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Solar energy answer to rural power in Africa

Robert van der Plas

In Kenya, more rural households get their electricity from solar energy than from the official rural electrification program (REP). The spread of the photovoltaic systems has been recent, rapid and market driven. The service is as good as the grid for the low power loads that prevail in many rural areas, and the price is competitive with other options for low loads. Customers can buy it "off the shelf". They don't have to wait the years it may take for the REP to come to their own area. REP expansion is slow because funding is tight. The program consists of extending the already existing national electricity grid, establishing decentralized generation capacity in combination with a local grid, or helping auto producers of power to start serving surrounding households and small commercial enterprises. New connections already require substantial government and donor outlay. The rate at which the program reaches households would have to increase ten-fold for it just to compensate for current rural population growth. At present only 0.5% of rural households have access to the grid. The chances of getting a grid connection through the REP look remote. Therefore, solar power is a serious and fast option for those rural households with limited power demand and enough money to afford it. More households could afford it if the Government removed "obstacles" like high duties which make the solar systems more expensive than they need to be. Their removal would be good rural pre-electrification policy. With easier access to solar power, the Government could achieve higher living standards more quickly for more Kenyans than it can through the existing rural electification program.

Thriving market

Today more than 1 MW of photovoltaic power has been installed in Kenya. Around 20,000 households have purchased solar energy for their homes compared to the 17,000 connected to the official rural electrification program. Demand for photovoltaic systems (PV) has grown exponentially since the mid 1980s when Kenyan entrepreneurs realized that photovoltaics could meet rural demand to operate electric lights, radios, televisions, or stereos often at a lesser cost than grid connections, systems driven by generators, or by using kerosene and (drycell) batteries. The market grew as mainly rural-based electricians linked up with urban businessmen, and formed business agreements with solar

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electric suppliers primarily in Nairobi. There are presently about eight companies based in Nairobi who supply this market. Each company has scores of agents based in rural areas who market, install and maintain systems. Solar electric systems are successful despite taxes and import duties, which combined amount to more than 30% of the final price users pay, and despite the absence of credit facilities. At present, the household systems range from $150 for a 10 W one-light system to $1500 for a 100 W five or six-lamp system with radio and television connections. Consumers can buy their systems (one or more photovoltaic panels, battery, charge controller, and lamps, wires & switches) straight off the shelf. The systems are flexible in design and can be configured to the user's wishes. When the electrical output is not sufficient more solar panels can be purchased at any time.

Solar power makes sense

Solar power can match the grid service partly because rural households do not consume much electricity—at least for the first few years. Household electricity usage for those just connected to the grid is often limited to a few lamps (3–6), a radio, and/or a television, or 30–60 kWh per month. These services can also easily be provided by solar systems. Household demand remains low for at least a couple of years, after which households will start to add higher power consuming appliances, such as rice cookers, tea kettles, or refrigerators if the grid capacity allows. Though solar electric systems are modular and more photovoltaic modules can be added, thermal applications (such as cooking and heating) are not feasible as this would be too expensive. However, thermal applications are often not possible either with grid based rural electricity systems as their generation capacity is normally limited.

Only in periods of extended rains or cloudy conditions that last entire days will the solar supply falter. Although under these conditions photovoltaic systems do generate electricity, it is considerably less than on sunny days and users must be aware that they should not draw down too much electricity so they avoid permanent damage to their batteries.

Rural grid electricity supply is not without its own set of problems either, and power outages or brownouts occur rather frequently. However, the difference is that the latter happen at irregular times while the photovoltaic electricity supply users know in advance when their supply is running out and that they should use electricity more sparingly.

From an efficiency point of view, PV systems score well because they don't depend on an energy source other than the sun, and the lamps they use are invariably the latest technology (tubular or compact fluorescents) available. These lamps are some five times more efficient than the incandescent lamps normally used in rural areas on the grid. Although fluorescent lights can be used with the grid also, this does not happen in practice because of the high cost and the problems of voltage drop associated with the grid connection.

Solar systems are price competitive with the rural grid and the genset (a small kerosene/petrol generator set) assuming a low level of electricity consumption and an "equal" level of service. Like the grid, the genset option is capable of satisfying higher demand for power and energy than the rural user normally makes. The capital cost is similar to a 50 W solar electric system, but gensets need imported fuel to operate and their service life is much shorter. Annualized costs of a 750 W genset (amortized over 5 years) plus fuel and maintenance (to deliver 40 kWh/month, at the pump price) amount to $195. The annualized cost to the consumer of a grid connection with a higher wattage capacity (amortized over 30 years) and electricity consumption of 40 kWh/month at the prevailing tariff amounts to approximately $51. By comparison, the cost is about $61 for the 50 W solar electric system, assuming a service life of 20 years and the purchase of a new battery every other year. Rural households would easily spend this amount on drycell batteries and kerosene for lighting—it represents less than 5 liters of kerosene and 10 drycell batteries per month—but get a lesser service for it.

