Public Understanding of Energy Efficient Household Technology: Exploring the Role of Standards and Labels in India

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DECLARATION

I declare that the thesis entitled **"Public Understanding of Energy Efficient Household Technology: Exploring the Role of Standards And Labels in India"** submitted by me for the award of the degree of **Doctor of Philosophy** of Jawaharlal Nehru University is my own work. The thesis has not been submitted for any other degree of this university or any other University.

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We recommend that this be placed before the examiners for evaluation.

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I find you here and everywhere,

When the first drop of rainfall falls on this soil,

I get mesmerized with your smile,

When the first ray of sun, shines on a leaf,

You are there, you make me believe,

When these birds fly in the sky,

I find you there, free for a while,

When I see through the window of time, I wish…

You my braveheart, live long in the horizon of time,

I'll meet your there at the lapse of time…

You, a beautiful soul,

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PhD was a cycle journey me, where I was on two wheels balancing, moving, meeting other cyclers[1]*, making friends, halting, speeding up, falling down, getting up, again falling, and again moving. The two tyres of my cycles were strong, kind and always supported me during rough weather, uneven roads and unseen circumstances. They have never failed me through this journey and have finally bought me towards the end of it. One of the wheels belongs to my university i.e. Jawaharlal Nehru University and other wheel were made by my family and friends.*

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[1] From *cycle* + *-er*; someone that uses a cycle (or bicycle). In my case, cycler refers to people who are riding the cycle of research and doing a PhD.

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Abbreviation

ACEEE	American Council for an Energy Efficient Economy
ACs	Air Conditioners
AQSIQ	State General Administration for Quality Supervision, Inspection and Quarantine
AUS	Australia
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BLY	Bachat Lamp Yojana
CCS	Carbon Capture and Storage
CEA	Central Energy Agency
CECED	European Committee for Domestic Equipment Manufacturers
CECF	Central Energy Conservation Fund
CFCs	Chlorofluorocarbons
CFLs	Compact Fluorescent Lamp
CLASP	Collaborative Labeling and Appliance Standards Program
CNIS	China National Institute of standardization
CO_2	Carbon dioxide
CPRI	Central Power Research Institute
CSIR	Council of Scientific and Industrial Research
CTE	Committee on Trade and Environment
DELP	Domestic Efficient Lighting Program
DISCOMs	Distribution Companies
DoE	Department of Energy
DSM	Demand Side Management
DST	Department of Science and Technology
DT	Distribution Transformers
EC	Energy Consumption
ECBC	Energy Conservation Building Code
EE	Energy Efficiency
EEA	Energy Efficient Appliances
EEC	European Economic Community
EEFP	Energy Efficiency Financing Platform
EESS	Energy Efficiency Standards Subcommittee
EET	Energy Efficient Technology
EGEE	Expert group on Energy Efficiency
ELIS	Environment Labeling and Information Schemes
EMIs	Equated Monthly Installments
EPS	Minimum Energy Performance Standards

ERDA	Electrical Research and Development Association
ESS	Evaluation Standard Subcommittee
EU	European Union
FAO	Food and Agriculture Organization
FEEED	Framework for energy efficient economic development
FTC	Federal Trade Commission
GDP	Gross domestic product
GHGs	Greenhouse Gases
GMOs	Genetically modified organisms
GW	The Gigawatts
IEA	International Energy Agency
IHDS	India Human Development Survey
IISc	Indian Institute of Science
IISERs	Indian Institutes of Science Education and Research
IITD	Indian Institutes of Technology – Delhi
IITs	Indian Institutes of Technology
INR	Indian National Rupee
IPCC	Intergovernmental Part on Climate Change
ISEER	Indian Seasonal Energy Efficiency Ratio
ISO	International Standardization Organization
JPN	Japan
LBNL	Lawrence Berkeley National Laboratory
LEDs	Light Emitting Diodes
LPG	Liquefied petroleum gas
MEES	Minimum Energy Efficiency Standards
METI	Ministry of Economy Trade and Industry
MNRE	Ministry of New and Renewable Energy
MoL	Ministry of Law
MoP	Ministry of Power
MPCE	Monthly Per Capita Consumer Expenditure
MTEE	Market transformation for energy efficiency
MW	The megawatts
N.I.T.I	National Institution for Transforming India
NAPCC	National Action Plan on Climate Change
NDCs	Nationally Determined Contributions
NFHS	National Family Health Survey
NGOs	Non-governmental organizations
NIST	National Institute of Standards and Technology
NMEEE	National Mission of Enhanced Energy Efficiency
NSSO	National Sample Survey Office
OLS	Ordinary Least Square
PAT	Perform, Act, and Trade

PDS	Public Distribution System
PUS	Public Understanding of Science
R&D	Research and Development
S&L	Standards and Labeling
S&T	Science and Technology
SBTS	State Bureau of Technical Supervision
SC	Stated Choice
SDAs	State Designated Agency
SDGs	Sustainable Developmental Goals
SEBs	State Electricity Boards
SEC	Specific Energy Consumption
SERB	Science and Engineering Research Board
SETC	Economic and Trade Commission
TC	Technical committees
TERI	The Energy Research Institute
TFLs	Tubular Fluorescent Lamps
TPB	Theory of Planned Behavior
UDAY	Ujwal Discoms Assurance Yojana
UGC	University Grants Commission
UJALA	Unnat Jyoti by Affordable LEDs for All
UK	United Kingdom
UNCED	The United Nations Conference on Environment and Development
UNOPS	United Nations Office for Project Services
US EPA	U.S. Environmental Protection Agency
USA	United States of America
UTs	Union Territories
W	Watts
WTO	World Trade Organization
WTP	Willingness to pay

Chapter 1
Introduction

1.1 Background

Being efficient in energy consumption and production is strived by every nation as it is increasingly recognized as the path towards reducing energy consumption and minimizing the impact of global climate change in cost-effective manner (Limaye and Limaye, 2011). Since 1970s, industrialized nations have focused to make themselves more energy efficient society by targeting their policies to improve energy efficiency in all sectors which allows them to reduce their energy consumption (Geller et al., 2006). Developing nations on the other hand are also trying to catch up in the race of increasing efficiency but fall short due to various barriers. Government of these nations are mainly focusing on demand side management (DSM) programs and providing financial incentives to promote increased energy efficiency as a measure to address the problem from consumption side (Limaye and Limaye, 2011). It is estimated that doubling the energy efficiency improvement would allow the world to hold CO_2 concentrations below 550 ppmv, avoid $3 trillion worth of new generation which can save $500 billion/year of consumers by 2030, and eliminate the same amount of energy supplied by 2000 coal power plants and also return to 2004 energy consumption level (EGEE, 2007). World scenarios for emissions can reach about 450 ppm CO2eq which is characterized by continuous improvements in energy efficiency and increasing the share of zero and low carbon energy supply from renewable, nuclear energy and energy with carbon capture and storage (CCS) facility or provision of bio-energy with CCS by year 2050 (IPCC, 2014).

Improving energy efficiency is assumed to be the key to solve the "energy trilemma" i.e. issues surrounding energy security, environmental sustainability and energy equity (WEC, 2013) and remains to be most cost effective option for GHGs mitigation for coming decades. Different lines of research have showed different pathways to policymakers to choose from the given alternatives like Lovin's soft energy path emphasize on shifting fossil fuel based centralized energy system towards energy efficiency and renewable energy based sources (Lovins, 1977). While others indicate that this path would not result in considerable increase in energy saving rather will increase the energy consumption (Sorell, 2009). To analyse what is wrong with energy efficiency and what is right with energy efficiency is not in the capacity

of this work[2]. This study assumes that energy efficiency can result in considerable reduction in energy use, if the individuals are enough aware about the present scenario of energy production, energy related concerns, energy pricing, consumption scenario and are motivated enough to change their energy consuming behavior.

Individual's energy consumption is shaped by various factor i.e. physical, socio-economic, cultural, technological, geographical, infrastructural and behavioral (Yun and Steemers, 2011), (Ekholm et al., 2010), (Jones et al, 2015), (Joon et al, 2009),(Pachauri and Jiang, 2008), (Van Raaij and Verhallen, 1983), (Schipper et al, 1989), (Brounen et al, 2012), (Subbiah et al, 2017), (Najmi and Keramati, 2016). In last few decades, energy demand from residential sector has sharply risen and it is projected to further increase in coming years (Isaac and Van vuuren, 2009). To reduce this ever increasing demand of energy, policymakers has advocated for various policies, programs and incentives across the world. Introduction of energy efficient technologies[3] is seen as a one of the most tempting option to reduce the energy consumption in households without compromising on quality and amount of service. Using energy efficient technology can result in avoiding electricity produced in otherwise inefficient system and reduces carbon emissions (Jaffe, Newell and Stavins, 2001). In India, studies have projected 45 per cent per unit energy saving by using highly efficient refrigerators and air conditioners between 2010 and 2020 (Mc Neil *et al.*, 2005). In another recent study, it is estimated that the energy savings of 52 bkWh to 145 bkWh from four appliances i.e. ACs, refrigerators, TV and ceiling fans by 2030 in India (Parikh and Parikh, 2016).

Even though there is availability of end-use energy efficient technology in the market, it is not widely adopted by the consumers ('*energy efficiency gap')* (Jaffe and Stavins, 1994; Hirst and Brown, 1990). It is crucial to appreciate that adopting a technology is a decision of "*complete use of a new product/technology as the best course of action available*" (Rogers, 2003, p.177). It can be adopted at different time frames of innovation i.e. there can be innovator adopters, early adopters, early majority, late majority, and laggards. The innovator adopters are highly innovative while laggards are least innovative. The adoption process is

[2] To discuss the debate around energy efficiency refer Shove (2018) who used Latour's notion of purification and Hodders's idea of entanglement. Shove advocates that to reduce carbon emissions, it is important to acknowledge meaning and level of service and its consumption types but, Fawcett and Rosenow (2018) in their commentary noted energy effficiecny is vital for low carbon future.

