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Energy consumption and Use of Solar energy in Kenya – Revised version 11/2013

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Content

1. Introduction

As most African countries Kenya is endowed with significant solar resources with "…annual averages well over 5kWh/m²/day available throughout the country" (GTZ, 2009, p.1). Even if Kenya is considered as having one of the most developed markets for solar technologies the role of solar energy is still rather limited. In the past the Kenyan government did not play a relevant role to promote solar technologies. In recent years the situation has changed. The Kenyan government is making some steps to promote the use of solar technologies in off-grid and on-grid areas.

Target of the paper is to

- describe the current status of solar technologies in Kenya in the fields of electricity generation and warm water preparation
- to analyze the obstacles for a more rapid diffusion of solar technologies
- to describe and analyze the policy programs to enhance the use of solar technologies

The paper is based on two types of sources: Firstly, papers and statistics on the Kenyan energy industry; secondly, interviews with experts of the Kenyan renewable energy sector.

According to the mentioned targets the paper is organized as following: Section 2 describes the dynamics of energy production and energy consumption in Kenya, with special focus on the role of traditional biomass and modern renewable energy technologies. Section 3 addresses the development of power consumption and generation and delivers detailed information on power consumption by sectors and per head. In section 4 the rate of electrification and public strategies of rural electrification are discussed. The low electrification rate in rural areas includes scope for pre-electrification strategies based on solar home systems (SHS). Sections 5 till 7 are the core part of the paper and inform about the current status markets for solar technologies in Kenya like markets for solar water heaters, solar home systems and grid connected PV. Besides market data public programs and instruments promoting solar technologies are presented and discussed.

2. Energy consumption and production in Kenya

The energy balance informs about the total primary energy supply (TPES), the importance of energy imports and indigenous production, the relevance of the different energy carriers and about final energy consumption by sectors. In the following we analyze the 2011 energy balance of Kenya (2.1.). In the next section we will have a closer look at the dynamics of energy consumption and production (3.2).

2.1 Energy Balance of Kenya 2011

The energy balance provides a first idea of a country's energy situation. The energy balance of Kenya is relatively slim, since some energy carriers like natural gas, lignite and nuclear power are not used in Kenya.

Indigenous energy production is concentrated on 3 types of energy: traditional biomass, geothermal energy and hydro. Biomass is by far the most important indigenous energy: 90,2% of all national energy production consists of biomass.

Table 1: Kenya - Energy balance 2011 (in thousand tons of oil equivalants (ktoe)

	Coal & Peat	**Crude Oil**	**Oil products**	**Hydro**	**Geothermal, solar etc.**	**Biofuels& wastes**	**Electricity**	**Total**
Production	0	0	0	297	1289	14616	0	16202
Imports	234	1781	2772	0	0	0	3	4791
Exports	0	0	-66	0	0	0	-4	-70
Int. Bunkers	0	0	-741	0	0	0	0	-741
TEPS	**234**	**1778**	**1965**	**297**	**1289**	**14616**	**0**	**20179**
Power Plants	0	0	-736	-297	-1289	-91	675	-1737
Oil refineries	0	-1778	1703	0	0	0	0	-75
Other transformation	0	0	0	0	0	-4893	0	-4893
Industrial own use	0	0	-89	0	0	0	-5	-94
losses	0	0	0	0	0	0	-114	-114
Total Final Consumption	**234**	**0**	**2843**	**0**	**0**	**9632**	**555**	**13265**
Industry	234	0	686	0	0	0	313	1233
Transport	0	0	1569	0	0	0	0	1569
Residential	0	0	294	0	0	9632	157	10084
Other (services, agricult.)	0	0	60	0	0	0	85	85
Non-energy use	0	0	234	0	0	0	0	234

Source: IEA

Beside indigenous energy production energy imports are relevant. About 24% of total primary energy supply is imported (especially crude oil and oil products).

The total primary energy supply (TPES) 2011 is dominated by traditional biomass (72,4%) and crude oil (8,8%) and oil products (9,7%). Other energies like geothermal energy (6,4%), hydro and coal play a minor role.

The total final energy consumption (TFEC) consists of only 4 types of energy: biomass, oil products, electricity and coal with biomass as the most relevant (72,6%).

If we ask where the final energy is consumed we find the residential sector to be the most relevant. About 76% of TFEC is consumed by private households, followed by the transport sector (11,8%) and industry (9,3%).

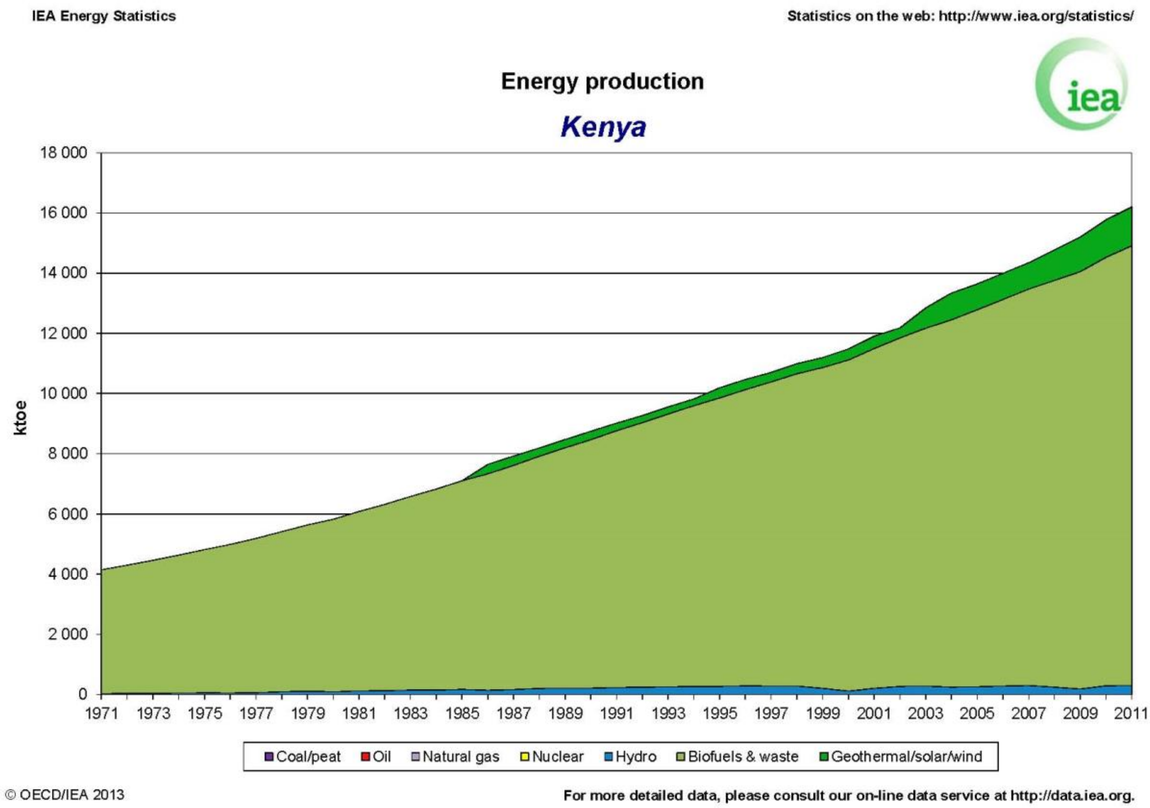
Final energy consumption of the residential sector is dominated by traditional biomass and charcoal (95,5%); modern energies like electricity or oil products play a minor role. The transformation losses of biomass (-4893 kt OE) indicate that a significant share of the biomass is transformed to charcoal.

Looking at the final energy consumption in the transport sector and industry we see that they are 100% relying on modern fuels like oil products and electricity.

2.2 Dynamics of energy production and consumption in Kenya

Beside the recent data we are interested in information about the long-run dynamic of energy production and consumption. As shown by figure 1 the structure of Kenyan energy production has not much changed during the past decades. Biofuels and wastes were the dominant energy carriers in the 70th of the former century, and still they are. Production of biofuels has almost quadrupled. It can be questioned whether this development is sustainable.

Figure 1: Energy production in Kenya 1971-2011 in ktoe

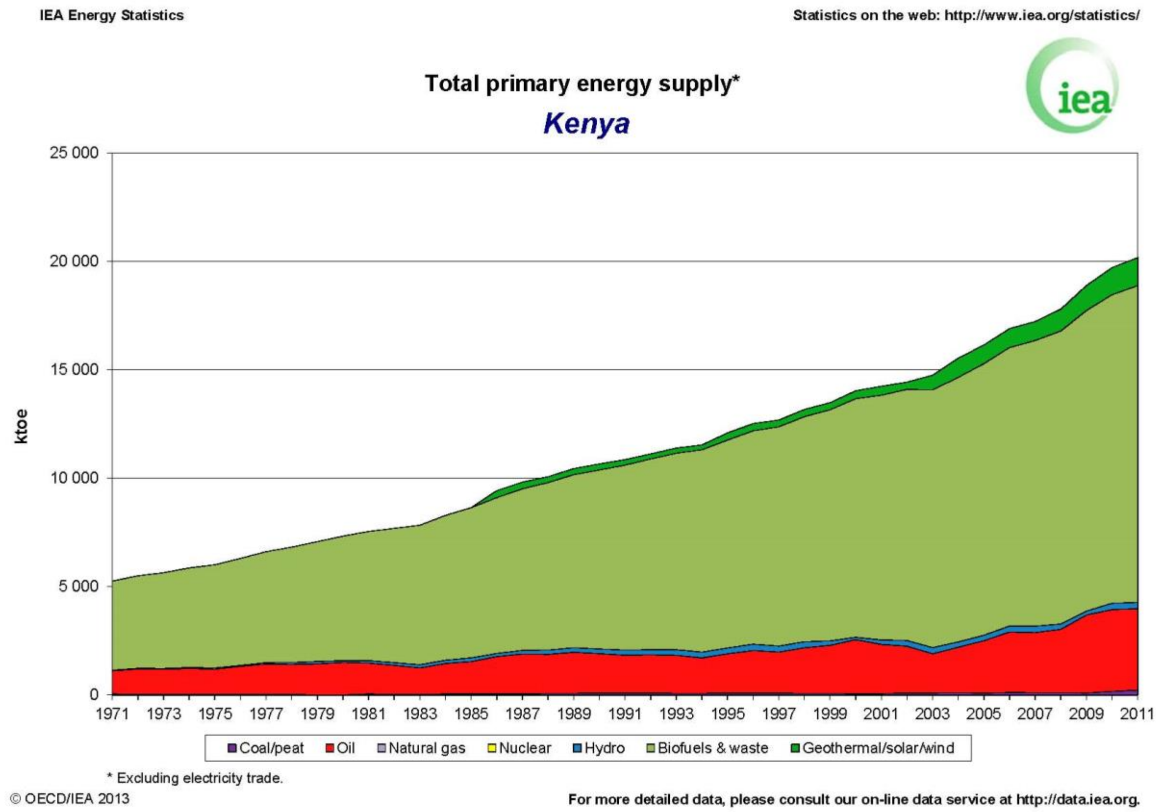


Source: IEA

Kenyan energy production shows a small share of hydro and geothermal energy, but no production of fossil fuels.

