MITIGATING CLIMATE CHANGE THROUGH RENEWABLE ENERGY DEVELOPMENT

CAPE TOWN, SOUTH AFRICA

Cape Town has set out to boost its use of renewables for both electricity and heating

South Africa has established plans to reduce its dependence on coal, which provides for some 70% of the country's primary energy consumption and 95% of its electricity generation (Department of Energy, South Africa, 2017). To substitute for coal-fired power plants, South Africa has committed to increasing its renewable generation capacity. This will help fulfil its international climate change mitigation commitments to reduce greenhouse gas (GHG) emissions made through a Nationally Determined Contribution (NDC) to the Paris Agreement (Department of Energy, South Africa, 2014; 2015).

Cape Town's target for renewables is 20% of total energy use by 2020

The National Development Plan (NDP) for South Africa indicates that an additional 29 000 megawatts (MW) of electricity will be needed by 2030 and seeks to ensure that at least 20 000 MW of this expanded capacity is sourced from renewable energy sources and liquefied natural gas (LNG); (Republic of South Africa Government, 2017). Out of the total installed capacity, 27% will be sourced from renewables including wind, solar photovoltaic (PV), hydro and concentrating solar power (CSP) by 2030 (Department of Energy, South Africa, 2016). Private investment through the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has been a major catalyst for developing the renewable energy sector (Energy Intelligence, 2016), contracting more than 6 300 MW of renewable capacity from more than 100 projects in four years at increasingly competitive prices.

The City of Cape Town has targeted major improvements to renewable energy generation and efficiency in both the electricity and transport sectors. These commitments have been made in the context of a business-as-usual scenario for 2040 that projects a two-fold increase in energy consumption and greenhouse gas (GHG) emissions, and a ten-fold increase in energy costs for the municipality (City of Cape Town, 2015a).

Accordingly, the city has undertaken initiatives and infrastructure projects aimed at reducing city-wide electricity consumption and increasing renewable energy capacity. In the absence of national legislation, the city has also regulated small-scale distributed energy (also called small-scale embedded generation, or SSEG) and supported legal connections to the electricity grid in order to meet the needs of its residential, commercial and industrial electricity consumers.

Energy in South Africa

South Africa has one of the largest economies in Africa in terms of GDP, amounting to approximately USD 316.4 billion in 2015.[1]

The country is Africa's largest energy consumer, accounting for some 30% of total primary energy consumption on the continent.

South Africa is the continent's largest CO_2-emitter and, as of 2016 was the 13th largest emitter in the world, accounting for 468 million metric tons of carbon dioxide emissions from fuel combustion.

Cape Town is both the largest city in terms of population and the economic hub of the Western Cape Province.

Source: Department of Energy, South Africa, 2014; 2015; IEA, 2015; Global Carbon Atlas, 2018.

1 Conversion rate is based on the average exchange rate for 2015 (1 ZAR = 0.07882 USD), generated at: www.oanda.com/currency/average

The challenges of coal reduction and meeting urban power demand

Cape Town is located on a peninsula in the South West of South Africa. As of 2016, it had four million inhabitants, at a density of 1 619 people per square kilometre (City of Cape Town, 2017a; Statistics South Africa, 2015). Like many other municipalities in South Africa, the sale of electricity provides part of the city's income. It purchases electricity from the state-owned electricity provider Eskom and then serves as the retailer to all local electricity consumers.

The city has encountered challenges in providing electricity access and service, particularly to low-income households, because Eskom is struggling to meet electricity demand in the face of a growing population and rising living standards. A very narrow margin between peak demand and available electricity supply, owing to poor maintenance and insufficient generation capacity, causes occasional load-shedding to balance the system.

The lack of adequate preparations by Eskom for future capacity expansion and the replacement of old equipment has resulted in a five-fold increase in electricity tariffs since 2009 (NERSA, 2009; City of Cape Town, 2018). However, since 2017, economic contraction, consumer efficiency measures and the commissioning of new coal-fired power stations have resulted in overcapacities in the short-to-medium term. Energy security concerns, rising electricity prices and increasing awareness of the promise of renewable energy technologies have prompted municipalities in South Africa to explore ways to play a greater role in generation.

