SEARCHING FOR SUSTAINABILITY

KENYA'S ENERGY PAST AND FUTURE

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Abstract

In 1981, Nairobi hosted the first international conference on New and Renewable Sources of Energy. World leaders came together for the first time to discuss potential pathways to a low-carbon future. Energy prices were at historic highs and, for many, a shift from conventional fossil fuels to renewable sources of energy seemed to be an obvious course of action. This view was held not only by leaders in wealthy countries; it gained a great deal of traction in the context of rural development and poverty alleviation across the global south, including the host-country, Kenya. A quarter of a century later, world leaders are again convening in Nairobi. The low-carbon future discussed in Nairobi 25 years ago seems as distant now as it did then. Promising steps have been made in a few sectors, but most areas remain with little or no access to modern energy services. This paper explores Kenya's experience with energy service provision between the 1981 conference and today. We use case studies based on empirical research in three areas: solar photovoltaics (PV), diesel mini-grids, and woodfuels to examine the role that energy plays in sustainable development in Kenya.

Introduction

One generation ago world leaders convened in Nairobi to discuss pathways to sustainability in the world's energy supply [1, 2]. At the time, the world faced record high energy prices and decision makers were gradually becoming aware of the social and environmental costs of their nations' appetites for energy. In 1981 in Nairobi, the representatives of the world's nations committed themselves to:

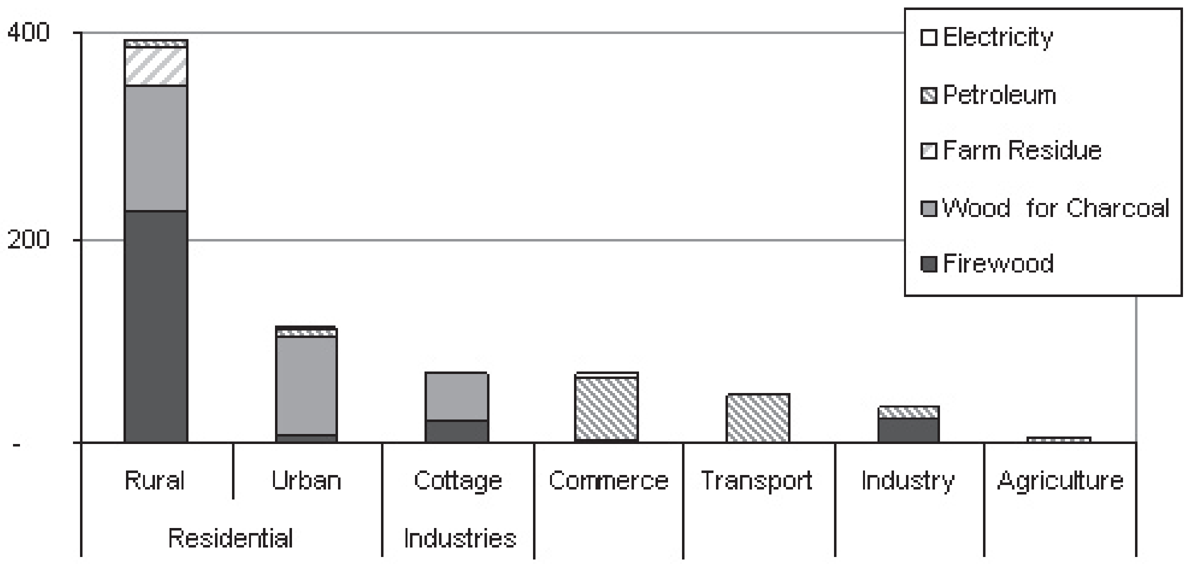
> . . . developing new and renewable sources of energy in order to contribute to meeting requirements for continued economic and social development, particularly in the developing countries, through, *inter alia*, the transition from the present international economy based primarily on hydrocarbons to one based increasingly on new and renewable sources of energy [2, paragraph 4].

