Research Journal of Applied Sciences, Engineering and Technology 6(3): 354-360, 2013
DOI:10.19026/rjaset.6.4086
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: July 02, 2012 Accepted: August 17, 2012 Published: June 15, 2013

Research Article

Effective Power Management in Homes and Premises in Ghana

C.K. Amuzuvi and J.C. Attachie
University of Mines and Technology, Department of Electrical and Electronic Engineering, Tarkwa, Ghana

Abstract: Inefficient use of electricity in residences and premises has been identified to be largely due to the use of certain household appliances. Household appliances such as refrigerators, deep freezers, television sets etc, have become an integral part of modern life. Though the power ratings of this equipment are not high, its misuse has led to energy wastage. It is therefore prudent to investigate measures aimed at eliminating waste, improving efficiency and reducing electric power consumption in households. It is commonly assumed that households must change their behaviour to reduce the problems caused by increasing levels of fossil fuel energy use. It is realised that strategies for behaviour change will be more effective if they target the most important causes of the behaviour in question. This study therefore first discusses the various types of energy meters in use. Next, the study elaborates on the optimal use of some electrical utilisation systems such as lighting systems, heating systems, electronic and electrical appliances, aimed at promoting household energy savings. Informational strategies aimed at educating electric power users are also discussed. Finally, this study proposes a public relation model to educate the public on efficient use of domestic power and also ensure that, information on energy management tool is right at the door-step of every consumer in Ghana.

Keywords: Behavioral change, energy management, energy efficient, energy waste, public education, public relations model

INTRODUCTION

Electrical energy is a fundamental and strategic component in the attainment of a good quality of life. Energy management is therefore a key to saving energy in homes and premises. Much of the importance of energy saving stems from the global need to save energy-this global need affects energy prices, emission targets and legislation, all of which lead to several compelling reasons why one must specifically save energy.

In the search for behavioural changes to reduce fossil fuel energy use, households are an important target group because they are responsible for approximately 15-20% of total energy requirements in Organisation for Economic Co-operation and Development (OECD) countries (OECD, 2001). Households use energy in direct and indirect ways (Vringer and Blok, 1995). In European countries, about half of total household energy use can be defined as direct energy use and in the UK about 40% (Kok *et al*., 2003; Reinders *et al*., 2003). Most studies typically focus on direct energy use, while indirect energy use has been addressed in only a few studies (Abrahamse *et al*., 2007; Gatersleben *et al*., 2002). Households use energy for many different purposes and different household activities vary widely in the amount of energy they use. In 2005, in the UK, about 53% of domestic energy use was related to space heating, 20% to water heating, 16% to the use of household appliances, 6% to lighting and 5% to cooking (Maslin *et al*., 2007). These data can help practitioners decide which sort of household energy conservation would be most worthwhile.

In Ghana, the Volta River Authority (VRA) was established in 1961 to provide electricity for powering Ghana's economic development. The VRA operates a total installed electricity of about 1740 MW made up of 1180 MW of hydro and 660 MW of thermal energies. In addition to these, there is a 126 MW from the Tema Thermal 1 Power Plant at Tema, which is currently operated only during contingencies. According to the 2002 census report, only 43% of the population has access to electricity supply. However, over 80% of the domestic electricity supply is consumed in the cities and urban settlements.

As at 1995, Ghana had excess electricity which led to the export of electricity by the VRA to Campagne Ivorien d'Electricite (CIE) of Cote d'Ivoire and Communuate Electrique du Benin (CEB) of Togo and Benin under a power supply contract. However, this has dwindled drastically over the years due to increasing

Corresponding Author: Amuzuvi, C.K., University of Mines and Technology, Department of Electrical and Electronic Engineering, Tarkwa, Ghana

local demand for power and inadequate expansion of the generation capacity. Power supply to CIE ceased after 1995. VRA now exports power only to CEB of Togo and Benin and imports a maximum of 250 MW from Cote d'Ivoire during contingencies. Inferring from the above is the need for an effective energy saving management policy to arrest the situation (Anon, 2004b).

This study therefore seeks to propose a public relation model which aims at educating and sensitising the general public on the efficient use of domestic power and also ensure that, information on energy management tool is right at the door-step of every consumer.

THE ENERGY (SERVICE) METER

Types of energy meters: The type of meters normally used for residential electric power users are the single phase type. Reading such energy meter has been made simple due to the introduction of the digital type of service meter. Currently, ECG supplies only the normal digital type and the pre-paid digital type for residential power users.

