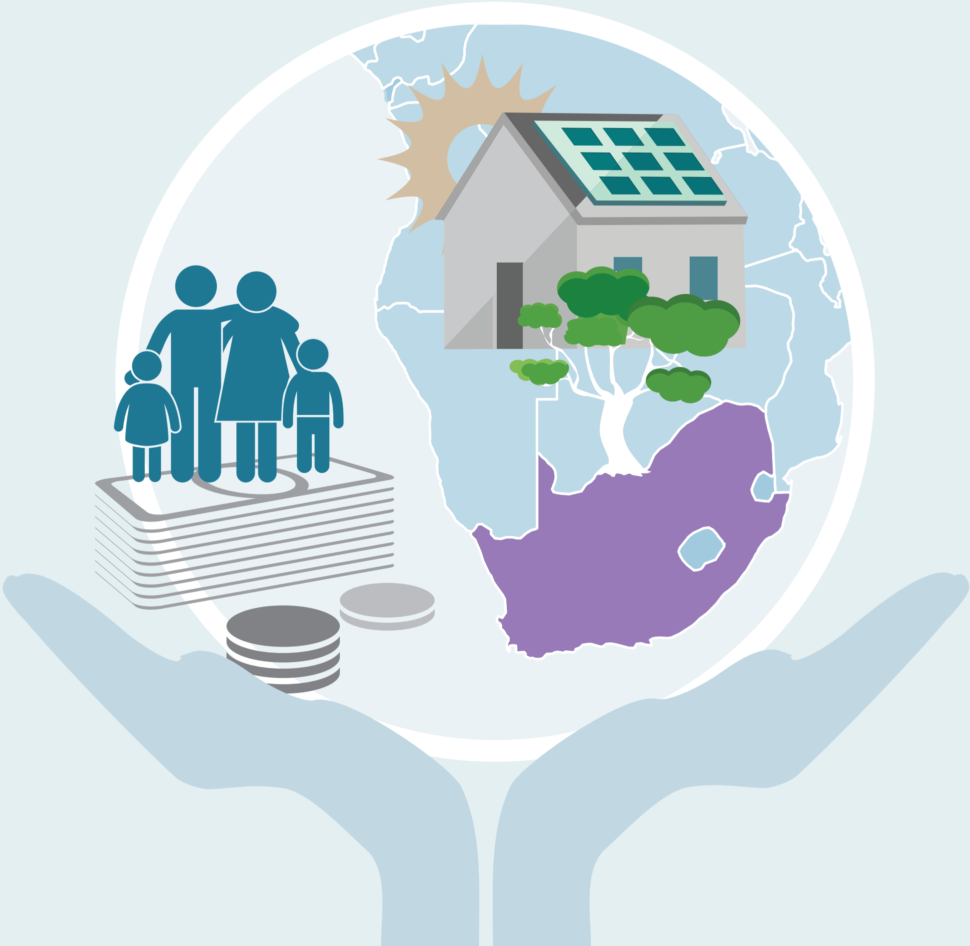
COBENEFITS STUDY

October 2019

Consumer savings through solar PV self-consumption in South Africa

Assessing the co-benefits of decarbonising the power sector

Executive report



This COBENEFITS study has been realised in the context of the project "Mobilising the Co-Benefits of Climate Change Mitigation through Capacity Building among Public Policy Institutions" (COBENEFITS). This print version has been shortened and does not include annexes. The full version of this report is available on www.cobenefits.info.

This study is part of a 2019 series of four studies assessing the co-benefits of decarbonising the power sector in South Africa, edited by IASS and CSIR. All reports are available on www.cobenefits.info.

- Improving health and reducing costs through renewable energy in South Africa
- Consumer savings through solar PV self-consumption in South Africa
- Economic prosperity for marginalised communities through renewable energy in South Africa
- Future skills and job creation through renewable energy in South Africa

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IASS POTSDAM · renac renewables academy · UfU Independent Institute for Environmental Issues · IET International Energy Transition · CSIR our future through science

COBENEFITS is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag. The project is coordinated by the Institute for Advanced Sustainability Studies (IASS, Lead) in partnership with the Renewables Academy (RENAC), Independent Institute for Environmental Issues (UfU), IET – International Energy Transition GmbH and the Council for Scientific and Industrial Research (CSIR).

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Editors: Ayodeji Okunlola, David Jacobs, Ntombifuthi Ntuli, Ruan Fourie, Laura Nagel and Sebastian Helgenberger – IASS Potsdam, CSIR and IET

Technical implementation: Mamahloko Senatla, Lehlogonolo Chiloane, Unarine Mudau and Raj Naidoo – Council for Scientific and Industrial Research (CSIR), Energy Research Centre and University of Pretoria, Smart grids research group, South Africa

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INTERNATIONAL CLIMATE INITIATIVE (IKI)

COBENEFITS of the new energy world of renewables for the people in South Africa

South Africa is in the midst of an energy transition, with important social and economic implications, depending on the pathways that are chosen. Economic prosperity, business and employment opportunities as well as health impacts, issues related to the water–energy–food nexus and global warming impacts: through its energy pathway, South Africa will define the basis for its future development. Political decisions on South Africa's energy future link the missions and mandates of many government departments beyond energy, such as environment, industry development, science and technological innovation.

Importantly, the whole debate boils down to a single question: **How can renewables improve the lives of the people in South Africa?** Substantiated by scientific rigor and key technical data, the study at hand contributes to answering this question. It also provides guidance to government departments and agencies on further shaping an enabling environment to maximize the social and economic co-benefits of the new energy world of renewables for the people of South Africa.

Under their shared responsibility, the CSIR Energy Centre (as the COBENEFITS South Africa Focal Point) and IASS Potsdam invited the Department of Environmental Affairs (DEA) and Department of Energy (DoE), together with the Independent Power Producers (IPP) Office, the Department of Trade and Industry (DTI), Department of Science and Technology (DST) and the South African National Energy Development Institute (SANEDI) to constitute to the COBENEFITS Council South Africa in May 2017 and to guide the COBENEFITS Assessment studies along with the COBENEFITS Training programme and political roundtables.

We particularly highlight and acknowledge the strong dedication and strategic guidance of the COBENEFITS Council members: Olga Chauke (DEA); Nomawethu Qase (DoE); Gerhard Fourie (DTI); and Lolette Kritzinger-van Niekerk, Frisky Domingues, Thulisile Dlamini and Lazarus Mahlangu (IPP Office). Their contributions during the COBENEFITS Council sessions guided the project team to frame the topics of the COBENEFITS Assessment for South Africa and to ensure their direct connection to the current political deliberations and policy frameworks of their respective departments. We are also indebted to our highly valued research and knowledge partners, for their unwavering commitment and dedicated work on the technical implementation of this study. The COBENEFITS study at hand has been facilitated through financial support from the International Climate Initiative of Germany.

South Africa, among 185 parties to date, has ratified the Paris Agreement, to combat climate change and provide current and future generations with opportunities to flourish. Under the guidance of the National Planning Commission, municipalities, entrepreneurs, citizens and policymakers are debating pathways to achieve a just transition to a low-carbon, climate-resilient economy and society in South Africa. With this study, we seek to contribute to these important deliberations by offering a scientific basis for harnessing the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating a just transition, thereby **making the Paris Agreement a success for the planet and the people of South Africa**.

We wish the reader inspiration for the important debate on a just and sustainable energy future for South Africa!

Ntombifuthi Ntuli
COBENEFITS Focal Point
South Africa
CSIR Energy Centre

Sebastian Helgenberger
COBENEFITS
Project Director
IASS Potsdam

Executive Summary

COBENEFITS

Consumer savings through solar PV self-consumption in South Africa

Assessing the co-benefits of decarbonising the power sector

Rooftop solar PV systems have the capability to revolutionise the energy system in South Africa. The metropolitan municipalities alone have an economic rooftop installation potential of more than 11 GW for the residential sector, after taking rooftop restrictions into account.

This study quantifies the expenditure savings that may be achieved by residential and commercial consumers in South Africa when installing rooftop solar photovoltaic (PV) systems with the aim of consuming most of the resulting electricity directly (henceforth termed self-consumption); the study was carried out in the context of the COBENEFITS project with the aim of assessing the co-benefits of a low-carbon energy transition in South Africa.

The analysis is based on scenarios for the future development of PV, including battery costs, the evolution of the retail electricity price and potential modifications to rate design (e.g., the introduction of demand charges). The study further analyses the uptake of PV and PV+Battery systems within these two consumer classes in South Africa up to 2030.

- **Policy message 1:** South Africa has a tremendous potential for rooftop solar PV. In the metropolitan municipalities alone, rooftop solar PV has an economic potential of 15 GW between now and 2030.
- **Policy message 2:** South African households and businesses can save money by investing in solar: annual savings for the residential sector alone sum up to around R12.8 billion.
- **Policy message 3:** In order to benefit from PV self-consumption in South Africa, it is crucial to establish attractive Small Scale Embedded Generation (SSEG) rates, to managing and forecasting the future uptake of self-consumption at municipal and national level and to establish incentives for low-income households to become prosumers.

KEY FIGURES:

- In the metropolitan municipalities alone, the potential installed capacity of economically viable residential rooftop solar PV amounts to 11.2 GW.
- Assuming that up to 11.2 GW of rooftop PV capacity could be installed by residential prosumers by 2030 (in the metropolitan areas alone), this would result in combined annual savings by all residential prosumers in South Africa of around R12.8 billion.
- For residential prosumers, monthly savings range from R200 to R543 for a 2 kW system (see 2 to 7 below). This would result in annual savings ranging from R2400 to R6500.
- For a typical 60kW commercial system, average annual savings of R20 000 can be realised over the system's lifespan.
- At present, payback times average 6 – 10 years for commercial PV systems and 10 – 22 years for residential systems, and are highly dependent on the valuation of PV by the local utility (SSEG tariff).
- PV/Battery systems will start to become economically viable as early as 2028.

