PROSPECTS OF THE USE OF SOLAR WATER HEATERS IN DEMAND SIDE MANAGEMENT IN UGANDA

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Abstract

The commercial sector in Uganda accounts for about 20% of the total electrical energy consumed in the country, with about 50% consumed in the domestic sector and the remaining 30% to the industrial sector. As the economy continues to grow due to attraction of foreign investment and improvement in local production, more challenges now come up in terms of sustaining the already-attained levels of development and social transformation.

It is known that Uganda has only 300 MW of installed electric power capacity. This power is insufficient and could be used better - it is estimated that about 40 MW of the total load is allocated to water heaters. Among the energy-saving schemes being implemented in the commercial sector to avoid or reduce load shedding and to reduce the use of costly generators is the use of Solar Water Heaters (SWHs).

A case study on the use of solar water heating in a three-star hotel as a means of implementing an energy saving scheme is presented and an economic analysis of the project is given. Finally, future prospects of use of solar thermal technologies in the commercial sector as a means of energy conservation and as a solution to some of the environmental concerns under Clean Development Mechanisms (CDM) are presented.

1.0 Introduction

The power sector in Uganda is now characterised by more hours of load shedding as a result of continued load growth without a corresponding increase in power generation. The present power situation is that the country has 300 MW total installed capacity from the two major Hydro-electric Power (HEP) stations, as well as several mini-hydro and thermal (diesel- and bagasse-fired) stations.

According to the 2006 Uganda Statistics Abstract, the peak demand load for Uganda in 2006 stood at 340 MW and has been growing at a rate of 4% per annum. However, power generation remains basically the same. This insufficiency of power generation compared to power demand has not only led to power rationing, but also contributed to the slow rate of growth in economic activities. The indicators of power availability are given in Table 1, showing a persistent increasing number of hours of power rationing in addition to shut-downs and faults, all increasing due to either overloading or accelerated ageing of equipment [1].
The only power utility (Uganda Electricity Board- UEB) was unbundled in 1999 with the aim of improving its service delivery and efficiency. The outcome of these efforts is that more IPPs are getting involved in power production under a World Bank project called Energy for Rural Transformation (ERT) by increased use of diesel or heavy fuel oil generators and develoment of mini-hydro stations to serve mini-grids in rural areas. In addition, the efficiency of distribution systems has generally been improved as the total losses have now been reduced to about 30% compared to 35% in the previous years [2]. Consumers are now using more energy-saving technologies such as Compact Fluorescent Lamps (CFL) and more efficient drives in industries**.**

However, all these efforts or energy savings are still small compared to the power deficit experienced and the load forecasts made as shown in Table 1.

Table 1: Load forecast base scenario for Uganda

Year	**2000**	**2005**	**2010**	**2015**	**2020**

Domestic	316	445	650	820	1073
Export	84	90	90	90	90
Total	400	535	740	910	1163

Source: Optimisation study, load forecasts by Electricite de France.

This, and other factors like inaccessibility to the power lines by some potential consumers, have forced individuals and even industries to purchase diesel generators to back up the power from the grid. In some cases, individuals have resorted to using car batteries, dry cells and some have installed solar photovoltaic (PV) systems as hybrids. These options are expensive – about four times as expensive as grid power [1].

Even where access to the grid is available, still the problem of meeting the monthly bills remains as illustrated from the disconnections of the live consumers due to non payment of electricity bills shown in Table 2.

Table 2: Trend of connections of electricity consumers, 2001 to 2004

Parameter	**Apr-Dec 01**	**Jan – Dec 02**	**Jan – Dec 03**	**Oct 04**
No. of live consumers	200,217	224,871	244,247	262,599
No. of new connections	18,794	19,719	17,730	16,572
Number of disconnections	5,121	25,525	24,276	32,355
Number of reconnections	5,435	15,230	13,807	19,913
Distribution losses (%)	33.9	36.7	28.1	36.6

Solar PV usage is now on the increase – though slowly – due to high initial capital costs. In the case of diesel generators, there is an increasing number of isolated diesel generators both for individuals and for small isolated mini-grids in the up-country towns, totalling about 68 MW countrywide.