The pre-paid energy meter: The pre-paid meter is a more efficient form of conservation of power since the consumer can effectively determine the quantity of power consumed over a period. If the consumer realizes the consumption for a given period, say, a week is on the high side, measures can be put in place to reduce the trend. Since the pre-paid meter is digitized, the layman can easily read the energy meter and make the necessary effort to minimize the rate of consumption.

Multiple energy meters: This is normally prescribed for compound houses and those living in storey buildings and flats. Instead of a compound house using one energy meter, each family could have its own energy meter. In this way consumers will be able to track their rate of consumption and make the necessary effort to manage it.

Billing structure of electrical energy: Most large commercial and industrial establishments in the country are currently billed using three cost structures; actual energy (kWh), apparent energy "demand" (kVAh) and power factor (surcharges). All users of electrical energy are charged for the amount of actual energy consumed which is normally measured in kilowatts-hour (kWh).

Electrical utility companies are faced with the major problem of handling the largest demand of their customers particularly at peak times. Therefore, electrical utility companies have added a demand charge which is related to the maximum average power per each large user demands during one of consecutive time interval throughout each billing period.

Electrical utility companies charge some category of customers by power factor, defined as the ratio of actual energy used to the apparent energy delivered by a utility company. The maximum power factor is 1.00 and currently ECG charges their customers for power factors below 0.90.

Table 1: Residential tariff build-up

UNIT	GHp (¢)	Dollars (cents) ($)
0-50 (exclusive "lifeline" block charge)	9.5000	5.59
1-300 (GHp/kWh)	17.5785	10.34
301-600 (GHp/kWh)	22.8135	13.42
600+ (GHp/kWh)	25.3483	14.91
Service Charge (per month)	165.3200	97.25
Government Special Levy (GHp/kWh)	2.0×10^{-4}	-
Street Lighting Levy (GHp/kWh)	1.0×10^{-4}	-
Exchange rate	170	100

The government of Ghana pays a subsidy of 9.50000 Ghana pesewas for rates of consumption between 0 and 50 units. All customers who consume above 50 units do not benefit from the subsidized and exclusive "lifeline" block charges. The procedure for calculating a monthly bill for a residential set-up by ECG (ECG, Tarkwa District Office), is as follows in Table 1.

OPTIMAL USE OF SOME ELECTRICAL UTILIZATION SYSTEMS

Lighting systems: Lighting systems can be classified as natural and artificial. Artificial lighting systems can be defined as any appliance or gadget that uses electrical power or otherwise to produce light. Natural light on the other hand is primarily light from the sun and other heavenly bodies.

The optimum use of these systems must take into consideration the positioning of buildings to allow enough light into the building and the provision of enough windows and doors to enable natural light to supplement indoor lighting systems. The type of window selected is also important to facilitate natural lighting.

The choice of fabric for curtains and interior decorations as well as the colour of paint can also affect the number of lamps and the wattage of lighting systems to use. A dark colour often calls for more artificial light which are expensive rather than natural light which is free and most often available. Also the ignorance of many people about rating of lamps, make them fix Incandescent Lamps (IL) with 100 W rating in their bedrooms and toilets instead of 40 W IL or better still 8 W compact fluorescent lamp (CFL).

For every 1 kWh of electrical power consumed, it takes 17 hrs for a 60 W IL and 93 h for its equivalent 11 W CFL. Even though the cost of one CFL is high, the operating cost is relatively cheap, highly efficient and lasts longer. It must be noted though that the life span of the CFL reduces drastically upon touching the tube. Contrast of CFL and IL is illustrated in Table 2 and 3.

For the effective use of lighting systems, the following measures should be taken into consideration:

Table 2: Contrast of CFL lamps and incandescent lamps in terms of wattage and lumens

CFL Watt	Incandescent watts	Lumen range
8-10	40	450
13-18	60	890
18 22	75	1210
23-28	100	1750
34 42	150	2780

(Anon, 2008)

Table 3: Contrast of incandescent lamps and CFL lamps in terms of consumption and service life

Comparison	CFL	IL
Wattage (W)	11	60
Service life (hours)	8000	1000
*Energy consumption per year per lamp (kWh)	48	262
**Energy cost per year per lamp (¢)	2.7984	15.2746