Figure 2 shows the development of the TPES since 1971. Even here, traditional biomass is dominating, but fossil fuels (Imported crude oil and oil products) play an important role. Their share seems to be quite stable. There is obviously no evident process of substituting traditional biomass by modern forms of energy.

Figure 2: Total primary energy supply in Kenya 1971-2013 in ktoe



On the other hand, as shown by table 2, the share of clean energy like modern renewables (hydro, geothermal, wind and solar energy seems to grow (2010 and 2011 almost 8%).

Table 1: Total energy consumption (in 1000t of OE) and share of different types of energy

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2010**	**2011**
Total Energy Consumption	15.039	14.973	15.032	15.648	16.821	17.328	19719	20.179
	Share of different types of energy (%)							
Fossil fuel	21,90	18,70	16,66	15,70	18,66	19,28	19,98	19,70
Traditional Biomass	74,77	77,07	79,22	78,09	74,54	74,25	72,20	72,40
Clean Energy	3,21	4,14	3,99	6,12	6,76	6,48	7,84	7,85
	99,89	99,91	99,87	99,90	99,96	100,01	100,03	100,01

Source: Worldbank indicators

2.3 International comparison of energy production, consumption and intensity

Considering the energy balance gives a first idea of a country's energy issues, but it does not allow a comprehensive understanding of the problems and the challenges. The dimensions of issues like energy poverty becomes only visible, when we compare the country's energy consumption or production figures with those of other countries, primarily with those of industrialized country. In the following we compare Kenya's primary energy supply per capita and electricity consumption per capita with those of South Africa and Germany.

Table 2 reveals that the TPES per inhabitant in South Africa is about 5 times higher than in Kenya. More important is the information that electricity consumption per head in South Africa is about 30 times higher than in Kenay. This means, that the people in Kenya are not only lacking energy in general, but they are especially lacking modern forms of energy like electricity that can be used for all kind of productive and consumptive activities.

Table 2: Selected Indicators for 2011

Country	**Kenya**	**South Africa**	**Germany**
Population (millions)	41.61	50.59	81.87
GDP (billion 2005 USD)	24.55	298.09	3048.69
GDP (billion 2005 USD) PPP	62.81	489.59	2827.99
Energy Production Mtoe	16.20	162.58	124.19
Net Imports (Mtoe)	4.72	-17.81	199.04
TPES (Mtoe)	20.18	141.37	311.77
Electricity cons. (TWh)	6.52	237.47	579.21
CO2 emissions MM t	4,5	367.60	747.58
TPES/ Pop (Toe/capita)	0.48	2.79	3.81
TPES/ GDP (Toe/000 USD)	0.82	0.47	0.10
TPES/ GDP PPP (Toe/000 USD)	0.32	0.29	0.11
Electricity cons. / Pop. (kWh/capita)	157	4694	7083
Source: IEA, Key World Energy Statistics 2013			

Furthermore, it is of interest to observe, that the energy intensity of Kenya (TPES/GDP PPP) is about 10% higher than in South Africa, but about 3 times higher than in Germany. One explanation for that is the high share of traditional biomass in the energy mix. The efficiency of converting biomass like wood in traditional stoves is typically lower than 20%. Another explanation is the low efficiency of old technologies (trucks, cars, power stations etc.).

Table 3 revels another interesting aspect. Even if the TPES has drastically increased (s. figure 2), the energy consumption per head has not changed significantly. With about 480 kg OE it is higher than in other central African countries like Ethiopia (<300 kg OE) or Tanzania (442 kg OE), but it is much lower than the world average or more developed countries like South Africa or Germany.

Table 2: Energy consumption per head (kg OE)

Country Name	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2011**
World	1.646	1.632	1.648	1.686	1.742	1.769	1.793	1.819	1.880
Kenya	478	464	453	460	482	484	494	485	480
South Africa	2.507	2.417	2.305	2.556	2.775	2.703	2.726	2.807	2.795
Germany	4.103	4.219	4.112	4.144	4.163	4.107	4.142	4.027	3.811

Source: Worldbank Indicators

Thus, we can conclude that traditional biomass is the back-bone of energy consumption in Kenya. Furthermore we can say that the share of traditional biomass is comparatively stable. Thus, as the demand for energy rises in Kenya, the use of traditional biomass increases, too.

2.4. Kenya on the energy ladder

The most relevant area of traditional biomass is cooking. In rural areas firewood represents about 90% of all fuels for cooking. In urban areas firewood is replaced by Kerosene (44, 6%) and Charcoal (30,2%).

Tab. 3: Firewood for Cooking as Percentage of fuels for Cooking in Kenya

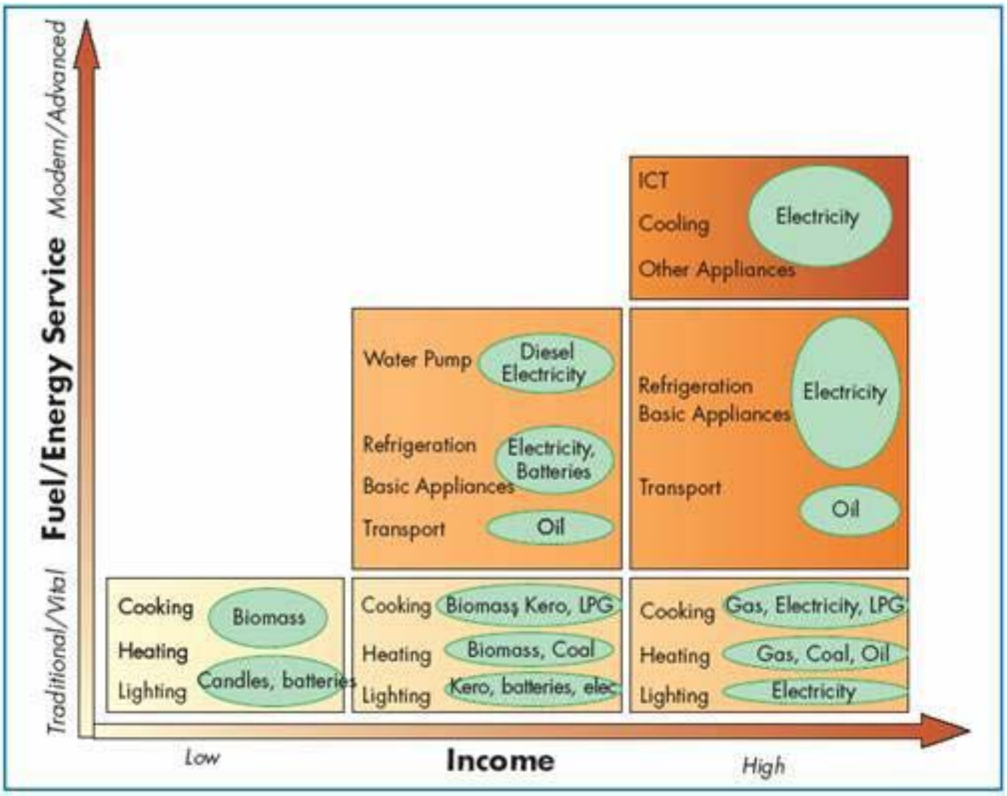
	1989	1999	2005/6
Kenya	73	68,8	68,7
Rural areas	90,1	88,4	88,2
Urban areas	13,1	9,6	10,3

Source: WHO/UNDP (2009)

According to UNEP the use of traditional biomass in Kenya is not sustainable (UNEP 2006, p. 41). “Without any policy interventions, the wood fuel deficit of 20 million tonnes reported for 2004 will grow to 33 million tonnes by 2020.”

In the coming decades the availability of wood fuel will decrease because of the current unsustainable overconsumption of wood fuel. “Availability and access to firewood on communal land is expected to diminish in most parts of the country, leading to lower consumption levels. A downward trend in firewood consumption to 11.8 million tonnes in 2030 is therefore expected” (UNEP, 2006, p. 41). Thus, without significant energy policy efforts Kenya will face a severe firewood crisis (UNEP, 2006, p.42).

Altogether we can conclude that the Kenyan energy development is confirming the theory of the energy ladder. According to that approach in countries with a per capita income of less than 300 US$ more than 90 % of energy is covered by traditional fuels, whereas in countries with a per capita income of more than 1000 US$ people are using modern forms of energy. Kenya with per capita income of about 500 US$ is between those extreme positions: It is on the way to climb the energy ladder and to apply more modern forms of energy. But the way to go is still long. Using more electricity can be an important step to increase the provision of energy services and to improve the standard of living.

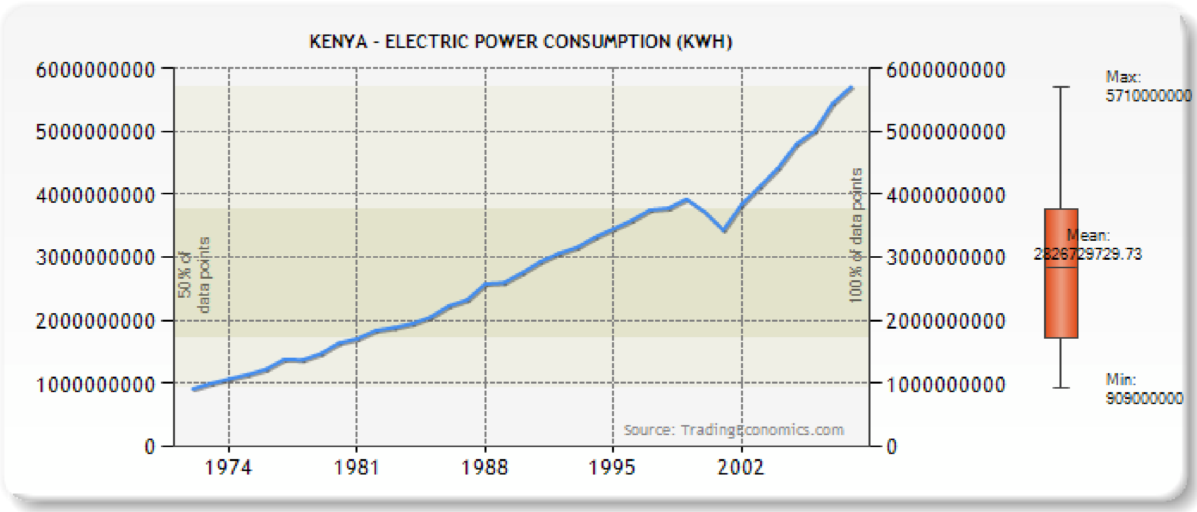


Source: http://www.rice.edu/energy/research/poverty&energy/index.html

3. Power Consumption and Production

3.1 Power Consumption

The electricity consumption in Kenya is continuously increasing. From 1993 (3.323 TWH) till 2010 (6.321 GWh) it has almost doubled (Worldbank, 2013).