2.0 Commercialization of Solar Water Heating Systems (SWHs)

2.1 Surveys

A survey was carried out in 2004 by M&E Associates Consulting Engineers under the funding of JICA to establish the extent of solar energy utilisation

in Uganda. Among the aims of the survey was the establishment of the total number of installed systems, their sizes in terms of collection area of panels, the storage capacity of the tanks, other operational and maintenance requirements (performance), total costs of the systems, barriers and the potential market. The dealers in solar thermal systems were also catalogued and the types of consumers considered to determine the affordability and acceptability, among other considerations.

The surveys revealed that there are over 10 systems with a collection area greater than 10 m^2 and over 90 solar systems with a collection area of about or less than 10 m^2. It was also discovered that a total of over 186 panels and 96 storage tanks of 300 litres each were installed in 3 regional hospitals alone. The majority of the consumers are large consumers; mainly regional hospitals, hotels and some high-profile households. Most of the installations have been in operation since 1997 and their performance is satisfactory. As regards the heat obtained from the sun, temperatures up to 60^oC may be attained for an average insolation of about 5.2 kWh/m^2/day [3]. About 80% of the installed systems had 2-4 panels with storage capacity ranging from 300 to 1,200 litres. Total system costs ranged from US$ 750 to US$ 2,000 for a 125 to 300 litre storage capacity.

Many of the systems, especially at the institutions, such as at the hospitals and a few schools, were acquired through projects wholly supported by external funding and other sources of funds from donors like African Development Bank (ADB). The owners of the other systems, especially hotels, were approached by the dealers and given explanation on the benefits of the systems, such as reduction in energy bill, short payback period, etc. It was revealed that, despite the benefit of reduced energy bills, the interviewed users experienced frequent power cuts which affected the availability of the hot water facilities to guests.

2.2 Opportunities

There is quite a big potential for the solar water heater in the country as solar isolation is quite high, averaging 5.2 kWh/m^2/day. The market is still largely dominated by the commercial sector – mainly hotels, which are numerous in major towns, government- and private-owned hospitals, schools, restaurants,

university residence halls and individual households, as well as some industries whose activities require hot water [3].

2.3 Barriers

One of the limiting factors to the spread of the solar water heater is the high initial capital costs – a 125-300 litre system costs between US$ 750 and US$ 2,000, which is rather expensive for a consumer in a country where the GDP per capita is about US$ 300 per year.

Secondly, for small consumers like households whose hot water requirements are low, the standard designs on the market are rather unattractive given its initial high cost and the consequent long payback period.

Thirdly, there are only two or three companies dealing in importation, installation and local manufacture of some components of the solar water heating systems.

However, as the awareness increases about the use of solar water heaters, amidst increased power rationing and increased electricity tariffs, more requests for the solar water heaters in addition to solar PV are being received.

3.0 Present Load Management Strategies

3.1 Efficient Energy Technologies

There are still few consumers using technologies like improved charcoal stoves, CFLs and other efficient electrical appliances, mainly because they are expensive compared to the conventional technologies. Even their availability on the local market is still limited as there are few shops which stock them. Table 3 shows the energy technologies and their costs.

Table 3: Energy technologies and their costs

Energy Technology	**Power rating**	**Life (hours)**	**Cost (US$)**
CFLs	11W	8000	4 - 5

Incandescent Bulbs	100W	1000	0.6
Fluorescent Lights	40 -60W	4000	9
Radiant Coils/Hot plates	1000-1800 W	-	5 -10
Improved Charcoal Stoves	-	-	5

3.2 Energy Substitution

Other sources of energy are being introduced for cooking and heating besides electricity. Whenever the electricity tariffs are raised, there is always a tendency for consumers to use less electricity in favour of other sources like wood fuel or fossil fuels (kerosene Liquefied Petroleum Gas (LPG) or even furnace oil in the case of boilers). Table 4(a) shows the trend in energy consumption in the whole country by source for the years 2001 and 2002.

Table 4(a): Energy sources and their proportions

Supply Option	**2001**	**2002**
Biomass	93.3%	93.4%
Oil Products	5.7%	5.7%
Electricity	1.0%	0.9%
Total	100.0 %	100.0%

There is a heavy dependence on biomass as shown in Table 4(a) because it is cheap and the related energy technologies are also cheap. The domestic sector accounts for about 72.3% of the total energy consumed in the country and electricity contributes about 40% of the different sources of energy consumed in the domestic sector. Table 4(b) gives the breakdown of the energy consumption amongst the different sectors.

