Energy Efficiency Policies in India: Implications for Climate Change Mitigation

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Abstract The role of energy efficiency in meeting domestic energy challenges and global environmental issues is well acknowledged. The need for policy intervention to maximize the potential of energy efficiency that can be realized is also widely accepted. The impact of the energy efficiency policies determines the extent to which they address the barriers to adoption of efficiency measures. Evaluating the impact of policy instruments is crucial to increase their effectiveness and maximize their energy and emission reduction potential. The data to estimate the impact of a policy intervention are often disaggregated, particularly in developing countries. The policy interventions adopted in India to increase energy efficiency include information programs, regulations, financial incentives, and other market-oriented mechanisms. The standards and labeling program is one the most important energy efficiency policies in India. It has been found that the program has significantly contributed to the energy and emission reduction in the country. A positive response from the consumers to the program has also been reported. In this chapter, the policy interventions in India to improve energy efficiency and impact on climate change mitigation are discussed.

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1 Introduction

As part of the international agreement, India has submitted to reduce the emission intensity of its gross domestic product (GDP) by 33–35% from 2005 levels by 2030. The role of energy efficiency in addressing the problem of carbon emissions and climate change is widely acknowledged. But, many of the policies for promoting energy efficiency implemented globally are derived originally from different rationales. In India, the primary drivers for the energy efficiency policies were meeting the demand–supply gap, enhancing energy access, increasing productivity, and reducing energy dependence. Energy efficiency is now also recognized as an important contributor to mitigating the risk of climate change and environmental degradation associated with energy use. The low adoption of cost-effective energy efficiency measures provided a basis for the policy interventions. The policy interventions adopted in India include information programs, regulations, financial incentives, and other market-oriented mechanisms. The standards and labeling (S&L) program, implemented in 2006, a combination of information and regulation program, is a flagship program to improve efficiency in appliances. The program has led to significant savings in the energy and emission reduction since its launch. The program has also received a positive response from the consumers and the market for appliances.

In this chapter, an overview of the energy efficiency potential and barriers to energy efficiency policies in India is presented. The impact of S&L program on energy and emission reduction and consumer response is also discussed. The chapter is divided into four sections. In Sect. 1, an introduction to the rising energy demand of the country and the global challenge of climate change mitigation is given. In Sect. 2, a review of studies that estimate the potential of energy efficiency and indicate the possible barriers to adoption is presented, followed by a discussion on policy interventions implemented in India. In Sect. 3, the impact of the S&L program in energy savings, emission reduction, and consumer response to labels is presented. The conclusions are summarized in Sect. 4.

1.1 India's Energy Demand

The total consumption of energy from conventional sources in India increased at a compounded annual growth rate (CAGR) of 5.5% from 2006–07 to 2015–16 (MOSPI 2017). The largest consumption of raw coal (61%) and the second largest consumption of natural gas (23%) were in electricity generation. The total electricity consumption has increased at a CAGR of 8.2% from 456 billion units (BUs) in 2006–07 to 1001 BUs in 2015–16. India's total emissions were 2137 million tonnes (MT) of the CO_2 equivalent greenhouse gas (GHG) emissions in 2010. In the overall emissions, the energy sector was the most significant contributor (71%) followed by agriculture (18%), industrial processes and product use (8%) and waste (3%). The land use, land-use change, and forestry offset 12% of the total GHG emissions. The total GHG emissions from energy industries and electricity production were 42 and 38% of the total emissions, respectively.

In 2015–16, the industry sector accounted for the most significant share in the total electricity consumption (44%), followed by domestic (22%), agriculture (18%), and commercial sector (9%). The electricity consumption in industry sector increased at CAGR of 9.5% followed by domestic and commercial at CAGR of 8% during 2006–07 and 2015–16 (MOSPI 2017). As per GOI (2017), urbanisation is expected to go up to 47%, and the population is predicted to go up to 1.6 billion by 2040. These developments will result in the energy demand to increase by 2.7–3.2 times between 2012 and 2040. The energy demand from buildings in India, including residential and commercial, is expected to grow at a CAGR of 7% during this period. As a result of rising standards of living and increasing urbanisation, the penetration of electrical appliances is rising. In 2011–12, television sets were possessed by 50% of the rural households compared to 26% in 2004–05, and by 80% urban households compared to 66% in 2004–05. Refrigerators were possessed by 44% urban households in 2011–12 compared to 32% in 2004–05.

