 12 Average monthly expenditure and consumption per customer (2018/19)

	Expenditure (per month)		Consumption (kWh/month)	Average cost (per kWh)	
Domestic customers	R935	$62	478	R1.96	$0.13
Lifeline (25 kWh FBE) customers	R308	$21	283	R1.09	$0.07
Lifeline (60 kWh FBE) customers	R135	$9	174	R0.78	$0.05

Note: Exchange rate used US$1 = R15 [November 2022]

FIGURE 15
Cost of electricity to households on the Lifeline tariff for varying monthly consumption since tariff introduction in 2003



THE ENERGY SYSTEM AND VULNERABLE COMMUNITIES

The communities most affected by a lack of access to energy live in informal settlements or backyards and are usually among the poorest of society. Within this group, the most vulnerable are those who live on land that cannot be electrified, as they face health risks from the use of dangerous and dirty fuels, crime-related risks because of inadequate outdoor/public lighting, and possible injury or even death due to illegal connections, particularly in flood-prone areas. Their vulnerability is heightened by other factors, including adults who work far from home and so children are left unsupervised, resulting in greater exposure to fire risk. Furthermore, when fires occur, poor households have little resilience, often losing their entire household possessions, which affects their children's schooling, mental well-being and ability to continue working.

BOTTOM-UP APPROACHES TO EXPAND ACCESS

Although national policy makes provision for **Free Basic Alternative Energy (FBAE)**, which allows for purchasing of solar home systems (SHS), bottled gas, mini grids for areas that cannot be electrified, in practice alternative, off-grid energy solutions and funding for these solution in urban areas are difficult to achieve.

- The current grant from the national government, which is meant to subsidize the FBE allocation, already falls short of what the City actually allocates to its residents.[52]
- Resistance from communities, which see accepting off-grid solutions as a sign they will not be connected to the grid.

- The Municipal Finance Management Act (MFMA) requires a competitive bidding process and choosing the most cost-effective option. Yet most service providers are non-profit organisations, as no alternative services (to grid power) are able to provide a return on income without an additional subsidy from the government.
- In some instances, the cost of alternative services (e.g., gas) may fluctuate over time, rendering the bidding process difficult.
- Pricing of off-grid solutions is uncompetitive compared to the heavily subsidized grid electricity.
- The level of energy service that off-grid solutions can provide is far below that of the grid electricity (legal or illegal) that is available in the city.

The City is exploring various solutions, including proposing a policy under which the City provides a monthly FBAE subsidy in the form of a coupon to qualifying residents (which can only be redeemed by an alternative energy service provider). Once the subsidy recipient has been electrified, the FBAE allocation falls away, and they receive the free basic electricity (FBE) monthly allocation. This approach has been workshopped with stakeholders, but the City is grappling with how to allocate the subsidy or coupon, as households need to be registered. To achieve this will require identifying and registering households to benefit from the subsidy. This process can include using shack numbers and GPS coordinates to verify residential addresses and an identification of the head of household. This approach is possible but takes substantial time and resources.

Given the challenging market conditions, the few market players are not-for-profit companies and social entrepreneurs and include:

- The iShack Project, which is based within the University of Stellenbosch, has been pioneering solar home systems for informal households waiting regularization and has a Pilot in Siqalo Informal settlement in Philipi area.
- Zonke Energy has piloted a mini-grid in the Brown's Farm area, which is not commercially viable.
- The Energy4Wellbeing project is a joint venture by the universities of Cape Town and Exeter (UK) that has piloted and installed solar-powered mini-grids in two informal settlements: Jabula in Philippi and Qandu-Qandu in Khayelitsha. Zonke Energy was the implementing partner that installed the mini-grids and provided solar DC-powered fridges at cost to project participants. A fee-for-service model was employed.
- GreenCape, in association with the Airports Company South Africa and The iShack Project, has been working on in the informal settlement communities of Malawi Camp and Freedom Farm to provide the community with alternative energy solutions to improve their living conditions while they wait to be relocated to formal housing. By April, 2022, the project has installed, a total of 580 solar home.[xvi]

xvi https://green-cape.co.za/news-renewable-energy-at-home-can-be-a-reality-for-all-south-africans/

LOOKING AHEAD: CRITICAL CHALLENGES

By 2050, forecasts predict that Cape Town will experience an increase in average temperatures of between 1 °C and 3 °C as well as very hot days (35+ °C) and heatwaves (32+ °C for three consecutive days), and an increase in annual average rainfall of between 60 mm and 120 mm.[53] These projected changes may increase the potential for solar energy but may affect hydropower generation in Cape Town. The climate change impacts, such as more frequent droughts, may limit the City's ability to respond to loadshedding, should the Steenbras pumped storage be affected, while severe storms and coastal flooding risk damaging power sector infrastructure, resulting in higher maintenance costs.