Table 4(b): Energy consumption in the different sectors

Year	**2001**		**2002**	
Demand	Energy	electricity	Energy	electricity
Residential	72.3%	38.9%	72.9%	41.6%
Commercial	14.1%	19.0%	13.5%	15.3%

Industrial	9.2%	42.1%	9.2%	43.0%
Transport	4.2%	0.0%	4.2%	0.0%

A typical load pattern in one of the hotels in Uganda (commercial sector) is shown in Table 5.

Table 5: A break down of end-use applications at a hotel

Activity/Load	**Energy Consumed Annually (kWh)**	**Proportion by Percentage (%)**
Air Conditioning	666,673	26
Lighting	146,931	6.0
Hot Water Supply	684,844	27
Catering	465,475	18
Laundry	331,647	13
Lifts	201,618	8
Health Club	64,649	2
Total	2,561,836	100

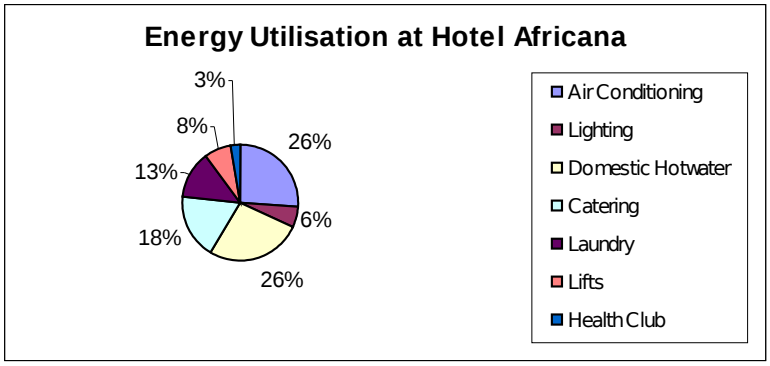
The end-use applications for electricity in a medium-size hotel include air conditioning, lighting, hot water supply, catering, laundry, lifts and health clubs. Hot water supply consumes the highest proportion of about 26% of the total energy consumption as shown in Table 5 and Figure 1.

4.0 Policies

Although it is within the policy framework and strategic plan of the Ministry of Energy and Mineral Development to promote the use of renewable energy technologies, there is no specific policy about development and promotion of solar thermal technologies and, more so, use of solar water heaters, except for the waiving of import duties on solar products and materials used in the manufacture/assembly of solar equipment. There is need for specific policies on the development and use of solar water heaters, such as a regulation or incentive for large institutions like schools, hotels, hospitals, universities, etc., which install them under energy-saving programmes. For instance, in Spain, under a solar ordinance, Municipal Councils require a major

proportion of the water for domestic use in buildings to be heated by solar collectors. Because of this regulation, Barcelona`s total installed capacity – which stood at only 700 m^2 of solar thermal collectors in 1995 – reached 19,593 m^2 of solar thermal collector area by January 2004, representing 13 m^2 per 1,000 inhabitants.

Figure 1: A typical hotel's energy use [4]



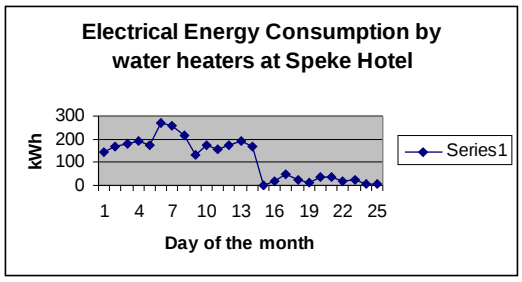
Since the cost of a kWh of electricity is likely to increase with the thermal plants being installed in the country and the high price of fossil fuel, and the cost of installation of solar thermal systems is going down, the benefits of installing solar water heaters would be easily realizable, such as a reduced pay-back period of about 2.5 years and below. A system of one 2.2m^2 panel and a 170 litre storage tank would typically have a pay-back period under three years, with annual savings up to US$ 420. For a system of two 4.4 m^2 panels, the annual savings may amount to about US$ 780.

The electricity consumption by water heaters at one of the typical large hotels in Uganda (which constitutes about 26% of the total energy consumed by all the loads in the hotel) is presented in Figure 2

At this hotel is a solar water heating system consisting of 34 panels with a total collection area of 74.8 m^2, a storage tank capacity of about 5,000 litres, and two booster electrical heaters of 12 kW each. It is ensured that water temperature may rise to 60^{o}C by pre-heating the water from 50^{o}C, the inlet

temperature of hot water from the solar panels. In case the hot water directly from the solar panels cannot attain 50°C, it is also pre-heated to 50°C. Table 6(b) gives the electrical energy consumption after the solar water heaters were installed at the hotel. There is a significant reduction of energy consumption from an average of 200 kWh per day to about 20 kWh/day after installation of the solar water heaters.