Source: http://www.tradingeconomics.com/kenya/electric-power-consumption-kwh-wb-data.html

Table 3 shows the structure of electricity consumption in Kenya. Large and medium commercial businesses and Industry is the most important electricity consuming sector. More than 50% of total electricity demand is concentrating on this sector. The demand of this sector is about 50% higher than that of the next relevant sector “Domestic and small Commercial”.

Tab. 3 : Electricity Consumption (GWh)

Source	2006	2007	2008
Domestic and small Commercial	1572,4	1650,7	2003,2
Large&Medium Commercial and Industry	2919,8	3019,7	3023,4
Off-Peak	44,6	65,4	74,2
Street Lighting	10	12,7	13,3
Rural Electrification	205,6	216,1	238,1
Total Domestic Demand	**4752,4**	**4964,6**	**5352,2**
Exports to Uganda	46,7	58,3	41

Source: Kenya National Bureau of Statistics (2009), p. 44

Annual electricity consumption per head is about 140 KWh if we consider the total energy consumption, but only about 60 kWh, if we consider the relation of Domestic Electricity Consumption (including Rural Electrification) (s. table 4). It is significantly lower than more developed countries like South Africa.

Tab. 4 : Electricity Consumption per Head (KWh)

Source	2006	2007	2008
Total Domestic Demand (million kWh)	4752,4	4964,6	5352,2
Population (millions)	36,1	37,2	38,3
Total Electricity consumption per head (kWh)	131,65	133,46	139,7
Domestic Electricity Consumption per head	49,25	50,18	58,52

Source: Kenya National Bureau of Statistics (2009), p. 10 und 44

One reason of the low electricity consumption per head is the fact, that the share of population with electricity access is still very low. Only 15% of the people are connected to the grid. Access to electricity amounts 51.3 % in urban regions and 5% in rural areas (WHO, UNDP, 2009, p. 68).

3.2 Electricity generation, transmission and distribution

Table 5 informs about the power generation in the years 2006-2008. We can see that the Kenyan power production stems from 3 major sources like hydro, geothermal and heating oil. Other sources like wind and cogeneration play a minor role.

Tab.5 : Electricity Generation by Source (GWh)

Source	2006	2007	2008
Hydro	3025,0	3592,0	3272,0
Thermal Oil	1818,5	1735,8	2145,4
Geothermal	1045,7	988,9	1039,0
Cogeneration	5,6	8,3	4,0
Wind	0,3	0,1	0,2
Imports	10,8	22,5	25,0
Total	5905,9	6347,6	6485,6

Source: Kenya National Bureau of Statistics (2009), p. 44

The most important energy for power generation in Kenya is hydro. Hydro power stations represent about 50% of the generation capacity and about 50% of power production. Figure 1 informs about hydro power production in 1993 – 2010. It reveals two interesting facts. Firstly, hydro power generation varies from year to year. In dry years it can drop significantly. Secondly, hydro power generation has not been increased during the past 20 years. The maximum output is around 3,500 GWh.

As a consequence, the importance of hydro power is dropping and other energies like thermal oil become more relevant. Whereas 1993 hydro power generation was sufficient to cover almost all the national power demand, the current share is about 50%.

Figure 1: Hydro power generation in Kenya 1993-2010 (in GWh)

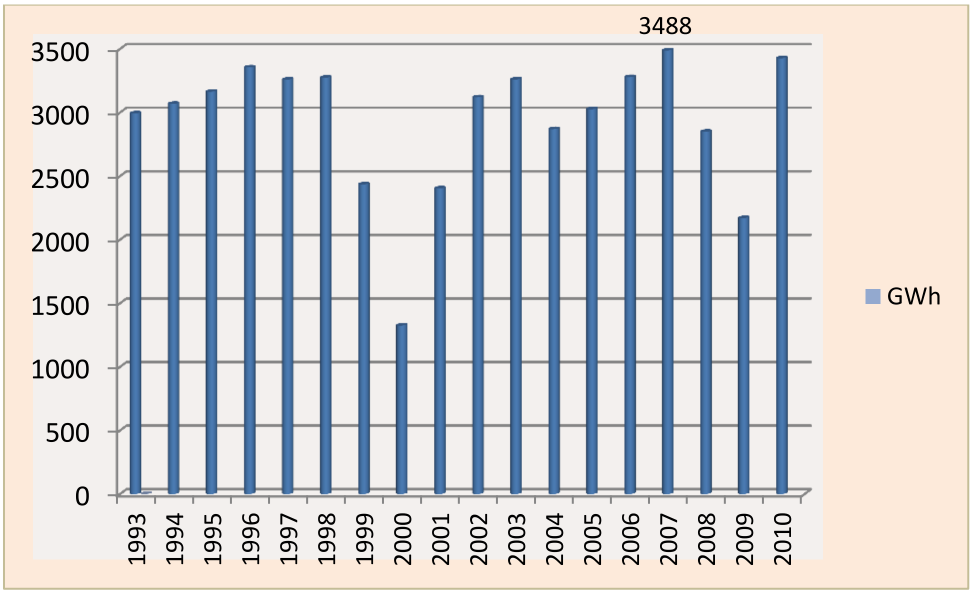


Table 6 shows the generation capacity and the hours of full load indicating the usage of the power stations. It is obvious that geothermal power stations work as base load power stations (8117 hours of full load). On the other hand the output of thermal oil power stations is varying. They show a high degree of usage in dry years like 2009, when the contribution of hydro power stations is low.

Tab. 6: power generation capacity and hours of full load

	Capacity (MW) 2005	Power generation (GWh) 2008	Hours of full load 2008
Hydro	677,3	3272	4831
Thermal oil	344,2	2145	6232
Geothermal	128	1039	8117
Wind	0,4	0,2	500

Source: UNEP (2006), p. 11; own calculations

A central issue of the Kenyan power system is the weak balance of supply and demand, caused by a scarcity of reserve capacity (Imitira 2009). This situation became obvious in 2008 and 2009 when failing rainfalls were reducing the supply of hydro power. As a reaction, thermal power generation was increased and power rationing was introduced. The increase of high cost thermal power generation has raised the power bills of residential and industrial power customers by more than 100% (Omonodi, 2009). The power rationing has led to a significant reduction of industrial production. "According to a statement released by the Kenya Association of Manufacturers (KAM) … up to 25 industrial enterprises located in areas that are experiencing three-times-a-week power rationing have been forced to scale down their operations by more than a half" (Omondi, 2009).

The 2008/09 power crisis underlines the need to strengthen the power system by

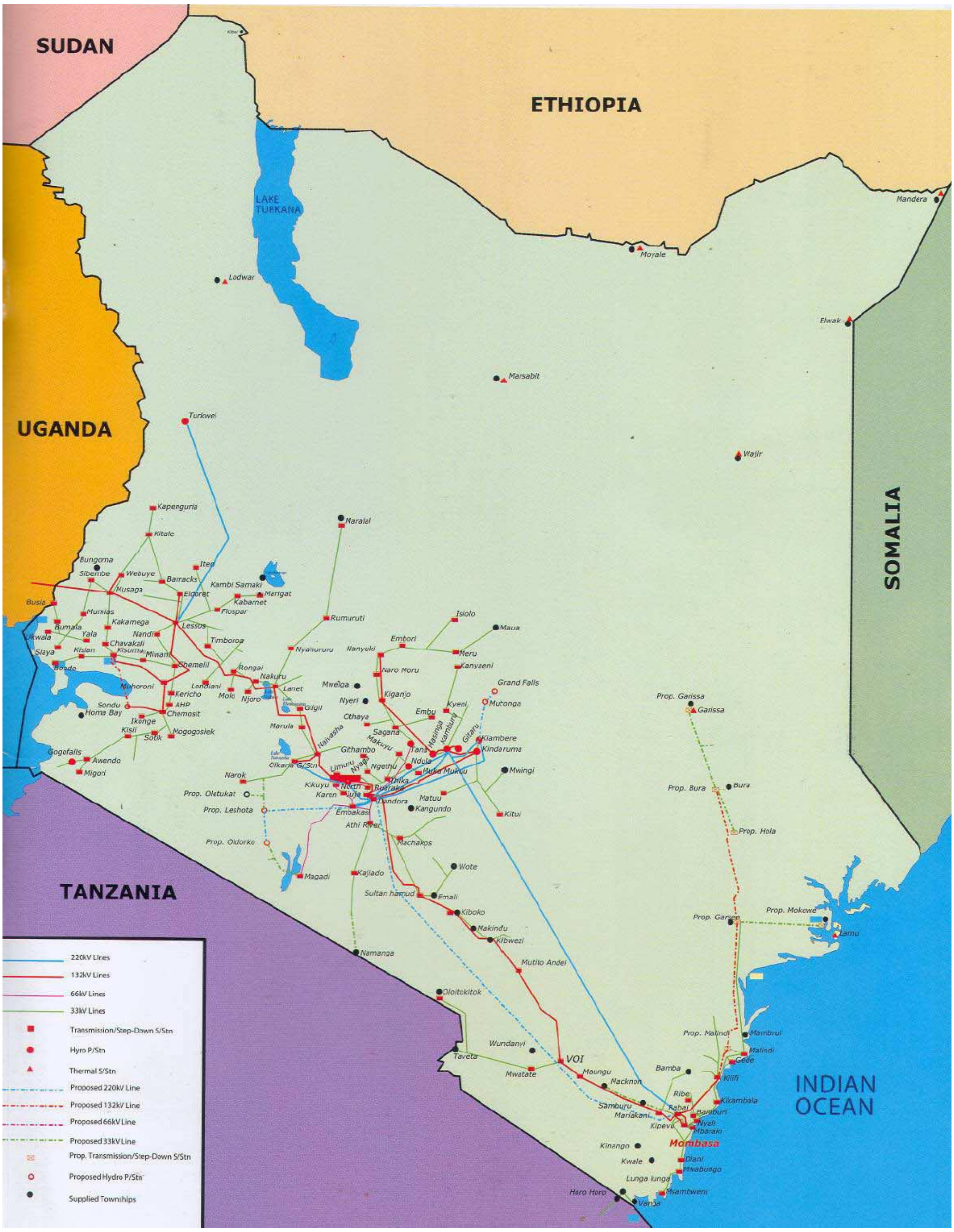
- enhancing the grid capacity
- attracting private investors (IPP)
- introducing demand side management
- increasing the opportunities for power trading with neighbouring countries and
- diversifying the power supply resources (Imitra, 2009, p.12; Kiva, 2009).

The need to diversify the resource basis includes decisions on the role of renewable energies.

Figure 2 informs about the existing HV and MV network. Even if it is continuously expanded the stability of the network is weak.