The data on household's monthly electricity consumption show that in the urban and rural areas, the share of households consuming less than 100 kWh per month is 60 and 90%, respectively (Chunekar et al. 2016). The appliance-specific energy consumption is commonly estimated using appliance ownership and usage patterns. The estimates vary across studies due to a difference in assumptions. Room air conditioners and refrigerators are one of the major contributors to the total electricity consumption in households. The sale of room air conditioners in India has increased from a million in 2003–04 to 3.1 million in 2010–11 and is estimated to be 4.3 million in 2016–17. The total number of refrigerators sold in 2010–11 was 8 million. These two appliances have been mainly studied in the literature owing to their significant contribution in electricity consumption and their potential in energy savings. It has been found that in addition to income and urbanisation, an increase in the number of cooling degree days may also contribute to an increase in appliance sales.

1.2 The Challenge of Mitigation

The global mean surface air is warming approximately proportional to cumulative CO_2 emissions. The relationship has been called the transient climate response to cumulative carbon emissions and has been used to link a global quota on cumulative CO_2 emissions to a nominated temperature threshold with a specified probability of success (Friedlingstein et al. 2014). Following the Copenhagen Accord in 2009, the United Nation Framework Convention on Climate Change (UNFCCC) formally decided in 2012 to pursue actions in line with a target to hold global temperature increase to below 2 °C above pre-industrial levels. About two-thirds of the available budget for keeping warming to below 2° have already been emitted (Friedlingstein et al. 2014).

Limiting warming to any level implies that the total amount of CO_2 that can ever be emitted into the atmosphere is finite implying that global CO_2 emissions need to become net zero. Limiting global warming to 2° requires negative CO_2 emissions (Gasser et al. 2015). It has been found that the positive CO_2 emissions are more effective at warming than negative emissions are at subsequently cooling, and the cooling effectiveness of negative CO_2 emissions decreases if applied at higher atmospheric CO_2 concentrations, further emphasizing the need for urgent action.

As part of the Paris Agreement in 2015, countries submitted plans for post-2020 to address a range of issues relating to climate change mitigation and adaptation. In these plans, known as Intended Nationally Determined Contributions (INDCs), countries have committed reduction of GHG emissions and have identified specific actions for the same. Rogelj et al. (2016) find that the INDCs collectively lower GHGs compared to where current policies stand, but still implies median warming of 2.6° to 3.1 °C by 2100. After the Paris Agreement, the INDCs are now nationally determined contributions. Studies have reported that if the current NDCs are found to be inadequate, there is a possibility of enhancement in the target in a potential new climate agreement in 2020 (Friedlingstein et al. 2014). As part of this agreement, India has submitted to reduce the emissions intensity of its GDP by 33 to 35% by 2030 from 2005 level. The mitigation strategies to achieve the target include reducing energy demand by energy efficiency and infrastructure development and meeting energy demand by renewable energy sources (GOI 2015).

In the literature, there is a divergence in view on technology readiness to address the carbon and climate-related problem over the short and the long term (Hoffert et al. 2002; Pacala and Socolow 2004). However, the importance of end-use efficiency in meeting the short-term climate mitigation is well established (Pacala and Socolow 2004; Dietz et al. 2009). The negative emission technologies are at an early stage of development, and hence, it is recommended that conventional mitigation, that is, reduced consumption of fossil fuels should remain a significant part of any climate policy aiming at this target.

2 End-Use Energy Efficiency

Most of the research and policy action relating to end-use efficiency began post-oil crisis in the 1970s. A techno-economic approach is most commonly used to calculate the potential of energy efficiency. The techno-economic studies are based on life-cycle cost analysis of efficiency measures. The costs and benefits of a durable are calculated over its lifetime and discounted at a market rate of interest for the individual. The investment with the lowest life-cycle cost is preferred to all other. The concern on profitable energy-saving measures not undertaken has been extensively studied in the literature indicating the presence of market failures such as inadequate information, indifference to energy cost, low energy cost, high capital cost, etc. Various policy interventions have been made, and the impact of these programs are being studied.