Currently, Eskom is responsible for 96% of electricity generation in South Africa and municipalities require special permission from the national government to procure electricity from independent power producers (IPPs); (Eberhard, Kolker and Leigland, 2014). Cape Town is now seeking such permission.

Municipal initiatives have prioritised sustainable procurement of renewable energy and deployed rooftop solar PV on public buildings. In addition, they have focused on energy efficiency in buildings, transport and street lighting, as well as on metering and monitoring.

The tariff for excess generation is not a significant incentive to invest in solar PV, but it allows consumers to offset their electricity purchases, letting them connect to the electricity grid and thus avoid the cost of purchasing batteries for energy storage. A limited utility bill credit is provided for surplus electricity fed back into the grid. This tariff structure particularly suits commercial and industrial customers, as their consumption primarily takes place during daytime when the sun is shining. However, when industrial units shut down over weekends, the resulting large reverse flows of power into the grid are challenging to manage.

Actions taken

The municipality has sought to increase renewable energy power generation (deploying 247 kW of capacity and incentivising SSEG), as well as to reduce electricity consumption across Cape Town. Activities include an electricity savings campaign encouraging both behavioural and technological change; a solar water heater marketing and accreditation programme; and the establishment of the technical and legislative conditions for rooftop solar PV to be legally connected to the electricity grid.

Municipal solar PV projects

Project name	Capacity (kW)
Manenberg Housing	20
Electricity Services	100
Gallows Hill	10
Wallacedene Taxi	20
Khayelitsha	17
Royal Ascot	20
Omniforum	60
Total	**247**

Source: SEA, 2017

The tariff for excess generation allows consumers to offset their electricity purchases

Cape Town has installed rooftop solar PV at numerous municipal buildings and facilities (Table 1) with additional installations currently planned. This includes the Wallacedene taxi rank, the first public transportation facility in South Africa to be rated by the Green Building Council of South Africa. The Wallacedene complex has a maximum daily output potential of 130 kilowatt-hours (kWh) and is supported by a storage system of 24 batteries with a capacity of 72 kWh in order to provide uninterrupted electricity supply (Transport for Cape Town, 2014; GIZ, 2017).

The city also maintains four micro-hydro generation turbines at its water treatment plants. The electricity generated at these four sites is sufficient for meeting 5% of the total electricity demand for municipal operations (City of Cape Town, 2015b).

In the absence of relevant national legislation, Cape Town and 17 other municipalities in South Africa have begun to facilitate SSEG in the residential, commercial and industrial sectors (GIZ, 2017). Cape Town has implemented SSEG tariffs without requiring generators to obtain a generation license from the National Energy Regulator of South Africa (NERSA), provided the user is a net consumer over the year (i.e. does not generate more than is consumed). Motivated by environmental awareness, continually increasing electricity prices and the steadily decreasing costs of solar technology, growing numbers of residents are installing rooftop solar PV panels and requesting municipalities to allow them to connect to the grid.

Cape Town has developed policies and practices that it sees as consistent with existing national policies. In particular, the city will not purchase electricity at a greater cost than Eskom-generated power and will not allow customers to sell electricity in excess of purchases from the city over any consecutive 12-month period. Customers who wish to pursue SSEG are required to move to a special tariff (see box) that incorporates a daily service charge in order to recoup the costs of operating the utility network (City of Cape Town, 2017b). The municipal role is thus focused on tariff-setting, quality and standards.

Electricity tariff structures in the City of Cape Town

The price paid by the city for electricity fed into the municipal grid by both residential and non-residential small-scale embedded generators in 2017 is 78.53 cents (South African Rand [ZAR]), or 5.9 US cents (USD 0.059), per kilowatt hour (kWh).[2] This is identical to the Eskom Megaflex (summer) Standard Time of Use tariff.