Due to a weak transmission and distribution (T&D) infrastructure grid losses are high. 2010 they amount to 15.7% (Worldbank 2013). The losses equals to the annual geothermal power generation (s. table 5)

Figure 2: Existing and proposed HV&MV Network



3.3 Power tariffs

Power prices and price regulation play an important role for investments in the power system and efficient use of electricity. Cost reflective power prices provide incentives for the efficient allocation of investments on the supply as well as on the demand side. On the supply side power prices send signals to investors to replace high cost resources by cheaper ones; on the demand side consumers receive incentives to replace grid power by power saving technologies like solar water heaters or PV plants. Since power prices in Kenya are set by the Kenyan power monopolist Kenya Power and Lighting Company (KPLC) power prices need to be regulated. In the following the rules of power regulation are outlined.

By approving power tariffs the control authorities follow different targets like efficiency, fairness, economic growth and sustainability. they

The target of efficiency is met if the power stations are used in accordance their marginal cost, the costs of the grids are allocated properly to the different consumer groups and the consumers receive incentives to shift their demand to times of low generation cost (time variable tariffs). Additionally, the level of the tariffs should be sufficient to cover the cost of the system.

The target of fairness requires that low income consumers are facing lower tariffs than more affluent consumers.

The target of economic growth is supported if power tariffs are low and thus lowering the production cost of industry and other productive sectors.

Finally the target of sustainability is met, if the tariff system is providing incentives to reduce power consumption, to avoid a waste of electricity and to substitute power saving technologies by electricity.

Regulation of power prices is executed by the Energy Regulatory Commission (ERC). The power prices of different consumer groups consist of several fixed and variable price elements. The variable price elements like Fuel Cost Charge, Foreign Exchange Rate Fluctuation Adjustment and Inflation Adjustment are adapted on a monthly base. An overview on the price dynamic since 2009 is published by Kenya Power (2013) and by Rayofsolaris (2013).

Table 6.1 shows relevant features of the Kenyan power tariff system. The information provided are not sufficient for a detailed discussion of the targets mentioned above. In general it can be said, that power prices in Kenya cover the cost of the system and thus can be considered as efficient. Considering the tariff for domestic consumers we see that the target of fairness plays a prominent role, too. Households with high power demand pay higher prices than households with low electricity consumption. This implies that high income households receive higher incentives to replace power by modern technologies like solar water heaters.

Table 6.1: Electricity tariffs for residential and commercial power consumers in Kenya

Tariff	Type of Customer	Supply Voltage (V)	Consumption (kWh/ month)	Fixed Charge (KES/ month)	Energy Charge (KES/ kWh)	Demand Charge (KES/ kVA/ month)
DC	Domestic Consumers	240 or 415	0-50	120.00	2.00	-
			51-1,500		8.10	
			Over 1,500		18.57	
SC	Small Commercial	240 or 415	Up to 15,000	120.00	8.96	-
CI1	Commercial/ Industrial	415-3 phase	Over 15,000 No limit	800.00	5.75	600.00
CI2		11,000		2,500.00	4.73	400.00
CI3		33,000/ 40,000		2,900.00	4.49	200.00
CI4		66,000		4,200.00	4.25	170.00
CI5		132,000		11,000.00	4.10	170.00
IT	Interruptible Off-Peak supplies	240 or 415	Up to 15,000	240.00 – when used with DC or SC	4.85	-
SL	Street Lighting	240	-	120.00	7.50	-
	Source: ERC					

Source: SREP, 2011, p. 18

4. Grid connection and rural electrification

As mentioned earlier the share of households with electricity access is still very low, only about 15%. Access to electricity amounts 51.3 % in urban regions and 5% in rural areas (WHO, UNDP, 2009, p. 68).

The general reasons for the low degree of rural electrification are manifold (Barnes 2007, p. 10 f):

- low population density
- high share of low income households
- as a consequence a low demand for electricity concentrated at evening peak times
- high cost of grid extension
- difficulties in operating and maintaining remote rural systems
- low interest of integrated power companies to invest in rural electrification because it is a loss maker
- local community problems e.g. objections of local elites
- issues to achieve a consensus among villagers concerning rules to share the cost of grid connection (Acker, Kammen 1996, p. 89)
- political considerations; rural electrification decisions are often used as reward for political support and thus often proceeding in a “haphazard and inefficient pattern that bears no relationship to local needs or the ability to profit from grid connection” (ibd. p. 89).

Self financed grid connection is only affordable if the grid is not further away than 600m.

Since electrification provides significant social and economic advantages in most developing countries rural electrification is granted by government programs. This holds for Kenya, too.

Considering the efforts of the Kenyan government to speed up the process of rural electrification we can distinguish two phases .

Phase 1: The Rural Electrification Programme (REP)

The first phase started in 1973 by launching the Rural Electrification Programme (REP) that was set up for the purposes of subsidizing electricity supply in the rural areas. This was upon the realization that many parts of the country could not get electricity on commercial basis.

The Government entered into an agreement with the then East African Power and Lighting Company (EAPL), now KPLC. Under the agreement, KPLC was appointed as a contractor for planning, implementation, operation and maintenance of rural electrification schemes. The Government is responsible for sourcing of funds for rural electrification and identifying projects to be implemented by KPLC."

The main instrument to facilitate rural electrification was the introduction of subsidies for grid connection. "Under this initiative, the customer only has to pay for the home wiring cost, a 'token' connection fee (KSh 2500 (US$40)), and a meter charge (KSh 300 (US$5)). While this largely surmounts the financial difficulties for rural customers, it does not address the organizational or bureaucratic problems, or those of patronage of the selection and support services provided to potential users. The REP has the reputation of a highly politicized programme…"(ibd. p. 90).
Another issue is that the available funds for the REP were rather small in comparison to the needs. "The REP has received only minimal financial support, and thus has been very slow to bring electricity to Kenya's rural customers. For the first 13 years of its existence the programme made fewer than 700 connections per year. Although the place of rural electrification has since increased considerably, with about 5000 connections per year in the 1990s, it is sobering to note that 5000 connections per year is less than 1% of current birth rate; even at this faster rate it will evidently take hundreds of years for all of Kenya's rural population to receive electricity" (Ibd. p.90)

According to available Worldbank figures the amount of people with access to grid electricity has risen significantly from 2,4 million (2000) to 4,8 million 2004. The most of the newly connected people are living in urban areas. The connectivity of households in rural areas remained low. Besides that, because of the increasing population the total number of persons without grid access has risen from 28 to 29 millions. http://info.worldbank.org/etools/ask4electricutilities/countrySnapshot.asp?dby=0&cat=1&cat=2&cat=3&cat=4&cid=24&heading=Select+Indicator

Phase 2: The Rural Electrification Authority and Rural Electrification Master Plan

As a result of this low connectivity the Government of Kenya 2004 undertook steps to accelerate the pace of rural electrification through the creation of Rural Electrification Authority (REA). By 2012, REA targets to have connected at least 22% of the rural population. REA has rolled out the Rural Electrification Master Plan which presents least-cost electrification options for target areas. The master plan prioritizes list of projects for implementation based on economic and social factors. Most important are public facilities like schools, hospitals and municipal buildings. The first master plan was developed in 1997 and is being updated to show what has been done so far and to come up with new load centers.

Besides developing the master plan the REA has to manage the Rural Electrification Fund (REF) that is fed by different sources. Another function is the promotion of renewable energies. REA's most important function are:

- Manage the Rural /electrification Programme Fund
- Develop and update the rural electrification master plan
- Promote the use of renewable energy sources including small hydro power plants, wind, solar, biomass, geothermal, hybrid systems and oil fired components taking into account specific needs of certain areas including the potentiality for using electricity for irrigation and in support of off-farm income generating activities.
- Implementation and sourcing of additional funds for the rural electrification programme
- Management of the delineation, tendering and award of contracts for licences and permits for rural electrification

The REA is managing the "Rural Electrification Programme Fund" that is fueled by several sources, like

a) the electricity sales levy
b) fees and other charges levied by the Commission under the Act;
c) such moneys as may be appropriated by Parliament for that purpose;
d) donations, grants and loans; and
e) all other moneys lawfully received or made available for the programme as the Minister may approve.

The main source is the 5% levy on electricity sales. Besides the mentioned sources the REA has the mandate to initiate agreements with the private sector like Public Private Partnership (PPP's). Under the Act REA is mandated to also explore, promote and develop the use of other renewable sources of energy. These include, Solar, Wind, Small hydro, Power alcohol, Bio diesel, Biogas and Municipal and Industrial Waste energy, among others.

4.1 Targets of Rural Electrification

Similar to other developing countries like South Africa[1] precise figures of the number of households connected to the grid in Kenya are not available. According to the Vision 2030, an official master plan to overcome poverty and to ensure sustained economic and social development, every Kenyan citizen must have electricity by 2030 (Ayieko, 2010, p.8). The target of 100% connectivity in 2030 is divided into sub-targets for specific periods

- Phase I 2008-2012
  - Connect all public facilities
  - Connect 1 million customers (about 200,000 p.a.)
  - Increase connectivity from about 12%-22%)

- Phase II 2013-2022
  - Connect Customers (increase connectivity from 22% to 65%)

- Phase III 2022-2030
  - Connect Customers (increase connectivity from 65%to 100%)

To achieve these ambitious targets electrification in both, urban and rural areas has to be increased. There is no doubt, that electrification of rural households is much more challenging and needs more government support than increasing urban electrification[2]. In this context, the role of solar energy has to be defined.

4.2 Means and Methods of Rural Electrification

Whereas urban electrification is in the vital interest of the power company rural electrification is facing a number of obstacles as mentioned above. Thus, significant amounts of money have to be used to overcome them.

Table 7: Funding for Rural Electrification up to 2009/10

Period	Funding (KSH MILL)			
	Internal Sources	External Sources	Total	%
1973 - 2002/03	4,271	2,994	7,265	20
2003/04-2009/10	29,091	5,686	34,777	80
Total	33,362	8,68	42,042	

Source: Ayieko, 2010, p.13

As shown by table 7 since 1973 about 42 billion Kenyan Shillings have been spent funding rural electrification. It is obvious that the efforts to promote rural electrification have been

1

2 According to P. Nyoike, permanent secretary in the Ministry of Energy, achieving this target by 2030 is virtually impossible because of the high cost. http://www.bukisa.com/articles/374334_solar-solutions-in-remote-africa

significantly enhanced during the last years. About 80% of all means have been spent since 2003/04. Furthermore it can be seen that internal sources became by far the most important source of funding rural electrification.

REA uses 4 methods of rural electrification

- Grid Extensions - for the interconnected areas
- Stand alone Diesel stations - for off-grid areas
- Solar PV - for institutions & homes within the off-grid areas
- Use of other renewable energy sources such as Mini hydro, wind and biogas (Ayieko 2010)

4.3 Outcomes of Rural Electrification

To evaluate the outcomes of rural electrification we have to distinguish the electrification of private households and public facilities. From table 8 we can see that the number of households connected to the grid has risen from year to year. But we are still far away from the electrifying 200,000 households per year, necessary to connect 1 million additional households to the grid.

