XXXIII IAHS
World Congress on Housing
Transforming Housing Environments through Design
September 27-30, 2005, Pretoria, South Africa

Residential Energy Savings Through Multi-Fuel Use and Energy Efficient Appliances

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Key words: Energy efficiency, utility, fuel, load

Abstract

Housing delivery is one of the most critical issues facing South African government today. While a minority of the population resides in comfort, the vast majority live in self-built, metal shacks of scarcely twenty square meters. In an effort to scale up housing delivery to meet political targets, energy and environment issues associated with the dwellings have been, and are likely to continue to be, left behind. Government programs require utilities to supply power to new electrification customers that are long distances away from generating stations. The problem is worsened by the fact that utilities are fast running out of supply capacity on their power networks. Hence in order for successful electrification of these households, it is necessary to minimise utility-based energy consumption and maximize energy efficiency. Low-income urban households in South Africa exhibit a main feature in their energy usage patterns. Multiple fuel use is common and the mix of energy usage is different for different types of households. Patterns of consumptions are dynamic in response to factors such as changes in fuel prices etc. Integration of multi-use fuels can provide a means for the government to provide the energy needs of more households than presently possible. This can only be accomplished if safety issues in conjunction with multi-fuel use are used. The current trend in electrical appliance manufacture is on producing appliances with low energy consumption. Proper usage of these appliances can result in recognizable immediate and future cost savings. In this paper, methods for reducing utility energy consumption through multi-fuel usage and low energy consumption appliances are presented.

1 Introduction

Demand side management (DSM) is a utilities program aimed at reducing consumer use of energy through conservation or efficiency measures. In 1996 the management board of the South African utility Eskom identified DSM as one of the priority issues to be addressed. As a result, an Integrated Electricity Plan (IEP) was developed for the period of 1996 to 2015. From the plan, it was estimated that approximately 7 000 MW of new generation plant could be avoided by 2015. The potential savings were to be exploited by means of interruptible load measures (3 200 MW), load shifting (1 600 MW) and energy efficiency improvements (2 500 MW) [1-2]. The end use contribution was predicted for the summer and winter months based on consumption trends and market research. As expected, the winter peak demand was significantly higher than the summer peak demand. By analysing previous trends, it was determined that the aggregated industrial and commercial sector demand at the time of system peak is not significantly influenced by temperature. The major contributor to the winter peak was identified to be the residential sector. Demand side management efforts in residential communities through ripple control, etc. has been successful at reducing the winter peak. However rapid rural electrification programmes in recent years has increased the winter peak to new highs. This has been of concern to utilities. The main reason for the concern is maintaining stability of the power system network while utilitising the network at almost peak capacity. The potential for DSM to significantly reduce the peak load is almost at its limit. Therefore, other methods have to be considered.

Energy efficiency is regarded as one of the most cost-effective ways of reducing energy-related emissions associated with climate change. For many years, efforts to finance energy management measures have been particularly focused on the industrial sector and power plants and less on the residential sector. The obvious requirement of any dwelling is to enable people to rest, eat and sleep in a comfortable environment. In cold climates some means of warming is necessary. Houses must be designed and built to use the least possible energy while providing health, safety and comfort needs. However, in South Africa, the design of low cost housing to meet these objectives is questionable. There is a concern that insufficient attention is being paid to the thermal performance of the low costing housing. Building without attention to thermal performance may reduce initial costs but expose residents to low thermal comfort, high-energy costs and increase levels of energy related air-pollution encountered in low-cost residential areas. Full housing subsidies does not necessarily mean that the house is of a good quality and energy efficient housing. Questions as to whether the current mass housing programmes are actually delivering houses that are affordable, comfortable and environmentally sustainable therefore should be asked.

Electricity appears clean and efficient. Most customers are ignorant of hidden costs such as pollution and ecological disruption. If one looks at the process of producing electricity, from the mining of the fuel to the construction of the transmission lines, a more accurate picture of the overall cost and efficiency of a supply network can be obtained. Inefficient use of electricity results not only in losses to the utility but environmental concerns as well. The aim of this paper is to identify suitable renewable energy for sustainable development in rural communities. Furthermore, increasing energy efficiency through improved design is presented.