Additionally, there is a daily service charge, held constant at ZAR 13.30 cent/kWh (USD 0.0091/kWh)[3] during 2016 and 2017, which covers the infrastructure costs of grid connectivity.

Residential customers who do not generate their own electricity pay a tariff of ZAR 192.80 cents/kWh (USD 0.1448/kWh)[4] for the first 600 kWh consumed per month. This is ZAR 66.07 cents/kWh (USD 0.0496/kWh) more than the tariff paid by small-scale embedded generators for the first 600 kWh consumed. For any electricity use over the initial 600 kWh drawn, the consumption tariff for small-scale embedded generators and regular customers is the same.

Tariff structures offer a substantial subsidy to the most vulnerable – nearly half of total residential consumers.

Source: City of Cape Town, 2017c; 2017d.

2 Conversion rate is based on the average exchange rate for 2017 (1 ZAR = 0.07511 USD), generated at: www.oanda.com/currency/average
3 Conversion rate is based on the average exchange rate for 2016 (1 ZAR = 0.06812 USD), generated at: www.oanda.com/currency/average
4 Conversion rate is based on the average exchange rate for 2018 (1 ZAR = 0.07511 USD), generated at: www.oanda.com/currency/average

SSEG electricity assists the city in attaining its renewable energy targets. Furthermore, if grid connection is maintained, Cape Town will continue to receive revenues from connection fees and electricity sales. However, the challenge for municipalities is to achieve a high percentage of registered installations in the absence of significant financial incentives. Of the estimated 6 MW of private residential PV capacity in the city, approximately 5 MW is connected without paying a daily service charge (City of Cape Town, 2017g).

Cape Town and other municipalities have turned to distributed systems

Electricity Savings Campaign

Cape Town's Electricity Savings Campaign (ESC) was initiated in 2009. The purpose of the campaign is to reduce residential and commercial electricity consumption and related GHG emissions. The ESC looks to accomplish this by initiating behavioural and technological changes.

Residential use accounts for 37% of total electricity consumption in Cape Town, while the commercial sector accounts for 44% (City of Cape Town, 2015b). The residential portion of the ESC consisted of a print and social media campaign, detailed information made available on the savingelectricity.org.za website, and exhibitions and events targeting high-usage electricity consumers. The City also provided information on the potential financial savings of increased energy efficiency.

The commercial portion of the ESC included the establishment of the Energy Efficiency Forum, developed in partnership with Eskom and the South African Property Owners' Association. Meetings that take place three times per year provide opportunities for the owners and operators of commercial buildings to network and share their practical experiences of energy efficiency measures. The Forum also provides frequent updates on opportunities for financing, technological improvement, and training and support within the energy efficiency field. It also runs a successful awards programme.

Solar Water Heater (SWH) programme

Water heating accounts for the largest share of residential electricity consumption in middle to high income households. The Solar Water Heater Accreditation and Marketing Campaign was launched in 2014 to promote the installation of high-pressure residential solar water heaters and improve the reliability, quality and standards of products and installations.

The SWH campaign thus looks to support the development of a local solar water sector by increasing consumer confidence in the technology. The campaign involves accrediting service providers and monitoring their performance, encouraging the uptake of SWHs by households through targeted communication and education campaigns, providing training to service providers and undertaking quality control. The Accredited Service Provider programme identifies and verifies companies that meet the required technical, customer service, knowledge, ethical and business practice standards.

Results to date

The City of Cape Town is moving forward to achieve its 2020 renewable energy targets. More than 274 small-scale embedded generation projects had been approved as of early 2018. The municipality is also aiming to procure more renewables from independent power producers. Meanwhile, building retrofits and the installation of solar water heaters have enabled energy savings.

Renewable power capacity and small-scale embedded generation

The solar PV projects installed to date on municipal infrastructure have a peak generation capacity of 247 kW, with more than 2 MW of additional capacity in the planning pipeline. In addition to the offset costs for electricity consumption, the solar PV installations provide the city with an opportunity to demonstrate its leadership in developing embedded, distributed energy services.