Table 8: Rural Electrification of households in Kenya 2002/03 till 2006/07

	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Rural El. Customers (Accounts)	87175	93445	101793	110728	133051		
% Growth		7,19%	8,93%	8,78%	20,16%	-100,00%	

Source: G. Owour Odhiambo (2007)

Table 9: Achievements of rural electrification - public facilities electrified

Facility	No. of facilities electrified by 2003/04	No. of facilities electrified 2003/04 - 08/09	No. of facilities to be electrified 2009/10	Total electrified June 2010	to be electrified 2010/11-2012/13
Trading Centers	1,096	4,215	858	6,169	3,324
Public Secondary Schools	285,000	3,217	408,000	3,910	5,039
Health Centers	348	1,433	233	2,014	1,565
TOTAL	1,729	8,865	1,5	12,094	7,906
Average p.a.	57	1,480	1,500		2,600
Level of Electrification	4%	10%	-	12%	22%
Access level		63%		68% (Est)	100%

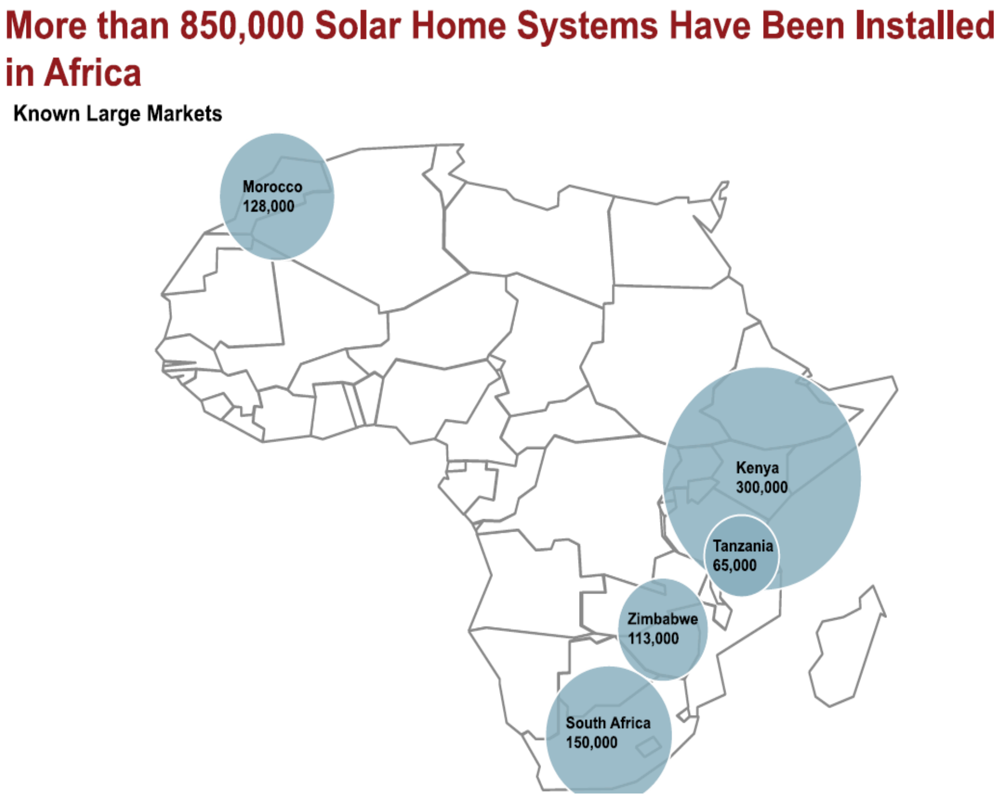
As shown by table 9 significant achievement has been made in electrifying public facilities in rural areas. In 2003/04 only 1,729 public facilities have been electrified. Between 2003/04 and 2008/09 another 8,865 public facilities have been provided with electricity. By June 2010 about 12,000 of ca. identified 20,000 public facilities requiring electrification have been so far connected to the grid. According to Abass, chair of the Rural electrification Authority, another 1,114 million US$ are needed to electrify the remaining facilities by 2030 (Abass, 2010, p. 11).

Concluding we can say that since 2004 the Kenyan government has significantly increased efforts to electrify the rural areas. Nonetheless, the situation is still worse than on the average of the developing countries.

5. The market for solar home systems

Resulting from the slow pace of rural electrification in Kenya there is a huge potential for decentralized off-grid technologies providing electricity. Decentralized power generation can be based on conventional (diesel generator) as well as renewable energies like biomass, small hydro and photovoltaic (PV). Decentralized conventional power generators, currently the most widely used option, are based on fuel and can become less attractive in case of soaring fuel prices. Wind and small hydro power plants can be very cost effective, but they are depending on a sufficient supply of wind or hydro. Furthermore, they show comparatively high initial cost and are thus best appropriate for mini-grids. Thus, PV is often the only way to provide electricity to the people in rural areas. "Due to the highly site-specific nature of all other renewable power sources, solar powered off-grid options are the only economically viable option for all dispersed users in LCD (Least Developed Countries) today" (GTZ, 2010, p. 4).

Figure 5.1: Known large SHS Markets in Africa



Source: Lighting Africa, IFC and Worldbank, 2010, p. 75

According to available data on SHS markets in Africa, Kenya is the country with the highest market penetration of SHS in Africa. Notwithstanding, millions of rural households are still lacking any kind of electrification. In the following we describe the demand and supply side of the PV market in Kenya. Furthermore we ask, whether in Kenya SHS are disseminated by a donors or by a market based approach. According to Nieuwenhout et al. (2000) 4 different models for dissemination of SHS can be distinguished:

- Cash sales by commercial dealers
- Donations by international organizations where customers pay only a small amount of the total cost
- Credit schemes (Banks of Micro finance organizations)
- Energy service companies with fee-for-service systems

5.1 Demand side of the market for SHS

Basically, people don't have a demand for electricity itself but rather for energy services like lighting, telecommunication and communication, cooling etc. that can only be provided by using electricity. Since on-grid electricity provides unlimited amounts of power and energy services it is most flexible and generally considered as "gold standard" of electrification.

On the other hand it is observed that on the early stages of electrification the demand for electricity and electricity based energy services remains very low[3]. "…rural grid users often continue to use surprisingly low electricity amounts on the long haul (average values below one kWh per day are frequent in rural areas in least developed countries (LDC), as they typically use it exclusively to power 2 – 5 lights, TV, radio and sometimes a cell phone. For these 'typical rural households', the electricity amounts generated by small, decentralized alternatives to grid power would therefore often suffice" (GTZ, 2010, p.4).

Considering solar powered off-grid options 2 different technologies can be distinguished, solar home systems (SHS) and Pico PV systems.

SHS consists of several components like PV-panel, battery, charge-controller and cables of a proper size. The power depends on the capacity and typically varies between 20W and 50W. A SHS with a capacity of 50 W, enough to provide electricity for light, telecommunication and radio, costs between 400 – 1000 US$, depending on the country (see table 10).

Table 10: SHS cost and Gross National Income (GNI) per capita in ten African Countries

Country	Estimated SHS cost (50Wp; US$)	GNI/capita (US$ per year)	Cost/income ratio
Ethiopia	750	100	7.5
Kenya	550	350	1.57
Sudan	650	340	1.91
Tanzania	850	270	3.15
Uganda	500 – 700	260	2.8
Zambia	1200	320	3.75
Zimbabwe	800	387	2.07

[3] This holds not only for developing countries today but also for the early stages of electrification in the industrialized countries. In Germany during the first 3 decades of electrification private households used electricity almost exclusively for lighting and tremendous marketing efforts by utilities were necessary to make electrical cooking or ironing becoming attractive.

Source: GTZ, p. 5 based on Schweinfurth 2009

Besides the purchasing cost transaction costs have to be considered. They are resulting from information efforts of the costumer to find the right supplier for suitable equipment and O&M services. They can be reduced by purchasing fully integrated systems.

Since the purchasing cost surmount the average income of the people they are often not affordable. "Yet, currently available PV solutions for household level use in LDCs – so called solar home systems (SHSs) are not affordable for the vast majority of these users and this is not expected for the next decade (in spite of falling photovoltaic prices) (GTZ, 2010, p.4). According to Abdullah SHS become only affordable if the high initial investment cost can be spread over 5 and more years (Abdullah, 2009). But financing for SHS is rarely available.

Since SHS are often not affordable to the people another less complex and less costly PV based technologies like Pico PV are suggested. Typically a Pico PV system consists of a CFL driven by a small PV panel. According to GTZ Pico PV systems show some striking advantages:

- low price (30 – 80 US$)
- over-the-counter consumer products needing no specific know-how for installation of O&M
- high welfare gain when replacing traditional flame based lighting by efficient electric lights
- significant cost savings (kerosene, candles)
- "Consumers do not fear that Pico PV lamps will bar them from future grid roll-out, as they often do in the case of SHSs" (GTZ, 2010, p.5).

Thus, Pico PV technology can be considered as a mean to avoid some of the problems of more complex and expensive SHS and at the same time allowing "pre-electrification".

Historically, the demand for SHS was driven by two groups, donors and wealthier households in off-grid regions. Donors started to finance large scale plants for public buildings like schools and hospitals. They played an important role to establish a PV industry in the country, but also to train electricians. The second group consists of people with a comparatively high income like tea and coffee farmers, doctors, teachers and university professors etc. This group was mainly interested in television, radio and lighting (GTZ, 2009,p. 2). According to Akker and Kammen the average household income of those who bought a SHS in the early 90th (US$ 2,800) was about three times the mean household value (US$ 1029)(Akker, Kammen 2006, p.94). These household bought SHSs even when they lived close to the grid and thus, grid connection was the cheaper solution. "The explanation of the process of dissemination is not only economically straightforward, but also illustrates the commonly cited 'affluent seeding' effect" (Akker, Kammen 1996, p. 94). The demand of the wealthier off-grid households was of great importance for the Kenyan PV market in the early 90th when the foreign donors widely withdraw from Kenya because of concerns of human rights violations (ibd., p.90).

Currently about 200,000 households use PV systems and the figure is growing about 20,000 per year (Abass, 2010, p. 13). Most of the SHS have a rated power of 12 – 20 W.

5.2 Supply side of the market for SHS

Typically the supply chain of PV systems in developing countries consists of several stages like

- producers and importers
- wholesalers
- retailers/installers

In Kenya most of the PV equipment has to be imported, but several parts like batteries are produced in the country. In 2010 a first factory for PV modules was built near Naivasha. The firm, named Ubbing East Africa Ltd., is owned by the Dutch company Centrotec Sustainalble AG "The solar modules to be built there - initially in the 3.6 Wp to 80 Wp performance range - will be manufactured based on reworked, broken high quality solar cells. The modules will then be suitable for use in private homes, village plants and solar power plants serving schools, hospitals, water supply infrastructure and telecommunications systems" (Steward 2010).

The bulk of modules and other equipment needed for SHS is imported by a small group of large firms. The most relevant importers, organized in the Kenyan Renewable Energy Association (KEREA), are

- Telesales Solar
- Cloride Exide
- Davis and Shirtliff
- Rencon Associates
- Sollatek Electronics

Cloride Exide is owned by the Kenyan battery producer Associated Battery Manufacters (GTZ, 2009, p. 18). The importers sell their products to wholesalers or retailers and installers. Some of the importers provide retail and installation services, too.