[3] Energy efficient technology "*seek to use less energy while performing any energy dependent activity and simultaneously minimizing the corresponding (negative) environmental impact of energy consumption"*. The definition is accessed from the website of UNIDO.[3].

related to personality, values and attitudes which affect the time and nature of adoption. It is also influenced by adopter's heterogeneity[4] and adopter's learning (Rogers, p.178). In case of energy efficient technology, adoption process can be affected by energy prices and technological innovation (Jaffe and Stavins, 1994). Few studies have tried to understand the adoption of energy efficient technology, but majority of them have focused on developed countries only (Mills and Schleich, 2012). Therefore, research has to be aligned in such a way that can successfully reflect the role of information in technology adoption process in different scenarios, boundaries and time.

Energy efficiency and Information

Various barriers explain the energy efficiency gap[5] and inability of consumers to adopt an efficient technology. Few barriers can turn into market failures when there is absence of adequate private sector incentives for Research and Development (R&D), or when there is not enough information available to consumers related to benefits and cost of adopting energy efficient technologies or when there is presence of principle-agent problem [6](Jaffe, Newell and Stavins, 2001). Information shortage or inadequate information related to energy efficiency and energy efficient technology amongst the consumers can also lead to market failure. It is observed when consumers are not able to inspect the energy efficiency due to the information asymmetry; they fail to invest in efficient technology, which leads to adverse selection in the market place (Akerlof, 1970).Thus, various policy interventions like standards and disclosure mechanism like energy labels, energy certificates and feedback programs are formulated to justify this lack of information (Gillingham and Palmer, 2013; Sanstad et al., 2006; Ramos et al.,2015; Weachter et al., 2015, Banerjee and Soloman, 2003; Davis and Metcalf, 2016).

[4] The adopter heterogeneity model assumes that different individuals put different values for innovation (Rogers, 2003).

[5] Hirst and Brown (1990) noted that the presence of structural and behavioral barriers. Structural barriers includes distortions in fuel prices, uncertainty related to future fuel prices, limited access to capital, government fiscal and regulatory policies, codes and standards while behavioral barriers encompasses perceived risk of investment on energy efficiency, information deficits, split incentives etc. while sorrell et al.,(2004) classified barriers into imperfect information, split incentives, bounded rationality, hidden costs, risk and uncertainty, lack of access to capital.

[6] Principle agent problem arises when landlords pay for utility bills rather than tenants which make it less rewarding for them to make their property as energy efficient.

Energy efficiency gap due to information asymmetry is projected to be reduced by introducing energy standards[7] and labels[8] which prescribe the energy performance of end-use household appliances. Standards are seen as creators of optimum order in man-made world as it creates common understanding of technology or management system between makers and users or between sellers and buyers. It also helps to reduce the transaction costs or risks in market economy to facilitate the exchange of information and merchandise (Kurihara, 2000). For ensuring energy efficiency, various standards i.e. Prescriptive standards, Minimum Energy Performance Standards (MEPS) and Class Average Standards are used by different countries to limit energy consumption levels[9] (McMahon, 2001) in end-use household technology. Most of the countries use MEPS for their household technology which is the combination of performance based and attribute based regulation[10] where maximum amount of energy a given product can use, is a function of small set of product characteristics. Standards reduce risk and uncertainties by creating a market for energy saving technologies. They also reduce the cost of technology with time and ultimately diminish the need for information and effect of split incentives which in turn help to overcome the inertia of routine and habits (Cooper, 2013).

Energy labels work along with standards in the form of standards and labeling (S&L) programs. These programs are usually the first order of policy intervention for market transformation of specific end-use. The energy efficient standards shift the distribution of energy efficient models of products sold in the market upwards by eliminating inefficient models whereas energy labels shift the distribution of energy efficient models upwards by

[7] Mc Mahon and Turiel (1997) defined energy efficiency standards are "well defined protocols or procedure used to estimate the sufficiently accurate energy performance of a product in the way typically used, or at least a relative ranking of its energy performance compared to other models"

[8] It is also considered as a label, mark or brand which expresses its distinguishing feature to a group of people which are related or it functions as a common language, required for communication between the labeled product and its users.

[9] Prescriptive standards require particular features to be installed in all new products. MEPS prescribes minimum efficiencies or maximum energy consumption that manufactures must be able to achieve in each product while class average specify average efficiency of manufactured product, allowing each manufacture to select the level of efficiency for each model so that overall average can be achieved. Mostly standards used for various households' products i.e. refrigerators, freezers, cloth washers, washing machine and others products have been applied to each unit of every model manufactured and for this manufacturer can use any combination of technologies to meet particular standards. In Japan and Switzerland, manufacturer has given discretion to achieve different levels of energy efficiency in different models till energy saving target is achieved. As average is aggregation of different efficiencies of different models and depends heavily on relative sales of different models which create uncertainty about meeting the target on reporting date for compliance with standards. Moreover, It also requires elaborate framework during formulating procedure, enforcing compliance, manufacturing, and shipping (McMahon, 2001).

[10] attribute based regulation are set as a function of size or overall capacity along with other features (e.g. design, color, mounting etc.) and try to ensure that the regulation does not restrict the choice set or distort the quality in the non-energy dimension (Ito and Sallee, 2014), While, however it is likely to distort the product quality (Houde and Spurlock, 2015)[10].

providing information to consumers which helps consumer to have rational decision and force manufactures to design products of higher efficiency with time. However, there is no consensus among the scholars whether availability of information through standards and labels leads to adoption of energy efficient technology or not, as all consumers react to information differently in different contexts (Anderson and Newell, 2004). It is highlighted that for some consumers, broad and simple information was found to be easy to understand and led to better choices (Banerjee and Soloman (2003) while other studies suggest that tailored and specific information lead to more informed and rational choices (Davis and Metcalf, 2016). Waechter et al., (2015) revealed that consumers in European Union (EU) base their estimates of a product's energy consumption majorly on energy efficiency class and ignore information about annual electricity consumption present on energy label. Labels was found helpful in disseminating important information to consumers about energy efficiency of the technology but was not found to be related to the change in energy consumption behaviour (McNeill and Wilkie, 1979).

Studies have also examined the role of information (general and specific) in shaping environmental attitudes and behaviour (Kollmuss and Agyeman, 2002; Schultz, 2002) but the relationship between information and attitude towards energy saving is still not very well understood. The energy consumption behavior is shaped by various factors like their energy concerns, money saving attitude, personal norms, and barriers to behavior, biospheric and altruistic values. It is highly complex system to understand the energy consumption and conservation behavior of consumer in clear picture. Studies shows that socio-demographics and social contextual variables like cost, legal regulations, policies, availability of technology and information, role models, pricing, values[11] and social conditions affect energy consumption behavior (Yan and Lifang, 2011; Gram-Hanssen et al., 2007) while routine, culture and technology was also found to be important in shaping energy consumption pattern (Lutzenhiser, n.d.; Elizabeth Shove, 2004).

As information on the energy labels is weighed differently by different consumers (Janßen and Langen, 2017), it becomes significant to examine how consumers react to information given on energy labels. Do their understanding of information on energy labels shapes the

[11] Schwartz (1992) defined values are *"desirable goals, varying in importance, that serve as guiding principles in people's lives"*

decision making of (non)adopting the energy efficient technology. If yes, then what kind of information and how much information are apt for consumers? All the above questions are discussed in energy efficiency literature but most of the studies have restricted themselves to developed nations. How consumers of developing nations react to such information is still under researched area. Thus, it becomes crucial to understand that the way consumers react to information is directly related to his/her understanding about the information and understanding of information is shaped by various internal (socio-economic, demographic, personal motivations etc.) and external (role of manufacturers, policy making etc.) factors.

Public understanding of 'energy efficiency'

Energy efficiency is most frequent term used in energy policy in context of energy saving but its understanding as a concept is not found to be well understood. It is seen as a process of saving energy and reducing energy bills (in households). The understanding of energy efficiency among consumers is restricted to energy consumption and energy saving aspect but, the science behind 'energy efficiency' and 'energy efficient technology' is least known and appreciated. It is considered as technical knowledge generated by established institutions and set of national and international experts. This knowledge is not visible to consumers as 'energy efficiency' is a technological innovation which limits the energy usage of a technology. It can be pointed out only if the information about the technological innovation is documented and presented in an easy to understand format. For government and policy makers labeling is important as consumers "need to know" (Caswell and Anders, 2011) about the product to make an informed decision. But studies have noted that the information presented on energy labels is not well understood by consumers which results in energy efficiency gap. Therefore, to enhance the public understanding about energy efficiency and energy efficient technology, labeling programs, advertisements (audio and video), information campaigns, and training programs are being carried out so that public can appreciate the energy efficiency and take a decision towards adopting a efficient technology.

The idea of making people understand about recent scientific information and artifacts is not a new one; it goes way back to the time of world wars. For the first time, Bodmer Report of Royal Society Committee (1985) of England noted the need of making people more aware about the science and scientific developments as it was assumed that public doesn't possess enough information. Therefore, providing more information about science was aimed at

making public more receptive to new scientific outcomes and technologies. It further led to the rise of deficit model of Public Understanding of Science (PUS) (Bauer et al., 2007). The term '*deficit'* reflects relative ignorance of public about science and therefore, experts or scientists are required to transfer the information to improve their understanding related to scientific facts and artifacts (Scheufele, 2013) and new technology (Ziman, 1991).