2.1 Estimates of the Potential and Barriers

Several studies have estimated the potential of end-use efficiency in India over the last three decades. In one of the early estimates, Nadel et al. (1991) assessed the technical and achievable conservation potential of end-use efficiency in different scenarios. The savings were estimated from twenty-seven conservation and load management measures using detailed techno-economic approach. The study determined that savings of 104–167 BUs were possible in 2004–05 from 1990 to 91, which is around 20% of the projected consumption. The weighted average capital cost of the measures was found to be ₹8800/kW. Reddy and Parikh (1997) estimated the economic and environmental impact of twelve actions in industries and found that 9.2% of the energy requirement can be reduced annually during 1995–2010 (around 113 BUs in 2010). Shrestha et al. (1998) estimated the economic potential of electricity generation savings from national, utility, and user perspective for appliances used in different sectors such as bulbs, refrigerators, and motors. The study estimated that around 1494 BUs could be saved during the period 1997–2015 which is 10% of the total cumulative electricity generation. The potential of the efficiency improvements in the residential sector from lighting and refrigerators was found to be 7.9% of the cumulative electricity generation.

In more recent studies, McNeil et al. (2008) calculated cost-effectiveness potential of air conditioners, refrigerators, motors, and transformers. The study projected that the electricity consumption of these four products would reach 410 BUs by 2020 and 4.3% of the total electricity consumption (54 BUs) can be saved using cost-effective measures from the base year of 2005. Garg et al. (2011) estimated the potential of energy savings from efficient air conditioners and refrigerators in the residential and commercial sector, and agriculture pumps in the agriculture sector in Gujarat. Assuming penetration rate of efficient technologies, the study estimated saving of 8.8 BUs over a period of 10 years from 2006 to 07. In the most recent study, Parikh and Parikh (2016) estimated the annual energy savings and emission reduction from efficiency improvements in air conditioners, refrigerators, televisions, and ceiling fans. The study estimates a range of electricity savings from these appliances between 52 and 151 BUs in 2030 from 2009 depending on the penetration of efficient technologies without any financing.

The projections in the studies discussed have used stock forecast approach to calculate the aggregate saving in the given period. The savings are estimated based on cost-effectiveness metrics such as the cost of conserved energy or the life-cycle cost. The results are not comparable due to differences in end-use technologies, period, and other assumptions. While most studies calculate the total economic potential assuming a 100% penetration of cost-effective technologies, other studies assume a penetration rate to account for other factors such as barriers to penetration of efficient technologies. The cash flows in energy efficiency investments are spread over a given period, and hence, assumptions on discount rates, duration of project or life of the appliance, and changes in electricity cost are also made. The potential of CO_2 emission reduction is calculated by multiplying the electricity savings in the generation with the emission factor for electricity generation.

The top three barriers identified by Nadel et al. (1991) to energy efficiency in India were lack of information, measure cost exceeding willingness to pay and electricity prices lower than marginal costs and the cost of electricity production. Given the existing efficiency programs, the study made several recommendations and emphasized on promoting high-efficiency technologies in India. Reddy (1991) presented an actor-centric approach to identify a comprehensive list of barriers for different stakeholders such as consumers, equipment manufacturers and providers, generation and distribution utilities, financial institutions and policymakers. The study suggested a combination of measures with a focus on policy assisted and market-oriented mechanisms. The study also emphasised on promoting innovation rather than energy efficiency alone. The study suggested that poor consumers have less capital, less information, and are more risk averse and hence offering financing schemes on efficient alternatives to convert the initial down-payment into a payments stream that coincides in time with the savings stream only to those who are first cost sensitive should be considered. Reddy (1996) offered some intervention mechanisms for the promotion of energy-efficient appliances, such as financial incentives like rebates and tax subsidies, installing energy-efficient equipment in households by government/electricity boards and collecting the payments in monthly installments and educating the consumers.