When Cape Town first developed its SSEG standards, there were no South African standards for the installation of panels and inverters and no wiring regulations, nor any nationally accredited training course, which meant that there were few qualified electricians experienced in the use of direct-current wiring.

In response, Cape Town promulgated requirements for becoming an embedded generator, published a brochure on the safe and legal installation of rooftop solar PV, and is now reviewing low-voltage network inspection practices to ensure the safety of municipal staff during operations. The brochure assists potential end-users in selecting a qualified service provider and details key requirements that must be met prior to, during and after installation.

By facilitating the uptake and standardisation of embedded generation, Cape Town has been able to strengthen control over its municipal grid. As of February 2018, 186 grid-tied residential installations and 88 commercial and industrial installations had been approved, with a total capacity of 13 Mega Volt Amperes (MVA). The government of Western Cape (the province of which Cape Town is the capital) estimates solar PV capacity in Cape Town at 15 MW. Energy modelling for 2022 – adjusted from 2020 to be in line with the new municipal Integrated Development Plan – anticipates generation capacities of 45 MW from residential embedded generation, 8 MW from small commercial generation and 54 MW from large commercial and industrial embedded generation (City of Cape Town, 2015c).

Cape Town is now reviewing low-voltage network inspection practices

Procurement from Independent Power Producers (IPPs)

Cape Town's renewable energy target is 20% of total energy use by 2020. Achieving this target will require significant large-scale procurement from IPPs. The city has sought the right to procure electricity directly from IPPs, but will need to secure a prior determination under Section 34 of the Electricity Regulation Act from the Minister of Energy and NERSA. This is essential for the IPPs to install new renewable capacity, generate the renewable-sourced electricity and sell the power to Cape Town. The city is therefore launching a High Court application seeking three substantive orders to allow the procurement of renewable-sourced electricity directly from IPPs (City of Cape Town, 2017d).

Municipal building retrofits

The city's Building Energy Efficiency Retrofit Programme has to date led to the retrofitting of approximately 26% of Cape Town's large building stock. Full energy efficiency retrofits were performed on four buildings, while 14 others underwent lighting retrofits.

The city has also installed smart electricity meters (AMRs) in about 60 large administrative buildings and is conducting a behaviour change programme to provide both building managers and end-users with the knowledge required to effectively manage electricity consumption. The programme has resulted in cumulative energy savings of about 1 068 MWh by 2015, 2.6% of the energy use for the buildings and facilities of Cape Town in 2009 (Western Cape Government, 2013, 2015).

The city has installed smart electricity meters in about 60 large administrative buildings

Solar Water Heaters Campaign

The Cape Town Energy 2040 Vision and Action Plan aims to install 525 000 solar water heaters and heat pumps by 2040, with an interim target of 116 000 by 2020. As of early 2015, more than 46 000 units had been installed (City of Cape Town, 2017g). These represent savings of ZAR 274 million (USD 20.58 million)[5] for end-users, an investment of ZAR 968 million (USD 72.7 million) in the local economy, 1,319 jobs, 128 gigawatt hours (GWhs) per year in energy savings and 132 000 tonnes of carbon emissions avoided per year (City of Cape Town, 2017g).

5 Conversion rate is based on the average exchange rate for 2017 (1 ZAR = 0.07511 USD), generated at: www.oanda.com/currency/average

Costs and financing

Increasing renewable power capacity and small-scale embedded generation

The installation of the rooftop solar PV panel system and other "green" retrofit activities at the Wallacedene taxi rank required a capital investment of ZAR 25 million (USD 2.3 million).[6] Estimates indicate that this capital cost will be recovered within six to ten years through energy cost savings (Transport for Cape Town, 2014).