The sentiment expressed in this UN document has since been echoed many times [3-5]. Although the connections are complex and causal mechanisms are, at times, difficult to identify, there is broad consensus that a positive association exists between access to convenient and affordable forms of energy and improvements in the human condition [6]. Moreover, lack of sustainability of modern energy systems puts the entire climate system at risk and creates a particularly grave threat to the poorest, least developed nations. The world uses more fossil-based energy now than in 1981: 33 per cent more oil, 58 per cent more coal, and 84 per cent more natural gas [7]. With the notable exception of sub-Saharan Africa, per capita fossil fuel consumption has also increased since the Nairobi conference. This growth comes despite growing evidence that our climate system is already showing the effects of human-induced change [8].

Of course, use of renewable energy has also grown. In relative terms, growth of renewables exceeds that of fossil fuels [7], but the starting point 25 years ago was miniscule. Kenya has benefited in numerous ways from this growth. As a result of the 1981 conference and the flurry of activity that followed, Kenya was the focus of numerous donor-driven projects in household energy, solar power, and other forms of renewable and/or decentralized power provision [9-11]. Not all of these activities were successful, but a combination of favorable political-economic conditions, capacity building efforts, and market development activities led to several successes in energy technology development and energy service provision. Lessons learnt from these advances have the potential to nudge the country toward a more sustainable energy future by expanding access to energy services with minimal environmental costs.

For example, Kenya currently has one of the highest per capita rates of solar photovoltaic (PV) adoption in the developing world [12]. Small, affordable

Figure 1: Kenya energy supply by fuel and end-use sector (2000)



Source: [13, 21]

PV systems have enabled a small but significant fraction of the rural population to gain access to electricity. In addition, Kenya stands out as a regional leader in the development of fuel-conserving biomass stoves.

However, many barriers remain that impede the provision of reliable and sustainable energy services in Kenya. For example, access to electricity in rural parts of the country remains around 4 per cent [13, 14]. Electrification with solar PV brings certain quality of life improvements by providing lighting, power for TV, radio, and perhaps a mobile phone charger, as well as a limited range of income generating opportunities. In the absence of credit or subsidies, however, PV systems are too costly to supply sufficient power for more remunerative applications such as shaft power or cold storage.

More affordable options exist for rural electrification through a variety of power generation technologies including micro-hydro or diesel-fueled generators. Both of these options for distributed generation (DG) are currently in use in Kenya, but are deployed in very limited numbers. Micro-hydro of course, is extremely site specific; nonetheless, in Kenya a significant number of sites with good potential for small-scale schemes remain untapped. Diesel "gen-sets" are less geographically constrained, as they can be deployed anywhere that fuel supplies are available and technical capacity exists for maintenance of the system.[1] Regardless of which technology is used, however, all DG systems face barriers because Kenya's current policy environment discourages the deployment of DG systems by imposing strict licensing criteria regardless of the scale of operations [11, 17].

Of course, electric power constitutes a tiny fraction of the nation's overall energy consumption. In order to fully engage in the question of energy sustainability in Kenya, we must turn attention to the country's biomass resources, which constitute the majority of Kenya's energy supply (Figure 1). Biomass itself is a "conditionally renewable" resource in that it can be used sustainably in a range of conditions [18]. However, the sustainability of Kenya's current exploitation of wood energy is in serious doubt [13]. Below we consider policies and practices in two critical sub-sectors of Kenya's energy economy: rural electrification and woodfuels.

Rural electrification

Kenya has a policy to promote rural electrification. The Rural Electrification Programme (REP) is financed by a tax charged to all customers of the national utility (currently set at 5 per cent of consumption charges). The REP has been in place for over thirty years; however, the overall rate of rural electrification barely keeps pace with population growth [19]. The failure to reach more rural households is not due to lack of funds. Since the early 1990s, revenues flowing into the REP have doubled in real terms. Despite additional funding, the number of new connections fluctuates from year to year rather than showing an increasing trend [14]. In addition, under the Moi administration, grid extension to rural areas had been politicized so that access was only provided to politically favored communities [19]. It is not clear if that situation has changed under the new government.