COBENEFITS South Africa (2019): Consumer savings through solar PV self-consumption in South Africa. Assessing the co-benefits of decarbonising the power sector

available on www.cobenefits.info

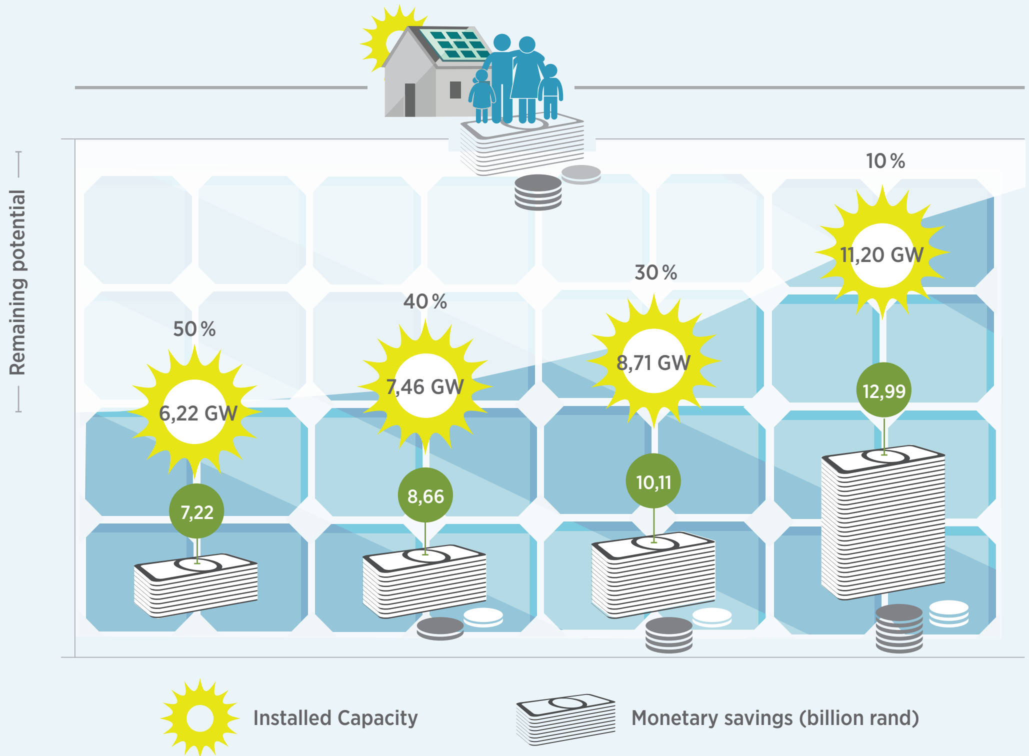
[1] The details of the project can be found on www.cobenefits.info

[2] The term **"co-benefits"** refers to simultaneously meeting several interests or objectives resulting from a political intervention, private sector investment or a mix thereof (Helgenberger et. al, 2019). It is thus essential that the co-benefits of climate change mitigation are mobilized strategically to accelerate the global transition to renewable energies and also low-carbon energy transition (Helgenberger et. al. 2017)

KEY FINDINGS:

- **Small-scale PV systems for self-consumption have already started to become economically viable for both residential and commercial customers.** The payback period for self-consumption systems has reduced sharply in recent years. This is due both to ESKOM tariff hikes and further reductions in the cost of PV systems. With a fair valuation of PV by the local utility (SSEG tariff), payback periods of PV systems for commercial and residential users can be reduced to 6 years and 10 years respectively.
- **An attractive payment scheme (FIT or SSEG tariff) also fosters self-generation and self-consumption** by enabling prosumers to design more capacious systems with the option to feed-in and sell surplus electricity back to the grid. At present, prosumers must design their system to avoid generating surplus electricity (optimisation of self-consumption), because the additional installation costs of a larger system cannot be recouped by selling any surplus energy into the grid. Generally, the tariff structure (i.e., electricity price composition) has a significant impact on the economics of solar (+battery) systems. Introducing demand charges, for instance, can make the business case unattractive.
- **Combined annual savings for residential prosumers in South Africa could add up to around R12.8 billion by 2030** in the metropolitan areas alone, assuming that up to 11.2 GW of rooftop PV capacity could be installed by residential prosumers. For residential prosumers, savings range from R200 monthly to R543 for a representative 2 kW system, giving annual savings of R2400 to R6500. For typical commercial customers, annual savings range from R20 000 (for a 62 kW system) to R65 914 (for a 1 MW system).
- **It is technically and economically feasible to install more than 11 GW of solar PV on residential rooftops in the metropolitan municipalities of South Africa by 2030** (total capacity in 2018: 285 MW). The of solar PV in these areas even adds up to 15 GW between now and 2030.
- **PV+Battery solutions can play an important role in incentivising prosumers and reducing peak load during evening hours.** Assuming further cost reductions for battery systems, economic viability can be reached in less than 10 years. Given that payback periods presently exceed 20 years, PV+Battery solutions need further investment incentives to provide an attractive business case.
- **Overall energy system costs can be reduced by optimally aligning the deployment of large-scale projects and distributed generation in South Africa.** To this end, detailed projections of the uptake of embedded generation will be necessary.

South African households can save up to **R13 billion** with solar PV self-consumption



Contents

List of Tables

List of Figures

1. Economic opportunities for consumers on the horizon

Rapidly falling costs of photovoltaic (PV) combined with sharply increasing electricity prices by ESKOM are opening the opportunity for a new wave of renewable energy investment by households and commercial customers in South Africa. For many consumer groups, it is already today more interesting to produce PV electricity themselves on their rooftops instead of purchasing it from ESKOM or the municipalities. And prices for PV and battery systems are expected to decline further in the future, thus improving the economics for so-called prosumers (i.e., consumers that produce a portion of their electricity on-site, based on rooftop solar PV).

In the past, South Africa has primarily focused on the deployment of large-scale renewable energy systems. The South African IPP program for renewable energy sources is one of the most successful procurement programs in the world in terms of low prices, job creation and large-scale investment. However, the small-scale deployment of renewables based on self-consumption can trigger a number of additional incentives which are in line with the South Africa "just transition" approach. With these social and economic co-benefits, small-scale deployment of renewables can be expected to considerably contribute to a low carbon and secure energy supply:

A multitude of actors will invest in renewable energies, including private households and businesses. And paying lower prices for electricity can lead to significant savings for households and commercial entities. In addition, low-income house-holds could also be financially supported to become prosumers and thus an integral part of the South African energy transition.

1.1 Rapidly declining costs of solar PV

In recent years, the cost of solar photovoltaic (PV) investment has reduced significantly, both nationally and globally. Worldwide, the cost of renewables, especially solar PV, has fallen drastically in most countries (Senatla and Bansal, 2017). International Renewable Energy Agency IRENA reported an 80% decline in the cost of PV modules between 2009 and 2015 (IRENA, 2016). Figure 1 shows the average auctioned price for utility-scale solar projects in different countries. Countries with high solar resources have the lowest cost (R/kWh). In South Africa, the cost of large-scale solar PV has reduced to an average of R0.62/kWh (Wright et al., 2017), and is assumed to decline further in future years.

For small-scale rooftop systems, IRENA has reported cost reductions of 44% in California and 66% in Germany in the past seven years (IRENA, 2017a). GreenCape (2017) showed that the cost of small-scale systems has fallen by between 25% and 46% in the past five years in South Africa.

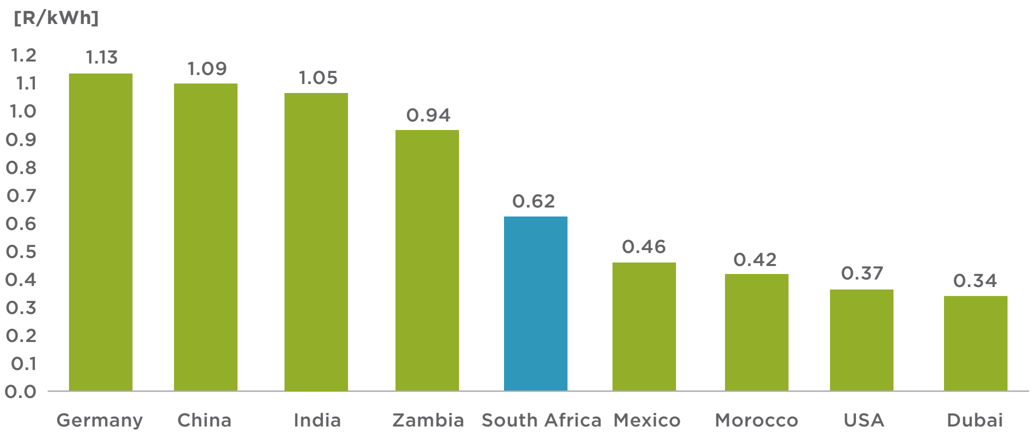


Figure 1: Auction results for large-scale solar PV projects worldwide

Source: Senatla & Mushwana, 2017, based on information from IRENA

1.2 Background to embedded generation in South Africa

Current market status of distributed solar PV in South Africa

There is a lack of reporting on distributed solar PV systems in South Africa. In 2012, Maphelele et al. (2013) recorded that South Africa had about 30 MW of small-scale PV systems installed by customers for various uses, such as rooftop installations along with powering cellular masts. The installed rooftop PV capacity in South Africa remains highly uncertain. Senatla and Mushwana (2017) reported that about 62 MW of PV capacity was installed by commercial, residential and agricultural establishments in 2017, of which 72 % was in the commercial sector (see Figure 2). The installed capacity increased by 16.7 percent annually. GreenCape reported that there was 94 MW of rooftop solar PV installed in South Africa in 2018 alone, of which 19% was located in the Western Cape (GreenCape, 2018). The latest study (Pandarum, 2018) shows that, in total, distributed solar PV systems amount to about 285 MW.