2.2 *Policy Interventions*

Following the oil crisis in the 1970s, several policy interventions have been made globally to address the barriers to energy efficiency. The first major policy initiative in India to coordinate various activities associated with the efficient use of energy and its conservation was the enactment of the Energy Conservation (EC) Act in October 2001. The EC Act provided creation of the Bureau of Energy Efficiency (BEE) which was established in March 2002. BEE works under the Ministry of Power and is responsible for spearheading the improvement of energy efficiency in the economy through various regulatory and promotional instruments. Among the responsibilities of BEE are the planning, management, and implementation of appliance standards and labeling (S&L), as well as Energy Conservation Building Codes. The Indian electricity sector is governed by the Electricity Act 2003, under the premise of which the Government of India notified the National Electricity Policy (NEP) in 2005. The policy mandated the BEE to set standards on energy conservation with a voluntary and self-regulating approach, to begin with, followed by a more regulatory approach. The Integrated Energy Policy Report (IEPR) released in August 2006 entrusted distribution utilities to undertake energy efficiency and demand-side management (DSM) programs.

In 2008, the National Action Plan on Climate Change (NAPCC) was introduced to address the growing issue of climate change. The plan identifies energy efficiency as an essential tool for addressing climate change issues. One of the eight missions of the plan is the National Mission for Enhanced Energy Efficiency (NMEEE). The four pillars of the NMEEE include a market-based mechanism to improve energy efficiency in energy-intensive industries, accelerating the shift to energy-efficient appliances in designated sectors, and to make the products more affordable, the creation of mechanisms that would help finance demand-side management program and the development of financial instruments to promote energy efficiency. The policy regime before the EC Act and till the formulation of the NAPCC is presented in detail by Balachandra et al. (2010).

The three most widely used policy interventions in developing countries identified in the literature are information programs, regulations, and financial incentives (Kelly 2012). Information programs such as appliance labeling address the barrier of inadequate information to consumers, regulation such as efficiency standards on appliances limit consumer choices and address barriers such as insufficient information and indifference to energy costs, and financial incentives aim to lower the high capital cost of efficient technology and push the market toward higher efficiency.

In the industry sector, BEE implemented the Perform, Achieve, and Trade (PAT) scheme in 2012 under NMEEE. PAT scheme is a regulatory instrument linked with market mechanism by way of certification of energy savings. The identified energy-intensive industries, called as designated consumers, were given unit-specific targets. The targets were designed to reflect relative responsibility by giving less target for more efficient and more for less efficient. It covered 478 designated consumers in eight energy-intensive industrial sectors accounting one-third of total energy consumption in the country. A decline of 4–5% in the specific energy consumption of designated consumers in 2015 from 2012 has been reported.

The first large-scale program implemented for appliance efficiency was the S&L program in 2006. It is a combination of information and regulatory intervention with the objective to inform consumers about actual and relative electricity consumptions of appliances and remove least efficient models from the market. In 2010, the Government of India initiated the Bachat Lamp Yojana (BLY) to transform the lighting market from incandescent lamps to energy efficiency compact fluorescent lamps (CFLs). In 2015, the BLY scheme was replaced by National LED program, renamed in 2016 as Unnat Jyoti by Affordable LEDs for All (UJALA) to promote energy-efficient LED lamps. The UJALA scheme has been extended to energy-efficient tube-lights and fans and is now renamed as Unnat Jeevan by Affordable LEDs and Appliances for All. These programs aim to reduce the high cost barrier to adoption of efficient technologies. The scheme operates in conjunction with the S&L program as the energy-efficient ceiling fans are identified by their labels. The impact of these programs on energy and emission reduction has been reported in the relevant policy documents. The savings are estimated primarily using engineering approach. However, study on the impact of the programs on consumers has not been undertaken. In the following section, a detailed analysis of the S&L program in India and its impact on energy and emission reduction and consumer repose is presented.