Due to the slow pace and politicized nature of the state-led REP, a substantial number of people in rural Kenya have turned toward alternative technologies in order to access electricity. Community-based DG systems constitute one alternative, but these are deployed in very small numbers in Kenya. Privately owned PV solar home systems constitute a second, more common option. Both DG and PV

Table 1: Existing DG schemes in Kenya[3]

Name/Location	Description	Sponsoring agencies[4]	Comments
Pico-hydro in Kirinyaga District	Two projects: 1.1kW and 2.2 kW serving 65 and 110 families respectively.	ITDG and local self-help group.	Only 20 W of power delivered to each household - sufficient for 1-2 efficient light bulbs and a radio or a small black and white TV. Costs are very low (~$US 60 per household plus in-kind community labor).
Tungu-Kabiri micro-hydro scheme in Meru South	18 kW micro-hydro system serving 90 households and a number of enterprises.	ITDG and local self-help group with support from the GEF small projects fund.	Power generated is owned by the community and sold to community members for household lighting as well as income generating activities like curing tobacco, pumping water, welding, carpentry, and battery charging.
Mpeketoni, Lamu District	50 kW diesel generators serving the entire community	GTZ and local management group.	GTZ started the project in 1994 and pulled out in 2002 when the local team took over management. The system serves ~100 households as well as cottage industries, retail shops, a secondary school, a polytechnic institute, a church, and a hospital, providing ~20 MWh/month [11].

are often proposed as alternatives to centralized power production for access in remote areas. However, each technology is only capable of delivering a limited range of benefits contingent on many variables. Moreover, each technology requires specific, though not necessarily unique, technical, social, and institutional conditions in order to be viable. These are discussed further below.

Distributed generation

DG systems can be constructed around a number of different technologies. Currently in Kenya, both micro-hydro and diesel-based generators are deployed in community-based mini-grids, but in very limited numbers (Table 1). For these systems to function, institutions have been mobilized at the local level to manage generation, distribution, sales, and system maintenance. In the larger systems in Table 1, a substantial fraction of power is directed toward income-generating activities. This is critical if rural electrification is to contribute to poverty alleviation. It is also crucial for the viability of DG projects, if they are designed to recover some or all project costs. Notably, all of the DG systems listed in Table 1 received assistance from donors for the establishment of the project. In addition to subsidizing the bulk of the capital cost, donors provided support through technical training in the management and maintenance of the systems [11, 22, 23]. In the absence of state support and commercial credit facilities for community-based DG, donor support during the early phases of system development is crucial. Communities, in turn, provided in-kind labor during construction. In addition, in the case of Mpeketoni, the community contributed 30 per cent of the capital costs and they continue to purchase electricity at rates that cover the full operating costs of the system[2] [11]. Despite paying higher prices, the Mpeketoni community has been able to take advantage of their electricity scheme, utilizing the power it produces in numerous applications and creating goods that compete in wider markets. However, research indicates that the scheme's success is as much the result of access to markets and infrastructure (roads and communication linkages), as it is the result of access to electricity. In the absence of critical infrastructure, power provision is unlikely to result in productivity gains.

PV solar home systems

PV systems are the ultimate form of DG, with power generation, transmission, distribution and consumption occurring within a single household. In addition, PV technology's clean and simple operation lead many to laud it as an important tool for rural poverty alleviation and sustainable development [24]. Since the late 1980s, the Kenya's PV market, which is now entirely self-supporting, has had cumulative sales of over 200,000 units. Sales are increasing at roughly 18 per cent annually and have exceeded 25,000 units in recent years [25]. This rate of adoption far outpaces the state's own efforts to electrify rural areas. However, the degree to which PV contributes to poverty alleviation and sustainable development in Kenya is limited by access dynamics in an unsubsidized market setting, which favor wealthy and middle class rural households over the poor. PV's contributions are also limited by cost. Even better-off rural households can only afford small systems capable of delivering limited quantities of power : typically less than 25 Watts.

Nearly half of all solar PV systems are owned by the wealthiest 10 per cent of rural Kenyan households. Access has expanded beyond these families through sales of very small PV systems. As a result, over 40 per cent of PV systems are owned by rural households in the 2nd, 3rd, and 4th wealth deciles. The key to expansion of PV ownership beyond the wealthiest families is a purchasing pattern in which households buy their small systems incrementally through cash purchases of individual components that generally cost from $50 to $100 per item. In this way, rural middle class families are able to spread the cost of a PV system, which can range from $250 to $1000 or more, out over time [25, 26].