Therefore, in the case of a light load, a grid connection and a solar electric system are comparable from a users' point of view. For lighting only, solar power is the more attractive option. The cost of lighting (the average incremental cost per Klmh, or kilo.lumen.hour) is some 10% lower for the solar electric system than for the grid: 2.0 vs 2.2 KSh/klmh. The cost of providing equivalent lighting from kerosene wick lamps is 10 times higher than either the grid or the solar systems.

Since most rural households will not have their homes connected to the electricity grid in the forseeable future, photovoltaics will often be the next best alternative. This remains true only so long as householder appetite for electricity remains limited to a few light points plus a radio and/or TV connection. The following table illustrates the circumstances in which solar power is a viable option.

Electricity Options

	load/demand		
provided by	*low*	*medium*	*high*
PV	yes	maybe	no
genset	no	yes	yes
grid	no	yes	yes

Better policy

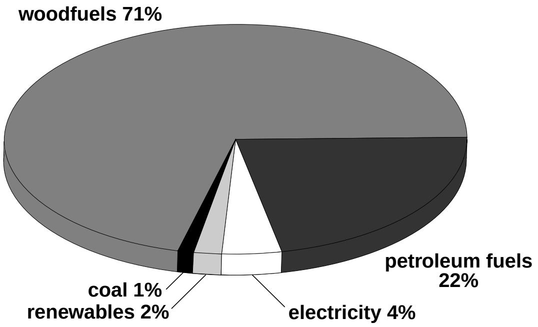
Better access to electricity would make a big difference to the quality of rural life. Many rural people do consume conventional modern energy, but they do so in small amounts. They also pay for it dearly: drycell batteries provide electricity for about $3 to $10 per kWh. A candle or a kerosene wick lamp does give a high quality light, but households need, respectively, about 60 or 20 of them to obtain the same amount of light emitted by a single 60 W incandescent lamp or a single 12W compact fluorescent. People who use candles or kerosene therefore typically limit themselves to using only enough light points to enable walking around the home; such practices usually do not provide enough illumination to read comfortably. Hence, although people in rural areas do have access to modern forms of energy, their use of these conveniences is limited because of this expense. The levels of services many rural households "enjoy" now is only barely distinguishable from that of medieval Europe. Rural households will never obtain a level of service even comparable to the urban population unless they get access to electricity in a different form than drycell batteries.

Obviously, households with a solar electric system at the moment are not among Kenya's poorest. They are part of the middle income class. But they are in exactly the same target group that receive large subsidies under the REP. The REP, run by Kenya Power and Lighting Company (KPLC), involves a subsidy for each new rural connection. These subsidies are largely funded by the Kenyan Government and aid donors.

The cost of bringing power to the vicinity of new rural customers under the REP is on average KSh 55,000 (US$ 720). New rural customers only pay KSh 2,500 ($38) each as a connection fee, though new customers have to for pay the step-down transformer (possibly shared with neighbors) and the cost of the distribution wires to their homes as well as in-house wiring. This policy of reduced connection fees would be justifiable if there were a provision in the electricity tariff to clawback the subsidy. However, that is not the case. Rural consumers have a preferential electricity tariff, cross-subsidized by urban consumers. This public policy preference position—subsidies for the REP and taxes for PV equipment—does not make sense.

The REP is a slow-track method of electrification. While the KPLC has succeeded in electrifying all 42 district headquarters, little rural electrification has occurred outside of these towns. In fact, less than 30% of urban and 0.5% of rural Kenyan households have access to electricity. In other

**Kenya energy consumption (1989)—
low share for electricity**



Source: Ministry of Energy, Kenya

words, the outlook for rural connections under existing policy is fairly bleak since even urban electrification has not progressed very far.

Although the actual numbers and details differ, similar circumstances are found in many other African countries. Despite substantial amounts of money that have been invested in the African power sector, only a minority of African households are able to enjoy modern services provided by electricity. The majority of rural households have no grid-based electricity, and will not receive it in their lifetime either. Government least-cost electricity extension programs usually exclude looking seriously at alternative approaches, such as (low load) electricity generation through photovoltaic panels placed in individual households. It would make sense to do so, particularly given the low population density in combination with the small demand for power and energy in rural Africa. The solar power option is an effective first step. And it can be market driven rather than depending on cash-strapped governments or aid donors. Governments should be encouraging this option rather than penalizing it by taxing imported components.

Future Action

Rural householders would benefit if the Kenyan Government removed at least four significant impediments to the solar power market. First, a more rational (comparable to rural electrification program equipment) import duty and tax regime should be applied. Second, competition should be further encouraged by opening the market to all potential investors. Investors are presently hampered by restrictions on access to foreign exchange. Third, financing mechanisms should be put in place to make solar electric equipment more accessible to a larger share of the population. Fourth, technical standards for solar electric systems should be established and applied. Solar electric companies have been compromising technical standards to offset the increase in price after the recent devaluations of the Kenyan Shilling. More frequent equipment failures may have a long term negative impact on the development of the market.

Robert van der Plas, Energy Planner, Finance and Private Sector Development