*: (Based on 12 hour use per day) **: (Based on October 2003 tariff, 1 kWh = GHp 0.0583) (Anon, 2001)

- Replacement of incandescent lamps with fluorescent or compact florescent lamps
- Frequent cleaning of light bulbs or fluorescent tubes, since layers of dust absorb up to 30% of the light
- Switching off of light in rooms, toilets, etc, when not in use
- Use of lower wattage bulbs in areas that do not need bright light e.g., storage rooms, bathrooms, etc
- Avoidance of the use of a cluster of incandescent lamps for decorations
- Avoidance of too many outside lights which do not necessarily provide security. Infra red sensors or motion detectors are a more energy efficient solution
- Removal of the starter together with a "dead" fluorescent lamp which is not to be replaced immediately is essential; otherwise the choke consumes electricity at the rate of 12 watts per hour

Heating systems:

Electric cooker units: The electric cooker is the highest electric power consumer in the home with an average power rating of 8500 watts. They consume one unit of electricity in just 7 min. Though electric cookers are convenient to use, nevertheless, they consume tremendous amount of power. Gas cookers which are relatively cheap should be encouraged unless inevitable. For judicious use of the electric cookers:

- Cooking utensils with larger diameter than the hot plate must be used to reduce heat loss
- Just enough water for cooking should be used. Too much water takes longer time to boil
- Lifting the lid off utensils when cooking should be minimized, since it reduces cooking temperature and wastes energy
- Aluminium pans with bright shiny exterior should be used, since they provide good heat distribution
- Utensils should have tight fitting lids to minimize heat loss

Electric iron: Electric irons are rated between 850-1000 watts (Donald and Wayne, 1987). Most of these irons have no energy efficient systems such as thermostats as such their power consumption is not regulated. Many of such electric irons take a long time to heat up and once they are heated take much longer time to cool. To rectify these, the right temperature setting for clothing should be when ironing. It is also more efficient to iron clothes in bulk.

Other heating elements: Washing machines, hand and hair dryers, immersion heaters and microwave ovens are other areas of interest. Although these appliances are not common in many households, it is gradually becoming an integral part of our everyday lives. The wattages range from 900-1500 watts. Even though these appliances are used for a short period of time, they consume a lot of power when misused. It has also been identified that bad habits such as boiling water in cups using the immersion heater is an everyday experience in our homes. To maximize the use of these appliances without undue waste of electric power, the following steps are recommended:

- Consumers should learn to boil just enough water for their needs
- Consumers should stop the practice of using water immersion heater to boil water in cups and boiling towels. It is a fire hazard. The gas cooker is a cheaper alternative
- For large families, energy efficient kettles should be used to boil water instead of using water immersion heaters
- Microwave ovens should only be used when necessary. It is also advisable to warm sizable quantity of food at the minimum amount of time possible
- Having your hair done or dried for that matter at the beauty salon is always economical however when there is the need to use hand-held hair dryers, it is wise to switch off the appliance when you finish

Electronic appliances:

Television sets, VCRS and hi-fi systems: Television sets and radio sets are found in almost every household. Video cassette recorders (VCR), Hi-Fi systems, all consume power at the rate of 15-25 watts when they are in "stand by" mode. To avoid excessive electric power consumption by these devices, remove plugs from socket outlet when not in use. It is always advisable not to switch on two or three of such appliances at the same time, say a radio and a television set.

Mobile phones: Mobile phone chargers could consume up to 10 watts of electrical energy if left "on" even though the phone may not be connected. It is therefore advisable to switch off completely or better still remove the charger out of the socket outlet. Using energy

Table 4: Annual electric power consumption of computer related equipment

Type of equipment	kWh/year
Micro computers (without monitors)	150
SVGA colour monitor (14") for computer	70
Laser Printer	100
Inkjet colour printer	60
Photo copier (high Volume)	750
Laser fax machine*	115
Thermal fax machine*	70

*: Fax machines are used 24 hrs a day. (Anon, 2003a)

efficient batteries for mobile phones are advised. Although they may be expensive, they take a short time to charge and a long time to discharge.

Computers: One other important electronic appliance is the computer. The power rating of this appliance is about 500 watts. Table 4 shows the annual energy consumption of a number of common computer related appliances used in the home today for about 4 to 5 h of usage.