Despite some success, however, incremental cash sales of small PV systems have limited potential to meet the energy needs of Kenya's

Figure 2: Charcoal production in Narok District

rural population. First, the small sized systems that are affordable to rural middle class families provide well under one-tenth of the electricity used by an average grid-connected household [26]. While this limited quantity of electrical energy can play a modest role in supporting income generating applications or educational activities, research in household uses of solar power has demonstrated that the majority of power consumed, particularly in households with small systems (< 25 Watts), is often devoted to entertainment, information, and communicative applications like television, radio, and mobile telephone charging [26]. Thus, the rural middle class, already living above the nationally-defined poverty line, utilize PV primarily to enhance their connectivity to urban Kenya and the world beyond Kenya's borders.

Second, solar PV remains largely out of reach for the poorest 60% of the rural population. In the absence of subsidies or massive declines in price, the possibilities for continued deepening of access appear to be linked to sales of ever smaller sized systems. For example, tiny one to two Watt PV systems that are used to power high efficiency white LED lamps cell may prove to be affordable for some low income households. While such micro-power systems have the potential to offer significant advantages relative to kerosene lighting, which is widely used by poor and middle class households alike, they do not provide a solution to the pressing needs for shaft power, irrigation pumping, cold storage, and other applications that are more commonly associated with income generation activities.

The woodfuels sector

Kenya's woodfuel sector stands in contrast to rural electrification. While electrification is typically spoken of as a means to raise living standards and reduce rural poverty, woodfuel is viewed as an embarrassing symbol of the country's failure to modernize its energy sector. Despite its widespread use, woodfuel has largely been ignored by policy makers, particularly the supply side of the sector [27, 28]. The nation's reliance on woodfuels is associated with several negative outcomes, which include impacts on public health and the environment. Health impacts particularly affect women and small children as a result of exposure to smoke from wood combustion, which is blamed for as much as 5 per cent of the region's total incidence of illness and death [29].

Environmentally, woodfuel consumption is often linked to deforestation [30]. This is particularly true when wood is exploited commercially, as with the charcoal trade, which primarily serves urban and peri-urban markets. Unfortunately, little can be said with certainty about the degree to which Kenya's exploitation of wood energy is leading to permanent forest loss. Reliable data on wood harvest and post-harvest management is very difficult to obtain. It is certain, however, that the country lacks an effective set of policies to promote or enforce sustainable woodfuel management. This void leads to a great deal of ambiguity in the woodfuel sector. While no overarching national policy exists, some charcoal regulations are in place at the provincial or district level, but these lack transparency and suffer from inconsistent enforcement. Consequently, in many parts of the country, charcoal is illegal to produce and transport, but it is perfectly legal to sell, buy, and consume in towns and cities. Such ambiguity discourages investment in the trade, encourages unsustainable practices, and fosters corruption [31].

For example, in Narok district, a major charcoal production zone, a ban on commercial charcoal transport was in effect between 2003 and 2005. Despite the ban, during that period, the district provided as much as 40 per cent of Nairobi's charcoal, with 10-20 lorries ferrying thousands of 40 kg sacks to the city every day [31]. The ban, which was ostensibly meant to protect nearby Mau Forest, was circumvented through bribery, which reached such high levels that as much as 25 per cent of the retail price of each sack of charcoal was captured by local authorities [32]. Ironically, Narok's charcoal does not originate from the forest that the transport ban was meant to protect. Rather, it is harvested from parcels of former group ranches that were subdivided and allocated to the district's Maasai population throughout the 1990s. Thus, land in Narok is being cleared for charcoal, but Mau forest is not. Moreover, the land supplying charcoal is private land that would likely be cleared in the absence of charcoal production: charcoal simply facilitates the process.

