Impact of Residential CFL Retrofit Program In Ghana

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ABSTRACT

The paper presents the background on electricity supply and demand in Ghana and reviews the opportunity for increasing the efficiency of electricity end-use through residential compact fluorescent lamp retrofit program.

Electricity demand in Ghana has increased tremendously from 2% per annum in 1985 to the present level of 13% per annum. To reduce this demand growth rate, the Volta River Authority (VRA), the main producer of electricity in Ghana, has adopted Integrated Resource Planning (IRP).

A study of the VRA's system load composition by end-use identified and ranked the energy-saving potential of various technical options in the industrial, commercial and residential sectors. A lighting program to replace incandescent lamps with compact fluorescent lamps in the residential sector would achieve the highest percentage impact of 4%. An empirical study of a model residential community was undertaken to confirm compact fluorescent lamps potential to reduce power consumption. The results were extrapolated to project the potential impact of an energy-efficient lighting retrofit program on the VRA total system load. The findings indicate that a residential lighting retrofit program could reduce VRA peak load by up to 28 MW (2.6%).

Introduction

Background On Electricity Supply And Demand

The main source of commercial electricity supply of Ghana is from the Volta River Authority (VRA), which operates a total installed electricity generation capacity of 1,422 MW. This is made up of two hydroelectric plants on the Volta River, with installed capacity of 1072 MW, a 30 MW Diesel Plant and a recently constructed 330 MW Combined Cycle Thermal Power Plant.

The availability of power from hydro plants depends on the rainfall pattern, hence due to drought in 1983, 1994 and 1998 in the Volta River basin, the electricity generation in Ghana suffered serious decline resulting in power curtailment in those years. In spite of these shortfalls, the demand for electricity is fast outstripping supply due to rapid economic and industrial growth. The demand for electrical energy has been growing at an average rate of 13% since 1993. This high growth of electricity demand in the country and the major droughts, compelled VRA to supplement and improve the security of its power supply with the 330 MW combined cycle thermal plant. The Ghana National Petroleum Company

(GNPC), is also finalising financing arrangements to install a 150 MW power plant to utilize natural gas from the Tano Gas Field (MOME, 1995).

The residential lighting load is normally at its peak from 18hrs to 22hrs which coincides with the system peak load period. It is therefore anticipated that a reduction in the power demand of lighting through DSM effort would reduce the system peak demand (Jackson, E.A 1997).

Access To Electricity Supply In Ghana

About 24 % of the estimated population of 17.2 million in Ghana has access to electricity. Out of the 69% of the population living in the rural areas, only 10% of this number, have access to electricity from the main grid (MOME 1993). The government has therefore, since 1989, embarked on an ambitious program to electrify the whole country, under the National Electrification Scheme (NES), by the year 2020. The two main programs of the scheme are:

(a) extending electricity to all 110 district capitals and to all towns and villages along the route of supply;

(b) extending electricity to communities within 20 km of an existing 33/11 kV transmission network through a Self-Help Rural Electrification Project (SHEP).

Since this program was started almost all the district capitals and over 200 towns and villages now have electricity.

The NES program will expand the extent and magnitude of electricity use in the country. Already, VRA has to import energy from La Cote d'Ivoire to supplement its generation during the peak periods. It also invested an estimated US$426.9 million in the thermal plant at Takoradi. It is therefore important to use this costly resource efficiently and economically as possible.

Demand Forecast

The present demand forecast for 2000 - 2011 is 2382 MW while additional generation capacity of 960 MW is needed to meet this demand. This is a high demand and steps should be taken to reduce it. Among other steps taken by the VRA to temper the high rate of increase in power demand is demand-side management (DSM).

Programs for the DSM are:

- To provide information to electricity end-users and decision/policy makers. This strategy entails activities such as publicity campaigns, public education programs, market research, load research, technology promotion/demonstrations, pilot studies, energy audits and report writing.
- To identify potential projects and link up with implementing agencies (eg. Non Governmental Organisations (NGOs) and Energy Service Companies) for the implementation of these projects.

Load Study And DSM Impact Analysis

A study of VRA's system load composition by end-use was conducted to identify and rank the energy-saving potential of identified end-uses (Acres 1995; VRA 1996). The results of the DSM impact analysis of the first four highest ranked end uses are shown in table 1.

