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Realizing potential savings of energy and emissions from efficient household appliances in India

Kirit S. Parikh *, Jyoti K. Parikh

Integrated Research and Action for Development (IRADe), C 80, Shivalik, Malviya Nagar, New Delhi 110017, India

HIGHLIGHTS

- Estimates the stock of selected household appliances with 20 classes of rural and urban households in the years 2030 in India.
- Assesses the economics of energy efficient appliances.
- Estimates spread of selected energy efficient appliances.
- Assesses savings in energy consumption and CO_2 emissions in four alternative scenarios.
- Suggests policies to promote energy efficient appliances.

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ABSTRACT

The paper projects households' stock of four major electricity consuming appliances till 2030 and explores policy options to accelerate adoption of more energy efficient appliances. India's rapid economic growth has enabled the growing middle class to buy household appliances in increasing numbers. The consequent rise in energy consumption and GHG emissions can be significantly reduced if consumers are motivated by awareness and options in the market to buy energy efficient appliances. India has introduced a star rating scheme for appliances, and even without incentives consumers purchase star-rated appliances. The stock of household appliances is projected using the data of a national sample survey of household consumption, observed sale of star-rated appliances and projected consumption distribution.

Estimated savings in households' electricity consumption from just four appliances, ACs, refrigerators, TVs, and ceiling fans, for which data were available, range from 52 bKwh to 145 bkwh in 2030, reductions of 10–27%. The corresponding reduction in CO_2 emissions will be between 42 Mt and 116 Mt in 2030. With policies of finance and bulk procurement to reduce costs, emissions reduction can be 128 Mt in 2030, a reduction of 30%.

1. Introduction

India's rapid economic growth has enabled the growing middle class to buy household appliances in increasing numbers. The consequent rise in energy consumption and GHG emissions can be significantly reduced if consumers are motivated by awareness and options in the market to buy energy efficient appliances, (Parikh et al., 2014; Banerjee, 2005). The paper projects appliance ownership by households, their adoption of energy efficient appliance models based on economic considerations, assesses the saving in electricity consumption and carbon emissions from them and explores policy options to accelerate adoption of more energy efficient appliance models.

Currently, due to low income levels, the appliance use is comparatively small. Thus, a very high growth in the ownership, often in double digits, is expected to continue for most of the high-energy-consuming appliances in the coming decades. For example, air conditioner (AC) ownership in 2009 was 1% in urban areas and less than 0.1% in rural India compared to 85% in USA in 2010 (EIA, 2011), more than 100% in Urban China in 2010 (Zhou et al., 2012) and 85% in South Korea in 2000 (McNeil and Letschert, 2008). As incomes increase, electricity consumption by appliances used in households can become quite large. For example, in the US, in 2009, the residential sector consumed 32.4% of the gross electricity generated not counting the 6.2% consumed by air conditioning. In 2009, a US household used 11,320 kWh of electricity;

* Corresponding author.
E-mail addresses: kparikh@irade.org (K.S. Parikh), jparikh@irade.org (J.K. Parikh).

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of which 45% was for space heating and the rest for water heating, air conditioning, appliances and lighting (US Energy Information Administration website: http://www.eia.gov/consumption/residential/). It is, therefore, important to project energy use by appliances and the energy conservation by the use of more energy-efficient appliances in India.

In India, the Bureau of Energy Efficiency (BEE), set up by the government, has initiated programmes to promote energy efficiency (BEE website: http://www.beeindia.in). One of these is the labelling and star rating of appliances (http://beestarlabel.com). A 5-star-rated appliance is the most energy efficient. This has created awareness as well as markets for energy efficient appliances by providing information on performance with gradation from 1 to 5 stars. The BEE provides data on electricity consumption per unit by different star-rated appliances. Also, after introducing the star rating system for appliances in 2007, it has commissioned annual assessments by an independent agency, National Productivity Council (NPC, 2007 to 2011). These assessments provide data on the sales of different star-rated appliances.