Small scale-embedded generation in Cape Town is at present driven by private investment decisions. Moving forward, however, the South African Council for Scientific and Industrial Research (CSIR) has proposed the creation of a state-owned or fully regulated central purchasing authority which can purchase the power produced by small-scale embedded generation. This would serve as an incentive mechanism to support the development of small-scale renewables while compensating municipalities for losses of revenue from reduced electricity sales. The proposal, referred to as NETFIT, is seen as a way to create a favourable regulatory environment for small-scale embedded generators.

For residents that invest in solar rooftop PV – and who do not finance their investment over an extended period – the projected period for amortisation is seven years. This projected period increases up to between nine and ten years for larger power users (City of Cape Town, 2015c).

Solar water heater campaign

Depending on the size of SWH units (from 150 to 300 litres) and the frequency of use, the initial cost of a SWH will range from ZAR 15 000 (USD 1 200)[7] to ZAR 34 375 (USD 2 700) and the minimum payback period will range from 3.9 years to 10.6 years, with monthly savings between ZAR 102 (USD 8) and ZAR 559 (USD 44); (City of Cape Town, 2015d).

Photograph: Shutterstock

Green bonds support Cape Town's climate projects

6 Conversion rate is based on the average exchange rate for 2014 (1 ZAR = 0.09222 USD), generated at: www.oanda.com/currency/average
7 Conversion rate is based on the average exchange rate for 2015 (1 ZAR = 0.07882 USD), generated at: www.oanda.com/currency/average

Photograph: Shutterstock

Solar panels have appeared across Cape Town in recent years

Green bonds

The City of Cape Town introduced its first ever green bond of ZAR 1 billion (USD 75.11 million)[8] on 12 July 2017 in a closed auction. Over a two-hour period, investors placed bids amounting to ZAR 4.3 billion (USD 323 million). The bond was certified by the Climate Bonds Initiative and its green credentials and controls received an 'excellent' rating from Moody's, an international ratings agency (City of Cape Town, 2017e).

The green bonds will be used to support projects that are aligned with the Climate Change Strategy of the City of Cape Town. Some of the projects contribute to achieving Cape Town's renewable energy targets, energy efficiency measures in buildings, procurement of electric busses and sustainable infrastructure projects (City of Cape Town, 2017f).

Lessons for other cities

Cape Town's rooftop solar procurement measures, SWH programme, use of municipal infrastructure and efforts to engage with IPPs highlight how proactive policies at the municipal level can increase electricity service quality and security, as well as advance renewable energy development and deployment. The potential impact on grid stability is a major challenge to small-scale embedded generation, as are improper installation of equipment, illegal grid access and the loss of revenue from electricity sales.

At the same time, the limits to Cape Town's solar rooftop programme appear to be primarily linked to market dynamics in South Africa's power market. This is a fundamentally different outcome to typical concerns about the viability of such a system beyond the demonstration phase, which usually include the technical challenges of integrating intermittent energy technologies and concerns about the cost competitiveness of such systems with conventional electricity. Moving forward, the city believes that rooftop PV will continue to proliferate and cheap battery storage will be the next big game-changer that enables further penetration of renewables.

8 Conversion rate is based on the average exchange rate for 2017 (1 ZAR = 0.07511 USD), generated at: www.oanda.com/currency/average

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Acknowledgements
This case study was prepared in co-ordination with ICLEI, under the guidance of Rabia Ferroukhi (IRENA). Content was authored by Michael Woodbridge (ICLEI), Brian Jones (City of Cape Town), Laura El-Katiri, Jinlei Feng, Ghislaine Kieffer, Verena Ommer and Michael Renner (IRENA). The study benefited from expert reviews by Sarah Stands (Skrander) and Zanie Cilliers (Sustainable Energy Africa NPC) and Wikus Kruger (University of Cape Town). Nicholas Goedeking (University of California – Berkeley), ICLEI colleagues Miriam Badino, Ana Marques and Pourya Salehi, and City of Cape Town representatives Hilary Price, Sarah Ward and Leila Mahomed Weideman also provided valuable input.