Item	Load Sector	End Uses	% Share of annual energy demand	DSM Measure Energy-efficient Technology Alternative	Energy Saving Potential of DSM Technology	Estimated DSM Impact	Ranking on the basis of DSM impact
1	Industrial	Motive power + pumping	14%	(i)Energy Efficient Motors (ii) Variable Speed Drives	(i) 5% (ii) 24%	(i) 0.5% (ii) 2.5%	2
2	Residential	Lighting	9%	Compact Fluorescent Lamps	80%	4%	1
3	Industrial	Heating & Cooling	8%	(i) Use of Scrap metal/ recycled hot waste gas plant/ Plasmamelt technology for furnaces (ii) Efficient central A/Cs	(i) 30% (ii) 59%	(i) 0.8% (ii) 1.6%	4
4	Commercial	Cooling	6%	Efficient central A/Cs	59%	2.5%	3

Table 1. Energy Saving potential of four highest ranked end uses.

The percentages applied as energy saving potential of DSM technologies were obtained from Jackson, E. A. (1996), a report on Energy-Efficient Programme for Akuse Township, prepared for VRA, Accra.

The largest savings potential was found to be in residential lighting through the introduction of CFLs. The rest of the paper describes the elements of a residential CFL program proposal for Ghana.

Residential Lighting Retrofit

Objectives

In order to verify the projections from the above DSM impact analysis, an empirical study of the impact of CFLs was undertaken. The objectives of the study were as follows:

1) To measure the peak demand (kW) saving and energy (kWh) saving impact of CFLs on a residential community's load based on the identified unit impact rate.
2) To project the System peak demand (kW) saving and annual energy (kWh) saving impact of CFLs, based on the unit impact rates (identified in 1).
3) To project the system load shape impact of CFLs.

Characteristics of the Residential Community

The residential community chosen for the study is a VRA staff housing community at Akuse.

The community is made up of 104 single-family buildings, comprising 88 two-bedroom houses and 16 three-bedroom houses. The two-bedroom units are of the same type and have five incandescent lighting points and two fluorescent lighting points. The fluorescent lamps are used for outdoor lighting. The three-bedroom units are also of the same type and have seven incandescent lighting points and three fluorescent lighting points. The fluorescent lamps are used in the kitchen and for outdoor lighting. Electric appliances in these houses include refrigerators, freezers, radio-cassettes, hi-fi sound systems, televisions, video decks, pressing irons, hot plates, cookers, blenders, fans, air conditioners and storage water heaters.

The average monthly consumption of this community is 375kWh. The average consumption of per residential connection in Ghana was 270 kWh/month (ECG 1998). The lower value is due to the fact that a number of residential connections do not have storage water heaters and air conditioners, which are high-energy consumers.

Methodology

The purpose of the study was explained to the community and residents who were willing to participate were given six free CFLs as an incentive. This resulted in a high participation rate of 89%. Load monitoring was undertaken over a period of 8 weeks. The first 4 weeks covered the base case and the last 4 weeks covered the DSM technology scenarios. The base case measurements were those with the incandescent lamps while the DSM measurements were those with the CFLs. Load monitoring was carried out from the 750 kVA transformer serving the community by means of a Dranetz PP1 energy analyser. Load recordings by the analyser were made at 15 minute intervals. Appliance saturation surveys were conducted during and after load monitoring to ensure that the base case and the CFL technology measurements were being compared on the same baseline conditions.

Impact Assessment of CFL

The power and energy charts derived from the load monitoring data indicate significant load variations between base case and CFL technology scenarios, especially between 18.00 hrs and 22.00 hrs. Since there were no changes in appliance saturation before and after the exercise, it is assumed that the changes are due solely to the use of the CFL.

Figure 1 shows the Power Demand Curve for the Akuse Residential Community. The VRA workers start their normal business at 7:30 am and this is reflected in their use of electric energy in their homes just before they leave for work. The morning peak is around 7:00 am and the evening peak occurs about 12 hours later.