In the last few decades, many studies have identified the lacunas in the deficit model of public perception, understanding and action about any techno-scientific phenomena (Owens, 2000, p.1144) due to its failure to appreciate the tacit knowledge and common understanding of public. It was also argued that everyone may not understand the complexities of the science but they are not empty-headed, "*they are aware about the commercial imperatives, skeptical about politics and distrustful of competence and impartiality of regulatory framework*" (Owens, 2000). The model fails to consider the psychological, social and institutional contexts which shapes the attitude formation (Nisbet and Scheufele, 2009; Owens and Drifill, 2008) towards new scientific advancement or new technology. Moreover, it allow communication to flow in one direction only i.e. from science to public and considers public as passive (Gross, 1994).

In modern democratic societies providing accurate information is found important, as it facilitate choosing the policy that best reflects interest of individual or group (Sturgis and Alum, 2004). Therefore, to inculcate the energy conservation and efficiency behavior, knowledge about energy related issues is seen as imperative (Bellinger et al., 2004). In some cases, knowledge is not a lever of positive attitudes rather of quality of attitudes. It makes the difference between attitudes and non-attitudes but not between positive and negative attitudes (Bauer et al., 2007, p.84). Research have also indicated that providing information in the form of energy label is important but not necessary (Grolleau, Ibanez, Mzoughi, and Teisl, 2016). As when consumers are provided with information in the form of labels, only few consumers may read and process all the information presented on the labels. Even if consumers recognize the label, it is difficult for them to understand that what label intends to communicate and the uncertainty in understanding the meaning is also found to be linked to mistrust (Thøgersen, 2000). In few instances, consumers are also found to suffer from information overload and mis-presentation of information (Banerjee and Solomon, 2003). Hence, information can lead to higher levels of knowledge but may not necessarily lead to change in behavior towards certain concerns (Abrahamse, Steg, Vlek, and Rothengatter,

2005). Energy labels were found to be negatively correlated with the purchase intention and do not encourage public to adopt more efficient technology (Zainudin, Siwar, Choy, and Chamhuri, 2014). It is important to note that the way issues and policies surrounding energy consumption are framed, it can influence how individual respond to various measures of energy saving. Thus, it becomes relevant to understand on how people conceptualize energy and energy efficiency. How energy labels shape the ways people understand energy labels. Which information is most important for them to make decision? Do people really understand and use all information provided on the labels? How various factors influence their understanding especially in developing countries like India?

1.2 Motivation of the study

In India, household sector is projected to emerge as one of the largest and strongest sector consuming electricity in coming years surpassing industrial, agriculture, commercial and other sectors (N.I.T.I., 2015; PTI, 2016; Bureau, 2017). This increase is accounted due to increase in income, availability of electricity, easy and affordable access to household appliances (PTI, 2016). It is projected that appliance ownership in Indian households will observe a rise in urban as well as rural areas because of first time electricity connections to 230 million people which are estimated to grow at 10 per cent annually in next 10-15 years (PTI, 2016). A special concern revolves around the increasing penetration of electrical appliances in rural households due to rural electrification in coming years in the country. These households will be first time buyers and if they take a decision of buying an appliance which is less efficient in terms of electricity consumption, it may result in to cycle of increased electricity demand and more production. As also projected in a study, every Indian household will possess an electric fan, mobile phones, and TV and 70 Per cent household will have refrigerators and 18 per cent will possess air conditioners (Parikh and Parikh, 2015). Therefore, shifting the policy directions towards energy efficient technologies can reduce energy demand and also reduce the emission from fossil fuel based sources.

The adoption level of energy efficient technologies in India is not well documented and even if there is any, author is unable to find it in public domain. Parikh and Parikh (2015) used the data from BEE website and gave the penetration levels of various energy efficient products of different star ratings in Indian households during 2008-12. They indicated that adoption of 5- starred electric fans; refrigerators and ACs are increasing with time. While, the same trend

cannot be observed for television as it is showing decreasing adoption of 5-star and 3-starred TV and increased penetration of 4 star TV. The reason for this shift can be due to price of product, need of consumers and usage behavior of consumers (refer figure 1, Annexure I).

Therefore, it will be important to have more awareness about the energy efficiency of those consumers who will be first timers, or consumers who will be replacing their 10-15 years appliances in coming years. It will be relevant that they can base their decision on standards and labels provided under Indian Standard and Labeling (S&L) program[12] which can help them to reduce the electricity consumption. Although, most of the high energy consuming appliance have to follow mandatory standards and required labeling, but people often fail to invest in most efficient product in the category. This can be partially due to inability to give full attention to these energy labels, understand it and take required decision. Sometimes people fail to calculate the energy savings from these labels and thus cannot compare the exact savings due to this buying decision. They also give higher importance to initial cost of the appliance (efficient appliances generally have higher initial cost) and fail to estimate the savings in terms of money by using an efficient product.

As energy consumption is something which people won't be able to see by seeing the label only therefore, it is more important to generate the trust on the knowledge generated by experts in the form of standards. Moreover, information on labels also needs to be trusted by the consumers to gain more attention towards labels. In particular, research on the effects of online information provision is required as consumer now a day's heavily rely on internet to collect information about household energy consuming technologies before making any purchase either online or offline (Gerarden et al., 2015). This research examines the public understanding of energy standards and labels in India and tries to see how this understanding shapes their decision making? This study can enable Indian policy makers and energy professionals in better planning further information related policies. Moreover, it can also show the way to government towards better diffusion of energy efficient technologies and can also indicates the changes need to be done at different levels i.e. retailers, shopkeepers and consumers. The research objectives and research questions are as following:

[12] Indian Standard and Labeling (S&L) program started in 2006 and was based on extensive consultation with industry, consumer associations and other stakeholders. Under this program, energy labels were formulated which provided information about the appliance e.g. dimensions of appliance, standard followed, energy consumption and energy efficiency and star rating ranging from 1 to 5 in ascending order of energy efficiency is given to product registered with the BEE (BEE website).

Research objectives

1. To examine the present scenario of energy efficiency in India.
2. To analyze the policies and programs for the promotion of energy efficient technology in households with special emphasis on S&L programs.
3. To explore the Public understanding of energy standards and labels at household level.
4. To analyze conceptualization of term 'energy efficiency' in India.
5. To examine the role of information on energy labels in influencing consumer's decision in adoption (non-adoption) of energy efficient technology?

Research Questions

1. What is the present scenario of energy consumption and energy efficiency in India?
2. What are various programs and policies at place for encouraging adoption of energy efficient technology in households?
3. How public conceptualize the term "energy efficiency" in Indian households?
4. How public understands the energy standards and labels for energy efficient technology in Indian households?
5. What role does information on energy labels plays in adoption or non-adoption of energy efficient technology?

1.3 Methodology

To cater to the above research questions in this study, mixed methods were used. It involved collection, analysis and interpretation of quantitative as well as qualitative data. An extensive literature review was conducted to examine the current scenario of energy consumption and energy efficiency in India. Secondary literature review was undertaken from libraries of Bureau of Energy Efficiency (BEE), The Energy Research Institue (TERI) and Jawaharlal Nehru University (JNU). While primary data was collected through a questionnaire which was prepared using an online platform known as SurveyMonkey. The questionnaire was divided into 3 major sections. First section included questions related to awareness and public understanding about energy consumption, energy efficiency and energy efficient technologies. Second section consisted of three stated choice experiment to understand the

energy efficiency gap among the respondents and also to measure the willingness to pay (WTP) for most efficient technology. Third section included respondent's socio-economic characteristics. The questionnaire was circulated among consumers of various age groups, educational qualification and different socio-economic conditions, who were asked to forward the questionnaire to their friends and relatives. The online survey collection method was used to reduce the cost of data collection and compilation, to save time and most importantly because respondents were comfortable responding to an online survey as compared to face-to-face method.

1.4 Outline of thesis

The outline of thesis is as follows:

Chapter 1: Introduction

This chapter provides the background to the present research underlines the motivation of this study in Indian Context and also highlights the research objectives and scope of the study surrounding the present research.

Chapter 2: Literature Review and Theoretical Perspective

This chapter examines the present electricity demand and consumption scenario in India with emphasis on household sector. The chapter also analyses the trend of knowledge production around energy efficiency in world and India through bibliometric analysis using Scopus database and further highlights the theoretical perspective around energy standards and labels.

Chapter 3: Public understanding of energy efficient technologies: A conceptual framework

This chapter highlights and discusses the conceptual approaches that provide a framework in which this study is situated. This study draws conceptual insights from Public Understanding of Science (PUS) and proposes a framework that helps to understand consumer decision

making of adopting and not adopting an energy efficient appliance. It also examines the role of various factors in decision making.

Chapter 4: Standards and Labels: Policies and Programmes in different Countries

This chapter aims to understand standards and labels in the context of energy efficiency in household sector as two entities which work together to achieve reduction of energy demand successful. It also provides an extensive literature review about standards and labels and explains the importance of standard and labels. The chapter will further analyse S&L programs of select nations i.e. China, European Union (EU), United States of America (USA), Japan and India to underline the differences in policy perspectives of these countries.

Chapter 5: Methodology

The chapter describes the fundamental research methods adopted in this study. It discusses the research strategy, research design and data collection methods.

Chapter 6: Public understanding of Energy Efficient Technology: An empirical Analysis

This chapter aims to discuss the results originated during the study. It analyses the public understanding of energy efficiency and energy efficient technology in Indian households.

Chapter 7: Energy Labels and Adoption of Household Technology: An empirical

This chapter analyzes the role of information on energy labels in decision making about energy efficient technology in Indian households. It also discusses the factors affecting the decision making of respondents.

Chapter 8: Conclusion

The chapter concludes the study and provides insights about the present in the lights of discussion. It discusses the contributions as well as the limitation of the research. It further proposes the recommendation on the energy policy makers and provides scope for further research.