The retailers consist of different types of businesses like shops for electrical equipment and warehouses. The installers are typically not specialized on SHSs, but have a background as radio technicians, automotive electrician or wiring technicians (KEREA, 2009, p.6). They provide the installation of PV plants as a side business.

There are few firms like Rural Electrification Solutions (RES) concentrating on Pico PV systems. RES imports high quality solar lamps directly from China and sells them mainly by providing it on meetings of agricultural cooperatives (see below). This approach includes the use of SACCOS as microfinance institutions.

5.3 Obstacles to a rapid diffusion of SHS

The markets for SHS and for Pico PV are highly competitive. But several obstacles and market failures have to be mentioned. Besides the high price of SHS the most important issues are

- poor quality
- financing

According to a comprehensive field study of KEREA (KEREA 2009) a significant share of SHS showed a poor performance. The reasons for the system failures are manifold. Some are caused by the installers, others by the system owner. The most common failures are:

1. Do-it yourself approach
2. Inadequate advice by vendors. The plant is often sold without proper installation and advice for usage.
3. Uncertified technicians
4. Uncertified products (lamps)
5. Use of second hand components (batteries)
6. User's insistence on specific components and budget constraints
7. Deceptive practices (unlabelled modules). Sometimes the labels were removed to suggest a higher wattage.
8. Wrong batteries (car batteries instead of PV batteries)
9. Charge controller bypassing
10. Incorrect sizing of loads (to many lamps)
11. Poor wiring practices
12. Protection against vandalism and stealing (leading to shading of the module)
13. Inappropriate installation practices
14. Use of inefficient incandescent lamps

Concluding we can say that two kinds of obstacles dominate: the provision of non appropriate components and systems by the suppliers and the lack of awareness on the demand side. The system owners play a significant role with respect to the poor performance of the systems.

Improvements can be achieved if the suppliers are offering integrated systems consisting of high quality components. Furthermore, the provision of warranties is important. This way is gone by RES, which offers solar lamps of high quality combined with a telephone hot-line that can be used in the case of failures.

Besides poor quality, another obstacle for a more rapid diffusion of SHS and PicoPV is the lack of access to affordable financing for private households (and suppliers).

Since SHS show high purchasing cost most rural household are not in the position to buy them, even if the use of SHS will lead to significant cost savings (kerosene, candles, and batteries). Consequently the preferred payment system is monthly payments over a period of 5 – 10 years, depending on the interest rate (Abdullah, 2009, p. 19). But for most of the people bank loans and microfinance are not available. "Most financial institutions in rural areas cater for salaried rural employees, such as: civil servants, teachers and self- employed proprietors. Therefore, for many first-time users wanting to connect to grid-electricity or PV schemes, financial schemes through banks and microfinancing are unavailable" (Abdullah, 2009, p. 19). Furthermore, the interest rates for bank loans are very high, between 16 – 18%.

A way out is micro financing organized by Saccos (Savings and Credit Cooperations). In this case, the interest rate for loans is 12%. Loans of Saccos are provided at returning rate and not as flat rate as in case of typical bank loans.

A comprehensive approach to meet the different obstacles is introduced by the Mobisol, a Berlin-based provider of remote controlled SHS. The firm offers a ready-to-use system, financing and remote control of technical performance and refinancing. The firm provides a monthly installment plan that "…affords customers the opportunity to own a superior solar unit with high quality components while ensuring the longevity of the system with remote monitoring, an extended warranty and free after-sales services" (Mobisol, 2013). Remote monitoring enables Mobisol to analyze system failures, to identify inappropriate user behavior (like deep discharge of battery) and to allow continuous user training. Furthermore, the remote control can be used to ensure discipline of payment. In case of defaults the SHS can be switched off. Mobisol has conducted comprehensive pilot projects in Kenya and Tanzania 2012/13. To ensure after sales services the firm focuses on off-grid regions with proper road infrastructure. Paving access to the rural customer Mobisol cooperates with local NGO like SCODE in Kenya and KAKUTE in Tanzania. Other partners are financing institutions like MicroEnergy and telecommunication firms.

Concluding we can say that the market for SHS is impeded by several market imperfections like insufficient information of private customers, asymmetric information between suppliers and customers, and lacking financing opportunities. However, interesting market based approaches to overcome these obstacles can be observed.

The dissemination of SHS was starting with donations of international organizations and was later switching to cash sales by private dealers, mainly to affluent customers. Financing SHS by bank loans and micro financing is not very common, but the provision of loans by Saccos seems to become an increasingly used way to disseminate SHS.

5.4. Policies supporting the diffusion of SHS in Kenya

According to economic theory the government should intervene to markets if significant market failures like market power, externalities or insufficient information exist. Furthermore, the government can play an active role to develop markets and market places. The government has several policy options to overcome the constraints mentioned and to promote the diffusion of PV technologies. These options include the provision of proper information, product standardization, quality controls, training campaigns but also the provision of subsidies to the supply or demand side and tax reductions. With respect to grid connected PV plants Renewable Energy Feed-In-Tariffs (REFIT) and quota schemes are relevant options, too. In the following we will ask what policy instruments are used by the Kenyan government to promote the use of SHS in remote areas. Similar to rural electrification we have to distinguish policies promoting SHS in private households and policies for lighting public facilities.

During the past years the Kenyan government has done several steps to lower the constraints for the use of SHS.

I. Reduction of import duties on PV components

Since most of the components of PV systems of imported, customs play an important role for the market price of SHS and thus for the affordability of these systems. Initially, the imported components were subject of an import duty of 30%, which raised the cost of these systems. These charges have been widely eliminated (Abdullah, 2009, p. 22). Today the tariff on PV cells, modules and panels is zero; this holds for solar water heaters, too. Only for solar batteries (25%) and charge controller (10%) tariffs still exist (Ikiara, 2009, p. 15).

II. Standardization

As mentioned above the poor performance of SHS has several reasons like poor quality of components, improper installation by insufficiently qualified technicians, inadequate information (labeling) of customers etc. Since poor performance of products can hamper the dynamics of the market the quality of components and installation needs to be regulated. Possible policy options are minimum standards for components, mandatory product warranties, etc.

The Kenyan government has done some steps to ensure a proper product quality like a standard for PV solar and a code of practice. “The standard and code of practice (are) designed to be used by the component manufacturers, personnel performing design, installation, inspection, maintenance or repair of PV systems” (ERC, 2010, p.14). These standards should result in

- safe, reliable, durable PV systems
- knowledgeable manufacturers, dealers, installers, consumers and inspectors.

The standards, developed by the Kenyan Bureau of Standards (KBS) are binding for all installations that are maid the Government (GTZ, 2009, p. 15). “However the KBS is not legally able to enforce its standards, and it has little recourse with companies that bring in equipment that does not meet the international standards, so there have been problems with quality control of modules and component in the market. In practice, local importers often work together to prevent offering agents from importing sub-standard equipment” (GTZ, 2009, p. 15). Another issue are SHS that are assembled by private households without trained personnel. “Private installations largely occur outside of any code or standards and there is no standard procedure for inspection of PV systems. An increase in awareness of standards might change the market status and perception of PV as a ‘cheap technology’ “(GTZ, 2009, p. 15).

III. Subsidies

Subsidies can be considered as an instrument to increase the demand for SHS, to provide SHS-related services to a greater number of households and businesses and to develop the market for PV technology. Subsidies can be paid to the suppliers and to the demand side.

The Kenyan Government does not provide subsidies for the use of SHS in private households. But as mentioned earlier the activities of the Rural Electrification Authority “…recognize a role and provide a planning budget for solar PV in off-grid electrification strategies for a) mini-grids and b) stand alone institutions (clinics, administration posts and schools)” (GTZ, 2009, p.15).

Implementing PV installations in public buildings the REA conducts annual tender. 2009/10 the Government is spending 273 million shillings (about 2.7 million Euro) to install solar panels in 117 schools and health centers in arid and semi-arid regions (Ovango, 2010).

6. Market for grid-connected Renewable Energy Power Plants in Kenya

Currently grid-connected PV-plants are rare in Kenya. Despite of comparatively high power prices there is currently no economic incentive to invest into this technology. The only known grid-connected power plants are donor financed. In April 2011 a 515 KW plant has been completed on top of the new UNEP building in Nairobi. It is currently the biggest PV plant of East Africa. It was planned and constructed by the Cologne-based firm Energiebau Solarstromsysteme and is encompassed "…to provide the exact amount of energy required for building operations over the course of one year" (http://www.pv-magazine.com/news/details/beitrag/first-energy-neutral-building-in-africa_100001437/).

Another grid connected PV plant was constructed in an SOS Children's Village, located in Mombasa. It has a peak capacity of 60 KW and was "…set up to supply part of the power required by the site. …A further part of the generated electricity will also be used for schools, where it is said over 500 students from the area are taught. Reportedly, the project is a first for Kenya in that it both generates electricity for the operator's own needs and feeds surplus energy back into the power grid. The statement continues: "So-called net metering ensures that the electricity meter in the Children's Village counts backwards whenever the system feeds power into the grid, thus reducing energy costs."(http://www.pv-magazine.com/news/details/beitrag/kenyas-first-net-metered-pv-project-completed_100003367/)

Both projects are dating back to the 'Renewable Energies Export Initiative' of the German Federal Ministry for Economics and Technology (BMWi).

6.1. Policies to promote grid-connected Renewable Power Generation

Increasing the share of renewable in the power sector can be done by using a variety of procurement mechanisms or policy instruments, including:

- offering renewable energy feed-in-tariffs
- implementing renewable energy tendering schemes
- introducing a quota system for renewable energy technologies, and
- creating investment grants, tax credits, rebates, etc.
- offering net-metering option

All these strategies are based on the assumption that renewable energy technologies encompass a bundle of advantages, such as making positive contributions to energy security, technological development and economic growth and reducing greenhouse gas and particulate emissions. The Kenyan government had decided to introduce renewable-feed in Tariffs (REFIT) added by bidding process in the case of large plants.

6.2. Renewable Feed-in-Tariffs (REFIT)

To increase the electricity supply and to diversify the electricity energy sources the Government of Kenya has introduced a REFIT scheme in 2008. The general objectives of the REFIT systems are both, macroeconomic and energy economic. "The government of Kenya recognizes that renewable energy sources (RES) including wind, biomass, small hydros, geothermal, biogas and solar and municipal waste energy have potential for income and employment generation, over and above contributing to the supply and diversification of electricity generation sources" (Ministry of Energy, 2010a, p.3). The specific objectives of the REFIT system are to:

a) "Facilitate resource mobilization by providing investment security and market stability for investors in electricity generation from Renewable Energy Sources.
b) Reduce transaction and administrative costs and delays by eliminating the conventional bidding processes.
c) Encourage private investors to operate their power plants prudently and efficiently so as to maximize returns" (Ministry of Energy, 2010a, p.4).

Targets like pollution control and mitigation of green house gases are not mentioned.