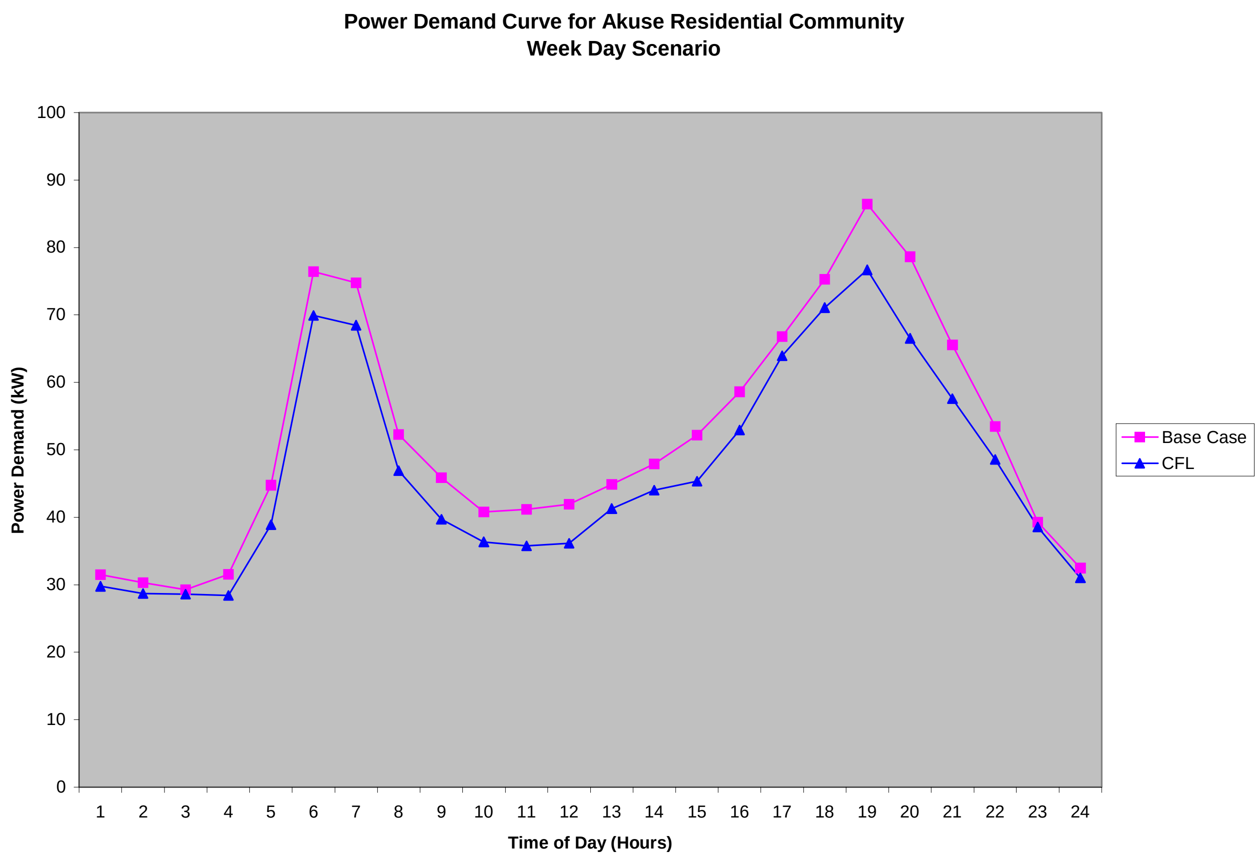

Figure 1. Power Demand Curve for Akuse Residential Community

Table 2 below summarises the CFL impact results in terms of kW and kWh savings, and unit impact rates.

ENERGY AND POWER SAVING IMPACT RESULTS							
	Measure	Base Case scenario		CFL savings impact			
		Weekday	Weekend	Weekday		Weekend	
		KWh	KWh	kWh	%	kWh	%
1	Energy/day	1245	1307	106	8.4	117	9.0
2	Average peak power	KW	KW	kW	%	kW	%
		72.2	73.3	9.53	13.2	11.4	15.6

Table 2. Impact of CFLs on Community Load

From the unit impact rates shown in table 2, the weighted average impact rates representing both weekday and weekend impact rates were computed as 13.9% and 8.6% for power demand and energy saving impacts respectively. This computation was based on 2 weekend days and 5 week days in a week.