1.1 Utility concerns

Readings of a typical electrification household was taken from 6:00 on a Friday morning until 22:00 in the evening. An assumption is that there will be a constant consumption of energy from 22:00 in the evening to 6:00 the next morning on a Saturday. This assumption is made due to the fact that all the members of the family are sleeping during that time period. The consumption pattern shows a peak at 07:00 and 19:00 which coincides with the national utility peak demand of approximately 1 650 MW. In [13], it has been shown that the significant increase in utility peak demand can be contributed to the electrification programs. The base load during normal operation is approximately 800MW. This means that the utility has to increase generation capacity to more than double for the peak period. This is not economically viable and increases carbon emissions.

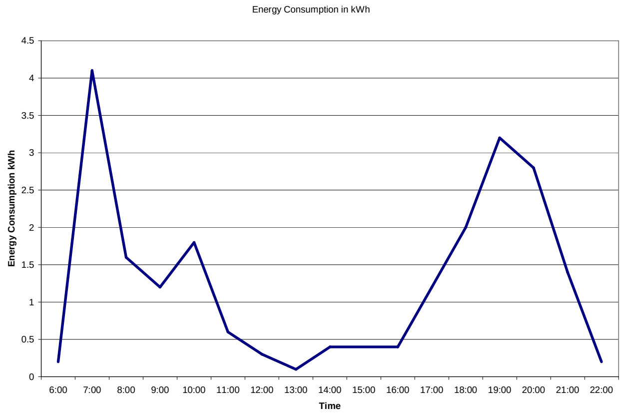

Figure 1: Typical electrification load profile

Since 1996, the South African government has electrified more than a million customers. The standard geyser is 3kW. Alternative energy such as solar can be applied to reduce the utility peak demand. Example if the average consumption of the million houses is 0.5 kW during the peak period, the saving to the utility is 0.5 kW x 1 x 10^6 = 500 MW.

2 Improving energy efficiency in households

Consumer education plays a vital role for energy efficient technologies to be accepted. It has already resulted in residents reducing monthly consumption through geyser control. Some residents use automatic devices such as timers whereas others manually switch off the geyser circuit breaker. The direct end result for the consumer is a reduced monthly bill. Indirectly, a positive energy consumption habit has been formed. For energy efficiency technologies to be accepted, a similar approach needs to be followed.

2.1 The South African context

Most townships in South Africa use coal as a main source of heating during the winter months. This results in problems such as the dense pollution of air. Multiple fuel usage is common and the mix of energy usage is different for different types of households. Problems facing rural households include security of wood, fuel supplies and the cost, health and safety aspects of coal and paraffin use. Patterns of consumptions are dynamic, in response to factors such as changes in fuel prices and access to fuel sources. Problems have emanated from injuries and death by burning shacks. This is either because a candle was left lit throughout the night or a gas/paraffin burner exploded. Furthermore, these liquids fuels pose a threat to children, as they are tempted to drink any form of liquid. Multi-use fuels are acceptable, as long as they are safe and energy efficient. The changeover to electricity consumption by rural communities remains a problem. There is a slow transition to electrical appliances. The biggest cause is public awareness. This is partly due to a lack of knowledge on energy efficiency and appliance operating costs. Appliance labeling forms a major component of household consumer education and assist people in their choice of appliances [9].

To provide residents with useful and appropriate recommendations, one has to determine the amount of energy they are currently using. Thereafter, savings need to be calculated. In order to help the residents really understand what is involved and to help them make significant and long-term changes in patterns of energy use, the technical information has to be explained in a language they can understand.

2.2 Consumer educational awareness

An important problem identified in low-income households is a lack of awareness of environment and health risks resulting from energy usage. Additionally they do not have access to real alternatives that they can afford. An awareness campaign should be implemented to address the following:

- Advantages of effective and efficient usage of energy.
- Usage of energy efficient appliances.
- Monthly expenditure on energy.
- Environment and health risks resulting from current energy usage
- Benefits i.e. direct savings in electricity bills and indirect benefits such as comfort and safety

2.3 Environmental management

Environmental impacts by households can be reduced by the use of cleaner energy end-use technologies. The result of coal and wood as a source of heat degrades the indoor and outdoor environments. Pollution levels inside dwellings are unacceptably high. The health effects that result from extended pollution exposures are generally long-lasting and, in some cases, life-threatening. Not only is the ailment burden borne primarily by those whom can least afford it, but also the social costs of these effects are likely to be very significant. These costs include additional expenditure on health care, and lost productivity through illness.