Despite instances of corruption and loss of forest land associated with Kenya's charcoal trade, wood energy remains a potentially renewable resource. With careful planning, the nation's woodfuel supply can be sustained in the long term. In addition, woodfuel, particularly the charcoal trade, provides direct employment for as many as 200,000 people across the country at different stages of the supply chain [33]. For some with little or no land to farm, charcoal provides full-time employment. For others, it presents an important source of income when farm production is low or when a bit of extra cash is needed. Of course, nearly all of this employment is in the informal sector. One exception is Kakuzi Ltd. near Thika, which produces charcoal from a Eucalyptus plantation. Their production costs compete favorably with charcoal produced from the bush. However, other attempts at commercial charcoal production or the production of a close substitute like char-briquettes have not been able to compete with "bush charcoal" in terms of price and/or quality.

While the current level of sustainability in woodfuel supply is questionable, Kenya has taken some important steps toward sustainability by introducing technologies to manage wood energy demand. Not long after the 1981 Nairobi Conference, Kenya was the focal point of several improved stove efforts. One effort led to the design of an extremely successful charcoal stove, the Kenyan Ceramic Jiko (KCJ), which is currently used in roughly 40 per cent of the country's charcoal-using households [13]. The stove, which can reduce charcoal consumption by 30-50 per cent, has been replicated throughout the region [9, 12]. Another effort that has seen some success in reducing woodfuel demand is the development of institutional woodstoves targeting schools [34]. Both the KCJ and the institutional stoves began as donor-driven projects, but have successfully made the transition to unsubsidized commercial dissemination.[5]

Kenya also has hosted several projects promoting improved household woodstoves in rural areas, but these have not been nearly as successful. Approximately 90 per cent of rural households report using fuelwood for cooking, but only about 4 per cent report owning an improved woodstove [13]. One of the reasons given for the success of the KCJ is that it targets urban charcoal consumers, a group that is accustomed to paying for both stoves and fuel. Thus, adoption of the stove requires little change in behavior and the subsequent reductions in fuel consumption translate to direct and immediate savings in household cash expenditure. In contrast, the majority of rural households burn wood that they collect themselves in an open fire that costs nothing to construct. Using limited household income to purchase a stove requires a significant change in behavior.[6] This is a critical sector that needs more attention from policy makers. Not only can improved woodstoves reduce fuel consumption and time devoted to fuel collection. Well-designed stoves can also dramatically reduce exposure to harmful emissions from open wood fires common across rural Kenya.

Conclusions

Kenya's experiences with renewable and alternative sources of energy since the 1981 conference in Nairobi has salience for the current meeting of parties to the Climate Change Convention. Twenty-five years ago, world leaders convened in Nairobi and made admirable statements about the potential for clean, environmentally friendly energy technologies to help raise living standards in developing countries. No doubt much will be said to the same effect during COP12/MOP2. However, the minimal strides that Kenya has made toward sustainable energy provision for its population in the generation that has passed between these two major conferences demonstrates that the developing world needs much more than admirable statements. First and foremost, there is a need for investment. Resources are needed for infrastructure development, institutional capacity building, and R&D. It's clear that a market-based mechanism like the Clean Development Mechanism (CDM) is not going to direct sufficient resources toward increasing access to clean and sustainable energy supplies for countries in sub-Saharan Africa. If this is to occur, other funding channels are needed.

In addition, Kenya needs policy makers at the national level who recognize the realities of energy provision in their constituencies. In Kenya, years of policies emphasizing grid-based electrification and fossil fuels, as well as the politicization of access to the electric grid, have created a great deal of uncertainty concerning which areas will be targeted for grid extension and in what time frame. In addition, years of emphasis on electricity and fossil fuels have combined to create a policy vacuum around wood energy, which still constitutes the primary source of energy for the majority of the population. As a result no one can say with certainty how much wood energy the country consumes, where it comes from, or what becomes of the land from which trees are harvested.