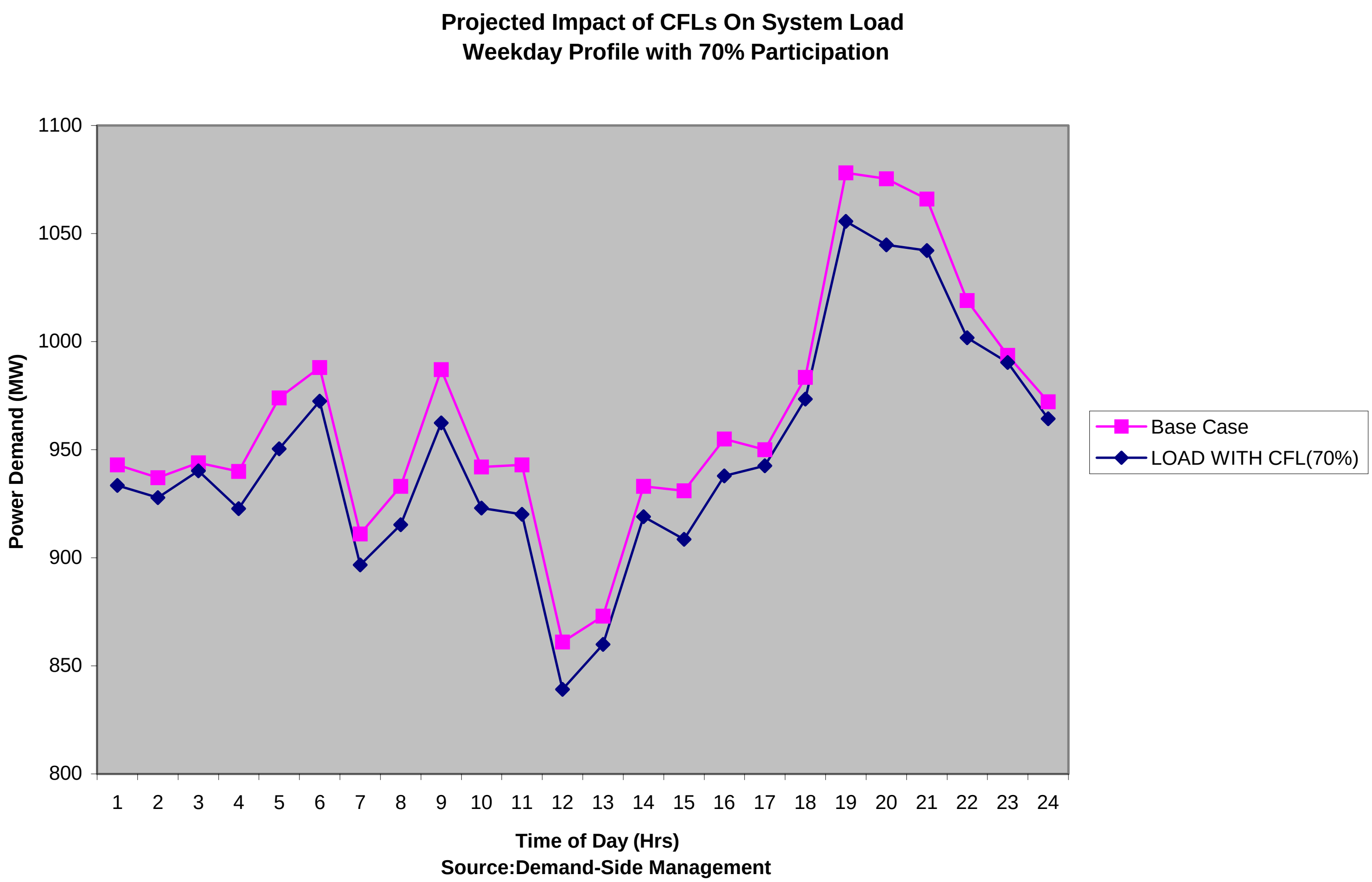

Figure 2: Projected Impact of CFLs on System Load

Figure 2 is a plot showing the effect of the projected impact of CFLs on the System Load. It shows the variations of power demand at time intervals of one hour.

PROJECTED IMPACT OF CFL ON SYSTEM LOAD						
	Measure	VRA System Data	% Share of Residential Load	System unit impact rate	Projected impact due to CFLs	
			%	%	70% Participation	
1	Energy	6886 GWh/yr	26.4	8.6	1.6%	110 GWh/yr
2	Peak Demand	1083 MW	26.4	13.9	2.6%	28 MW

Table 3. Impact of CFLs on System Load

From Table 3 the unit impact rates for the system load is based on 6 CFLs/home as obtained from the VRA community. It is assumed that if customers are made aware of the impact of energy savings of CFLs and there are 70% program participants, the peak demand will be reduced by 28 MW or 2.6%. The projected savings in system energy consumption would be 110 GWh/yr or 1.6%.

The system load factor is also improved by 0.4% from 89.4% without CFL to 89.8% with CFL.

Conclusion and Recommendation

This study has confirmed a significant technical potential for energy saving through an energy efficiency residential lighting retrofit program using CFLs to replace incandescent lamps.

At 70% participation, the peak demand impact is projected as 28 MW (2.6%) and the energy impact is 110 GWh/yr (1.6%). The load factor is also improved by 0.4%.

For a residential customer population of about 480,000 and a CFL distribution of 6 lamps/home, a total of 2 million CFLs would be needed for a nation-wide residential lighting retrofit program based on a participation rate of 70%.

It is evident that CFL lighting retrofit program can provide capacity relief and contribute to the achievement of the operating objectives of VRA. The Volta River Authority, the Electricity Company of Ghana and a few non governmental organisations have imported CFLs into the country for sale to the public. However these lamps have not sold as fast as hoped for because of the initial high cost. It will be important to embark upon more aggressive marketing strategies to sell these CFLs to capture their beneficial impact on the System load.

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