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Rooftop solar provides a simple solution to issues of local economic development, energy justice and poverty

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Rooftop solar refers to the placement of photovoltaic (PV) panels on the rooftops of buildings, whether these are homes, industrial facilities or commercial premises. The panels generate electricity (when the sun is shining!) which can then be consumed by the building's occupants, or stored, or sold into the national grid. Many countries already have operational schemes which support the installation of such systems and have become additional sources of revenue for homeowners and businesses (1).

Rooftop solar could (and should!) be used as an ideal solution to the multiple problems which remain unsolved in low-income areas (LIAs), including the big four of economic development, employment, municipal debt and energy justice. Although this claim sounds preposterous, given how wicked these problems have been shown to be, and how many other approaches have been tried, but have failed, it is made without any presumption or disingenuity.
This article is based on a more detailed publication which outlines the development of PV and provides a more detailed rationale for why and how rooftop solar could be used as a means of development (2). Here the main points are reiterated and the material is presented in three sections: the first section will cover the supply side aspects of PV, the second the demand side, and the final section the potential socio-economic impact of rooftop solar.

Supply side aspects of rooftop solar: costs

Over the last two decades, PV technology has become an increasingly competitive energy source to the extent that it is now cheaper than coal or nuclear-based technologies (3). Although Eskom has consistently refused to divulge the costs of newly build power stations, such as Medupi and Kusile, the levelised cost of electricity (LCOE), which is the commonly used comparator in the energy sector, is reported to be about 125 RSA cents per kWh (4). The equivalent cost for onshore wind and utility PVs is 62 RSA cents per kWh respectively (see Table 1; both sources are identical in cost and about 50% of newly build coal-based electricity generation).

There are two important considerations, however, in making such comparisons. The first is that solar and wind are intermittent sources of electricity since the sun does not always shine and the wind does not always blow. Grid systems based on renewable energy need to be designed to include either storage or dispatchable sources of energy such as gas or hydro. The least cost option is gas, which makes the total cost about 105 to 185 c/kWh, depending on the extent to which gas needs to fill the gaps left by the renewable sources. Battery storage is more expensive and does not scale easily. For this reason, most national grids are moving to a blend of gas and renewable energy (5).

The second consideration is that rooftop solar is more expensive (206 c/kWh; see Table 1) than the utility-scale installations (62 c/kWh), since each system needs a separate power inverter and control system. In effect, the most efficient option for PV systems is utility-scale installations, which is the approach being used by the Renewable Energy Independent Power Producers Procurement Programme (3). Unfortunately, this option does not allow for the delivery of a 'social electricity grant' and the additionality of local employment, which are the main propositions of this article. Although more expensive, rooftop solar has a broader and more critical impact, addressing simultaneously and more elegantly a range of socio-economic problems.

Table 1. LCOE for various energy sources (2016 data)

Technology	LCOE (RSA c/kWh)	Source
PV (Utility)	62	Bischof-Niemz and Fourie (6)
PV (Rooftop)	206	Ram, Child (4); Walwyn (2)
Wind (Onshore)	62	Bischof-Niemz and Fourie (6)
Coal with flue gas treatment	125	Ram, Child (4); Bischof-Niemz and Fourie (6)
Coal with external costs	288	Ram, Child (4)
Natural gas	123	Castillo, Gutierrez (7)
Nuclear	140	Ram, Child (4)
Li-ion storage (Utility)	165	Ram, Child (4)
Li-ion storage (Rooftop)	272	Ram, Child (4)

Supply side aspects of rooftop solar: environmental benefits

Wind and solar (electricity generation) have a minimal environmental impact, as shown in Table 2. In the South African context and pertaining in particular to the water and air quality conditions which affect the residents in Mpumulanga, the reduced carbon (and other pollutants) and water usage are of major importance. The ongoing generation and expansion of coal-based electricity generation, given the negative public health consequences of this technology, is illogical and unnecessary. Even the argument about the loss of (mining) jobs is weak given that with proactive human development interventions, the loss of unskilled jobs could be mitigated.

Table 2. Comparison of environmental impact of various energy sources

	Water Usage (kl/MWh)	Jobs Created (No/MW_p)	Carbon Emissions (kg CO_2/MWh)
PV (Utility and Rooftop)	0.00	15	40
Wind	0.00	4	5
Coal	2.27	1	1 070
Gas (CCGT)	0.00	2	440
Nuclear	2.65	2	5

Source: Water usage from (8), employment figures from (2) and (7), carbon emissions from (9)

The above has shown that utility-scale PV can be used to reduce both the cost and environmental impact of electricity generation, both of which are important considerations for South Africa. Rooftop solar, while sharing the positive aspects of employment and environmental impact, is more costly than other technologies and can be justified only in cases where it achieves cost savings or can be combined with important social objectives. Below it is explained how rooftop solar could be used as a means of delivering social grants, which makes the necessary investment in infrastructure more economical for the state.