Similarly, a narrow focus on grid extension has led to the neglect of alternative paths of rural electrification. The DG projects described above, which provide power both for quality of life and productive end-uses, are ignored by current laws governing Kenya's Power Sector; technically, they are illegal. Nevertheless, they result in measurable benefits for the communities in which they're situated. However, the notion that increased access to energy services leads to unconditional benefits for all, which is often assumed by policy makers, also needs to be critically examined. Kenya's experience with PV demonstrates that it is possible to expand access beyond the wealthiest rural households through unsubsidized, market based sales. However, this occurs through the sales of ever smaller systems. While these micro-power systems can provide beneficial services, the tiny amounts of electricity that they generate limit their use to applications such as television, lighting, radio, and mobile telephone charging. These services are not unimportant, but market based solar electrification is not a route for delivering energy for many of the key applications, such as shaft power, irrigation pumping, and cold storage, that are so critical for rural income generation.

Several policy changes are required to increase access and promote sustainability in Kenya's energy economy. First, credit mechanisms targeting entire communities and entrepreneurial ventures should be put in place to encourage the development of DG for rural electrification. Moreover, for DG projects to contribute to income generation, steps must be taken to ensure that critical infrastructure exists to enable access to markets for goods and services. In addition, the current policies restricting the development of small-scale DG projects must be revised to ensure that small-scale energy service providers have a right to sell power to isolated communities.

Lastly, to ensure sustainability in Kenya's wood energy sector, regulations governing the woodfuels trade must be rationalized and clarified to remove the legal ambiguity that currently characterizes the commodity. Currently, the political space in which to create a wood energy policy is not well delineated. The Ministry of Energy, Ministry of Environment and Natural Resources (MENR), the Forest Department (which falls within MENR, but acts independently of it), and the recently created National Environmental Management Authority, as well as Provincial and District Administrations, local government, and police authorities neither communicate nor coordinate in order to meet the nation's need for woodfuels. Before any effective policy is introduced, the mandates for different institutions addressing wood energy issues should be made explicit in order to eliminate jurisdictional conflicts in the sub-sector. Clarifying institutional responsibilities should also reduce the degree to which corrupt authorities are able to capture rents from the woodfuel trade.

Finally, a system of long-term monitoring and data collection must be established in order to understand trends in woodfuel utilization. Such data collection will also enable policy makers to understand the impacts of woodfuel exploitation on ecosystems as well as on populations living in woodfuel production zones. Policies that are developed without accurate and reliable data are unlikely to lead to effective or desired outcomes.

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Footnotes

1. The long-term sustainability of diesel, or any fossil fuel-based DG is, of course, a cause for concern. However, Foley [15] estimates that installing diesel-based DG in 1000 Kenyan communities would increase petroleum imports by *less than one percent*. Further, the short-term benefits of access to electricity for the rural poor very likely outweigh the costs of carbon emissions that would result. Moreover, asking the rural poor to forego the benefits of electrification because of the small burden of harmful emissions that would result is questionable from a moral standpoint given the present inequality in emissions that exist between the North and the South. This remains true unless, of course, the North is willing to pay for the incremental costs of carbon-free technologies [see 16 for a similar argument in the context of fossil-based cooking fuels].

2. Electricity customers in the Mpeketoni scheme pay nearly $0.30/kWh which is about three times the average price paid by grid-connected consumers [11].

3. In addition to these schemes, there are several DG systems owned and operated by KenGen, the unbundled portion of the national utility responsible for power generation. KenGen's DG systems target remote towns rather than rural populations. For example, Lamu, Marsabit, Lodwar and Garissa are all served by diesel-powered mini-grids.

4. ITDG is the Intermediate Technology Development

Group. They have since changed their name to Practical Action (www.practicalaction.org). GTZ is Gesellschaft für Technische Zusammenarbeit, a private company owned by the German government with the mission of promoting "political, economic, ecological and social development worldwide, and so improve people's living conditions" (http://www.gtz.de/en/index.htm).

5. Some institutional stove producers still receive some donor support. For example, Rural Energy Technology Assistance Programme, (RETAP) used donor funds to establish a revolving credit mechanism, which allows them to offer credit to buyers who would otherwise not be able to purchase stoves and permits them to recover the costs of the stove with moderate interest to cover their own transaction costs and pay their staff.

6. The decision to buy an improved stove is a function of household priorities relating to the allocation of labor time, (typically that of women and children), and cash expenditures (usually decided by the male head of household). Thus, there is an important gender and age-component to such decisions which, until recently, was often ignored by stove programs [35].

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ACTS

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