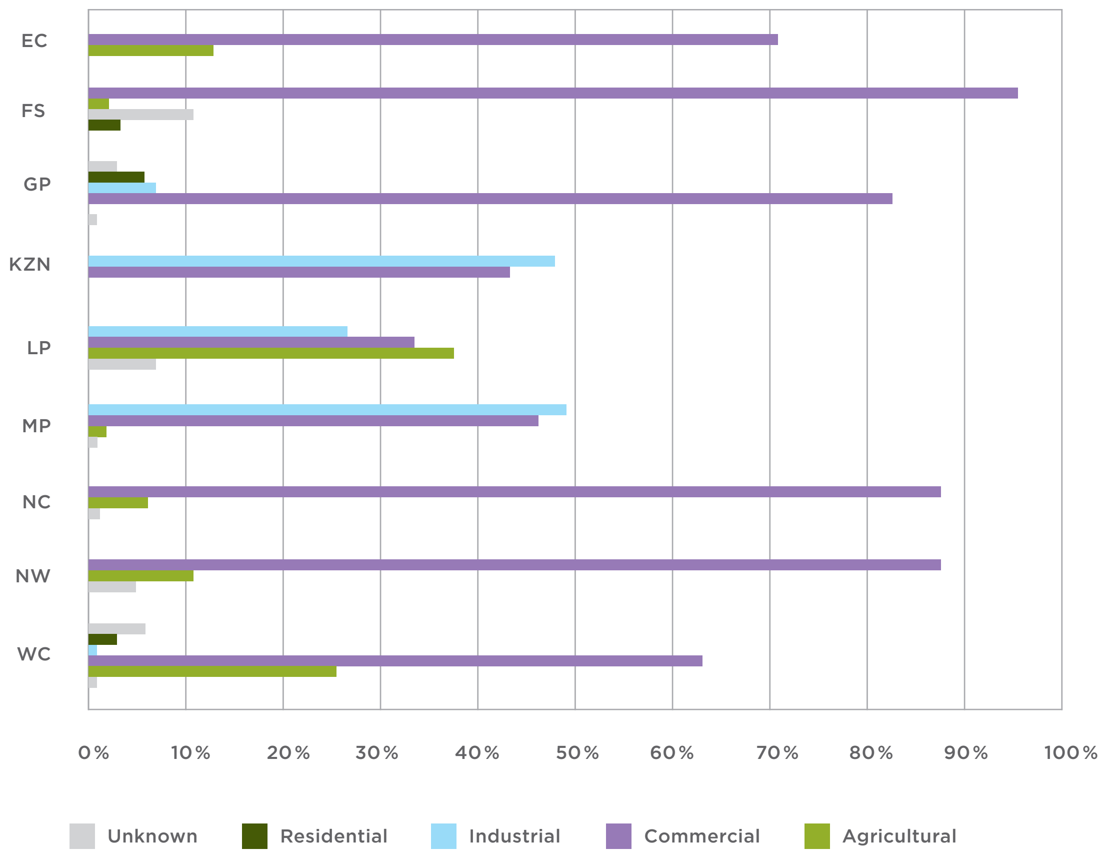


Figure 2: Share of installed embedded PV by sector and province

Source: Senatla and Mushwana, 2017

Studies on embedded generation

Studies of embedded generation are fragmented, and few studies have shown the uptake of rooftop PV by either the residential or commercial sector. It is estimated (GreenCape, 2018) that about 200 MW will be installed in the Western Cape by financial year 2019/20. A study by the Western Cape Government (2018) used an International Futures (IFs) model, which forecast that the Western Cape would have 4 GW installed rooftop capacity in the residential sector by 2040. Only one prior study, conducted by Eskom's Sustainability Division, concentrated on uptake at the national level (Pandarum, 2018). That study forecasted that 2.33 GW of embedded generation will be installed by 2025.

In the latest draft Integrated Resource Plan (IRP, Department of Energy, 2018), rooftop solar PV is assumed to be 2.6 GW by 2030 and 7 GW by 2050. It is assumed that there will be an addition of 200 MW every year (starting from 2018) until 2030. The recent IRP draft deviates from the 2013 draft IRP, which assumed an uptake of 22 GW by 2030 and 29 GW by 2050. Figure 3 provides a figurative comparison of both resource plans.

Both plans lack a detailed analysis of how the capacities are determined. Given these two disparities, it is clear that a more detailed projection of the uptake of embedded generation is necessary to optimally align the deployment of large-scale projects and distributed generation in South Africa, thus reducing overall system costs.

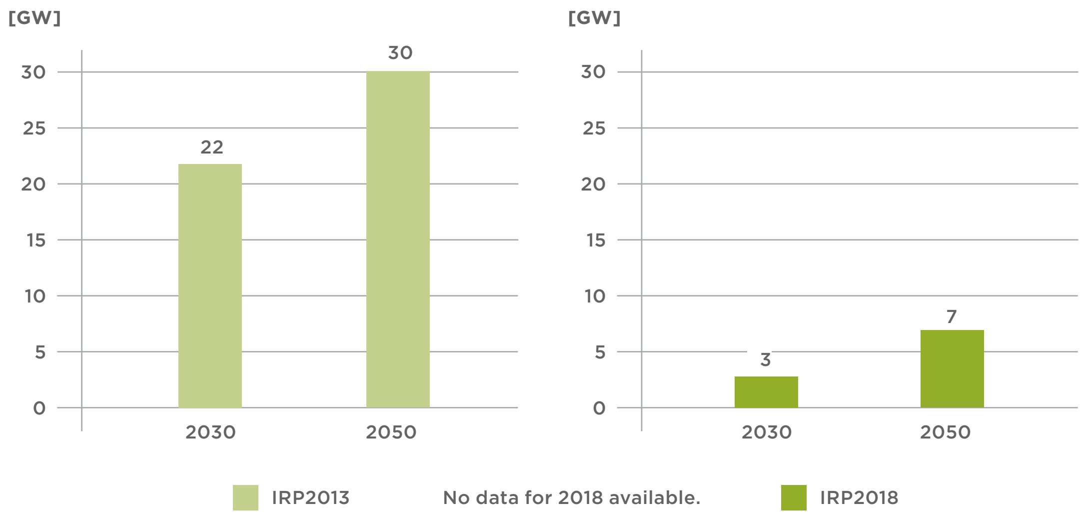


Figure 3: Comparison of 2013 and 2018 Draft IRPs regarding projected uptake of distributed generation

Source: own

INFOBOX: Prior studies on the uptake of distributed generation and roof-mounted PV

- According to IRP2010 Update, 21 GW and 29 GW of residential rooftop PV were assumed to be installed by 2030 and 2050 respectively (25 GW in 2037; in the same document, total national installed capacity is around 100 GW in 2030 and 123 GW in 2050).
- IRP2013 assumed that the capacity will come from higher-income households (LSM 7–10)[3] and that by 2020 about 50% of the households in this group would have rooftop systems. The average individual system size was assumed to be 5 kWp.
- Poller and GIZ conducted a flexibility study that tested scenarios with up to 20 GW of rooftop PV by 2030 (Pöller, 2017). That study did not quantify PV uptake but simply tested what might happen to the network in the case of massive adoption.

[3] The LSM (Living Standards Measure) was developed by the South African Advertising Research Foundation (SAARF, since renamed the South African Audience Research Foundation).

1.3 Scope of the study

The first objective of the present study is to model the energy and financial savings that result when residential and commercial consumers install solar PV on their rooftops. The second objective is to assess the economic potential of rooftop PV in the residential sector when extrapolated to the national scale. To achieve the first objective, the following analyses were performed:

- Detailed analysis of electricity consumption for selected customers (residential and commercial), with analysis of weekly and annual load profiles.
- Detailed analysis of the electricity price regime for selected customers (residential and commercial), including an analysis of tariff categories and rate design.
- Analysis of potential changes to rate design in South Africa (e.g., higher demand charges, time-of-use tariffs) and potential impacts on distributed generation and prosumerism (i.e., payback times).
- Analysis of the installed costs of solar PV rooftop systems in South Africa for the selected customers, including learning rates for future costs.
- Analysis of the installed costs of solar PV+battery systems for the selected customers, both with and without future cost reductions.
- Detailed analysis and quantification of solar resource profiles for selected regions.
- Expenditure savings that result from installing rooftop systems for individual customers.
- Expenditure savings that result from national uptake of PV+battery systems.

The following analyses were conducted as part of the second objective:

- Quantification of residential customers per tariff and their per living standard measure (LSM).
- Analysis of available roof-space in South Africa as one limiting factor.
- Analysis of additional limiting factors, namely levels of home ownership.

Study limitations

To develop business cases, high-income households (LSM 10) are assumed to be on the highest, most costly tariff block. However, in practice, some households in LSM 10 might be on a tariff with a lower inclined block. This simplified assumption allowed for assessment of the technical and economic potentials. To more accurately calculate the uptake of rooftop PV systems, the number of customers in each tariff category and each municipality need to be known. This will indicate which of the tariffs presents a viable business case for the concerned customers. These data are not presently available, hence assumptions had to be made in estimating the economic potential of rooftop uptake.

2. Methodology

2.1 Overall methodological approach

The present study employs a two-tier methodology. The first tier deals with the business cases of individual customers. The second tier assesses the future economic potential of rooftop systems using the metrics derived from the tier-one assessment. An overview of the methodology is shown in Figure 4. Monetary savings are calculated at individual customer level, sectoral level, and finally at city level.

2.2 Quantifying financial expenditure and PV savings

In calculating potential expenditure savings, the first step is to establish present expenditure levels, i.e., what customers pay the municipality for grid electricity in the absence of a rooftop solar system (PV or PV+battery). The financial or expenditure savings resulting from customers' usage of PV are calculated for a sample of selected residential and commercial customers over the lifetime of a PV and/or PV+battery system. For this study, the lifespan of a solar PV system is assumed to be 25 years, and the battery and inverter are assumed to operate for 10 years, after which they must be replaced.

2.3 Business cases for selected customers

The step-by-step process of calculating the expenditure savings is presented in Figure 5. The second step involves calculation of business case parameters. These parameters are net present value (NPV), internal rate of return (IRR), payback period (PBP) and the levelised cost of electricity (LCOE) production for PV/battery systems. IRR gauges the profitability of PV installations in relation to the tariff that the customer is billed. NPV will be used to assess whether the solar PV and/or PV+battery installations will break-even within the system's lifetime when located in different regions. The resulting levelised cost of electricity (LCOE) will indicate the cost at which the owner is producing electricity from the rooftop system.