3 Standards and Labeling Program in India

BEE launched the S&L program with the objective to provide information on the electricity consumption of appliances to the consumer and remove the least efficient models from the market. The S&L program was developed using consumer research and stakeholder interactions to integrate consumer preferences in the design process (Dethman et al. 2000). The label design research was initiated in 1999, and the program was launched in May 2006 under the name of the National Energy Labeling Program. The program is implemented by the Bureau of Energy Efficiency (BEE) under the provisions of the EC Act 2001 (CLASP 2007). Under this program, a comparative star-labeling system has been established where higher numbers of stars imply lower electricity consumption. A total of twenty-one electrical appliances have been covered by 2016–17 (BEE 2017). The EC Act 2001 was amended in 2010 which provided a process for the phasing out of energy-inefficient products for which mandatory labeling had been introduced. There are now six appliances on which labeling have been made mandatory. For the appliances under mandatory labeling, the lowest level of efficiency is the minimum energy performance standard (MEPS). The labels are also mandatory for tubular fluorescent lamps, distribution transformers, electric geysers, and television.

3.1 Energy Savings and Emission Reduction

Few studies have evaluated the impact and the potential of the S&L program in energy savings and emission reduction. GOI (2014) shows that the estimated savings in electricity consumption from labeling of four key appliances—air conditioner, refrigerator, ceiling fan, and television—are 136.8 BU in 2030. The estimated savings are from the use of star-rated appliances as compared to non-rated appliances in 2030 from 2009 to 10. The penetration rates of the star-rated appliances are assumed based on the cost-effectiveness of higher star rating. The contribution of air conditioners and refrigerators in the estimated saving is 23% and 54%, respectively. Dhingra et al. (2016) report the cumulative energy saving and emission reduction achieved from the S&L program in 2012. The total energy saved from eight product categories is estimated to be 6 BUs and GHG reduction of 5.5 Mt of CO_2 in 2012. The contribution of air conditioners and refrigerators in the savings and emission reduction is 22 and 61%, respectively. The cumulative energy savings estimated by BEE (2018) in 2016–17 since 2011–12 are 81 BUs from all appliances covered under the program.

The S&L program was implemented in 2006, and the air conditioners and frost-free refrigerators were the first two appliances on which the labeling was made mandatory in 2010. The data on the share of different star rating in the total sales are available on the Web site of BEE from 2011–12 to 2017–18 (BEE 2018). The impact of labeling program is seen on the sales of the labeled products since the

