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Energy Policy 35 (2007) 1648–1657

ENERGY POLICY

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Energy and associated greenhouse gas emissions from household appliances in Malaysia

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Available online 30 June 2006

Abstract

Today, electricity is an indispensable key for civilization and development. The trend of electricity consumption is rather escalating. Electricity generation principally depends upon fossil fuels. In one hand, the stocks of these fuels have been confirmed to be critically limited. On the other hand, in process of electricity generation by means of these fuels, a number of poisonous by-products adversely affect the conservation of natural eco-system. Further, electricity driven appliances use emanate anti-environmental gases that also affect human health and climate. Therefore, estimation of energy consumption for operating household appliances, savings of energy under policy intervention, and emission of poisonous gases in a fast developing country deserve academic attention.

This paper focuses on estimation of energy consumption, energy savings, reduction of emissions of greenhouse gases for use of household appliances in Malaysia between 1999 and 2015. In the upstream side of electricity generation, the study estimates the amount of greenhouse gases (GHGs) resulting from burning of fossil fuels. In downstream side, it considers the energy savings and reduction of CHGs. The results show that significant amount of energy can be saved and thus huge volume of toxic emissions can be controlled. The findings can be useful to policy makers as well as household appliances users.

Keywords: Household appliances; Energy savings; Greenhouse gas (GHG) emissions and reductions

1. Introduction

Electricity is an essential input for economic growth and development of a nation. The use of electrical energy has tremendously increased in recent years. This will rather increase in an accelerated fashion in the days to come. The demand for this energy is expected to grow rapidly throughout the world, particularly in developing countries, say in Malaysia, where rapid economic growth is versioned (Mohamed and Lee, 2006). The growing demand of electricity will definitely put enormous pressure upon the upstream sources of energy such as petroleum fuels and natural gas. It has been widely accepted that the reserves of these resources already been depleted to an alarming level. In the downstream side, combustion of these fuels releases several gases such as carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen oxide (NO_x), carbon monoxide (CO), and a few organic compounds that are detrimental for a living-friendly natural environment. Over the past few decades, it has been observed that there is an increasing concentration of these greenhouse gases (GHGs) that have harmful impacts on the environment. Principally, burning of fossil fuels emits these gases that cause greenhouse effect, acid rain and other negative impacts on the environment and humankind (Mahlia, 2002). In particular, CO_2 is the significant by-product that stems from the burnt of these fuels used to generate electricity in conventional power plants. It absorbs radiant energy that contributes to the greenhouse effect. Further, the unjustified dependence on hydro-power source has already signaled some grievous effect on ecological balance.

Efficient use of energy and maintenance of eco-efficient environment are obviously interlinked. Energy use has been a policy issue since 1970s. After the oil crises in 1973

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0301-4215/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2006.05.006

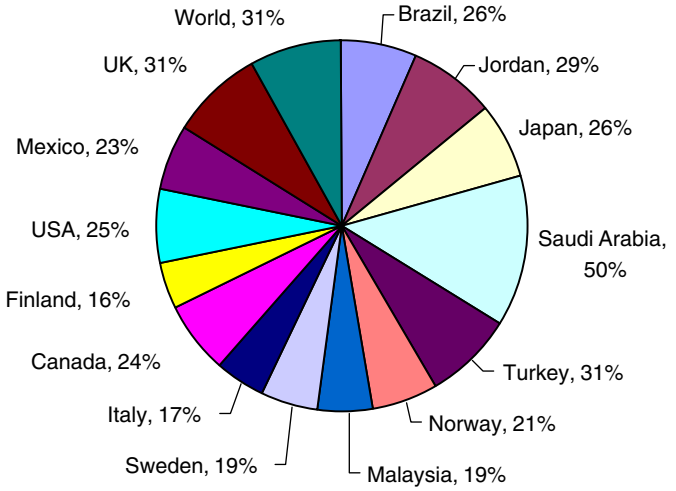

Fig. 1. Worldwide residential energy consumption (*Data Sources*: Meyers et al., 2003; Morelli, 2001; Boardman, 2004; Ueno et al., 2006; Almeida et al., 2001; Kamal, 1997, Lenzena et al., 2006).