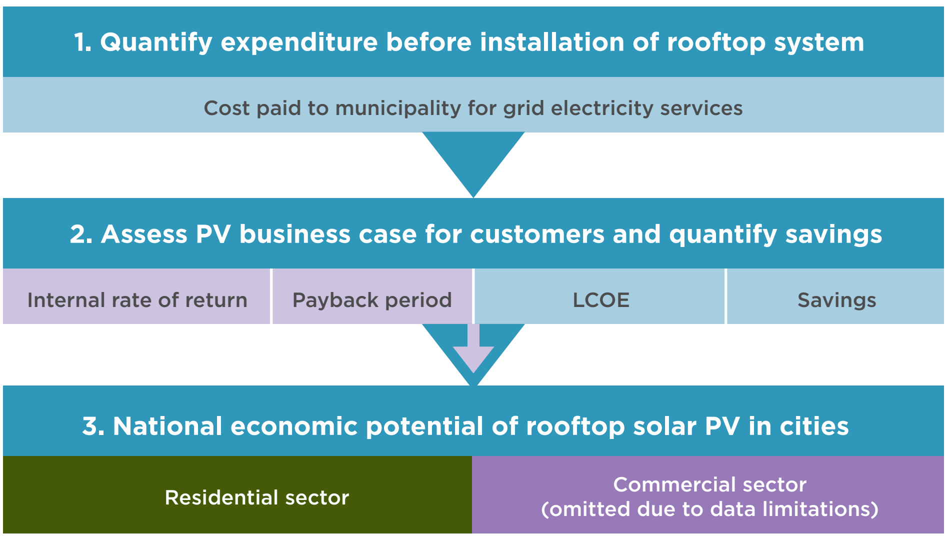


Figure 4: Schematic overview of study methodology

Source: own

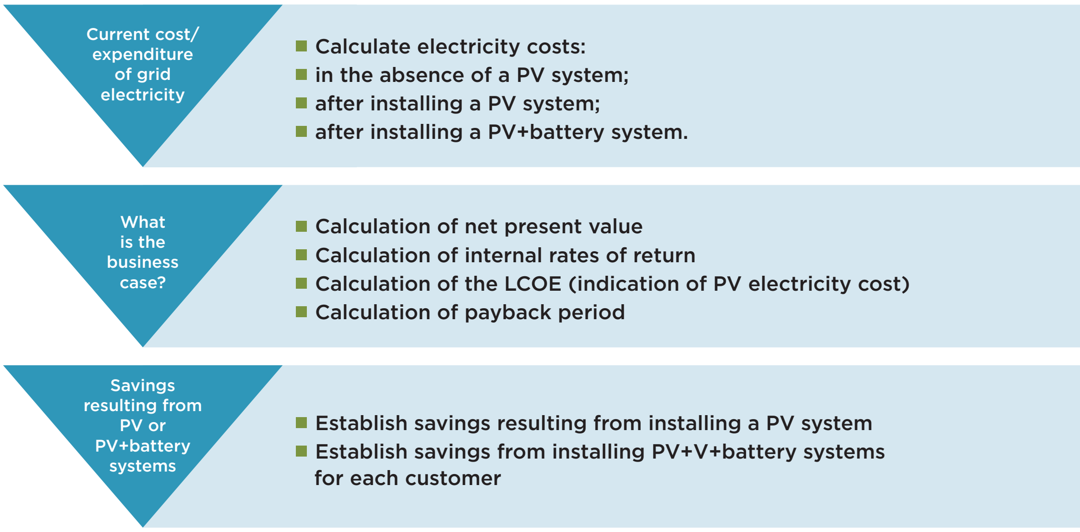


Figure 5: STEP 1: Schematic overview of the methodology for analysing business cases for PV/battery systems

Source: own

Business case for individual solar PV installations

The business case for individual customers is calculated using the open-source model developed by GENESIS (2017). The model calculates the financial impact of the increased uptake of solar PV on municipal revenues, and develops business cases for customers who install solar PV. The financial impact model allows a municipality to determine the impact on its revenue if some of its customers decide to install solar PV. The business case model tests whether the chosen small-scale embedded generation (SSEG) tariffs chosen by the municipality make the installation of solar PV by customers financially viable. For this project, the business case model is used to calculate important economic parameters that highlight the attractiveness of investing in solar PV.

The parameters of interest in quantifying the business case are presented in Figure 5. NPV must be positive; PBP must be shorter than the lifetime of the asset (here, reasonable PBP is assumed to be 5–10 years); and for IRR higher rates are preferable (here taken to be >10%). The main inputs to the model are load and tariff data for each municipality. The original model does not calculate the business case for PV+battery combinations. However, since this study is interested in both types of system, some adjustments were introduced to calculate the business case for both PV and PV+battery systems. The commercial sector customers analysed in this study are presented in Table 1. Although the original intention was to obtain data from a district or local municipality, this proved difficult; therefore, only data for metropolitan municipalities were used.

Modelling PV+battery business cases with the SSEG tool

The GENESIS SSEG tool was not designed to quantify business cases for energy storage systems, and therefore adjustments to the model were required in order to model the business cases for systems that incorporate a battery. The model was adjusted such that 90% of the power consumed by the households or commercial customer was assumed to be from the PV+battery system, thereby leaving the grid to supply only 10% of overall electricity demand.

Customer class	Region	Municipality
Research institution	Pretoria, Gauteng	City of Tshwane
Office complex	Johannesburg, Gauteng	City of Johannesburg
Game lodge	Durban, Kwazulu-Natal	EThekwini
Butcher	Johannesburg, Gauteng	City of Johannesburg

Table 1: Commercial entities with load data as of 20 April 2018

Source: own

3. The economics of rooftop PV systems

In this chapter, the economics of different types of rooftop PV system for self-consumption are investigated:

- The economics of rooftop PV for residential prosumers
- The economics of rooftop PV for commercial prosumers
- The economics of PV+battery systems for commercial and residential prosumers

3.1 The economics for residential prosumers (without battery) are rapidly improving

This section presents five case studies that estimate the economic viability of rooftop PV systems for residential customers under different market conditions. The analysis shows that the available tariffs and the structure of the electricity price (the rate design, including potential demand charges) can significantly affect economic viability for prosumers.

KEY FINDINGS:

- The availability of a SSEG tariff, i.e., a tariff that pays prosumers for surplus electricity that they feed into the grid, significantly improves economic viability and also incentivises the deployment of large-scale rooftop PV systems.
- The level of feed-in payments for surplus electricity obviously also impacts the economics of rooftop solar installations. Municipalities that remunerate excess electricity in line with the retail electricity price usually establish attractive conditions for prosumers. However, many municipalities are reducing SSEG/FIT tariffs in order to recover some costs related to grid services.
- Time-of-use tariffs employ different rates according to fluctuations in demand for electricity across the grid. Depending on their design, these time-varying rates can either improve or worsen the economic viability of PV systems for prosumers.
- Higher fixed charges and demand charges will lead to longer payback periods and lower internal rates of return.

Case study 1: SSEG tariff; no fixed charges; remuneration of excess electricity in line with retail electricity price

In past years, several municipalities have established specific SSEG tariffs that pay small-scale power producers for each kilowatt-hour exported to the grid. These tariffs usually offer an interesting business case for prosumers. Using the examples of Nelson Mandela Bay Municipality: Once residential customers install an SSEG they are migrated to an SSEG tariff that is based on time-of-use. Under the SSEG tariff, the customer's electricity feedback is valued at R1.20/kWh (equal to the standard rate tariff the municipality charges the customer).

This case shows that valuing the customers' excess generation at the retail electricity price makes an attractive business case for SSEG. Under such a tariff, larger-scale rooftop PV systems that feed their excess electricity into the grid may even generate revenues (e.g., 6 kW systems, see System 2 in Table 2 below).

	System 1: Small system for self-consumption 2 kW (no tariff SSEG)	System 2: Larger system for feed-in 6 kW (with current SSEG tariff)
Objective	Maximise self-consumption ratio	Maximise use of existing roof-space
Payback period	7 years	8 years
Expenditure saved/Revenue gained	R294/month	-R182/month
Compensation (Feed-in tariff)	R83	R546
Bill from the municipality	R310	R-182
Internal rate of return	16 %	15 %
LCOE	R1.59/kWh	R1.59/kWh

Table 2: SSEG Tariff of Nelson Mandela Bay (NMB) Municipality

Source: own

Case study 2: Time-of-use tariff and increased monthly fixed charges

In the wake of increasing self-consumption, many municipalities are considering higher fixed monthly charges or higher demand charges in order to recover some of their fixed costs from prosumer clients. For example, customers who install SSEGs in the City of Cape Town face increased monthly service charges. Increasing this monthly fee reduces the attractiveness of the business case significantly. In this municipality, a household consuming more than 600 kWh/month is charged R1.98/kWh plus a fixed monthly service charge of R136.61. Once a customer decides to install a PV system, the monthly fixed service charge is increased to R383. Once a customer migrates to a SSEG tariff, the requirement to pay an additional fixed administrative charge makes the business case unattractive. For a smaller system of 2 kW the payback period is 22 years, while that for a 4 kW system is 17 years (see Table 3).

	System 1: Small system for self-consumption 2 kW	System 2: Larger system for feed-in 4 kW (with current SSEG tariff)
Objective	Maximise self-consumption ratio	Maximise use of existing roof-space
Payback period	22 years	17 years
Expenditure saved/Revenue gained	R386	R699
Compensation (Feed-in tariff)	R51	R336
Bill from the municipality	R846	R533
Internal rate of return	1 %	4 %
LCOE	R1.56/kWh	R1.56/kWh

Table 3: City of Cape Town under SSEG tariff

Source: own

If the fixed proportion of the tariff was not increased, the business case would remain very attractive for both small and larger systems. Table 4 shows that the payback periods for 2 kWp and 4 kWp systems would then reduce to 8–10 years with internal rates of return of 14% and 10% respectively. This example clearly shows that additional fixed charges or demand charges can significantly reduce the economic viability of rooftop solar PV.