1.5 Summary

World economies are concerned with plethora of issues and “energy” is one of most important concern for every nation as each nation wants to increase their energy consumption and make them energy ‘secure’. Along with the increasing energy demand they want to decrease their carbon emissions. This conundrum of ‘want to increase the energy demand’ and ‘want to decrease the carbon emission’ is known to everyone and it seems as if there is no way out of it because energy demand is bound to increase, so will its generation and therefore carbon emission (till the time fossil fuels are available). Various measures have been found and various technologies were sworn upon to mitigate climate change. Research has highlighted the importance of energy efficient technologies in reducing the demand and decreasing emissions. To inform public about such technologies standards and labels are being increasingly used. This study tries to understand how this information i.e. standards and labels shape the understanding of people and affect their decision making.

This investigation of public understanding of energy efficiency and energy standards and labels can help practitioners and policymakers in formulating policies related to disclosure mechanism. Though various studies (as mentioned above) have indicated the relevance of energy labels in shaping decision making in developed nations but its impact in developing nation is still under wraps and needs to be explored. This research provides an opportunity to examine the relationship of public understanding and decision making related to energy efficient technology.

Chapter 2
Literature Review and Theoretical Perspective

2.1 Introduction

After the oil embargo of 1975 and energy crises of 1979, world started emphasizing on energy conservation and energy efficiency to reduce the energy consumption. 'Energy efficiency' and 'energy conservation' are two different concepts which aim to achieve similar goal. Energy efficiency reduces demand of energy by "*using less input energy and producing more output*". It is a long run change, usually harnessed with the use of technology and does not seek to compromise on consumption behavior while 'energy conservation' is defined as "*reduction of total amount of energy consumed"* and requires change in consumption behavior. Both of them have their relevance, but yield better results when used together.

Energy efficiency have gained more limelight as a system to reduce energy demand from industrial, domestic, agricultural and transportation sectors and considered as low cost 'low hanging fruit' for governments and policy makers. It has also gardened attention from policy makers around the world as it is seen as a game changer in limiting temperature to 1.5 degrees Celsius (WRI, 2018). This chapter gives an overview of energy consumption and energy efficiency in India. It discusses the need of energy efficient technology in lowering the energy demand from the Indian households which is bound to increase in future scenarios. The chapter further underlines theoretical perspectives used for the present study. It is divided into various sections to give a glimpse of present electricity demand and consumption scenario in India (Section 2.2) with emphasis on domestic sector (Section 2.3), its consumption pattern, majorly through appliance ownership. The need of energy efficiency in reducing energy demand highlighted in section 2.4 and section 2.5 gives a glimpse of research around energy efficiency in world and India using bibliometric analysis. The energy efficiency and rebound effect is discussed in section 2.6. The energy efficiency gap due to various factors is discussed in section 2.7.

2.2 Indian Electricity Generation and Consumption Scenario

Towards the end of the 18th century, electricity[13] was discovered and was recognized as immense force in civilization which cannot be reused or resold once it reaches to its ultimate consumers and is used up in the process of production or doing work ("An Electric Kitchen", 1912). Electricity is meaningful in the social contexts of people's lives. It is a material force in a technical and scientific sense and harnessed through social world of machines, people and work (Rupp, 2013). In Households, electricity consumption relates to energy practices[14] that involve technology use that is linked to a broader energy infrastructure which is invisible to the eyes of end-users. These practices shape the energy demand and consumption especially in households, where even an individual also plays a crucial role in shaping overall demand and consumption. During the early independence of India, the major focus of policy makers was on increasing electricity generation as it a crucial factor in shaping a country's development. As noted in a newspaper article of 1948, "*Electricity must play a major role in India's regeneration. More and more power is essential to economic advance"* ("Electricity", 1948). Other excerpt from Times of India (ToI, 1954) indicated that,

> *"… a country cannot ignore the social aspect of life of its communities because improvements in agriculture and industry is only a means to an end. The present gap between the amenities of urban and rural population in regard to modern sanitation, running water, electric lights, fans and radio and several other gadgets to relieve the day to day drudgery has to be narrowed down*"("Problems Of Rural Electrification", 1954).

In 1945, over 42 per cent of electrical energy produced was utilized by big cities i.e. Bombay and Calcutta and less than 7 per cent of electricity used in India was consumed in domestic sector. The electricity production increased from 2440 mkWh in 1939 to over 4900 mkWh in

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[13] The Electricity was noticed by ancient people as phenomena, an outcome or a natural fury. Other noticed the presence of electricity in few substances i.e. amber, jet and few other bodies have power, after being rubbed of attracting light objects, was known to Thales of Miletus (600 B.C.) and was mention by Theoprastus in (321 B.C.) and Pliny in 70 AD (ToI, 1956). Wilbert Gilbert (1544-1603) found that many substances possess the power in question and called such as attractions '*electric*' after the Greek word '*Amber*'. The word he used for attraction was '*Vis electric'*. Later, Walter Charlton in 'Ternary of Paradoxes' in 1650 used the term electricity. Bodies having this power of attracting light objects are said to be electrified to be charged with electricity (ToI, 1956). Electricity is measured in units of power called Watts (W).

[14] Practices are "routinized type of behavior which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding , know-how, states of emotion and motivational knowledge" (Cited in Wilhite (2013),p.62).

1947 ("India's Output of Electricity", 1950). Various schemes were promoted to ensure electrical energy connection in villages along with electrification of railways ("Development of Electricity", 1945). There was marked increase in sales of electricity during 1947 for lighting and public irrigation ("Consumption of Electricity in Indian Union", 1949). After independence, the electricity (supply) Act, 1948[15] gave an institutional framework and financing norms to electricity sector of country with an aim to increase production and ensure supply of electricity in rural and urban areas in most efficient and economic manner.

Since 1947, electricity generation capacity in India has steadily increased from 1361 MW to 326,833 MW in 2017 (Figure 2.1(a)) and has become third largest electricity producer after China and United States in year 2018[16]. As on December 2018, the generating capacity of electricity (MoP, 2018)[17] was 349,288 MW with largest share of thermal power plants (63.9 per cent) of the total installed capacity in the country. Renewable energy sources which include, biomass power gasifier, biomass power, small hydro project, urban and Industrial waste power, and Solar and Wind energy account for 21.2 per cent whereas share of hydro energy, Nuclear energy has a share of 13.0 per cent and 1.9 per cent respectively (Ministry of Power, 2018). Keeping Nationally Determined Contributions (NDCs) as per Paris Summit in consideration, India will increase its share of renewable energy to achieve the target of 40per cent of total installed power generation. This target includes 100 GW of electricity from solar, 60 GW from wind, 10 GW from bio-power and 5GW from small hydro power. Thus overall electricity generation is also bound to increase. On the other side, electricity consumption has also increased at a continuous pace from 4.182 TWh to 106.6 TWh in 2016-17 (Figure 2.1(b)). The increase in electricity consumption results from increased access to electricity connection, affordable appliances and other technology, transformation of rural areas to semi-urban areas to urban areas. In per capita terms, India uses lesser electricity relatively to other countries. Over the period of time, per capita consumption[18] of electricity has also increased in India from 98.1 kWh/capita in 1971 to 805.6 kWh/capita in 2014 which

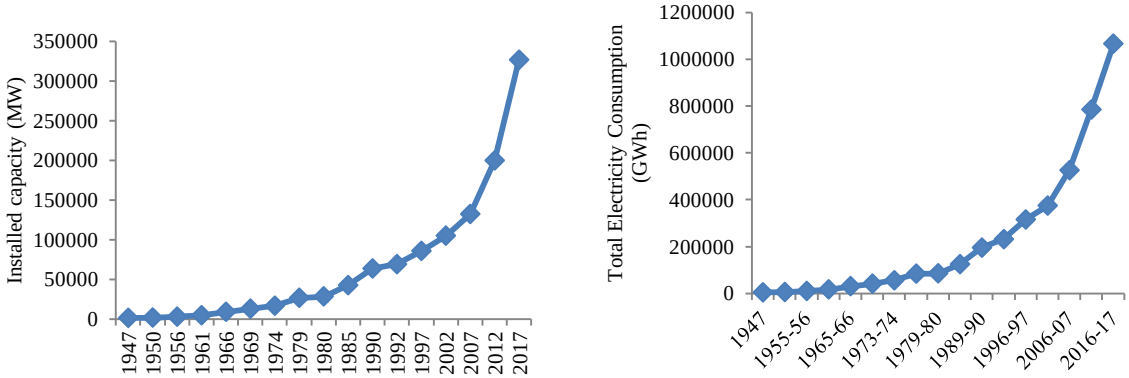
[15] It also led to creation of State Electricity Boards (SEBs) for planning and implementing power development in the states (Electricity Supply Act, 1948).

[16]"Now India is the third largest electricity producer ahead of Russia and Japan" accessed fro https://www.business-standard.com/article/economy-policy/now-india-is-the-third-largest-electricity-producer-ahead-of-russia-japan-118032600086_1.html on 6 June 2018.

[17]Power sector at a glance all India accessed from https://powermin.nic.in/en/content/power-sector-glance-all-india on 6 June 2018.

[18]Per-capita Energy Consumption (PEC) during a year is computed as the ratio of the estimate of total energy consumption during the year to the estimated mid-year population of that year.

is lower than other countries i.e. China (3927.0 kWh/capita) and USA (12986.7 kWh/capita) (World bank, 2018).