and 1979, governments of many countries intensively promoted energy conservation activities. In 1980s, the primary focus shifted to air pollution caused by the combustion of fossil fuels. In recent years, energy use and associated GHG emissions and their potential effects on the global climate change become a worldwide concern. The introduction of Kyoto Protocol in 1997 is the first serious step in putting in place an effective international mechanism for the reduction of emissions of the GHGs (NO_x, SO_2, CO and CO_2). Within the framework of this Protocol, developed countries committed to a legally binding GHG emission reductions of at least five percent below the level of 1990 between 2008 and 2012 (Mirasgedis et al., 2004).

Malaysia, being a newly industrialized and fast developing country should have concern to evaluate and apply every feasible measure to reduce energy consumption and GHG emissions without sacrificing its economic growth.

Residential electrical energy consumption is about 16–50 percent of total energy use in different countries, as shown Fig. 1. Therefore, efficient and effective uses of electrical energy in this sector deserve research attention. A comprehensive assessment and representative figures on its consumption and GHGs emission is needed for feasibility applications of numerous potential strategies in order to reduce energy consumption and GHG emissions. Such assessment can also be used to conduct comparative evaluations and guide the policy instrument to achieve the overall GHG emission reduction in a country, such as Malaysia. This paper discusses the emission of selected air pollutants, viz NO_x, SO_2, CO and CO_2.

2. Approaches applied for data analysis

No comprehensive study in this area has been done earlier. It was not possible to collect a complete set of data from a single source. Therefore, data on the relevant areas were collected from several sources and analyzed by using several mathematical formulas. The following sub-sections describe the methods used to estimate appliances' energy consumption, energy savings, GHGs emissions and emission reductions from the use of fossil fuels in power generation and operation of household appliances.

2.1. Estimation of energy consumption

Energy consumption depends on appliances ownership levels, appliance utilization hours, and power ratings of an appliance. Data on the various relevant issues were collected from the Annual Reports of Tenaga Nasional Berhad (TNB) Malaysia, (1999); and Statistical Department of Malaysia (1970, 1980, 1991, 2000).

The data on ownership of different household appliances for 1999 and 2000 is shown in Table 1. A polynomial equation with an order k and constants c_i,

$$y = c_0 + c_1 x + c_2 x^2 + \cdots + c_k x^k \quad (1)$$

was used to predict the ownership of the listed appliances. Historical data for 1970–2000 was used to estimate the size of ownerships for each category of appliances for 2001–15. The number of air conditioner units in use was estimated by the following equation:

$$y_{AC} = 13251 - 1979x + 638.79x^2, \quad R^2 = 1.00. \quad (2)$$

In order to determine the total amount of energy consumed by different household appliances, the duration of appliances in use was considered. The necessary data on hours of usage of appliances was collected from the Energy Commission Report (2002). The data comprised of usage hours during weekdays and weekends for each appliance. The average usage durations were estimated with reasonable accuracy to make them representative. This data is presented in Table 2.

Power needed to operate an appliance is normally described by the wattage or power rating of an appliance. Power rating depends on types and brands of appliances. Usually, an appliance of the same type (refrigerators of different models or brands) works within a given power range. Therefore, it may be appropriate to find the power ratings of the major types of appliances along with their ownership categories. The average power ratings of different appliances are shown in Table 2 (*Source*: TNB Research Sdn. Bhd, 2001).

Therefore, the amount of electrical energy (E_e) consumed by an appliance can be determined by using the following formula:

$$E_e = N_a \times P_r \times D_u, \quad (3)$$

where N_a is the number of appliances of a particular type, P_r the average power rating of a unit in watt, D_u the duration of usage of a unit in hours.

The total amount of energy consumed by all appliances for a period of 1 year can be calculated by using the