Table 4: City of Cape Town under no fixed charges

Source: own

	System 1: Small system for self-consumption 2 kW	**System 2:** Larger system for feed-in 4 kW (with current SSEG tariff)
Objective	Maximise self-consumption ratio	Maximise use of existing roof-space
Payback period	8 years	10 years
Expenditure saved/Revenue gained	R386	R699
Compensation (Feed-in tariff)	R51	R336
Bill from the municipality	R846	R533
Internal rate of return	14 %	10 %
LCOE	R1.56/kWh	R1.56/kWh

Case study 3: No SSEG tariff; no payment for excess electricity

For municipalities that do not have an SSEG policy and tariff and therefore do not remunerate any excess electricity fed into the grid, the sizing of rooftop PV units is crucial for customers, since self-consumption needs to be maximised and excess generation capacity should be avoided (see Table 5). Buffalo City has three types of tariff (R1.24–R1.80/kWh) for its residential customers. Two of these (the prepaid and high-end credit tariffs) result in attractive business cases. However, Table 5 clearly indicates that only very small PV systems (2 kW) are economically attractive, since these allow for the highest ratio of self-consumption.

Table 5: Buffalo City under no SSEG tariff

Source: own

	System 1: Small system for self-consumption 2 kW	**System 2:** Larger system for feed-in 4 kW (with current SSEG tariff)
Objective	Maximise self-consumption ratio	Maximise use of existing roof-space
Payback period	11 years	22 years
Expenditure saved/Revenue gained	R302	R327
Compensation (Feed-in tariff)	R0	R0
Bill from the municipality	R502	R478
Internal rate of return	10 %	2 %
LCOE	R1.59/kWh	R1.59/kWh

Case study 4: No SSEG tariff; time-of-use rate versus flat-rate

Without any payment for surplus electricity (no SSEG tariff), a customer on a time-of-use (ToU) tariff in Tshwane pays R1163 per month. Installing a small-scale rooftop solar PV system sized to maximise self-consumption would have a 12-year payback period and provide monthly savings of R237. Again, if no tariff is provided for surplus electricity generated, prosumers are only incentivised to select relatively small PV systems that optimise self-consumption while avoiding generating a surplus. As shown in Table 6 below, the internal rate of return for a 4 kW system is significantly less than for a 2 kW system. Interestingly, in the case of the tariffs offered by the Tshwane municipality, the inclining flat rate tariff (Table 7) offers slightly better conditions than the city's time-of-use tariff.

Table 6: City of Tshwane (time-of-use tariff)

Source: own

	System 1: Small system for self-consumption 2 kW	**System 2:** Larger system for feed-in 4 kW (with current SSEG tariff)
Objective	Maximise self-consumption ratio	Maximise use of existing roof-space
Payback period	12 years	22 years
Expenditure saved/Revenue gained	R237	R303
Compensation (Feed-in tariff)	R7	R46
Bill from the municipality	R926	R859
Internal rate of return	9%	2%
LCOE	R1.43/kWh	R1.43/kWh

Table 7: City of Tshwane (Inclining block tariff)

Source: own

	System 1: Small system for self-consumption 2 kW	**System 2:** Larger system for feed-in 4 kW (with current SSEG tariff)
Objective	Maximise self-consumption ratio	Maximise use of existing roof-space
Payback period	11 years	18 years
Expenditure saved/Revenue gained	R335	R401
Compensation (Feed-in tariff)	R7	R46
Bill from the municipality	R498	R432
Internal rate of return	10%	4%
LCOE	R1.43/kWh	R1.43/kWh

Case Study 5: Effects of the introduction of a demand charge

The fifth case study reveals the effects of introducing additional demand charges, as defined by the monthly peak demand of an individual customer. Modest demand charges, introduced by municipalities that offer remuneration for excess electricity (see the metrics for Nelson Mandela Bay municipality in Table 8 below), have very limited effects on the economics of rooftop PV systems. As indicated by Table 8, the resulting payback period is only slightly longer. However, more aggressive demand charges could undermine the economic viability for commercial prosumers.

Table 8: Customers with a demand charge

Source: own

	Current tariff		Tariff with additional demand charge	
Parameters	EThekwini	Nelson Mandela Bay	EThekwini	Nelson Mandela Bay
Demand charge	R0	R0	R100	R100
Payback period	14	7	17	8
IRR	7 %	16 %	4 %	15 %

3.2 Attractive economics for commercial prosumers (without battery)

This section analyses the economic viability for commercial prosumers of solar PV systems that lack a battery component. Several commercial customer types were modelled and are presented in the following case studies.

KEY FINDINGS:

- The economics of rooftop PV systems for commercial prosumers are even more attractive than for residential consumers. The payback period for commercial entities is between 6 and 10 years.
- All of the business cases for commercial customers are analysed using the time-of-use tariff within differing municipalities.
- Other framework conditions discussed for residential prosumers also apply to commercial prosumers: Attractive remuneration for surplus electricity would allow larger-scale PV systems to be economically viable; Changes to the rate design (higher fixed charges or demand charges) would reduce the economics of systems designed for self-consumption.

Case study 6: Butchery business

A butchery business located in Johannesburg, signed up to City Power's feed-in tariff of R0.39/kWh, has a payback period of 9 years (see Figure 6), an LCOE of R1.39/kWh and IRR of 13%.

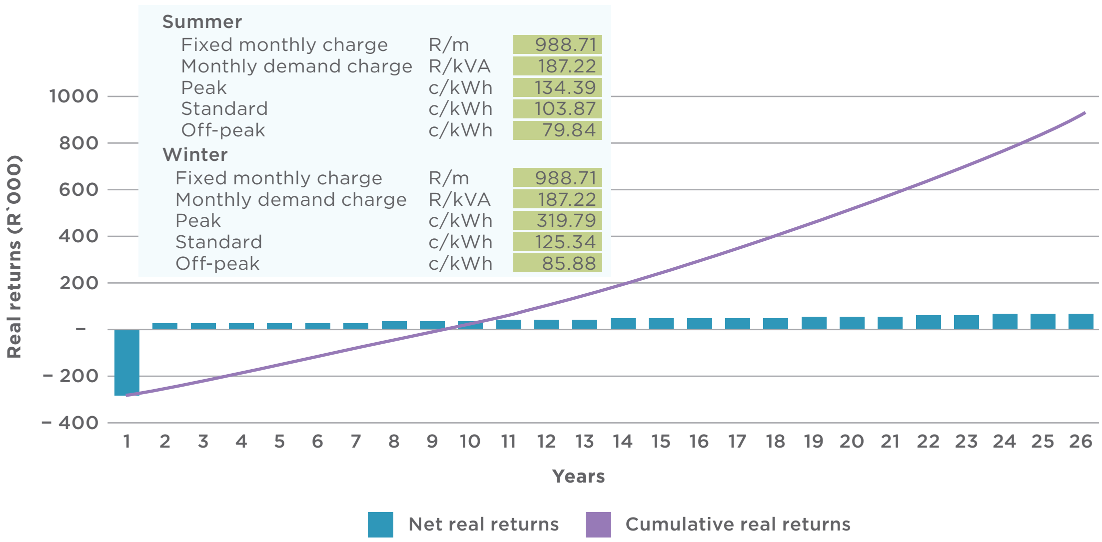


Figure 6: Payback period for butchery business in Johannesburg (City Power)

Source: own

The importance of correct system sizing is again demonstrated in Figure 7, where the payback period increases to 17 years under the same tariff and load. If the City Power municipal electricity provider would introduce remuneration for excess electricity, this would improve the economic viability of these larger-size rooftop systems. Remuneration of R1.25/kWh for each kilowatt-hour fed into the grid would reduce the payback period to only 8 years.

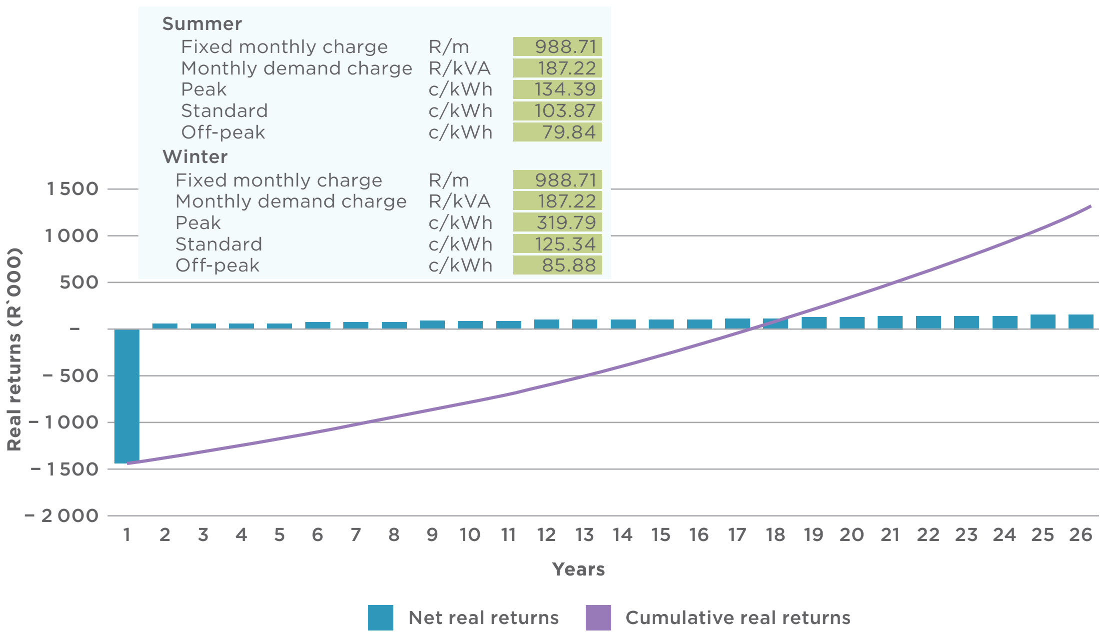


Figure 7: Payback period for a butchery business with FIT/SSEG

Source: own

Case Study 7: Office Complex

The case study for an office complex has a payback period of 10 years for a system of 42 kW (see Figure 8). The 42 kW system already covers the entire roof space, and so this customer cannot install a larger-scale system with the aim of feeding surplus energy back into the grid. The project would result in an IRR of 11 %.