Demand side aspects of rooftop solar

There are three components on the demand side which need to be discussed before closing the loop on the overall proposition of this article, namely household-level electricity consumption, the cost of social grants and the cost of municipal debt. Consumption of electricity in urban areas is a function of household income, which varies widely. Mostly the level of consumption in LIAs is between 250 and 450 kWh per month, equivalent to between R300 to R600 per month or up to R 7 200 per year. Different municipalities have different policies regarding subsidies of low-income customers, so it is necessary to make some assumptions for the cost/benefit analysis. Consumption of 450 kWh/month at the cost of R1.20 per kWh is used as the benchmark for the household model. Such a demand can be met easily with a $4kW_p$ (where the subscript p denotes peak capacity) grid-connected rooftop solar system.

The cost of social grants has risen sharply over the last two decades, and it is reported that as of 2018, 17 million persons are receiving a grant at a total cost of R193 billion per year (2). If one assumes one grant holder per household, this support is equivalent to more than R11 000 per household per year. Also, the level of Eskom debt due to non-payment by municipalities has risen to R13.5 billion, which equates to a low-income household subsidy of about R275 per month.

Impact of rooftop solar

In demonstrating the socio-economic impact of rooftop solar, we consider a grid-tied rooftop solar system of 4 kW capacity. Such systems require a rooftop area of 30 m^2 and can be easily accommodated on the standard township residential building. Each homeowner would have to be assessed for eligibility and agree to accept a portion of the household's social grant in the form of electricity. The system would provide 8 300 kWh per year, of which a portion could be sold back to the municipality as a means of earning a cash income. In this sense, one could consider a qualifying low-income household as a power producer, or what is referred to as a 'prosumer'. In the example of the study, it is assumed that 75% of the total energy output is used by the consumer, with the remainder being sold to the utility provider.

The financial impact of the installation on the three key parties to the transaction, namely the household itself, Eskom/municipal authority and the state/National Treasury is shown in Table 3. The impact is either neutral or slightly cash positive to the homeowner and the utility provider but is an additional financial expense (of R5,000 per household per year) for National Treasury. However, there many benefits to the state including the creation of one job for every 16 such units installed at an average cost per job of about R85,000, improvements to air quality, and greater water security due to lower water usage by the coal-based power stations.

The details of this analysis provide a compelling argument. Replacing a system of social grants with a subsidised means of individual households becoming energy prosumers (consumers and producers) will have benefits at a number of levels. Firstly, it will improve both access to and the affordability of electricity, which is recognised as a fundamental means of accessing other public goods. Secondly, it will create local economic and employment growth at a competitive value. Thirdly, it will decrease levels of poverty in low-income communities without resorting to the use of a social grant. Fourthly, it will address the need for the transition of South Africa's energy sector from non-renewable to renewable resources, as has been outlined in the Integrated Resource Plan and promised in the Paris Agreement (10); and finally, it will reduce the exposure of municipalities and Eskom to debt.

Table 3. Monetised values of costs and benefits from LIA rooftop solar (all values in R/year/household)

Item	Home owner	Municipality/ Eskom	National Treasury
Annualised infrastructure cost			-14,980
Social wage	-8,628		8,628
Electricity purchase (saving)	6,480		
Electricity subsidy (saving)	Not required	75	
Income (electricity sales)	2,192	Unaffected	1,315
Saving on debt financing		275	
Net value	43	350	-5,036

Source: (2)

This article began with the proposition that rooftop solar is an attractive option for uplifting low-income areas. It concludes with a stronger statement that this is indeed an imperative. Rarely is an opportunity presented in a way which allows multiple objectives to be achieved with a single instrument. Rooftop solar is one such opportunity; it should not be ignored.

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References:

1. REN21. Renewables 2018 Global Status Report. Paris: REN21 Secretariat, 2018.
2. Walwyn DR. The Use of the Technological Innovation Systems Framework to Identify the Critical Factors for a Successful Sustainability Transition to Rooftop Solar in Low-Income Communities within South Africa. In: Zobaa AF, Afifi SN, Pisica I, editors. Sustainable Energy - Technological Issues, Applications and Case Studies. Rijeka: InTech; 2016. p. Ch. 03.
3. Walwyn DR, Brent AC. Renewable energy gathers steam in South Africa. Renewable and Sustainable Energy Reviews. 2015;41(1):390-401.
4. Ram M, Child M, Aghahosseini A, Bogdanov D, Lohrmann A, Breyer C. A comparative analysis of electricity generation costs from renewable, fossil fuel and nuclear sources in G20 countries for the period 2015-2030. Journal of Cleaner Production. 2018;199:687-704.
5. Stephens A, Walwyn DR. Wind Energy in the United Kingdom: Modelling the Effect of Increases in Installed Capacity on Generation Efficiencies. Renewable Energy Focus. 2018; 27(Dec 2018):44-58.
6. Bischof-Niemz T, Fourie R. Least Cost Electricity Mix for South Africa – Optimisation of the South African Power Sector until 2050. Pretoria: CSIR Energy Centre; 2016.
7. Castillo L, Gutierrez W, Gore J. Renewable Energy Saves Water and Creates Jobs New York: Scientific American; 2018.
8. Macknick J, Newmark R, Heath G, Hallett KC. Operational water consumption and withdrawal factors for electricity generating technologies: a review of existing literature. Environmental Research Letters. 2012;7(4):045802.
9. Baldwin S. Carbon footprint of electricity generation. London: Parliamentary Office of Science and Technology; 2006.
10. Department of Energy. Request for Comments: Draft Integrated Resource Plan 2018. Pretoria: Department of Energy; 2018.