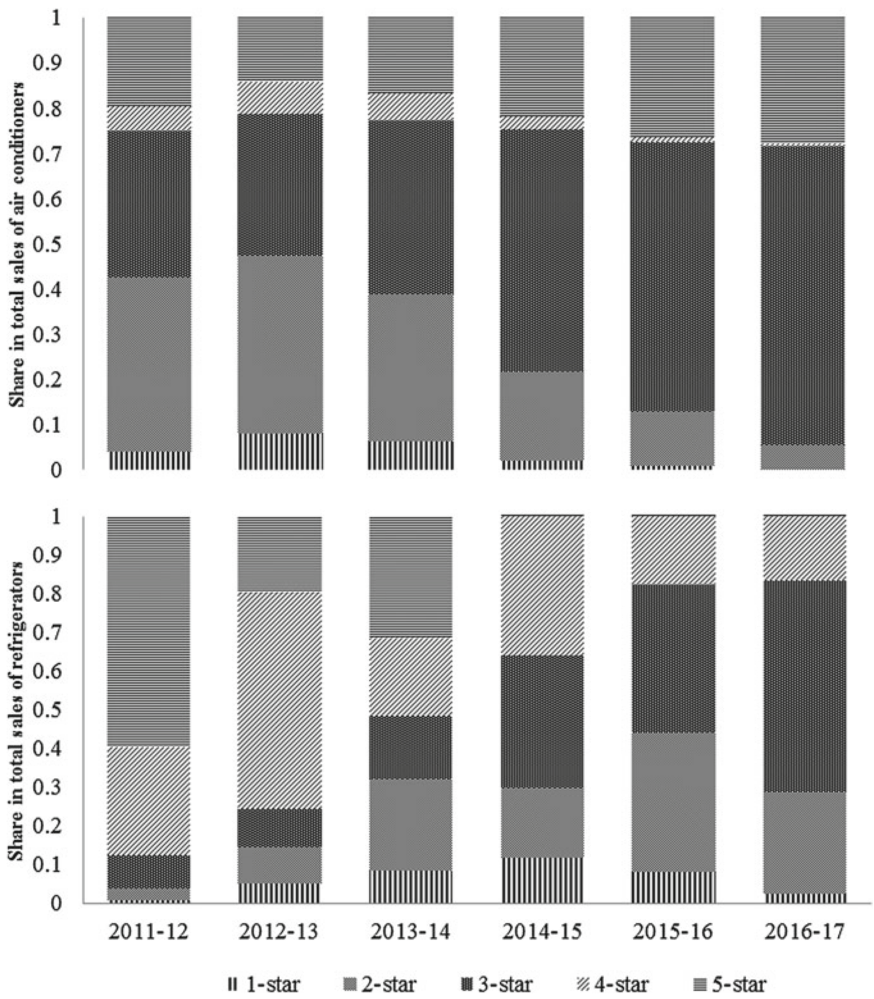

Fig. 1 Share of star rating in total sales of air conditioners and refrigerators in India

launch of the program. As shown in Fig. 1, the share of higher star rating model has been increasing since the launch of the program.

The star rating on air conditioners is given based on a range of energy efficiency ratio (EER) calculated using cooling output (W) and power input (W). The lowest level of allowed EER corresponds to the lower value of the range of 1-star rating. The star rating in refrigerators is given based on a range of electricity consumption calculated using total adjusted volume, constant multiplier (kWh/litre/year), and constant fixed allowance (kWh/year). The maximum allowed electricity consumption corresponds to the lower value of the range of 1-star rating. The minimum allowed EER for room air conditioners have been increased two times in 2012 and 2014. The

Table 1 Periodic strengthening of performance standards of split air conditioners in India

	Range of EER (W/W)					
	2010–11		2012–13		2014–	
	Min	Max	Min	Max	Min	Max
1-star	2.30	2.49	2.50	2.69	2.70	2.89
2-star	2.50	2.69	2.70	2.89	2.90	3.09
3-star	2.70	2.89	2.90	3.09	3.10	3.29
4-star	2.90	3.09	3.10	3.29	3.30	3.49
5-star	3.10		3.30		3.50	

Table 2 Periodic strengthening of performance standards of frost-free refrigerators for a given storage volume in India[a]

	Range of electricity consumption (kWh/y)							
	2010–11		2012–13		2014–15		2016–	
	Min	Max	Min	Max	Min	Max	Min	Max
1-star	1015	812	812	650	520	416	416	333
2-star	812	650	650	520	416	333	333	266
3-star	650	520	520	416	333	266	266	213
4-star	520	416	416	333	266	213	213	170
5-star	416		333		213		170	

[a]Storage volume of 250 litre

maximum allowed electricity consumption of frost-free refrigerators has been decreased three times in 2012, 2014, and 2016. The impact of the strengthening of standards on the range of EER for split air conditioners and the range of electricity consumption for frost-free refrigerators of the most commonly sold size of a refrigerator in different star rating categories is shown in Tables 1 and 2.

The impact of the strengthening of standards on the share of the star rating in the two appliances is also seen in Fig. 1. In the air conditioner sales, the share of 3-star and 5-star has increased steadily despite an increase in efficiency standards in 2012 and 2014. In the refrigerator sales, after an increase of standards in 2014, the market is dominated by 2-star and 3-star refrigerators. This shows that the impact of the strengthening of the standards is not the same in the two appliances. Particularly, this indicates that after strengthening of standards, the air conditioner market continued moving toward higher star rating, but the refrigerator market shifted from higher star rating models to lower star rating models.