Improved measures to improve pollution levels include:

- Clean fuels (e.g. low-smoke fuels, LP Gas, etc.) as a substitute for bituminous coal.
- Thermal improvements to existing and new houses to reduce the amount of coal required heating dwellings in winter.
- Continued electrification of households.
- The installation of chimneys in existing and new houses.
- Improved ventilation in existing and new houses.
- The development and implementation of improved stoves with regard to performance and safety.

- The development and implementation of improved coal and wood burning practices.
- Education programmes on the implementation and application of the above measures.

3 Multi-fuels

Alternative energy sources or multi-fuels can be used to address concerns of energy savings and adverse environmental impacts through:

- A reduction in oil usage
- The availability of specific fuels
- The reduction of harmful emissions contributing to global warming, ozone depletion, acid rain and negative human health outcomes

3.1 Biomass

Biomass energy source that is available in South Africa include wood fuel, agricultural residues and animal waste. Wood is used both in rural and urban areas in the form of logs. Wood is inferior in calorific value as compared to coal and when bought it can become an expensive fuel. Some of the advantages of using wood fuel are its environmental friendliness as well as safe as compared to other fuels like coal and oil.

Wood burns in three distinct phases. Firstly, the moisture within the wood is driven off. In the second phase wood breaks down into charcoal where volatile gases and liquids are produced. Finally, the charcoal itself burns. The volatile gases that are produced in the second phase contain 60% of the heat potential in a given quantity of wood [6]. In a fireplace these volatile gases escape combustion and are carried up the chimney and contribute to the large inefficiency of fireplaces.

3.2 Active Solar

Research in solar energy has been ongoing for many years, but only recently, with the rise in the price of coal, oil and natural gas has it become economically viable. Solar energy provides a virtually inexhaustible energy source and does not contribute to pollution or global warming.

The widespread installation of solar water heating in industrial and commercial buildings and houses has the potential to defer the need for building new power plants. The main constraint on implementing a national solar water-heating programme in the residential sector relates to cost, which is a function of the current small market and lack of economies of scale. This lack of demand in itself is due to low public awareness of the technology or its economic benefits. Currently the cost of a domestic solar water heater would take in excess of 5 years to pay back.

The solar panel can be purchased specifically to heat the water as an alternative to the electric geyser. The amount spent to purchase the solar panel and the installation fees, as well as maintenance cost can be calculated. The economic life of the solar panel needs to be taken into consideration.

If a geyser consumes say on average consume 10kWh for every 24 hours and the dweller pays a tariff of 31 cents per kWh, the cost of the geyser consumption is 10 x 31 cents = R3.10 per day.

The average monthly saving is R93,00 with an annual saving of R1 116.00. The future value of this after 5 years at an interest of 10% is R6 813.00. A solar panel can be purchased and installed at the

cost of R5 000 (R4 000 selling price and R1 000 installation cost), and with maintenance cost of R200 per year. With a depreciation value 2%, the value of the solar panel after 5 years will be:
Y1: R3 920
Y2: R3 841.6
Y3: R3 764.77
Y4: R3 689.48
Y5: R3 615.69

Thus after 5 years the value of the solar panel will still be R3 615.69. Including the yearly maintenance costs it will be R200 x 5= R1 000 + Initial expenses = R6 000. This clearly indicates savings as compared to an amount of R6 813.29 that would have been spent on the cost of the geyser.

3.3 Paraffin

Almost all un-electrified households use candles or paraffin for lighting, both of which have specific hazards. A large number of accidental fires occur every year in informal settlements, usually with devastating impacts on the residents’ property, and frequently resulting in deaths of less mobile people, such as infants and the elderly. The cause of these fires include not only accidents with candles and paraffin lamps, but also poor quality paraffin appliances which sometimes explode under conditions of heavy or improper use. The impact of these fires and burns, in social and economic terms, are significant in total.
Paraffin poisoning is a common occurrence, especially among infants of less than three years of age in low-income households. These tragedies arise because paraffin is purchased and stored in drinking bottles, which are easily mistaken by young children as containing water or other drinking liquids.