(a) (b)

Figure 2.1 (a) Growth of electricity generation in India (b) Total growth of electricity consumption (in GWh)

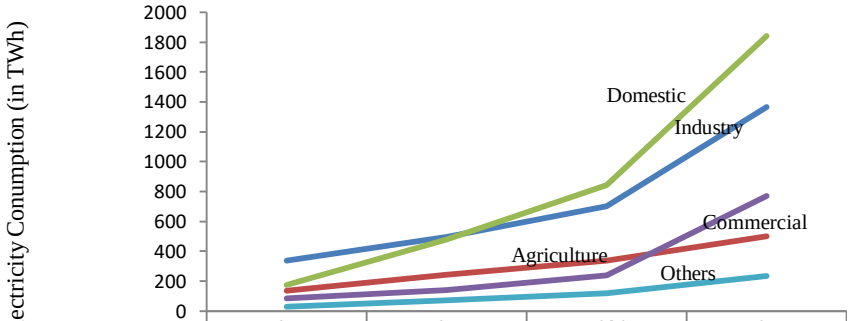
Source: (a) Central Energy Agency (CEA), 2017, (b) Ministry of Power (MoP) and Central Energy Agency, 2017

Various sectors have contributed to increased electricity consumption over the years. Industrial sector had a major share in consuming generated electricity but this share has decreased from 70.78 per cent in 1947 to 40.01per cent in 2016-17. Overall Industrial sector remained largest electricity guzzling sector whose consumption has increased from 2.96 TWh in 1947 to 426.6 TWh to 2016. Agricultural sector has also increased its share of electricity consumption from 8.37 per cent during 1968-69 to 18.33 per cent during 2016-17. Domestic sector is one of the sectors which have seen continuous growth in its share of electricity consumption with 7.69 per cent during 1968-69 to 24.32 per cent during 2016-17. Various reasons account for this steady growth in this sector will be further discussed in the next section.

2.3 Indian Domestic Sector: A Hungry Giant

This section is dedicated to understand the trends and reasons for the rise of domestic sector in India in last few decades. There is steady growth of electricity consumption as a fuel and also as a means to provide various services. In coming years, the consumption is bound to increase due to first time electricity connections to 230 million people which are estimated to

grow at 10 per cent annually in next 10-15 years. The increase in income, availability of electricity, easy and affordable access to various appliances, emphasis on domestic manufacturing sector is going to play a major role in increased consumption ("India's electricity consumption to touch 4 trillion units by 2030", 2016). A study by Central Energy Agency (CEA) has estimated that the domestic sector will increase its share from 28.2 per cent in 2017 to 30.6 per cent in 2027 becoming the largest consumer segment ("Electricity consumption in India: power demand to rise 7 per cent CAGR in 5 year", 2017). NITI ayog in one of their study in 2015, projected increased demand from industrial sector due to increased demand for material in buildings, transportation, capital goods and infrastructure resulting into doubling the electricity demand from 336 TWh in 2012 to 703 TWh by 2030 and growth in urban spaces, rising income, higher adoption of electrical appliances is also estimated to result into increased electricity demand in residential sector. They further projected that overall consumption is going to witness a surge from 175 TWh in 2012 to 842 TWh in 2030 (N.I.T.I., 2015). It is also estimated that total consumption by industrial, domestic, commercial and agriculture sector will account 2899 TWh, 3337 TWh, 1237 TWh and 1218 TWh respectively by 2047 (Figure 2.2). The above projections clearly show that domestic sector will emerge as major electricity consumer in coming years.



	2012	2022	2030	2047
Industry	336	494	703	1366
Agriculture	136	245	336	501
Domestic	175	480	842	1840
Commercial	86	142	238	771
Others	29	71	121	233

Figure 2.2 projected electricity consumption by various sectors

Source: NITI (2015)

The studies mentioned above clearly indicate that Indian domestic sector will emerge as one of the largest and strongest sector consuming electricity in coming years surpassing industrial, agriculture, commercial and other sectors. This growth is attributed to increase in disposable income, access to household appliances, better reach to electricity and its availability, changing lifestyles and many other reasons (Pachuri, 2004). The consumption pattern of Indian households is further discussed in next section.

2.3.1 Consumption Pattern of Indian Households

In a household[19], various kinds of energy sources are used to perform different activities. Energy consumption is dependent on an "*established infrastructure of taken-for-granted hardware or technological systems*", which structure patterns of daily life. Various studies have examined different factors affecting energy demand in households (Owens and Drifill, 2008) but research identifying these factors in developing countries is very limited (Kowsari and Zerriffi, 2011). In India, for studying electricity consumption pattern, most of the studies use National Sample Survey (NSS) data for their estimations and projections. National Sample Survey Office (NSSO) undertakes nationwide consumer expenditure survey at household level at regular time periods usually one year through interviews of sample of households selected randomly covering entire Indian Territory. This consumer expenditure survey generates household Monthly Per Capita Consumer Expenditure (MPCE)[20] and the distribution of households and persons over the MPCE varies for urban and rural sectors, for states and Union Territories (UTs), and for varied socio-economic groups of India (NSS, 2011-12, p.14).

The findings of NSSO indicate that in 2011-12[21], 80.99 per cent of Indian households use electricity for various purpose, 65 per cent of households used firewood for cooking and

[19] "*A group of person usually living together and taking food from a common kitchen*" constitutes a *household* as per NSSO.

[20] MPCE at household level is defined as "*household monthly consumer expenditure divided by household size"*. It serves as the indicator of the household's level of living. Whereas MPCE at individual level is defined as the MPCE of the household to which the person (man, woman or child) belongs. This represents his or her level of living (refer NSS 2011-12). Expenditure from Indian households is categorized into different categories of indirect energy in the form of goods and services. It includes food, paan, tobacco and intoxicants, clothing and footwear, miscellaneous goods and services, durable goods, and fuel and light.

[21] In 2011-12, NSSO collected data from 101651 households (59683 rural and 41968 urban) in 7469 villages and 5268 urban blocks covering the entire country. For energy use, the classification of sources of energy used for lighting includes kerosene, other oil, gas, candle, and electricity; other and no lighting arrangements (refer Table 2.1 in appendix).

other purposes. 82 per cent used kerosene (PDS and other) and 37 per cent of households used LPG as a major fuel for cooking. MPCE of urban consuming households (INR 2399.2) is almost twice the rural households (INR 1278.4), while average mean value per person in all consuming households is INR 1627.13. Urban households have almost double the consumption of rural households and reasons for such consumption patterns can be higher incomes, better access to fuels and technology and consumerist lifestyles. For lighting, 96.11 per cent of urban and 74.12 per cent rural households used electricity. 84 per cent of rural and 23.4 per cent of urban households used firewood for various purposes including cooking. LPG as a fuel is used for cooking in 22 per cent of rural and 70 per cent of urban households. Other energy sources are also playing significant role in shaping the consumption patterns (Table 2.1 in annexure I).

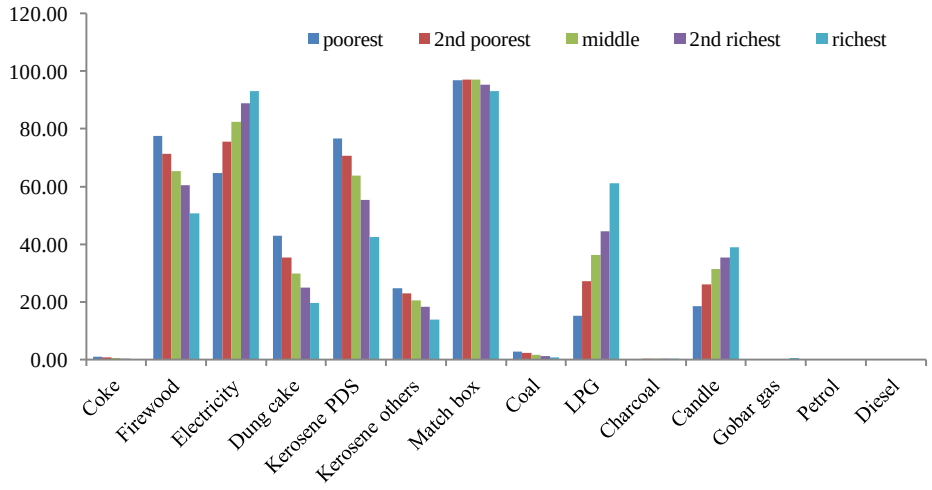


Figure 2.3: Energy Consumption pattern in various quintile group[22]

Source: NSS Consumption Expenditure Survey (CES) 2011-12

As consumption expenditure is associated to household income, it is evident that the households with more income will consume more and thus more demand for electricity. During 2011-12, it was indicated that rich quintiles (top 20%) used more of electricity and LPG for various purposes when compared with their poor quintiles (lowest 20%). The figure 2.3 showcases interesting and apparent patterns when moving from poor to rich quintiles. It

[22] For understanding the consumption pattern in Indian households, all the observations were categorized into 5 quintiles i.e. poorest quintiles (lowest income group), 2nd poorest quintiles (second lowest income group), middle quintiles (medium income group), 2nd richest quintiles (second richest income group) and richest quintiles (richest income group).

shows that consumption of firewood, kerosene, coal and dung cake decreases with the increasing income whereas electricity, LPG consumption increased with increase in income. Since 1993-94, there is a phenomenal shift observed in the usage pattern of kerosene and electricity (table 2.1). The share of kerosene used in rural and urban areas has decreased within the span of 20 years while usage of electricity in rural areas has increased from 37 per cent in 1993-94 to 72.7 per cent in 2011-12.

Areas	**1993-94 (%)**		**1999-00(%)**		**2011-12(%)**	
	Electricity	**Kerosene**	**Electricity**	**Kerosene**	**Electricity**	**Kerosene**
Rural	37	62	48	51	72.7	28
Urban	83	17	89	10	96.1	3

Table 2.1: Use of electricity and kerosene for lighting

Source: NSS (1999-00) and NSS (2011-12)

The trend of increasing electricity consumption can be easily understood and related to various factors i.e. lifestyles, number of family members, access to energy sources, access, institutional and financial policies and access to technology *etc*. Lifestyle affects energy demand in present and future scenario and is affected by broad societal and technical change (Weber and Perrels, 2000, Hubacek et al., 2007). The availability of disposable income also provides more option to use more resources (Hubacek et al., 2007). In urban Indian households, urbanization, increase in personal incomes and increased penetration of electrical appliances have led to rise in energy demand (Reddy and Balachandra, 2003). Energy demand is also associated to changes in consumption pattern, change in the productive energy intensities of goods and services consumed, change in per-capita level of energy using activities and increasing population (Pachauri and Spreng, 2002). The next section discusses more about increased electricity consumption in Indian households due to appliance ownership.