The impact on the electricity consumption of the two appliances due to the program can be calculated using data on the share of star rating in sales and allowed electricity consumption in each star rating. The maximum allowed electricity consumption in each star rating is used to calculate the maximum weighted electricity consumption in the two appliances. The annual electricity consumption of refrigerators under test conditions is given on the star labels in kWh/year. The information

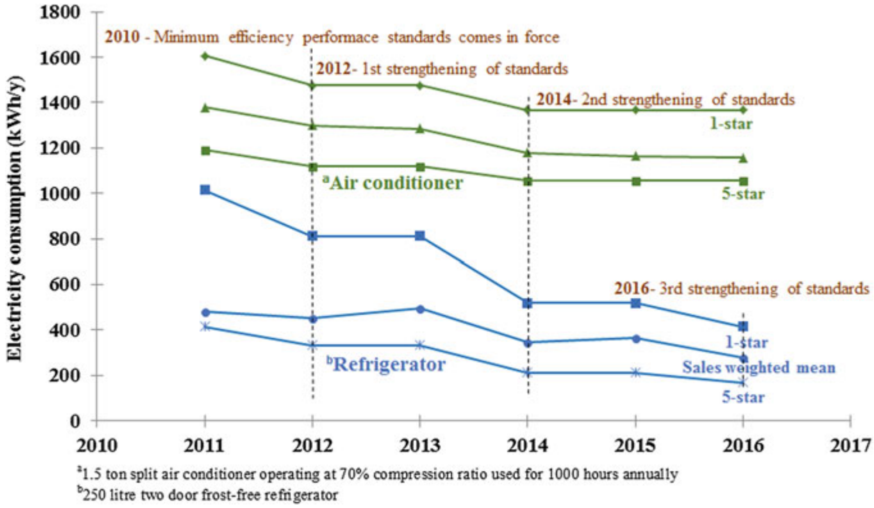

Fig. 2 Star rating range and sales-weighted electricity consumption of air conditioners and refrigerators in India

on the labels relating to the electricity consumption of air conditioners is the EER. The annual electricity consumption of air conditioners can be calculated by assuming usage and compression ratio. The cooling capacity of a 1.5-ton air conditioner is 5275 W (18,000 Btu/hr). The ratio of cooling capacity and EER gives the power input of the air conditioners. The annual electricity consumption in different star ratings is calculated assuming compression ratio of 70% and usage of 1000 h. The range of electricity consumption between 1-star and 5-star rating and the sales-weighted electricity consumption using the maximum allowed electricity consumption is shown in Fig. 2.

The electricity consumption of the air conditioners has declined at an average annual rate of 3% during 2011–2017. The percentage of reduction in energy consumption in refrigerators in the period 2011–2017 is 8%. The electricity consumption is calculated for the most commonly sold sizes of the two appliances for comparison purpose. The sales-weighted electricity consumption is estimated using the maximum allowed electricity consumption in each star rating band and hence is only indicative of the change in electricity consumption. The maximum allowed electricity consumption of air conditioners and refrigerators decreased at annual rate of 2.3 and 12%.

A rough estimate of the realized energy savings from the program can be made using the growth rate in sales of appliances and the change in the rate of efficiency improvements due to the program. The sales of room air conditioners have increased from a million in 2003–04 to 3.4 million in 2010–11 and are estimated to be 4.3 million in 2016–17 suggesting a CAGR of 10% over the last thirteen years. The sale of refrigerators has increased from 8.4 million in 2010–11 to 11.4 million in 2016–17 growing annually at 7%. It has been reported in the literature that in the absence of S&L program the rate of efficiency improvements will be in the range of 0.5–1%. Assuming 1% annual reduction in energy consumption in the absence of the S&L program in India, the savings due to 3 and 8% reduction in electricity consumption of air conditioners and refrigerators, respectively, are calculated. The cumulative energy saving in 2016–17 from 2011 is 3.5 BUs due to air conditioners and 4.3 BUs due to refrigerators. The cumulative energy saving from the two appliances from 2011 to 2017 is approximately 7.8 BUs.

The electricity savings at the generating plant is calculated by taking into account the transmission and distribution losses (T&D). The emission reduction is calculated by multiplying the saving at the generating end by the emission factor for electricity generation. In India, the CO_2 emission factor for all grids in 2013–14 was 0.83 t CO_2/MWh, and the T&D losses in 2015–16 were 22%. The cumulative emission reduction due to energy efficiency improvements in air conditioners and refrigerators is 7.8 MT of CO_2 equivalent.