The incidence of fires and burns is expected to decrease as a direct result of electrification, because electricity is an effective substitute for candles and paraffin lamps. It will be necessary to monitor whether this result does occur. Electrification should, to a lesser extent, also reduce the number of paraffin poisoning cases and the number of accidents with paraffin stoves. Nonetheless, the continued presence of paraffin in newly electrified homes, coupled with the cost-effectiveness of prevention measures, provides a clear rationale for the use of safer containers and stoves in the short term to medium term.

3.4 Coal

Coal still remains one of the major sources of energy. Since the use of this fuel carries with it the potential for significant negative environmental impacts such as carbon dioxide emissions it is necessary to develop policies to ameliorate these impacts. Low smoke coal should be advocated. Coal discards, even though of low quality can be used. Since they are located above ground they can be reclaimed by benefication at a competitive price, as they do not incur a further mining cost.

South Africa is one of the countries that are heavily dependent on coal as one of the sources of energy for both rural and urban residential areas. Coal fireplace can be in the form of a stove or traditional tin stoves. The tin stoves, which are made of unused metal container of about 20-25 litres, can be very dangerous if left in a closed area where people are sleeping.

4 Energy Efficient Appliances

The White Paper on Energy Policy (1998) recognized that standards and appliance labeling should be the first measures to put in place in implementing energy efficiency. At the same time, consumers of energy also need to perceive the cost-benefits they can derive from energy efficiency measures and it is here that demonstration are essential [5]. Major energy savings can only be achieved through changes in people's behaviour, and that depends on informing them about what options exist. In a paper presented by Robert Henderson Electrotek, Technology Group Eskom, at the Domestic Use of Electrical Energy Conference 1999, the use of Compact Fluorescent Lamps (CFLs) in households is promoted [11].

4.1 Efficient lighting initiatives

For a typical installation with a large number of CFLs, a small transformer can be derated up to 88% of its full load current. The current reduction using CFLs instead of the normal incandescent lamp is a reduction in load of 80% that is from 60 watts GLS to 15 watts CFL, or 100 watts GLS to a 20 watts CFL. This results in a 72% reduction in transformer load current which means the transformer can supply 3.5 times more CFLs light points than normal incandescent lights [11]. The cost of an 11W CFL is approximately R12.99. A savings of R5.99 x 3 = R17.97 – R12.99 = R4.98 from purchasing cost can be realised. For a light that is on for about 12 hours daily or 12 x 30 = 360 hours/month, the energy consumption for the GLS will be 0,1kW x 360h = 36kWh as compared to 0,02kW x 360h = 7.2kWh. If one assumes a rate of 31^{c} per kWh, the saving per month will be (36 x 31c) – (7.2 x 31) = R11.16 – R2.23 = R8.93. When buying globes, most South African consumers make their purchasing decision based on first costs rather than life-cycle costs. As a result, a relatively expensive compact fluorescent lamp (CFL) is much less attractive than its standard incandescent counterpart. To encourage consumers to make their purchasing decision on life-cycle costs, Eskom's Efficient Lighting Initiative (ELI) which forms part of the central component of Eskoms' Residential Demand Side Management (RDSM) programme plans to introduce a CFL hire-purchase programme that will remove the first-cost barrier [12].

5 Conclusions

Rapid electrification of rural areas has resulted in problems of generating electricity during the winter peak. Demand side management has assisted significantly in the past in reducing peak generation requirements. However, DSM initiatives can only be implemented up to a certain point. It is therefore necessary for other avenues to be considered. Alternative energy and energy efficient appliances can be used to reduce the utility peak demand. The shading of a portion of the geyser consumption of a million residents can result in a peak energy saving to the utility of up to 500MW. It is also shown that by using the CFL, energy savings of up to 80% can be realised. Furthermore, rural consumers can benefit from the reduction in monthly energy bill.

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