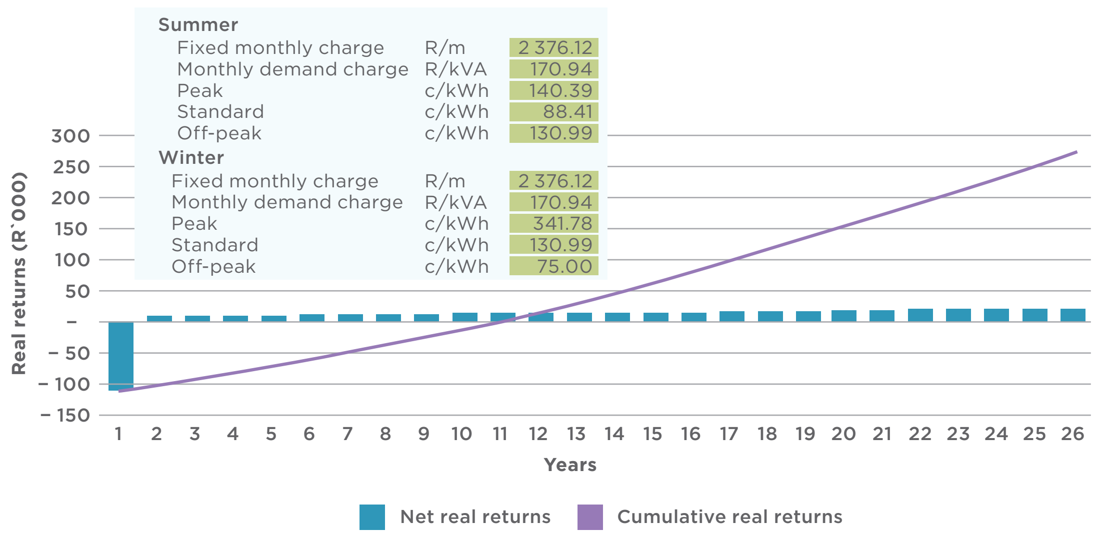


Figure 8: Payback period for office complex in Tshwane Municipality

Source: own

Case Study 8: Research Institution

For a research institution, the appropriately sized PV system can generate an IRR of 20% and a payback period of only 6 years. At both 3358 kW and 5670 kW installed capacity, the business case for the research institution is still favourable without a feed-in tariff.

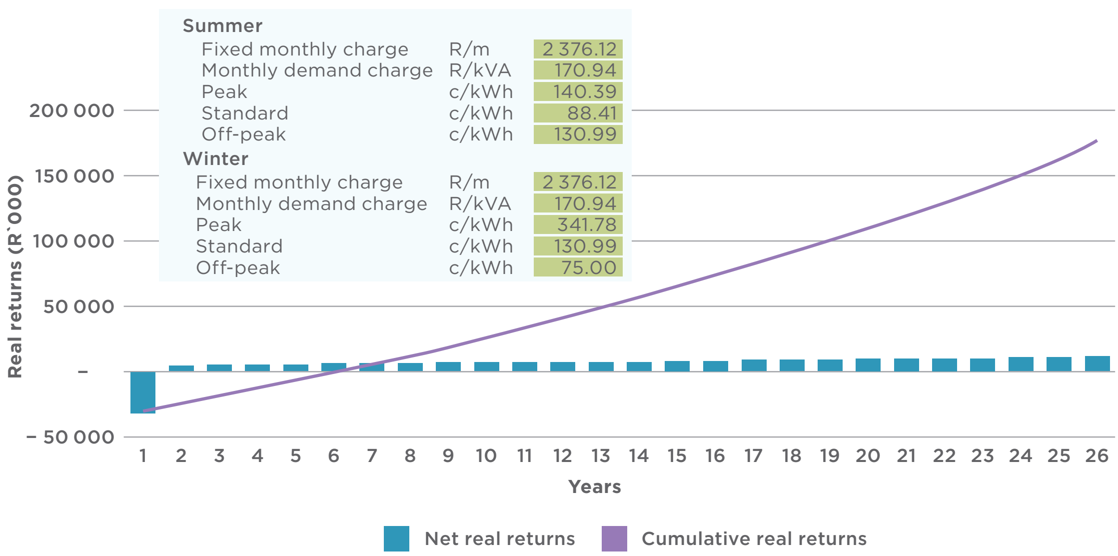


Figure 9: Payback period for research institution

Source: own

3.3 Economic viability of prosumer systems incorporating battery storage

Batteries will play a significant role in decarbonising energy systems worldwide (IRENA, 2017b), and will serve several purposes. For onsite generation – especially for industrial, commercial and residential customers – batteries are mainly used to increase the proportion of self-consumption, to reduce demand charges (peak demand charges) and for shifting to the use of retail electricity when the retail price is low.

Despite these promising roles that batteries can play in the energy transition, they do not currently present an attractive business case. As shown in Table 9, residential customers with a 4 kWh battery pack would face payback times that exceed the economic lifetime of solar PV systems. For the depicted commercial prosumers, it would not be cost-effective to add battery storage to a solar PV system. Usually, commercial prosumers require payback periods shorter than eight years and expect IRR >10%.

Parameter	Residential customer	Butchery	Office complex	Research institution
Battery size	4 kWh	4 MWh	1 MWh	75.4 MWh
Payback period	26 years	18 years	20 years	21 years
Internal rate of return	0 %	4%	2%	2%
LCOE	R3.12/kWh	R3.74/kWh	R3.25/kWh	R2.29/kWh

Table 9: Business case parameters for prosumer PV systems with battery storage (2018)

Source: own

However, the cost of battery technologies is expected to further decrease in the coming years and decades. Therefore, with increased tariff prices (assumed to be 6% per annum in the next 12 years), and decreasing cost of PV and battery systems (R25 000/kWp in 2030 versus R28 000/kWp in 2018), the business case improves as presented in Table 10.

Parameter	Residential customer	Butchery	Office complex	Research institution
Payback period	13 years	11 years	16 years	18 years
Internal rate of return	0 %	4%	2%	2%
LCOE	R2.60/kWh	R1.39/kWh	R2.86/kWh	R2.86/kWh

Table 10: Business case parameters for prosumer PV systems with battery storage (2030)

Source: own

It should be noted that relatively large battery sizes have been assumed for the cases modelled. The battery size assumptions would allow prosumers to be almost fully autarch, providing 90% of total power demand with the domestic PV+battery system. However, by choosing smaller battery sizes, the economics will improve and the application of PV+battery systems would become cost-effective sooner.

4. Assessing the untapped potential for solar rooftops within the residential sector

There are three different approaches for assessing the potential of solar PV: resource potential, technical potential, and economic potential (Gagnon et al., 2016). Resource potential refers to the solar radiation available in a given country. South Africa is well known for having good solar resources: many regions average more than 2500 hours of sunshine annually, and average solar radiation level ranges between 4.5 and 6.5 kWh/m² in one day.[5]

Technical potential is the amount of resource that can be captured by a particular technology, in this case rooftop PV. This technical potential excludes economic factors, and only considers system and topographic constraints, land use constraints and system performance (Gagnon et al., 2016). According to Knorr et al. (2016), South Africa's technical potential for solar PV rooftop systems is 72 GW.

The assessment of the economic potential goes one step further, and assesses the proportion of the technical potential that is actually economically viable under present market conditions. This study analyses the economic potential of solar PV (and battery) systems within metropolitan municipalities.

Assessing the economic potential for residential solar PV, and making assumptions for future developments, is relatively complex. In the absence of data, this study only quantified the economic potential of rooftop solar PV within the metropolitan municipalities (metros) for the residential sector (see Figure 11). The total economic potential within the metros is 15 GW, with Gauteng metros accounting for 65% of this.

The assessment of the potential uptake of rooftop solar PV in the residential sector has several limitations. Many assumptions had to be made regarding customers' particular tariff categories. This approach might give less robust results; however, given the paucity of data, it represents the best option at this stage. A typical municipality has about 10 tariffs for a particular class of customers (e.g., residential customers). For example, Nelson Mandela Bay has 3 types of tariffs: domestic (indigent), domestic credit and prepaid tariffs and an embedded generation tariff. Both domestic (indigent and credit) are on inclined block tariffs, while the embedded generation tariff is based on time-of-use. Therefore, assessing the business case for a customer requires knowing their tariff category. However, since such information is not publically available, the present study makes several assumptions.

Households are classified into Living Standards Measure (LSM) groups as per the South African Audience Research Foundation (SAARF). Households in lower LSMs (LSM 1–4) are assumed to be on the indigent tariff, if one exists for the municipality; otherwise, the lowest value of the inclined tariff block is assumed for this class of customers.

The model assumptions covered:

- Type of tariff
- Number of customers per LSM in that tariff category
- Average PV system size per LSM

Rooftop solar PV projects were deemed economically viable under the following conditions:

- IRR of 5% or higher;
- Payback period of 10 years or less for residential customers.

The metros have an economic potential of 15 GW within their residential sectors. Figure 11 shows that this potential lies within higher LSMs, mainly because they are charged higher tariffs, thus making self-consumption more attractive. LSM groups 1–4 have the lowest economic potential. These are households that benefit from subsidised electricity prices.