Figure 2: Electrical energy consumption at a hotel in Kampala



From Figure 3, it may be observed that the hotel is able to make a daily energy reduction of 180 kWh equivalent to a saving of about

Ushs 180 x 30 x 171.4 = Ushs 925,560, equivalent to US$ 538.

According to information available from the hotel itself, an actual figure of Ushs 900,000, equivalent to US$ 523 (1 US$ = Ushs 1,720), is saved per month. If, however, the electricity bill is revised upwards as has been the trend, then the net savings would also increase, thus reducing the pay-back period to less than two years.

5.0 Environmental Considerations

LPG emits 15 times more carbon dioxide (CO_2) per kilogramme than wood, and kerosene nearly 10 times as much. Carbon dioxide is the main source of global warming.

Wood burning leads to CO_2 emissions nearly twice as much as for the burning of natural gas. Biomass burning produces 60% of the nitrous oxide in the atmosphere and yet nitrous oxide has a global warming potential over

300 times that of carbon dioxide. Besides the global warming caused by the burning of these fuels, there is also a problem of indoor air pollution, which poses direct health hazards to households.

The prospects of solar thermal systems are quite high considering that environmental conservation matters are gaining more and more prominence following the Kyoto Protocols. Already, there are projects under CDM targeting a reduction of CO_2 emission levels in the atmosphere. These could be financed from the Carbon Fund. The use of solar water heaters in households and in the commercial sector – mainly hotels, restaurants, schools and hospitals – could be financed under such projects to substitute wood-fuel, LPG and kerosene or at least to reduce the consumption of such fuels where pre-heating of water is done with the solar thermal systems. Such funding would result in a substantial increase in the numbers of solar thermal installations, as well as leading to a reduction in CO_2 emissions.

6.0 Conclusions and Recommendations

The prospects for solar water heating are encouraging in all the sectors, namely; domestic, commercial and industrial. More than 100 solar water heaters of at least $10m^2$ collector area have so far been installed in hotels, hospitals in Uganda. Their operational performance has been satisfactory .Temperatures up to 60^oC may be attained as the solar radiation in Uganda is quite good with average insolation levels of 5 kWh/m^2 /day attainable in almost all parts of the country.

There are still many barriers to overcome, the major ones being the high initial capital costs. On average, a solar water heating system costs between US$ 750 and US$ 2,000 for a storage capacity of 125–300 litres. Other potential barriers include the lack of awareness on the benefits of solar water heating systems and the lack of an adequate policy framework to promote their use. For example, there is currently only one company which designs, fabricates/assembles and installs them in the whole country.

The potential for energy savings is very encouraging. A case study taken at one of the hotels in Uganda, where a solar water heating system of collector

area about 75m^2 and storage capacity about 5,000 litres was installed, reveals a net saving of about US$ 6,280 annually with pay-back period less than 2.5 years.

As the initial investment of purchasing a SWH is rather high, which makes it unaffordable to the majority of our people, it is proposed that government and micro-financing institutions give loans for this purpose with reasonable interest rates. Schemes such as Shell Foundation-DFCU, where about US$ 4 million per year is placed at the disposal of people willing to invest in renewable energy, should be also encouraged.

- Private Sector Foundation gives grants to companies setting up PV systems (US$ 2.5 per installed Wp). Some similar scheme should be put into practice for the thermal systems as well.
- The Faculty of Technology, Makerere University (Kampala), has developed – in partnership with Solar Construct Ltd – a more cost-effective solar water heater for households. It serves not only as a demonstration but also a teaching aid to Undergraduate students and helps raise awareness among the community around and beyond. A sample SWH has been installed by Solar Construct at the Faculty of Technology building to demonstrate and promote the use of SWHs in educational institutions in the country as shown in Figure 3.In view of that we recommend that the Ministry of Energy and Mineral Development woks to have a by-law passed in Parliament making it compulsory for each new household or commercial building to have a Solar Water Heater installed.

Figure 3: A solar water heater at the Faculty of Technology, Makerere University

7.0 References

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