Electrical appliances:

Electric fans and refrigerators/deep freezers: These groups of appliances are more often than not driven by relatively small motors normally between 70-100 watts for fans and 200 watts for deep freezers and refrigerators. Although their wattages are not that high they consume substantial amount of electric power since they are used for long periods. There has also been an avalanche of second hand freezers and refrigerators in this country. Not only do they have outmoded and old motors which are not energy efficient, but their door seals are worn out and do not close tightly thereby increasing the energy consumption. For optimal use of these appliances:

- Open windows for easy flow of air into the room when using a fan. Note that fans do not produce air but blow air
- Know what you want to pick from the refrigerator/freezer before you open it. Do not put hot food in the refrigerators or deep freezers
- Do not put the refrigerator/freezer close to a hot object such as a cooker unit.
- Keep refrigerators away from direct sunlight
- Clean the coils at the back of the refrigerator as often as possible. Dirt build-up leads to energy waste
- Defrost the freezer compartment regularly
- Avoid placing refrigerators/deep freezers too close to the wall so as to allow adequate ventilation of the coil at the rear of the gadget

Air conditioners: Air conditioners are by far the highest consuming appliance after the electric cooker. They normally have power rating of about 1500 W and are used mainly in business premises and affluent homes. The types of air conditioners known today are large central air conditioners, window type units and the modern split systems. Quite recently, a mobile type of air conditioner has been introduced onto the Ghanaian market. To reduce electricity consumption:

- Always check for energy efficient labels before buying an air conditioner
- Air conditioners (window type) should be at least 1.5 m above ground level
- All windows and doors to an air conditioned room must be as air tight as possible to prevent hot air from entering the room
- Louver windows are not the best for air conditioned rooms because of gaps between the blades. However if you use louver windows, keep them firmly closed. The modern sliding windows and doors are the best alternatives
- Always switch off the air conditioner when leaving the room for more than 10 min
- Avoid direct sun rays into rooms, use thick curtains or reflective glaze
- Leaving the room during warm weathers and sitting under a tree or otherwise is always advisable
- Temperatures which are 4-5°C below the outside air temperature (room temperature of 25-27°C) are comfortable enough for normal work or relaxation. Do not "over cool" or "over chill" your room

PUBLIC RELATION MODEL OF EDUCATION

Public education:

Radio and TV campaign: The power of the press and the electronic media can be harnessed in the bid to inform the general public about the efficient use of power. Well structured educational programmes compatible with the listening public aired on both national and local radio and television stations would serve as a step towards the eradication of ignorance. Electrical power suppliers and energy-saving organizations as well as energy-saving oriented Non Governmental Organizations (NGO) should be encouraged to sponsor such programmes.

Talk-shows: Talk-shows held with professionals with the technical know-how can be aired both on radio and television and further translated into the local languages to increase the coverage of the listening audience.

Mini-series: Drama programmes could be aired both on radio and TV taking into consideration the age groups, language barrier, etc, all directed towards the sensitisation of the public towards energy conservation.

Promotions and advertisements: Intermittent promotions on radio as well as occasional campaigns on TV can be embarked upon to create awareness and realisation. This would be an effective way of combating ignorance.

Advertisements on bill boards, radio and television, can also serve as another means to champion this cause. This measure will surely produce massive response in the reduction of consumer bills.

Brochures, books and handouts: Energy saving tips can be summed up on colourful eye-capturing and captivating leaflets, teasers and brochures. Newsletters can also be displayed at vantage points such as supermarkets, shopping malls, banks, etc, which can easily be picked up by energy users.

The postal service can be helpful in the distribution process by placing a copy in each letter box. A column could be created in the features column of the national dailies purposely dedicated to educate the reading public. This could be done on weekly bases.

School clubs and websites: In furtherance of the awareness and publicity campaigns; clubs, societies and associations can be formed at all levels of the educational structure. The formation of clubs would offer the members first hand information of the most efficient method of saving energy. The activities of the societies would further educate the community at large and the school in particular. Such activities could include symposia, lectures, walks, campaign and talks. The students can also use their vicinity as case studies to assess their impact.

Special websites purposely for feeding the general public with latest technologies and energy efficient products such as CFLs can be created. An online help service (hotline) can be incorporated to provide technical advice and instant reply to nagging questions and offer further explanations.

It will be prudent to link these special websites with all the websites of governmental agencies, media houses and all educational institutions. This will help increase the target base and go a long way to increase the rate of dissemination of information.