[5] http://www.energy.gov.za/files/esources/renewables/r_solar.html

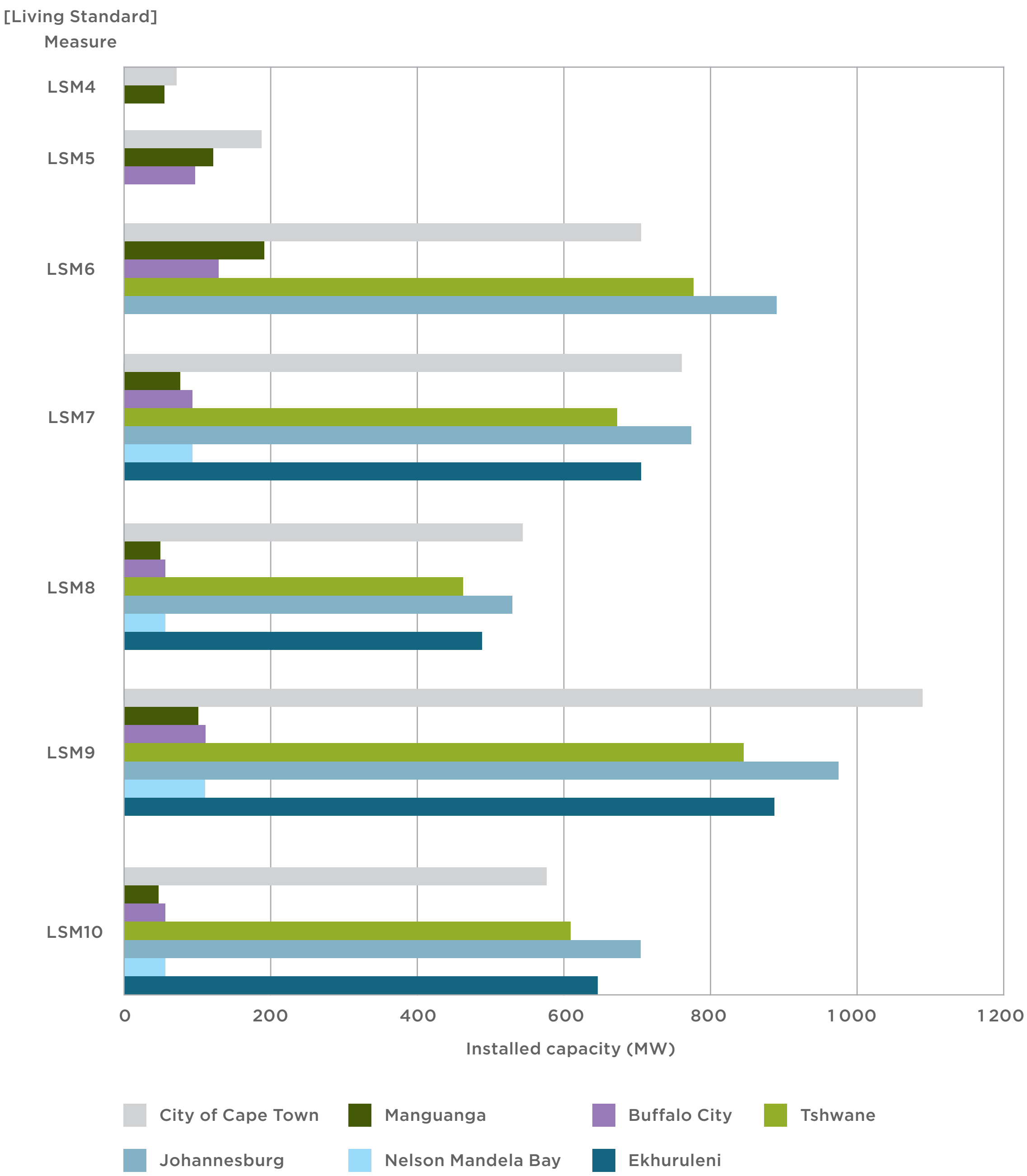


Figure 10: Economic potential of rooftop solar PV within metros in South Africa

Source: own

The economic potential presented in Figure 10 is further restricted by roof-space availability and the percentage of households that own the homes in which they live. For simplification, it was assumed that only home-owners would install rooftop PV for themselves, and not for potential tenants.

In order to assess roof-space limitations, the following data were collected: In 1998, settlements covered 14% of the total surface area of South African (Hoffman and Todd, 1998), of which area the metros accounted for 17%. It was further assumed that the surface area covered by settlements had likely increased to about 20% in subsequent years, due to population growth since the 1998 study.

In order to assess roof-space as a limiting factor, the following assumptions were made: Given the high population density in cities, especially in South African metros, this study assumes that at least 50% of the total area is used for settlements, which translates into a corresponding area of roof-space. Under this assumption, more than 6 GW of solar PV capacity could be deployed on rooftops in the metros alone. Assuming even higher shares of land used for settlements in the future and an even more densely populated area within the metros, i.e., 90% of space being used for buildings by 2030, the total installed capacity could increase to 11.2 GW (see Figure 11 below). South Africa's metropolitan areas cover an area of 29 513 km². In other words, despite having an economic potential of 15 GW, the metros can only accommodate up to 11.2 GW of solar PV rooftop potential.

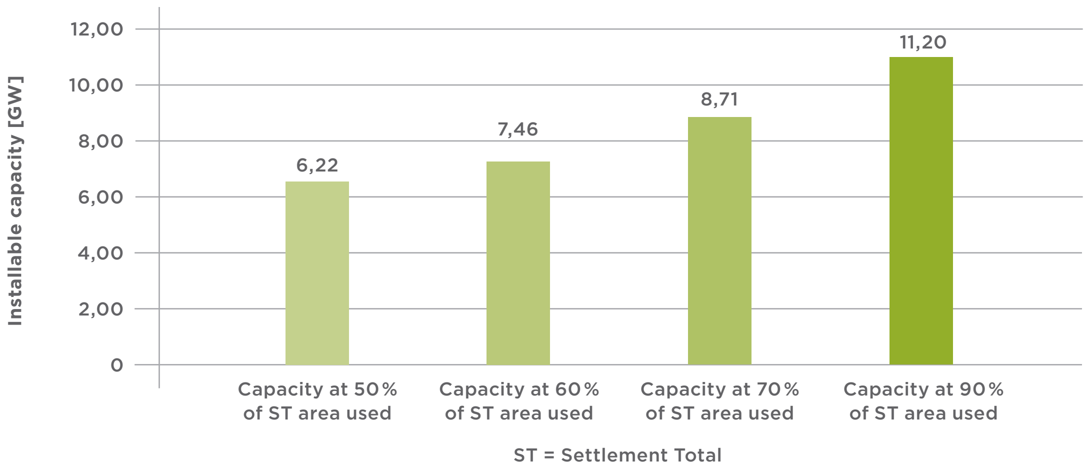


Figure 11: Technically viable solar rooftops in residential sector

Source: own

5. Expenditure savings for individual and aggregated prosumers

The objective of this research project was to quantify the potential savings for residential and commercial customers in South Africa that deploy rooftop PV (plus battery) systems for self-consumption. This involved calculating the potential savings for individual prosumer groups (see annex of the full version of the report on www.cobenefits.info) and then aggregating and extrapolating the findings to the national level.

5.1 Savings for residential prosumers

- For residential prosumers, monthly savings range from R200 to R543 for a 2 kW system. This would lead to annual savings of R2400 to R6500.
- On a per-kilowatt basis, this translates to annual savings of R1160 to R2000.
- Assuming that up to 11.2 GW of rooftop PV capacity could be installed by residential prosumers until 2030 (in the metros alone), this would lead to cumulative annual savings by all residential prosumers in South Africa of around R12.8 billion.

5.2 Savings for commercial prosumers

- For a typical 60 kW commercial system, average annual savings of R20 000 can be realised over the system's lifespan. A favourable rate design that considers the viability of commercial prosumers can considerably improve the system's payback period and savings potential.
- Calculating nation-wide savings for commercial customers is not feasible, since there is a lack of data on the number of commercial customers.

The total, accumulated savings calculated above are based on various assumptions and should therefore be interpreted with some caution. Firstly, potential savings were estimated for a few, representative municipalities in South Africa, but not all of them. Secondly, the average savings were calculated for one system only, and this value was then used to calculate national savings potential. Thirdly, potential future changes to the rate design were not factored in. As described above, changes to the rate design can considerably affect economic viability for prosumers.

6. Creating an enabling environment for pursuing rooftop solar PV in South Africa

Impulses for furthering the debate

The analysis has revealed the vast potential for rooftop solar PV in South Africa. The economic viability of PV systems for self-consumption will further improve in the coming years and growth rates will further accelerate. However, certain policies and regulations will need to be put in place or adjusted in order to manage sustainable uptake in the rooftop PV sector, including:

This COBENEFITS study has quantified the vast potential for rooftop solar PV in South Africa while decarbonizing the power sector. The economic viability of PV systems for self-consumption will further improve in the coming years and growth rates will further accelerate. However, the study also found that the tariff structure has a significant impact on the economics of solar (+battery) systems. Introducing demand charges, for instance, would make the business case unattractive.

What can government agencies and political decision makers do creating a suitable enabling environment to maxi-mise cost savings and financial benefits for the people and businesses in South Africa?

How can other stakeholders harness the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating a just transition?

Building on the study results and the surrounding discussions with political partners and knowledge partners we are proposing to direct the debate on three areas where policy and regulations could be put in place or enforced in order to facilitate consumer savings through solar PV self-consumption in South Africa within the shift to a less carbon-intensive power sector:

- Payment modalities for excess electricity
- The future rate design for prosumers
- Incentives for low-income households to become prosumers
- Managing and forecasting the future uptake of self-consumption

Payment modalities for excess electricity (FIT payments or similar approaches)

The study has shown that small-scale PV systems can be economically viable even without compensation for excess electricity. However, the analysis also indicated that municipalities can significantly improve the economics for prosumers by offering SSEG tariffs that provide payment for excess electricity that is fed into the grid. The question remains whether PV (plus battery) systems will be financed based on optimised self-consumption alone. Financing a PV system based on self-consumption is relatively risky for investors, especially in the commercial sector based on certain factors. Key among them are:

- A prosumer's electricity demand might change over time, meaning that it can be challenging to calculate optimal sizing of the system (this is especially risky for commercial and industrial prosumers, where electricity demand can very largely depend on business cycles).
- The electricity rate design might change, thus undercutting the economics of existing rooftop PV systems. Currently, SSEG tariffs can change every year.
- Prosumers (especially in the commercial sector) might look for very short payback periods and high returns to justify any investment (since such investments are not part of their core business).

Therefore, several jurisdictions worldwide have supported prosumers by offering a low but stable price for any excess electricity that is fed into the grid. For investors and banks, this low but stable remuneration level can serve as a fall-back option (in case of changes to onsite demand or rate design), which can make larger projects that rely on debt-finance more bankable. By allowing rooftop PV systems to feed excess electricity back into the power network, distributed generation can contribute to meeting national renewable energy targets.

Future rate design for prosumers

The study has also shown that changes to the rate design (e.g., higher fixed charges and demand charges) can undercut the economics of self-consumption. Therefore, any modifications to the existing rate design should be undertaken prudently.

In addition, the effects of the new rate design need to be further analysed. Research in other countries has shown that higher fixed charges can lead to higher electricity prices for low-income households (Whited et al., 2017). Moreover, demand charges can hamper demand-side flexibility and thus become a barrier to the energy transition in South Africa. Alternative rate design options, including time-of-use rates, real-time pricing and locational pricing should be further analysed.