The potential cumulative energy reduction can be calculated assuming the growth rate of annual sales of appliances and reduction in energy consumption due to energy efficiency. If the energy consumption of the two appliances continues to decrease at 3% annually, the energy consumption of average appliance in 2035 will be equal to the most energy-efficient appliance in India in 2017–18. If the sales of appliances continue to grow at the current rate and the energy consumption decrease at 3% each, the emission reduction from the two appliances will be 156 Mt CO_2 equivalent in 2035. The emission reduction can be accelerated by boosting the rate of efficiency improvements in appliances.

3.2 Consumer Response

The rate of energy efficiency improvements in appliances and hence the potential of emission reduction depends critically on consumer willingness to pay (WTP) for higher efficiency. Based on a country-level survey, Dhingra et al. (2016) show that consumers have responded positively to the S&L program. The study reports that energy efficiency is not a top priority for the consumer in the purchase decision as compared to other factors such as product life and brand name. The consumer WTP for a labeled product is also estimated using direct elicitation method. It is found that most consumers are willing to pay 10% price premium for a labeled product.

In a recent study by the authors, the consumer WTP for the presence of labels and higher star rating is estimated using a discrete choice experiment. In a stated preference survey in April 2015, the choices of a random sample of 302 consumers in Mumbai suburban district were observed in a hypothetical purchase of air conditioners and refrigerators. The findings of the study on consumer preference for labels in air conditioner purchase can be found in Jain et al. (2018). It is found that consumer WTP for the presence of a label on air conditioners is 36% of the price of the air conditioner. It is also found that the consumer preference for star rating levels varies in the sample such that 69 and 78% of consumers place a positive value on the 3-star and 5-star, respectively. The mean of the value placed on the 3-star and 5-star is 12 and 25% of the price of air conditioner, respectively. The consumer WTP for higher star rating is also found to be varying in the sample. The distribution of WTP is such that 62% of the consumers have placed a higher value on the 5-star over 3-star. The mean WTP for the 5-star as compared to 3-star is 12% of the mean price of the air conditioner. The differentiated response to the star rating levels in refrigerators is also reported by the authors in Jain (2018). It is found that consumers differentiate between star rating levels in air conditioners but not in refrigerators. In a between-group experiment design, the impact of additional information on annual operating cost on consumer WTP is also estimated. The impact of the additional information is not significant in air conditioner purchase. However, the consumers use the annual operating cost information in refrigerator purchase to differentiate between star rating levels.

Empirical research on consumer response to policy intervention can provide useful input to improving the effectiveness of energy efficiency policies. For example, as found by the authors, the difference in consumer response to labels in air conditioners and refrigerators shows that even large appliances cannot be considered together in policy design. Energy efficiency programs are sometimes designed in conjunction with labeling programs such as information programs and financial incentives. The choice between alternative policy instruments based on cost-effectiveness can be facilitated by research on consumer response. For example, it is found that in general, consumers have high WTP for efficient air conditioners and may not require financial incentives for adoption of higher-rating models. Consumers are also found to have high WTP for efficient refrigerators. However, the reported indifference to star rating levels could be due to factors such as lack of information on operating cost. Hence, provision of information on operating cost can be considered to increase the rate of penetration of high star rating refrigerators.

4 Conclusions

The mitigation strategies identified in India's NDC to achieve the emission reduction target rely upon technology policies. Ensuring efficient outcome of these policies is hence critical. Energy efficiency is playing an important role in the reduction of emissions intensity of the Indian economy. The improvements in energy efficiency in appliances have been facilitated by policy interventions such as information programs, regulations, and financial incentives. The potential of energy efficiency can be realized by monitoring the impact of the existing programs and designing new programs to complement the existing programs. Development of database of key parameters relating to the program to facilitate empirical research can contribute in overcoming the barriers to program evaluation. Improving the effectiveness of policy interventions by timely evaluation can enhance the contribution of energy efficiency to energy savings and emission reduction.

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