Policy advocacy:

Appliances standards and labelling: The Appliance Standard and Labelling initiative involves the development of a standardisation regime that will ensure that all electrical appliances imported or manufactured for use in the country meet a certain minimum level of energy efficiency.

The Ghana Standard Board in collaboration with the Energy Commission has set the minimum efficiency level at an Energy Efficiency Ratio (EER) of 2.8 w of cooling per watt of electric power. This will result in energy cost savings of US$ 13 million in the first year of implementation, culminated into a national energy cost saving of US$ 775 million by 2020 if implementation of the standards regime begins in 2003 (Anon, 2004a).

This measure if implemented would drastically reduce the overwhelming importation of inefficient second hand appliances on the market. These appliances do find their way into most homes because they are relatively cheap, but its long term energy losses make them uneconomical. Thus, devising a standard for their use will automatically reduce their use.

Integration of Energy-Saving Management (IESM) into school curriculum: The formal educational structure can be a good platform for the dissemination of energy-saving ideologies for the present generation and those yet unborn. Energy saving management can be included in the Integrated Science programmes in Basic Schools and Senior Secondary Schools.

This measure would arouse interest in students and also cause them to be more cautious of energy usage and wastage. Also lecturers and professors could carry out research work in this area and students at the tertiary institutional level could also take project topics in this area and use their vicinities as case studies.

Presidential Special Initiative (PSI) on energy management: A PSI on Energy Management can also be set up by the Government of Ghana to advance this educational drive. With the necessary support and funding from the government, coupled with a feasible working document, much can be accomplished within a short time.

The Energy Foundation (EF): Since its establishment in November 1997 and subsequent commencement of activities in early 1998, the EF has created and maintained a leadership role in energy-saving management in Ghana. However, financial constraints have impeded their vision of assisting in the transformation of Ghana's economy into the most energy efficient economy in Africa and one of the most energy efficient in the world.

The Energy Foundation undertakes programmes and activities in Public Education, Policy Advocacy, Energy Efficiency and Renewable Energy.

The Energy Foundation has within the relatively short period of its existence made a very significant impact on the energy sector in Ghana. It has provided information to both residential and commercial energy consumers on the methods and benefits of energy waste reduction and has assisted a large number of industrial establishments in identifying and implementing energy efficiency and conservation measures.

The penetration of Compact Fluorescent Lamps (CFL) in Ghanaian homes has increased from 15 in 1,000 homes in January 1998 to nearly 200 in 1,000 homes by the end of year 2000 and 300 in 1,000 homes in 2003. Many industries have implemented measures that have resulted in significant energy cost savings.

The Power Factor improvement programme in particular has been so successful that private sector

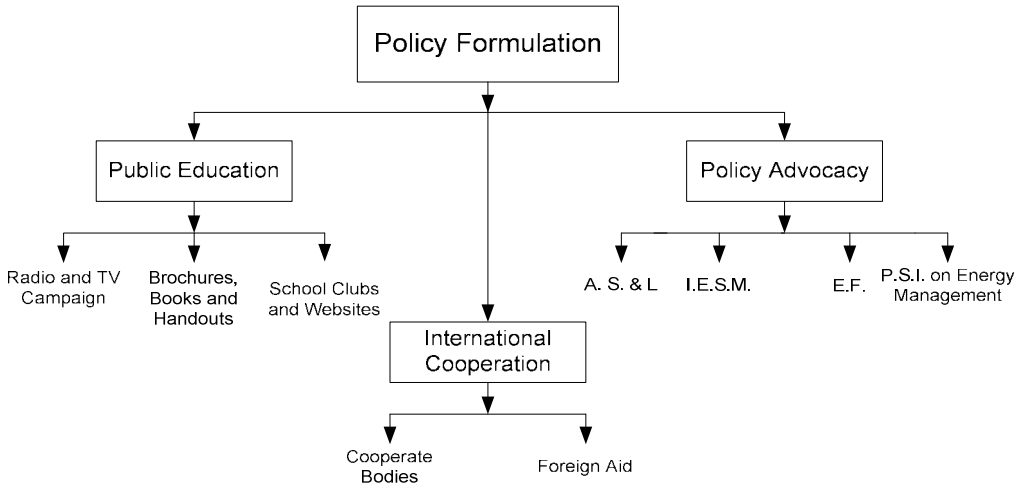

Fig. 1: A proposed public relation model of education

energy service entrepreneurs have now invested in the supply and installation of capacitor banks for industries. They demand payment for the installations only when energy cost savings are realised. The Foundation has chalked these successes not in isolation but by working together with the various energy sector stakeholders, donors, consumers and the general public (Anon, 2003b).