Incentives for low-income households to become prosumers

This study finds that, at present, self-consumption is primarily economically viable for high-income households (e.g., LSM 7 or higher). This is largely due the 'inclining block' rate structure applied in South Africa: Consumers with higher electricity demand pay more per unit of electricity.

However, the energy transition towards renewable energy sources can be managed in a socially inclusive way. In the spirit of the "just transition", specific subsidy or support programmes could be established to also enable low-income households to benefit from rooftop solar PV. Recently, the emergence of new business models (e.g., community ownership and third-party ownership) have created new opportunities that could also be explored further in the South African context.

Managing and forecasting the future uptake of self-consumption

Finally, the report highlighted that there is very limited knowledge about the recent and future growth of PV self-consumption in South Africa. As indicated in Chapter 1.2., the draft IRPs from 2013, 2016 and 2018 have either very distinct or no projects for the development of distributed generation until 2030 and beyond. The latest draft IRP from 2018 only included a 200 MW placeholder for all years until 2030. However, it is arguably clear today that the growth of the prosumer market segment will be more dynamic.

Therefore, it will be crucial to keep track of the development of rooftop solar PV. It is vital for policymakers to have reliable statistics in order to make informed decisions and to design the most cost-efficient power system (including distributed and centralised power generation units). At the municipal level, it is important to set up simple and cost-effective registration systems in order to avoid the implementation of increasing numbers of unregistered systems. These local registries could also provide vital bottom-up information for a national registry.

It is recommended that a dedicated study should examine bottom-up uptake of PV rooftop systems nationwide, using well-known methods such as Bass diffusion modelling. The Bass model requires detailed data on market trends of the technology whose uptake is being estimated. Once such relevant data are acquired, future studies should use optimisation tools dedicated to the uptake of rooftop PV, such as the DOGMMA model (Distributed Generation Market Model of Australia). However, such a model would require modification in order to be applicable and reliable in the South African context.

References

Adam, K., Hoolohan, V., Gooding, J., Knowland, T., Bale, C.S.E., Tomlin, A.S., 2016. Methodologies for city-scale assessment of renewable energy generation potential to inform strategic energy infrastructure investment. Cities 54, 45 – 56. https://doi.org/10.1016/J.CITIES.2015.10.015

Department of Energy, 2018. Draft integrated resource plan 2018. Pretoria.

Gagnon, P., Margolis, R., Melius, J., Phillips, C., Elmore, R., 2016. Rooftop solar photovoltaic technical potential in the United States: A Detailed Assessment Available at: https://www.nrel.gov/docs/fy16osti/65298.pdf

GENESIS, 2017. Financial impact of the increased uptake of Solar PV on municipal revenue; (2) Business case for customers who install Solar PV.

GIZ, 2018. Solar Rooftop PV: Financial impact of SSEG. Tshwane.

Green Energy Markets, 2018. Renewable Energy Index.

Greencape, 2018. Small scale embedded generation in the Western Cape. Cape Town.

Greencape, 2017. Energy services – 2017 Market Intelligence Report. Cape Town.

Helgenberger, S., Gürtler, K., Borbonus, S., Okunlola, A., Jänicke, M, 2017. Mobilizing the co-benefits of climate change mitigation: Building New Alliances – Seizing Opportunities – Raising Climate Ambitions in the new energy world of renewables. – COBENEFITS Impulse (Policy Paper), November 2017: Available at: http://publications.iass-potsdam.de/pubman/item/escidoc:2892889:9/component/escidoc:2892890/IASS_COBENEFITS%20Impulse_2892889.pdf

Helgenberger, S., Jänicke, M, 2017. Mobilizing the co-benefits of climate change mitigation: Connecting opportunities with interests in the new energy world of renewables. – IASS Working Paper, July 2017. Available at: http://publications.iass-potsdam.de/pubman/item/escidoc:2348917:7/component/escidoc:2666888/IASS_Working_Paper_2348917.pdf

Helgenberger S., Jänicke M., Gürtler K, 2019. Co-benefits of Climate Change Mitigation. In: Leal Filho W., Azul A., Brandli L., Özuyar P., Wall T. (eds) Climate Action. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. Available at: https://doi.org/10.1007/978-3-319-71063-1

Hoffman, T., Todd, S., 1998. The South Africa environment and land use.

International Renewable Energy Agency, 2017a. IRENA cost and competitiveness indicators.

International Renewable Energy Agency, 2017b. Electricity storage and renewables:Costs and markets to 2030. IRENA, Abu Dhabi.

IRENA, 2016. Solar PV in Africa: Costs and markets.

Knorr, K., Zimmermann, B., Bofinger, S., Gerlach, A.-K., Bischof-Niemz, T., Mushwana, C., 2016. Wind and solar PV resource aggregation study for South Africa [WWW Document]. URL www.csir.co.za/study-shows-abundance-wind-and-solar-resources-south-africa

Maphelele, T., Standford, R., Kooverii, B., 2013. South African PV Industry – Overview PV Development in South Africa.

Millson, C.R., 2014. The potential for rooftop solar photovoltaic installations on commercial sector buildings in the City of Cape Town. University of Cape Town.

Ntsoane, M., 2017. Rooftop solar PV potential assessment in the city of Johannesburg 61.

Nykvist, B., Nilsson, M., 2015. Rapidly falling costs of battery packs for electric vehicles. Nat. Clim. Chang. 5, 329 – 332. https://doi.org/10.1038/nclimate2564

Pandarum, A., 2018. Trends and statistics of solar PV distributed generation in South Africa, in: Energy Storage. Johannesburg.

Pöller, M., 2017. Impact of Variable Generation in South Africa on System Operations (Flexibility Study). GIZ.

Senatla, M., Bansal, R., 2017. Review of planning methodologies used for determination of optimal generation capacity mix: the cases of high shares of PV and wind. IET Renew. Power Gener. 12, 1222 – 1233.

Senatla, M., Mushwana, C., 2017. A mini-integrated resource plan for a commercial entity in Gauteng Province: Planning for energy autonomous businesses, in: Proceedings of the Conference on the Industrial and Commercial Use of Energy, ICUE. https://doi.org/10.23919/ICUE.2017.8068005

The Climate Group, 2017. The business case for off-grid energy in India.

Western Cape Government, 2018. Towards a smarter grid. Cape Town.

Whited, M., et al, 2017. Caught in a fix: The problem with fixed charges for electricity, (Synapse Energy Economics), Available from http://www.synapse-energy.com/sites/default/files/Caught-in-a-Fix.pdf

Wright, J.G., Bishof-Niemz, T., Calitz, J., Mushwana, C., Heerden, R. van, Senatla, M., 2017. Formal comments on the Integrated Resource Plan (IRP) update assumptions, Base Case and observations 2016. Pretoria, South Africa.

Glossary and abbreviations

Demand charges	Demand charges are fees that utilities charge customers in addition to typical volumetric charges (per kWh). Demand charges are usually calculated based on the maximum demand of a customer in a certain time period (e.g., monthly).
Distributed Generation	Refers to small-scale power generation units, including rooftop solar PV that produce electricity in the close proximity to the final consumer. In contrast, traditional centralised energy grids employ large-scale power stations from which energy must be transmitted over long distances.
Embedded generation	See “Distributed Generation”
Excess electricity	Excess electricity is surplus electrical energy that cannot be self-consumed onsite and therefore either needs to be curtailed or exported to the electricity grid.
Fixed charges	Fixed charges are fees that utilities charge customers in addition to typical volumetric charges (per kWh). They are usually defined as a fixed monthly payment.
IASS	Institute for Advanced Sustainability Studies, Potsdam, Germany
Inclined block tariffs	Inclined Block Tariffs divide the electricity price into several steps or blocks. For the lower blocks (e.g., 0 – 50 kWhs) a relatively low price needs to be paid per kilowatt-hour whereas for the higher blocks (e.g., 500-1000 kWh) higher prices need to be paid per kilowatt-hour.
IPP	Independent Power Producers
IRP	Integrated Resource Plan
Internal rate of return (IRR)	Internal rate of return is a metric used to evaluate the attractiveness of a project or investment. The internal rate of return is a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero.
IRENA	International Renewable Energy Agency
Kilowatt peak (kWp)	The nameplate capacity of photovoltaic (PV) devices, determined by measuring the electric current and voltage in a circuit, while varying the resistance under Standard Test Conditions.
Levelised cost of electricity (LCOE)	The levelised cost of electricity (LCOE) is the net present value of the unit-cost of electricity from a specific power generation source over the lifetime of the power plant.
Net Present Value (NPV)	Net present value (NPV) is a metric used to analyse the profitability of a projected investment. It is the difference between the present value of cash inflows and the present value of cash outflows over a period of time.
Payback period (PBP)	The timespan required for an investment to recover its initial outlay in terms of profits or savings.
Prosumer	Customers who both produce and consume electricity (by virtue of installing a PV system or other distributed generation units for self-consumption).
SSEG	Small Scale Embedded Generation
Time-of-use rates	Time-of-use tariffs charge different prices for electricity according to demand at a given time of day (or seasonally; weekdays versus weekends, etc.), thereby better aligning energy prices with the cost of production. Cheaper prices during off-peak periods can encourage customers to shift their energy use away from more costly peak periods. This can reduce strain and demand peaks on the grid, lowering costs for both the utility and its customers.

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Connecting the social and economic opportunities of renewable energies to climate change mitigation strategies

COBENEFITS cooperates with national authorities and knowledge partners in countries across the globe such as Germany, India, South Africa, Vietnam, and Turkey to help them mobilise the co-benefits of early climate action in their countries. The project supports efforts to develop enhanced NDCs with the ambition to deliver on the Paris Agreement and the 2030 Agenda on Sustainable Development (SDGs) and to enable a just transition. COBENEFITS facilitates international mutual learning and capacity building among policymakers, knowledge partners, and multipliers through a range of connected measures: country-specific co-benefits assessments, online and face-to-face trainings, and policy dialogue sessions on enabling political environments and overcoming barriers to seize the co-benefits.

Contact

COBENEFITS focal point South Africa
Ruan Fourie, RFourie@csir.co.za

COBENEFITS project director
Sebastian Helgenberger, Institute for Advanced Sustainability Studies (IASS)
sebastian.helgenberger@iass-potsdam.de

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