2.3.2 Appliance Ownership in India

The appliance ownership in India is steadily increasing in urban as well as rural households mainly due to rise in income levels and increased accessibility of affordable electric supply (N.I.T.I, 2015). In Indian households, 80 per cent electricity consumption is due to lighting (end-use), ceiling fans, TVs and Refrigerators (Boegle et al, 2010). A study by Phadke et al.,

(2013) indicates that lighting takes around 40 per cent of electricity, followed by fans (31 per cent) and other household appliances (28 per cent).

In terms of appliance ownership, a report named as *"India Energy Security Scenario, 2047"* indicates that fan is the most owned appliance with 93 per cent and 64 per cent respectively in urban and rural households. In entertainment category, 80 per cent of urban and 50 per cent of rural households owns a television (Table 2.2). Refrigerators and Air conditioners are still luxury items in rural India as they are quite expensive but it is assumed that rural demand will significantly increase with the ownership of appliances in rural households matching the demand of urban counterparts by 2032 (N.I.T.I, 2015).

Appliance/Category	Urban (per cent)	Rural (per cent)
Fans	93	64
Refrigerator	44	9
Televisions	80	50
Airconditioners/Air Coolers	24	6

Table 2.2: Appliance ownership in Indian households

Source: India Energy Security Scenario, 2047

According to NSS 2011-12, 68 per cent of rural and 88.4 per cent of urban households owns electric fan showing the highest penetration amongst all households. Television, electric fan, and refrigerators are owned by 81.76 per cent, 88.40 per cent and 44.75 per cent respectively in urban households. The penetration of air conditioners and refrigerators is 22.21 per cent and 44.75 per cent respectively in urban households which is more than double when compared to rural households who own 8.89 per cent of ACs and 19.12 per cent of refrigerators (Table 2.3). As these appliances consume substantial amount of electricity, their penetration scenario needs to be understood well to develop policies which can cater to increasing energy demand from these appliances and also to chart out the scope of increasing energy efficiency of electrical appliances.

Items	Rural (per cent)	Urban (per cent)	Mean total (per cent)
Radio	25.07	23.67	24.49
TV	62.16	81.76	70.25
Electric fan	68.27	88.40	76.58
AC	8.89	22.21	14.39

Table 2.3: Appliance ownership in 2012-13

Source: NSS 2011-12

Appliance ownership was also found to be closely associated to income the income of households. NSSO results indicate an increasing trend of appliance ownership with the rise in income. Stove, fan, pressure cooker and TV are the major appliances which dominate the poorest quintile (lowest 20 per cent) group whereas among richest quintile (top 20 per cent) TV, refrigerator, AC, fan, stove, and pressure cooker dominates. All the appliances are showing similar pattern except lantern i.e. with increase in income, appliance ownership increases (Figure 2.4).

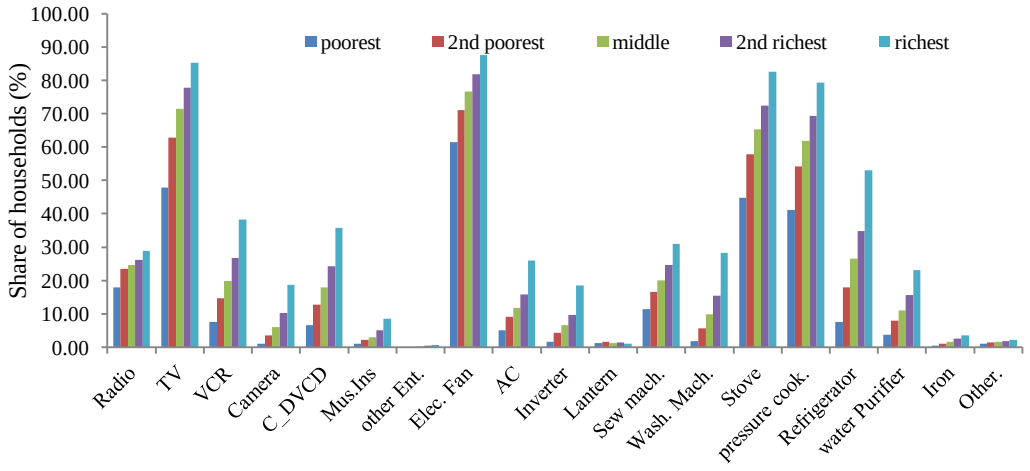


Figure 2.4: Appliances ownership (2011-12) across quintiles

Source: NSS 2011-12

During 2015-16, highest owned appliance is fan (78.2 per cent), followed by TV, refrigerator and AC/ air coolers at 63.5 per cent, 29.6 per cent and 17.9 per cent respectively (NFHS survey-4)[23] which was found to be line with NSS data. When the two datasets i.e. NSS and NFHS were compared, NFHS indicated the increased possession of television and air conditioners especially in rural households. Although NSS and NFHS data sets cannot be compared to each other because of difference in sample size, data collection methods and various other spatio-temporal differences but it can be indicative of appliance possession pattern at different time periods. Surveys i.e. NSSO, IHDS provides the data on fuel

[23] National Family Health Survey-4 (2015-16) was conducted to provide key indicators for urban and rural areas for each 29 states and 7 UTs. Regarding the household appliances, it provided the data for various household appliances possessed by the respondents in 2015-16.It was a nationally representative survey with 628,892 residential households in all sample households (NFHS survey 4).

consumption and expenditure, appliance ownership and purchase but fails to indicate about number of appliances used by households and also does not give any information about age of users, efficiency of appliances, ownership and usage pattern, whether it is first hand or second hand, years of ownership, attitude and behavior towards usage of appliance (Dukkipati, Sreenivas and Iyer, 2015). All the above information is highly crucial to analyze to formulate the effective policies in household sector.

Appliance/Category	Urban (per cent)	Rural (per cent)	Total (per cent)
Fans	95.1	69.1	78.2
Refrigerator	54.2	16.4	29.6
Televisions (Color)	86.0	51.5	63.5
Air conditioners/Air Coolers	32.9	9.9	17.9

Table 2.4: Appliance ownership

Source: National Family Health Survey-4 (2015-16)

From above sections, it is quite evident that in Indian households, the electricity demand is increasing along with appliance ownership (Isaac and Van vuuren, 2009). The increased demand of electricity with time will lead to increased generation. If produced from fossil fuel based source, electricity generation will pose a huge cost of environmental burden in the form of air, water and land pollution, climate change, increasing GHGs emissions, increased global temperature, depletion of fossil fuels, degradation of ecological diversity and other associated risks. It is estimated that total CO_2 emission for all grid connected power station during the period from 2008-09 to 2012-13 with an installed capacity for more than 25MW has increased from 548.6Mt to 696.3Mt (Singhal, 2014). While, globally energy demand is estimated to increase by over one-third till 2035 and power sector related CO_2 emissions is expected to rise from an estimated 13 GT in 2011 to 15.2 GT in 2035. Almost 30 per cent of global energy demand is estimated to be arising from India by 2040 (World Energy Outlook, 2012). Thus, there is an identified need to reduce the emissions and its impact due to increased electricity generation. Researchers have suggested that energy efficiency can solve this problem of increasing demand of electricity by improving the efficiency of systems which will be discussed in detail in following section.

2.4 Energy Efficiency: Current Scenario

Various studies have noted the significance of energy efficiency policies and programs in reducing the carbon emissions and energy intensities. Energy efficiency[24] is defined as the ratio of useful outputs to energy inputs for a specified system (Sorrell, 2005) and its measurement depends on how input and output is defined and measured. In simple terms, it is *"energy services provided per unit of energy input"* (Gillingham et al., 2009). At the individual product level, it is one of a collection of product characteristics with product cost and other attributes while at aggregate level, sectoral energy efficiency or economy in aggregation can be defined as "*Gross Domestic Product per unit of energy consumed in its production*". Energy efficiency can be achieved at different stages i.e. extraction and conversion of primary energy, transmission and distribution (T&D) of energy delivery services, end use of energy through improved operation and management, by using efficient technology and retrofits and through energy efficient systems (Goldemberg et al., 2006).

Studies reveal that energy saving potential by increasing efficiency of industrial sector is 25 per cent, agricultural sector is 30 per cent, and the share of domestic, commercial, transport and other sectors is 20 percent each. This can reduce the future energy demand to 3080 BkWh and thus reducing the supply and demand gap to 50 per cent (Bansal, 2014). In Industrial sector is directed to increase the direct and indirect emissions and also the process emissions by 50-150 per cent by 2050 in baseline scenario (without rapid energy efficiency improvements). 25 per cent of energy intensity of industrial sector compared to current level (2014) could be directly reduced if there is wide-scale upgrading, replacement and deployment of best available technologies specifically in those countries where these are not in use (IPCC, 2014, p.81). In transportation sector, 30-50 per cent reduction of emissions relative to 2010 can be due to potential energy efficiency and vehicle performance improvements (ibid, p74). From buildings, direct and indirect CO_2 emissions are projected to increase from 8.8 Gt CO_2/yr in 2010 to 13-17 Gt CO_2/yr in 2050 in baseline scenario and can be reduced with shift in policy making towards change in behavior, lifestyle, low-carbon fuel usage, high performance retrofits, and use of efficient appliances (ibid, p.79).

[24] National Laboratory (LBNL) defines energy efficiency as "*using less energy to provide same service*".