International cooperation: Collaborations with worldly recognised bodies, such as, International Institute for Energy Conservation (IIEC) and Collaboration Labelling and Appliance Standards Program (CLASP) will result in a major market transformation. This will control the influx of second-hand and inefficient appliances into the country and also benefit from international efforts to develop efficiency standard and labels for household appliances. Exchange programmes between such international co-operations and their local counterpart capitalizing on energy efficient technologies will be a step in the right direction.

A summary of the above Public Relation proposals is illustrated in Fig. 1:

CONCLUSION AND RECOMMENDATIONS

Conclusion: In conclusion, the following points are worth noting:

- Electrical power consumers waste a lot of power owing to improper house wiring and misuse of appliances
- The only way to combat ignorance is through education, as such all stake-holders including the government should endeavour to put in more effort to ensure that the consuming public is well informed on the need for efficient energy management

Recommendations:

- The spread of the methodologies described in the earlier chapters, if followed religiously will tremendously curb ignorance and promote energy management
- Labelling of appliances with information on their efficiency of operation and knowledge on how to interpret this information can help in the choice of the optimum system
- A well structured national public relations policy that considers the economic, energy supply, environment and social costs should be implemented in both short and long term basis to boost awareness
- Major campaign on energy efficient appliances should be advocated. This will affect and increase competition in industries involved in the production of electrical appliances. This will also allow electric power consumers direct access to a variety of energy efficient electric power appliances
- Careful design and insulation, use of energy-efficient lighting systems, installation of better control systems leading to more efficient energy management and the use of computerized energy-management systems should all be encouraged
- The Public Utility Regulatory Commission (PURC) should be charged to use energy management personnel to educate the public on efficient domestic power management

ACKNOWLEDGEMENT

The authors gratefully acknowledge the support of the district ECG office and from a former student of the Electrical and Electronic Engineering Department of the University of Mines and Technology, Tarkwa.

REFERENCES

Abrahamse, W., L. Steg, C. Vlek and J.A. Rothengatter, 2007. The effect of tailored information, goal setting and tailored feedback on household energy use: Energy-related behaviours and behavioural antecedents. J. Env. Psyc., 27: 265-276.

Anon, 2001. Annual report and financial statements. Energy Foundation Report, pp: 1-4.

Anon, 2003a. Energy Wise. Energy Foundation Brochure, pp: 3-19.

Anon, 2003b. Brief Profiles of Sector Institutions. pp: 21, Retrieved from: http://www. energymin. gov.gh.

Anon, 2004a. Retrieved from:www.energycom.gov.gh, pp: 11-13.

Anon, 2004b. Retrieved from:www.vra.com.

Anon, 2008. Retrieved from: www.ecohouse footprint. com.

Donald, G.F. and H.B. Wayne, 1987. Standard Handbook for Electrical Engineers. 12th Edn., McGraw-Hill, NY.

Gatersleben, B., L. Steg and C. Vlek, 2002. Measurement and determinants of environmentally significant consumer behaviour. Env. Behav., 34(3): 335-362.

Kok, R., H.J. Falkena, R., Benders, H.C. Moll and K.J. Noorman, 2003. Household Metabolism in European Countries and Cities: Comparing and Evaluating the Results of the Cities Fredrikstad (Norway), Groningen (The Netherlands), Guildford (UK) and Stockholm (Sweden). Integration Report of WP2 (Toolsust Deliverable No. 9), Groningen, The Netherlands: IVEM, University of Groningen, Retrieved from: http://www.toolsust.org/ documents/ D-9%20European%20report.pdf, (Accessed on: October 10, 2007).

Maslin, M., P. Austin, A. Dickson, J. Murlis, M. Owen and V. Panizzo, 2007. UK Greenhouse Emissions: Are We on Target? University College London, Environment Institute, London.

OECD, 2001. Environmental Outlook. Organisation for Economic Co-Operation and Development, Paris.

Reinders, A.H.M.E., K. Vringer and K. Blok, 2003. The direct and indirect energy requirement of households in the European Union. Energy Policy, 31: 139-153.

Vringer, K. and K. Blok, 1995. The direct and indirect energy requirements of households in the Netherlands. Energy Policy, 23(10): 893-910.