The Kenyan FIT scheme was introduced in 2008 and revised 2010 and 2012. Here, we present the version 2010 and then outline the revised version 2012. Originally the FIT were only provided for wind, biomass and small hydro. The revised version of 2010 includes tariffs for biogas, geothermal and solar resources. The FIT for wind and biomass were raised to increase the incentives for investments (Ministry of Energy 2010a, p.4).

The calculation of the FITs is principally based on the generation cost of renewable power plants, but other factors like avoided cost and international FIT-levels will be considered, too. "19. Feed-in-Tariffs are based on the generation cost but having regard to the avoided cost, the Feed-in-Tariffs in other parts of the world and the specific socio-economic conditions in Kenya" (Ministry of Energy, 2010a, p.6). The avoided costs are oriented to the specific cost of new build diesel generators and power stations.

The Kenyan FIT scheme 2010 shows some peculiarities that are worth to be mentioned. Firstly, different tariffs are offered for firm power and for non-firm power. According to the orientation to the avoided cost the tariffs for firm power (fed in accordance to a given schedule) is higher than for fluctuating supply. Since the output of most types of the renewable energy power plants is fluctuating the tariffs for non-firm power are most relevant.

A second peculiarity of the Kenyan FIT-scheme is that the FITs are not minimum tariffs that must be paid by the grid company, but maximum tariffs that must not exceeded. The supplier and the grid company may agree upon lower tariffs.

In general, the Kenyan FIT scheme it is oriented to attract (international) investments in large RE power plants. The minimum size must not be smaller the 0.5 MW. The provided technology specific tariffs are granted for 20 years (extended from 15 years 2008).

Table 11: Feed-in-Tariffs in Kenya 2010

Technology type	**Plant capacity (MW)**	**Maximum firm power tariff (US$/kWh) at the Interconnection point**	**Maximum non-firm power tariff (US$/kWh) at the Interconnection point**
Geothermal	up to 70	0.085	
Wind	0.5 – 100	0.12	0.12
Biomass	0.5 – 100	0.08	0.06
Small Hydro	0.5 - 0.99	0.12	0.10
	1 – 5	0.10	0.08
	5.1 -10	0.08	0.06
Biogas	0.5 – 40	0.08	0.06
Solar	0.5 – 10	0.20	0.10

In the case of Solar the FIT is provided for both, solar PV as well as Concentrating Solar Power (CSP). In the case of solar power (PV) the minimum size is 500 kW. Thus, there is a focus on large ground based plants and not on top-of-roof plants. “Small scale solar PV does not meet expressed policy goals of rapidly scaling up power availability with low cost electricity” (GTZ, 2009, p. 16).

The Ministry of Energy expected that solar power generation will start in remote off-grid areas. “Due to the relative high cost of this technology, it is intended to be used to supply the isolated/off-grid stations, to partly displace the thermal generation” (Ministry of Energy, 2010a, p. 11).

Beside the plant size the maximum aggregate plant capacity is defined for each technology. In all cases the cap for the firm capacity is higher than for the non firm capacity (s. table below). Summing up all caps we get a maximum capacity of 1750 MW, more than the currently existing generation capacity (see table 6).

Table 12: Capacity caps for firm and non-firm generation

<table>
<tr><th>Technology type</th><th>Plant capacity (MW)</th><th>Cap for firm capacity (MW)</th><th>Cap for non firm capacity (MW)</th></tr>
<tr><td>Geothermal</td><td>up to 70</td><td colspan="2">700</td></tr>
<tr><td>Wind</td><td>0.5 – 100</td><td colspan="2">300</td></tr>
<tr><td>Biomass</td><td>0.5 – 100</td><td>200</td><td>50</td></tr>
<tr><td rowspan="3">Small Hydro</td><td>0.5 - 0.99</td><td rowspan="3">150</td><td rowspan="3">50</td></tr>
<tr><td>1.00 – 5</td></tr>
<tr><td>5.1 -10.0</td></tr>
<tr><td>Biogas</td><td>0.5 – 40</td><td>100</td><td>50</td></tr>
<tr><td>Solar</td><td>0.5 – 10</td><td>100</td><td>50</td></tr>
</table>

The cost of the REFIT scheme is shared between the electricity consumers and the grid operator. The grid operator is entitled to "…recover from the electricity consumer 70% of the portion of the Feed-in-Tariff except for solar which will be 85%, or as maybe directed by the Energy Regulatory Commission…"(Ministry of Energy, 2010a, p. 12). Since the grid operator is not entitled to recover all cost of the REFIT system it is reducing its profits and reducing its capability to follow other economic objectives like rural electrification.

The FIT of 2010 has led to increased investor's interest, but only 2 Power Purchase Agreements (PPA) have been signed. Up to spring 2011 the FIT policy has elicited 49 expressions of interest (EOI) from potential investors, most of them for wind power plants (23) and hydro power projects (19) (SREP, 2011, p. 21). The received proposals included a capacity of about 1,500 MW, of which 1,311 were approved, most of it wind power. If all these projects were implemented the Kenyan generation capacity would be doubled. But by now, only for 2 projects Power Purchase Agreements (PPA) have been signed: A 920 KW hydro power plant owned by the Kenya Tea Development Association and a 5 MW geothermal power plant run by KenGen (Heinrich Böll Stiftung 2013, p. 39). The others projects are undertaking feasibility studies (SREP,2011, p. 22).

Table 13: Received and approved proposals under the Kenyan FIT scheme

		Received Proposals			Approved Proposals	
	Technology Type	No.	Capacity (MW)	% of Total	No.	Capacity (MW)
1	Wind	23	1,118	74%	20	1,008
2	Biomass	4	164	11%	4	164
3	Hydro	19	111	7%	16	81
4	Geothermal	1	70	5%	0	0
5	Biogas	1	40	3%	1	40
6	Cogeneration	1	18	1%	1	18
	Total	**49**	**1,521**	**100%**	**42**	**1,311**

Source: SREP, 2011, p. 21

The poor outcome of the 2010 version of the REFIT scheme, mainly caused by the long negotiations of Power Purchase Agreements, made another revision necessary. The review started in 2011 and resulted in the 2nd revision of the feed-in regulation in December 2012. "The feedback from the PPA negotiation process has necessitated review of some of the policy clauses for clarity and also to ease interpretation of the policy as well as negotiations and implementation of the Power Purchase Agreements" (Ministry of Energy, 2012, p.7)

The mayor changes of the 2012 version are:

- Introduction of Standardized PPA for small projects up to 10 MW to reduce transaction cost associated with negotiating and signing a PPA.
- General revision of the tariffs
- Specific tariffs for off-grid solar power (20 Ct/KWh) and on-grid solar power (12 Ct/kWh)
- Abolishing of special tariffs for firm and non firm power
- No explicit limits for the maximum aggregate plant capacity
- The feed-in policy shall be subject to review after 3 years

The introduction of Standardized PPA can be considered as an institutional change that might help to ease the implementation of renewable power projects. But still it is questionable whether the Kenyan REFIT will be a "success story".

Firstly, the tariffs are not very attractive - compared to the tariffs in other developing countries as well as industrialized countries. The incentives for International investors will be limited.

Secondly, in the case of large projects, the FIT approach can be replaced by a bidding process, increasing uncertainties for investors. "For large projects involving utilisation of significant national renewable resources, Government preference is to carry out preliminary identification studies and then initiate a competitive bidding process. In this approach, Government will solicit bidders, short list them on the basis of qualifications and competencies, and at the full proposal stage have the short listed candidates compete for the lowest levelised price" (Ministry of Energy. 2012, p.9).

Thirdly, smaller projects with a smaller capacity than 500 KW are still excluded. By this way, mainly local investors are excluded. In Ghana there are hundreds of grid-connected PV plants owned by firms and private households, but most of the rated capacity is smaller than 50 kW.

Fourthly, cost of grid connection and grid extension for large plants (> 10 MW) has to be borne by the investors. Since this cost can only be estimated in advance this rule includes another source of uncertainty for potential investors.

Concluding we say that the Kenyan Government is focusing on large projects, developed and financed by international investors. Facing comparatively high power prices the Kenyan Government tries to extend the share of renewable energies in the power sector without increasing the costs of power generation. Small projects with higher specific cost are excluded. The only exception is rural areas where off grid PV plants compete with diesel generators.

Excluding smaller projects implies excluding local investors and solar PV. There is evidence that local investors mostly invest in smaller plants. Experiences from other African countries show that firms and private households do invest in PV plants, even grid-connected plants, that help to stabilize own power supply. In Ghana there exist hundreds of grid-connected PV plants owned by firms and private households, but most of the rated capacity is smaller than 50 kW. The current Kenyan REFIT scheme is not appropriate to give incentives for developing grid-connected urban PV markets. According to Mark Hankins, director of Nairobi-based Africa Solar Designs, there is "need to move – today – towards grid-connected and urban markets". Facing the immature status of PV markets today there should be "…a focus on intermediate-sized 50 kW to 200 kW installation market segments" driven by local investors, supported by net-metering instead of FIT.

"Feed-in tariffs are less suited to PV than other renewable technologies for several reasons. First, there is much less economy of scale in PV; it does not matter whether a PV installation is 10 kW or 1 MW – the costs are broadly the same. Secondly, because of this scale issue, thousands of dispersed PV installations make as much sense as a single large plant. But right now PV is still more expensive than wind, hydro or biomass, so it is hard for governments to justify PV as part of their 'least cost power plan'. However, there is no need to block private consumers who want to invest in Africa's nascent solar market.