Energy Efficiency and Its Rebound

Various energy efficiency measures are on rise with an assumption that it will result in reduction of energy consumption (IEA, 2014) and reduce carbon emissions, but Wilhite and Norgard (2004) identify this relation of equating 'efficiency' with 'reduction' and 'sustainability' as '*self deception*' because energy efficiency supports the contention that technological improvement can offset continued growth in energy services to the extent where reducing energy use is possible. There is another dimension which questions the idea of increasing efficiency and advocates that it may not always result in reduction in energy demand. Studies have noted that increasing energy efficiency is associated with increased energy demand (it was first proposed by S. Jevons in 1965 therefore called as Jevon's Paradox) (Khazzoom, 1980). Daniel Khazoom during 1980's proposed that increased energy efficiency lead to increased energy demand rather than decreasing it, based on the contention on price elasticity arguments in household electric appliances sector. While Brookes in 1990, deemed energy efficiency as a flawed concept based on the macroeconomic view. According to him, energy efficiency is flawed as "reduction in energy intensity of output that are not damaging to the economy are associated with increase in energy demand" (Saunder, 1992). Examining energy efficiency from neoclassical growth theory added more weight to Khazzoom-Brookes postulate and found that energy use will increase in lock-step with economic growth (When prices are kept fixed) (Saunder,1992).

Energy efficiency might increase consumption of energy by making it appear effectively cheaper than other inputs and by increasing economic growth. This increase in energy consumption after adopting energy efficient technology or using energy efficiency measures is called as ***Rebound effect***. Rebound effect reduces the potential energy savings from the measures of energy efficiency improvements. It includes various mechanisms that diminish the effect of potential energy savings from improved energy efficiency. Rebound effect can be direct or in-direct. Simple economic theory suggests that energy efficiency improvements reduces the marginal costs of energy services and therefore consumption of these services are expected to increase and this increased consumption of these services are expected to increase and this increased consumption may offset some or all of the predicted reduction in energy consumption. This is called as direct rebound effect (Khazzoom, 1980). When there is no direct rebound effect, there can still be increased consumption in the form of indirect-rebound effect. In this even an individual does not increase the energy services can still lead

to increased consumption as one use the saved money by engaging into some activities which consumes much more energy. The sum of direct and indirect effects leads to overall or economy-wide rebound effect and expressed as a percentage of the expected energy savings from an energy efficiency improvement. A 100 per cent of economy wide rebound effects means that the expected energy savings are entirely balanced and when it exceeds 100 per cent, it is called back-fire effect means overall energy consumption has increased. Sorrell (2009) emphasized on defining the rebound effects with respect to particular time frame (e.g. Short, medium or long term and spatial boundary (system) for the relevant energy consumption (i.e. Households, firms, sectors, national economy *etc.*). The economy wide effect is normally defined with respect to a country's economy.

The various 'indirect rebound effects' are embodied energy effects (manufacturing of Energy efficient technology requires energy and this embodied energy consumption can offset some of the energy savings), Re-spending effects (Savings from energy efficiency improvements are used to purchase other goods which itself need energy to run), output effects (saving costs are utilized to increase production output thus increasing the consumption of capital, labor and material which themselves requires some energy to provide), Energy market effects lowers the energy prices and therefore increase the energy consumption, Composition effects (both energy efficiency improvements and energy price reduction will reduce the cost of energy-intensive goods and services thus increasing demands shifts towards the former (Chitnis et al., 2014). Research suggests that rebound effect do increase the energy consumption after technical improvements, but the size of rebound effect is estimated to be very small to moderate depending on time, location, sector of economy and end-use. Very few studies have estimated direct and indirect rebound effect in domestic sector (table 2.7).

Moreover, in different sectors also the rebound effect varies. As per IEA (2005) it is minute (less than 10 per cent) for residential appliances, residential lighting and commercial lighting and less than 20 per cent for industrial processes uses. For space heating, water heating and automotive transports the rebound effect has been found to be small to moderate (<10-40 per cent) for residential cooling it is in the range of 0-50 per cent. Therefore, it becomes highly important to keep rebound effect in consideration while making energy efficiency policies to have its economy wide positive impact.

Author	Region	No. of commodity categories	Measure	Area	Metric	Energy/ emissions	Estimated rebound effect (%)
Lenzen and Dey (2002)	Australia	150	Efficiency and sufficiency	Food; heating	GHGs	Direct and embodied	45–123
Alfredsson (2004)	Sweden	300	Sufficiency	Food; travel; utilities	CO_2	Direct and embodied	7–300
Brannlund et al., (2007)	Sweden	13	Efficiency	Transport; utilities	CO_2	Direct and embodied	120–175
Mizobuchi (2008)	Japan	13	Efficiency	Transport; utilities	Energy	Direct and embodied	12–38
Kratena and Wuger (2008)	Austria	6	Efficiency	Transport; heating; electricity	Energy	Direct only	37–86
Druckman et al., (2011)	UK	16	Sufficiency	Transport, heating, food	GHGs	Direct and embodied	7–51
Thomas and Azevedo (2013)	US	74	Efficiency	Transport, electricity	GHGs	Direct and embodied	7–25
Murray (2013)	Australia	36	Efficiency and sufficiency	Transport, lighting	GHGs	Direct and embodied	4–24
Chitnis et al., (2013)	UK	16	Efficiency	Heating, lighting	GHGs	Direct and embodied	5–15

Table 2.5 : Estimates of combined direct and in-direct effects for households

Source: Chitnis et al., (2014)

Studies have indicated that in domestic sector rebound effect has very small to medium impact. Therefore, for this study the author is not keeping rebound effect as a center idea. As this study tries to understand the public understanding of energy efficiency and energy efficient technology through the lens of standards and labels we are looking at the other aspect of energy efficiency i.e. energy efficiency gap. Various studies have noted that despite the presence of various energy efficient technologies to provide better service, people fail to invest in them, even when investment is economically justified (termed as energy efficiency gap or paradox) (Jaffe and Stavins; 1994),(Allcott and Greenstone, 2012).

2.4.1 Tracing Research around 'Energy Efficiency'

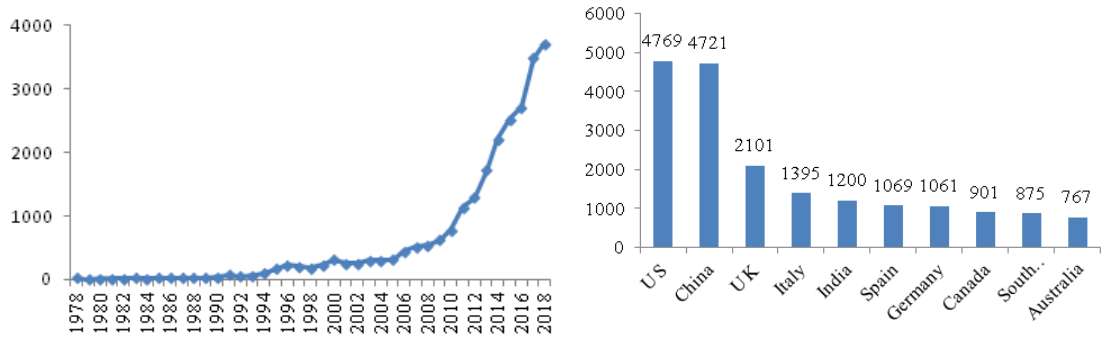
With the rise of energy efficiency as a policy to mitigate the impact of climate change, the Research and Development (R&D) activities surrounding it have seen surge in last few decades. This section traces the research progress around the term 'energy efficiency' and

'energy efficiencies' using bibliometric analysis[25]. For preliminary search, the word "*energy efficiency*" or "*energy efficiencies*" in Scopus have been used. The present search terms are in line with a study by Du et al., (2013) which evaluated the global trends of energy efficiency research literature from 1991 to 2010 using Web of Science. Their study yielded 8,244 results and showed that literature on energy efficiency grew moderately from 1991 to 2003 and gained a momentum after 2003 around the world. In our study, preliminary search yielded 91,444 results. This search is refined according to relevance of the study i.e. to map the knowledge production scenario of energy efficiency in household sector with special emphasis on India. The subject area like medicine, veterinary science, biology, microbiology, astrophysics, computer science etc. were excluded from the analysis as they were not found to be related to the research area and 61,013 results were captured. Only relevant publications which has been published during 1978-2018 (n=24,994) have been discussed in the following section. Detailed search strings are given in annexure I.

The analyses found that after 1973 oil crises and energy crises of 1979, the publications in the field of energy efficiency attracted a limelight around the world especially in developed nations. Most of articles are published in the area of Energy (31.4 per cent), Engineering (28.0 per cent), Environmental science (24.2 per cent) and remaining subject areas i.e. mathematics, material science, chemistry etc. covers 16.4 per cent of total publications. 98.8 per cent of publication are published in engish language while reminaing 1.2 per cent are published in other langauges like Chinese, German, Polish and Japanese. Most of publications are published in Journals (96.7 per cent) while remaining 3.3 per cent are published in book series (n=67), trade publications (n= 546), conference proceddings (n=188) and book (n=12). The figure 2.5 (a) represents the number of publications around world during period of 1978-2018. Before 2010, energy efficiency was discussed and researched in slow and steady manner. The total numbers of articles published during 1978-2009 were 5,457 but after 2010, field of energy efficiency has gained a sudden momentum and by the end of 2018, total number of articles published during 8 years i.e. 2010-2018 is

[25] Bibliometric analysis involves statistical methods of bibliography counting to evaluate and measure the literature production for a particular subject (Tsay, 2008). It helps in assessment of particular research or scientific productivity over a specific area in a period of time by using various indicators (Garfield, 1979). For the analysis, SCOPUS database was used. According to Scopus website, it is the largest abstract and citation database of peer-reviewed literature including scientific journals, books and conference proceedings.

19,537. This sharp rise in the publication can be due to rise of inter-disciplinarity in the field of energy and increasing concerns about increasing energy consumption and its effects on climate change. Moreover international climate change agreements e.g. Kyoto Protocol (2008-2012) might have also played a crucial role in shaping the need for research in energy efficiency domain.