To project energy savings from the use of star-rated appliances in the year 2030, we project the use of appliances by the households of different expenditure classes and assess what proportion of these would be energy-efficient appliances assuming that consumers will buy energy-efficient appliance models that are economically justified. The study estimates the energy savings from the star rating of four major appliances, air conditioners (ACs), refrigerators, TVs and fans. The paper addresses the following questions:

- What is the stock of household appliances with rural and urban households in India in 2009?
- What will be the stock of appliances in 2030 and electricity consumption by them?
- What will be the uptake of energy efficient appliances by consumers on their own without any subsidy and what would be their spread?
- How much savings of electricity and emissions will result?
- What pro-active policies can increase spread of energy efficient appliances over the normal rise and how much electricity and emissions savings can result?

Energy savings by efficient appliances have been highlighted by India's Low Carbon Strategy for Inclusive Growth (Parikh, et al., 2014). A number of papers have projected ownership and energy use for selected appliances; e.g. air conditioners (Sivak, 2013; McNeil and Letschert, 2008; Auffhammer and Maximilia, 2011; Phadke et al., 2014); fans, televisions (TVs), and refrigerators, etc. (Rathi et al., 2012); a World Bank (2008) study provides a detailed analysis of residential electricity consumption in India. It projects appliance ownership by households till 2030 and estimates energy savings under alternate efficiency scenarios.

Our study is different in that it uses data of a more recent survey, accounts for income distribution in rural and urban areas and projects adoption of energy efficient appliances based on economic rationality the importance of which was brought out by Chatterjee and Singh (2012).

Parikh et al. (1994) examined the potential gains from specific measures to improve energy efficiency and found that barriers prevent industries from adopting energy-efficient equipment, even those with a very low payback period. It is therefore important to base our projection on the observed behaviour of households. Further, it helps to design programmes to incentivize consumers to purchase more energy-efficient appliances, as shown by Parikh and Banerjee (1994).

We also compare our results with other studies. Palmer et al. (2013) assessed the household-level electricity savings for the UK and Hubacek, Guan, and Barua (2007) compared appliance ownership in China and India. Sanchez et al. (2008) have assessed energy savings from USA's ENERGY STAR program and METI (2015) examines the impact of Japan's "Top Runner" program. IEA (2015) provides an assessment of energy efficient end-use equipment in different countries.

Section 2 describes the available data on household appliances in India, our approach and the methodology used. Section 3 discusses the ownership of appliances. Section 4 deals with the economics of different star-rated appliances and examines policies to accelerate adoption of more efficient appliances. Section 5 presents the use of star-rated appliances and the corresponding energy and emissions savings. *For simplicity of exposition, we use the terms ownership, use, and possession interchangeably*.

2. Available data, approach and methodology

Our approach to projection is based on the available empirical evidence.

2.1. Available data

In India the National Sample Survey (NSS) in its household survey carries out household consumption expenditure survey regularly since 1950. The sample size in recent surveys exceeds 200,000 households. This data is a valuable source of any analysis of how the standard of living and consumption patterns are changing. Apart from consumption expenditure it also provides data on the possession of appliances by households belonging to different per capita monthly expenditure classes. Since income data are considered unreliable in India, we use consumption expenditure in its place. The National Council of Applied Economic Research (NCAER) also periodically carries out more detailed household surveys but with a much smaller sample size than NSS. We have also used these data for our analysis. Data from BEE (2015) is used to assess the electricity consumption of various star rated models of the selected appliances.

The NSS is a quinquennial survey of consumer expenditure. The 66th round data (April 2009–March 2010; henceforth, we refer to this period as 2009) provides the number of households possessing an appliance per 1000 households for the year 2009. The population is divided into 10 decile classes of monthly per capita consumer expenditure (MPCE). The survey generates estimates of average MPCE by households and its distribution over households and persons.

2.2. Approach and methodology

Thus, we take the following step by step approach:

a) Total appliance ownership in the base year: Using the data of the 66th round (2009) of the household consumption survey by the National Sample Survey Organisation (NSSO, 2011) provide appliances possessed by households belonging to different decile classes of per capita consumer expenditure.
b) Income distribution of appliance ownership – urban and rural: Appliance ownership depends on household income or total per capita consumption expenditure. For a particular appliance we can stipulate that

$$X_{ij} = f(c_j) \quad (1)$$

Where X_{ij} = appliance i used by a household of per capita consumer expenditure class j
And c_j = total per capita consumption expenditure of