Like other metros in South Africa, Cape Town's population will continue to grow as a result of urbanization – "by 2030, almost three-quarters (71.3%) of the country's population will be living in urban areas".[54] Most of these new households will be low income and live in informal settlements, which will put further pressure on the City's ability to provide services and may lead to increased losses through illegal connections. For Cape Town (and other metros), a major challenge will be financial, as under the current 'electricity business' model, tariffs charged to mid- and high-income households are used to cross-subsidize low-income households. However, at the same time, increased tariffs and the impacts of loadshedding are driving mid- and high-income households to reduce their electricity consumption from the grid, through energy efficiency and choosing off-grid solutions, thereby reducing City revenue. If the move to distributed renewables and energy efficiency outpaces the ability of the City to transition to new business models at the same speed, tariff structures and revenue collection may become inequitable, resulting in grid infrastructure collapse and/or tariffs that are even more exclusionary for the poor.

Other challenges that Cape Town faces include:

- **Governance and financial crisis at Eskom**. Much of the City's current ability to provide energy and reduce emissions depends on Eskom's performance and transition away from coal-powered energy.
- **Carbon sanctions or taxes**. Should the City not transition fast enough to clean energy, carbon taxes may increase the cost of electricity and/or products produced using electricity or make local products uncompetitive on the international market due to carbon border adjustments.
- **High crime levels, poverty and inequality**. These may result in civil unrest, theft and vandalism of power

sector infrastructure in some of the city's most vulnerable and underserviced areas.

- **Cumbersome legislation and regulations**. In particular, those related to procurement make entering into public-private partnerships and long-term contracts complicated.
- **Trade-offs between affordability and large-scale projects**. The City's own revenues are relatively small, mostly from property rates and tariffs for services that need to remain affordable for households, but the costs of implementing or scaling up alternative energy projects are high.
- **Limited climate data collation and disaster incidence response costing**. Although the City collects some data on climate variables, this is not sufficiently collated across the City or considered against disaster costs to provide a solid evidence base against which to evaluate the cost of system shocks and stresses.

ANNEX A: CITY-LED RESEARCH, DEVELOPMENT AND INNOVATION

The City's SEM Department's main research areas are energy and climate data, generation development and municipal operational efficiency, renewable energy and energy efficiency facilitation, and energy poverty alleviation.

ENERGY AND CLIMATE DATA

- Evidence-led strategy since 2003
- Advanced scenario modeling from early LEAP (Long-range energy alternative planning) to CN2050
- Electricity pathways least-cost study to roadmap City's energy objectives (energy security, lower cost, resilience)
- Financial modeling, e.g., valuing savings, investigating funding models (e.g., green bonds), Property Assessed Clean Energy (PACE) model
- Energy and carbon data management and monitoring and reporting systems
- Buildings and facilities energy efficiency management systems
- Energy efficiency behaviour change survey/market research
- Climate action behaviour change survey/market research

GENERATION DEVELOPMENT AND MUNICIPAL OPERATIONAL EFFICIENCY

- Large-scale IPP program institutional set up (legal, financial) and court challenge
- Medium-sized 'own' municipal generation program
- Installation of rooftop PV on city facilities
- Wheeling/trading platform framework development
- Liquified Natural Gas (LNG) business case and defining role of the City

- Employment equity in City operations
- Regulatory review and response
- Project-based technical work
- Grid impact studies
- Battery storage research

RENEWABLE ENERGY AND ENERGY EFFICIENCY FACILITATION

- Advocacy, campaigns, education, communication, and awareness raising
- Stakeholder forums (Energy, Waste, Water Forum)
- Electric vehicle (EV) Framework development and implementation
- SSEG promotion, accreditation, compliance
- Tariffs and smart meter research and development
- Blockchain tech/platforms for distributed energy

ENERGY POVERTY ALLEVIATION

- City social housing 'backyard' meter rollout
- Extensive research and surveys including financial sustainability investigations and implementation models for alternatives energy services
- Project implementation of ceiling retrofits and solar water heating
- Low carbon urban development and housing approaches
- Solar public lighting exploration

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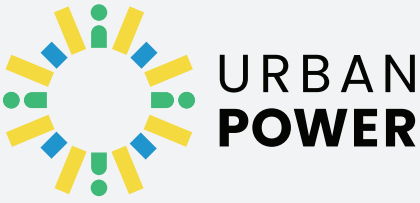
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