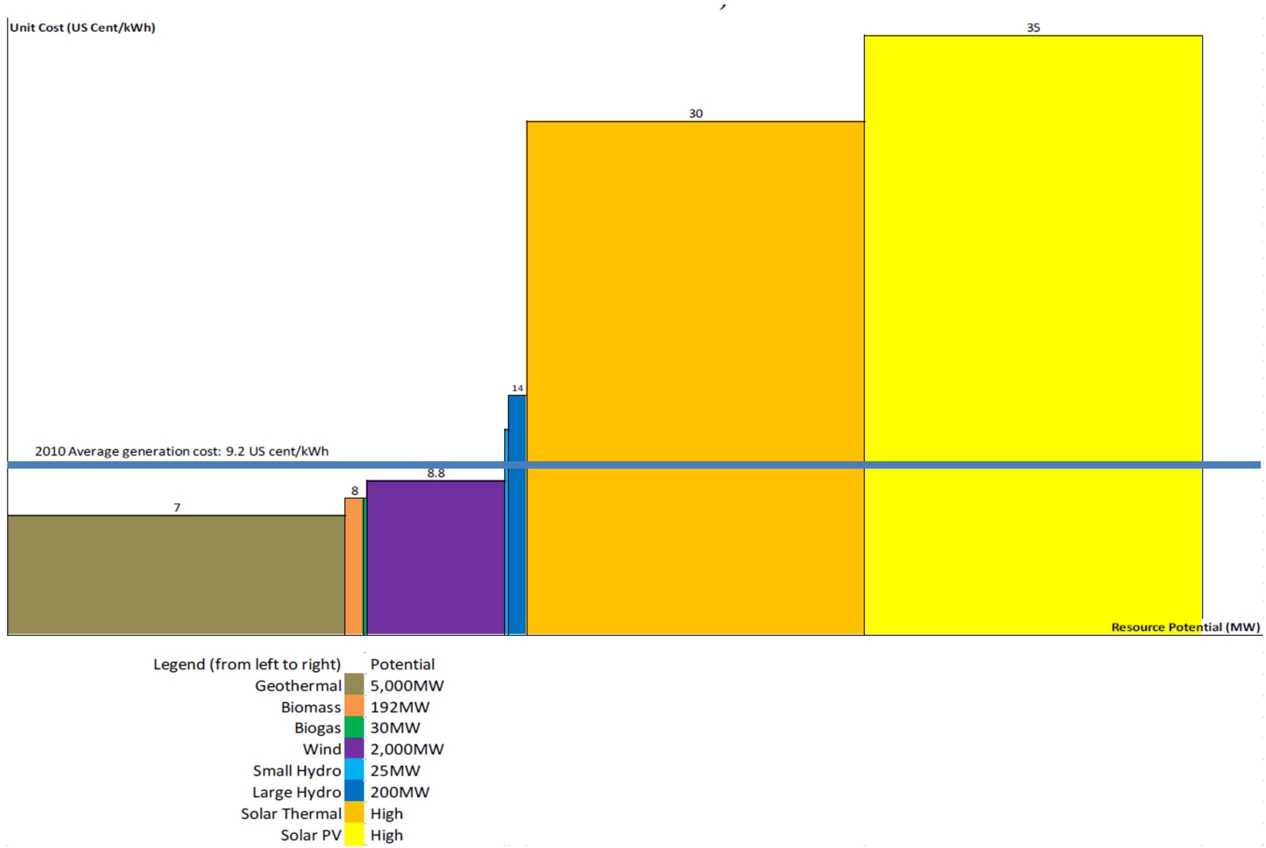
Net metering is a low-cost policy tool that allows electric utilities to incentivise on-grid PV investment by private consumers. With it, consumers invest in a PV system. Instead of storing their PV power in a battery during the day, they store it on the grid by running their meter backwards and selling their output at a retail rate. In the evenings they draw back the electricity that was generated during daylight hours, with the result that at the end of a month consumers could potentially have a zero-value bill.

Unlike feed-in tariffs, net metering does not require massive grant support or additional levies on electricity consumers by cash-strapped African governments. Net metering cannot be unscrupulously 'rigged' because there is no incentive – electricity bills are offset, and no cash changes hands. Net metering also allows demand to develop naturally. Those, who want solar PV and are willing to pay a premium for it will be rewarded. In short, those that want to buy and sell PV power should be encouraged, not discouraged" (Hankins, 2011).

The position to exclude PV from a feed-in tariff scheme is supported by the SREP (Scaling-Up Renewable Energy Program) Investment Plan for Kenya. According to the SREP there are plenty of other renewable energy sources that can be used at low cost, even lower than the current average generation cost of 9.2 USCt/kWh. A least cost approach of integrating renewable energies into the energy system should focus on these resources (s. figure 3). To provide net-metering for PV (instead of fixed tariffs) can be considered as a proper approach to spur the dissemination of PV technology and to develop a PV market without burdening power customers or tax-payers[4].

[4] In a study for the Government of Namibia a feed-in tariff was proposed for low cost renewable energy technologies and net metering for PV solar (Martin Meyer-Renschhausen et al. 2011)

Figure 3: Comparison of generation cost for various renewable energy sources



Source: Kenya, SREP, 2011, p. 26

Source: SREP, 2011, p. 26

7. Market for Solar Water Heaters

Kenya has a well-established market for solar water heaters (SWH). SWH systems are sold in Kenya for more than 2 decades. In the following we describe the demand and supply side of the SWH market and Kenya as well as policy strategies to promote the diffusion of that technology.

7.1 Demand side of the market for SWH

Households and many businesses have a significant demand for warm water for cooking, cloth-washing, dish-washing, cleaning etc. The demand for warm water can be met by electric water heaters as well as by SHW. Since the price for SWH is significantly higher than that of electrical geysers the demand of SWH is increasing in periods of soaring power prices.

Exact figures on the number of SWS currently used are not available. Generic Energy, a Nairobi based supplier of solar technologies, estimates that about 140,000 SWH-systems are in use today. http://www.genericenergy.co.ke/GENERIC%20ENERGY%20COMPANY%20PROFILE%20PDF.pdf Other firms mention smaller figures. According to Go Solar Ltd. the number of SWS-systems in Kenya is about 65000. (Go Solar, http://www.gosolarltd.com/hotwater.html). The most important demand groups are middle and high income households, institutions like hospitals, commercial establishments and tourist facilities. They react to soaring electricity prices. (http://igadrhep.energyprojects.net/Links/Profiles/SolarWaterHeaters/SWH.htm).

Developers of residential housing projects are among the first who are installing SWH. “From a developer's or a home owner's perspective, installing a solar energy system is no longer just about environmental consciousness; it is also a financially intelligent investment. When your home is solar powered, experts say, the benefits are immediate and long-lasting. The obvious benefit of installing a solar energy system is the saving you get from lowering or eliminating your electricity bills. It is estimated that households can save up to 60 per cent on power bills compared to relying solely on electricity when it comes to water heating”(F. Ayieko, 2011).

In 2008 between 8000 – 10000 m² of SWH were installed. Due to sharply increasing power prices for final customer the demand has increased by 25% per year (F. Ayieko, 2011). About 50% of the systems were installed by urban households, the remainder in businesses like tourism (see table 14). According to Generic Energy the total number of SWS will increase to more than 400,000 units by 2020. http://www.genericenergy.co.ke/GENERIC%20ENERGY%20COMPANY%20PROFILE%20PDF.pdf

Table 14: Capacity of SWH in Kenya by sector

Solar Water Heater Technology	Estimated installed capacity (m²)	Estimated installed per year (2008) (m²)	Estimated financial volume (million €/year)[5]
Urban Households	N/A	4000 – 5000	4.5
Tourism and Insti-tutions		4000 – 5000	4.5

Source: GTZ 2009, p. 4

7.2 Supply side of the market for SWH

SWH supplied on the Kenyan market include different types of technologies like

- direct flat plates
- indirect flat collectors
- vacuum tube collectors

Today most of the equipment is imported. Only water tanks are manufactured in Kenya. “Although local manufacturing and assembly of flat plate thermosyphon-type collectors was common in the 1990’s, virtually all collectors are imported today. The main exporting nations of units to Kenya are Greece, Australia, Turkey, Israel, and China. A few companies manufacture their own water tanks” (GTZ, 2009, p. 4).

7.3. Policies of supporting the diffusion of SWH in Kenya

Since 2008 Kenya is suffering from frequent power shortages and accompanying price increases. According to World Bank estimations this is reducing Kenya’s GDP by 1.5 percent per year and it is weakening Kenya’s ability to attract fresh international investments.

According to estimations of the Energy Regulatory Commission (ERC) water heating accounts for about 25 per cent of the power consumed by households. 2009 private households “… used 1,254 GWh of electricity or 24 per cent of Kenya’s total power consumption of 5,155 GWh. This means that use of solar to heat water could therefore cut demand on the national grid by 314 GWh, pushing the reserve margin closer to the internationally recommended level of 15 per cent”(Kimani, 2010).

Replacing electric geysers by SWH can contribute significantly to reduce the demand for power and thus to stabilize the grid and to avoid further increases of power prices. Having this in mind the Kenyan Government has taken several steps to increase the use of SWH in residential and institutional buildings.

[5] Total system volume including PV and BOS

I. Building Codes

In summer 2010 the Energy Regulatory Commission (ERC) has proposed a new regulation to promote the applications of SWH in new and existing buildings. The new regulation will be integrated to the Energy Act 2006 (ERC, 2010a).

Section 3 of the proposal rules that "all premises within the jurisdiction of a local authority with hot water requirements of a capacity exceeding 100 liters per day shall install and use SWH". The new regulation will be mandatory for

- domestic houses with a warm water consumption of more than 100 l per day[6]
- commercial buildings such as hotels, lodges, clubs, restaurants, cafeterias, laundries, eating places and similar premises;
- health institutions such as hospitals and health centers;
- educational institutions such as universities, colleges, boarding schools;

Existing premises with hot water requirements of a capacity exceeding 100 liters per day shall install and use SWH within a period of 5 years from the date of gazettement of the new regulation,

All new and existing buildings shall have a minimum annual solar contribution of 60%. The amendment includes detailed technical prescriptions: "A glazed and evacuated tube collector shall be used in all installations except installations for heating swimming pools which may use unglazed collectors".

II. Standardization

The SWH devices used have to comply with the Kenyan Standards. Persons who carry out SWH installation works need to be licensed by the Commission as a SWH technician or a contractor.

Persons who contravene the provisions of the SWH regulation will be punished by fines (up to two million shillings) or imprisonment of two years, or to both.

Responsible for the implementation of the SWH regulation is the ERC. The SWH regulation has the potential for a significant reduction of the power demand. But the success will very much depend on the availability of sufficient resources to control the compliance.

[6] It is assumed that domestic residential houses have a specific daily hot water demand of 30 liters per person at 60°C (see ERC, 2010a, Form 2).

8. Concluding remarks

Even if the Kenyan energy sector is still dominated by traditional fuels the demand for modern energy forms like electricity is strongly raising. With an improving economic performance and increasing GNP per capita Kenya is climbing the energy ladder. Even if the government of Kenya is making several important steps to increase the energy supply like inducing structural reforms in the power sector the energy sector is still facing some major challenges like

- high and even raising dependence on traditional fuels often associated with harmful impacts on the environment
- low rate of electrification (especially in rural areas)
- electricity supply is dominated by hydro-power stations showing poor performance in years with poor rainfalls ("skewed energy mix", Imitira)
- soaring power prices due to increasing use of high cost peak-load power plants

Renewable energies in general and solar energy in particular can contribute to solve these issues. PV based SHS can help to bring electricity to rural population, while large PV plants can be conductive to improve the power mix and system stability. The use of SWH reduces the power demand of residential and commercial customers and thus contributes to balance electricity supply and demand.

Despite of its significant potential to release the Kenyan energy situation the deployment of solar energy does not happen automatically. The diffusion of solar technologies is hampered by many obstacles like imperfect information, poor product quality, high initial investment cost and lacking financing options. An active role of government is required to overcome these barriers.

In the past decades the dissemination of solar technology in Kenya was driven by commercial considerations without significant government support. In recent years the government of Kenya has started to play a more active role. The most prominent examples of active support of solar technologies is introducing a REFIT scheme for large PV systems and the amendment of building codes including binding rules for the use of SWH. Some efforts have been made to install PV systems to lighten schools and other public buildings in remote areas. On the other hand, the government is still very reluctant to promote the diffusion of SHS in the residential sector.

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