(a) (b)

Figure 2.5 (a): Number of publications (1978-2018); (b) Top 10 Countries contributing to publications related to energy efficiency

Source: Data retrieved from Scopus by author

United States and China are two countries producing highest number of articles i.e. 4769 and 4721 respectively during (1978-2018), while India is amongst the top five countries to focus on the issue pertaining to energy efficiency (Figure 2.5 (b)). among the most productive institutes Chinese Academy of Science (China), Lawrence Berkeley National Laboratory (US), Ministry of Education (China), Tsingua University (China) and Tianjin University (China) are top most institutes involved in knowledge production (in the form of publications) related to energy efficiency. It is noted that Chinese Academy of Sciences ranked highest with 522 articles; followed by LBNL (454) and Ministry of Education China (450) (For details, refer Table 2.4 in Annexure I). 73 per cent of publications on energy efficiency are being produced from top 20 journals. *Energy* journal was found to be most productive journal with 3471 articles (14 per cent), followed by *Applied Energy* (2708, 11per cent) and *Energy Policy* (2084, 8per cent) (For details refer Table 2.5 in Annexure II).

2.4.2 Energy Efficiency research in India

From the above analysis, it is evident that India holds fifth position after United States of America (USA), China, United Kingdom (UK), and Italy. India started publishing the

research papers with emphasis on energy efficiency in year 1983. It was same period when India started shifting their energy policy towards energy efficiency during sixth Five Year Plan[26](1980-85). During this time, Indian policy makers introduced the concept of '*efficiency*' in Indian energy sector and emphasized on increasing efficiency measure in industries and domestic sector. During period of 1983-2018, 1,200 publications were published (Figure 2.6). Out of total publication (n=1200), 91.8 per cent of them are research articles and 8.2 per cent are review papers.

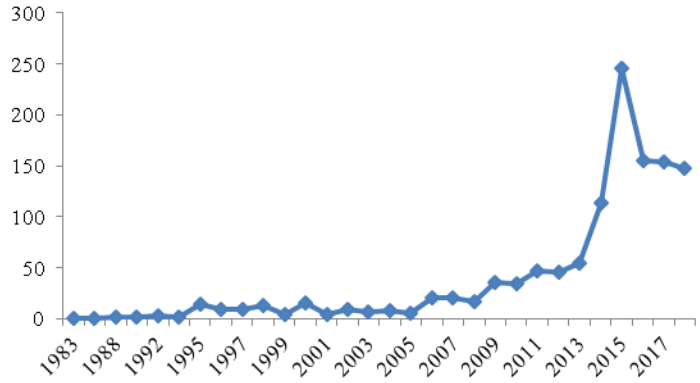


Figure 2.6 Number of publications on energy efficiency in India (n=1200)

Source: Data retrived from Scopus by author

The figure 2.6 points out towards a sharp increase in number of publications in year 2015 followed by a downfall. Overall the trend of pulications have increased in last 33 years. Various factors for sudden rise of publications in 2015 can be due to introduction of various plans and policies by Indian government in the area of energy efficiency, increased collaboration in research and increased funding in areas related to energy efficiency by national and international agencies before year 2015.

Another reason for sudden spike in publications can be due to international collaborations and availability of funds for research in the given feild. Analysing the funding details of the publications can give a fair idea about the motivation behind the research. but for all the publications, information about funding is not provided. 120 publications out of 1200 provides the funding information and using the same information, it can be deciphered that

[26] Sixth Five Year Plan accessed from www.planningcommission.nic.in/plans/planrel/fiveyr/6th/6planch15.htm on 30.4.2018

after 2013 the funding from various sources increasesd sharply. There is also increase in international funding by US, South Korea, France, Sweden and other countries. US holds a major share in funding in Indian research on energy efficiency and this research is based on collabrative nature. While in India, agencies i.e. Council for Scientific and Industrial Research (CSIR), University Grants Commission (UGC), Depratment of Science and Technology (DST), Science and Engienering Research Board (DST-SERB), Ministry of New and Renewable Energy (MNRE) and state Governments are major funding agency for research. In Year 2015, maximun number of publications are published which are funded by DST, UGC, CSIR, DRDO and MNRE while international funding is coming from South Korea, European Commission, Singapore and Canada.

Most of articles published in India are found to be in the area of engineering (31.2 per cent), Energy (28.8 per cent), Environmental science (20.5 per cent) while remaining subject areas i.e. mathematics, material science, chemistry etc. covers 19.5 per cent of publications. Indian Institute of Teechnology (IIT) Delhi is most productive institute with 98 publications (8 per cent) followed by IIT-Madras (n=59, 5 per cent) and Anna University (n=57, 5 per cent). 36 per cent of publications are contributed by the top 10 institutes (table 2.6 in Annexure I). Looking into funding agencies for IIT-D, it is found that most of the publications are not funded by any agency, but few publications are funded by MNRE and DST. In terms of source, top 10 journals produce 62 per cent of total publications in the field of energy efficiency. *Energy* Journal is most productive (n=174, 15 per cent) followed by IJAER (n=164, 14 per cent) and Applied Energy (n=81, 7 per cent). Indian Journal of Science and Technology (INDJST) is an Indian journal started in 2007 shows an impressive growth of publications (n=59, 5 per cent) in the areas of energy efficiency (For details, refer table 2.7 in Annexure I).

Examining the various policies and program can also explain the surge of research in area of energy efficiency concerning household sector. Indian government introduced programs i.e. **Standards and Labeling program** (2006) to shift the market towards efficient appliances and also to inform consumers. **National Mission of Enhanced Energy Efficiency (NMEEE)** was launched under aegies of National Action Plan on Climate Change (NAPCC) in 2009 to strenthen market for energy efficiency with the provision of conducive regulatory and policy regime ("Ministry of Power", n.d.), **Bachat Lamp Yojana (BLY)** was launched

in 2010 to replace incandascent bulbs with efficient lighting in households (CFLs), later Government of India in 2015, extended the earlier Domestic Efficienct Lighting Program (DELP) in new form and named it as **'Unnat Jyoti by Affordable LEDs for All (UJALA) Yojana'** which aimed to replace the 200 million incandascenet bulbs to LED light bulbs by providing it to consumers at subsidized rates and saving 10.5 billion kWh of electricity ("Ministry of Power", n.d). By 2nd July, 2019, the number of LEDs distributed to reached to a number of 35,17,20,099 with estimated energy saving of 45,677mkWh/year ("Ministry of Power", 2019). This sections highlighted that there is huge attention hovering over energy efficiency in household sector in terms of research as well as poliy making in India as well as around the world. Even though there is presence of various energy efficiency policies and programs at place, but individual households or individuals fails to capture full potential of same by not being able to take a rational decision. This gap between the current levels of energy efficiency and those that should be observed if consumers had made appropriate "rational decisions" is termed as energy efficiency gap (Jaffe and Stavins, 1994) which will be discussed in detail in the following section.

2.5 Energy Efficiency Gap

Energy efficiency gap is identified as a "*wedge between the cost-minimizing level of energy efficiency and level actually realized*" (Allcott and Greenstone, 2012). In one of the study, it was concluded that there is presence of investment inefficiencies in various settings but the magnitude of energy efficiency gap is relatively small (Allcott and Greenstone, 2012, p.27). There is lot of skepticism about estimation of energy efficiency gap by the engineering studies as it fails to encompass various costs and particular type of economic behavior (K Gillingham and Palmer, 2013). Thus, extent of gap is still not clearly known but, research has indicated the presence of energy efficiency gap in various sectors.

energy efficiency gap has been categorized into private and social energy efficiency gap on the basis of inability of target population to adopt energy efficient technologies (Backlund, Thollander and Palm, 2012). In *'Private energy efficiency gap (PEEG)'* a gap arises when adopter deviates from private optimality, while '*social energy efficiency gap (SEEG)'* arises when socially desirable technologies are not adopted. Private energy efficiency gap can be situated within the scope of social energy efficiency gap. It is important to analyze social energy efficiency gap in policy making as it is a appropriate lens to evaluate impact of

government policies (Gerarden, Newell and Stavins, 2017). In this study, term 'energy efficiency gap' will be used throughout instead of any specific energy efficiency gap to avoid deviation of any kind. Literature related to energy efficiency has immensely contributed to identify various causes leading to energy efficiency gaps in domestic sector with special emphasis on developed nations. The following section will discuss various reasons leading to energy efficiency gaps in household sector specifically.

2.5.1 Barriers to Energy Efficiency

Studies suggest that energy efficiency gap can arise due to many barriers which include informational, financing, regulatory, institutional and behavioral barriers (UNESCAP, 2008; Ready, 2004; Balachandra et al.,2010; Waide and Gerundino, 2007, Jaffe and Stavin, 1994; Newell and Siikamaki, Sutherland, 1991; IEA, 2005; Ready, 2003; Zilberman, 2001; Chatterjee and Singh, 2012, Ready, 2003; Schleich and Gruber, 2008; Larson and Subbiah, 1994, Uihlein and Eder, 2009). These barriers can be distinguished into market barriers and market failures. Market barriers are barriers which lead to energy efficiency gap or slow the adoption rate of energy efficient technologies[27] while market failures are market barriers that justify an intervention in the form of public policy to overcome them. There might be some market barriers which are not market failures but related to energy efficiency gap and therefore, does not require a policy response. On the other hand, some failures which are not related to energy efficiency gap may require policy interventions. Most of the market failures are not unique to energy efficiency but requires broad policy responses to be addressed (Gillingham, Newell, and Palmer, 2009). At individual level, contextual or external factors facilitate or constrain personal factors which may lead people or avoid them to adopt efficient technology. It may include regulations, institutional constraints, availability of information, monetary incentives, public policies, capabilities and constraints provided by technology (Claudy and O'Driscoll, 2008).

[27] Energy efficient technologies are found at all stages of energy conversion process i.e. from production of primary energy resources, to power generation and oil refineries to electricity grids to end use in different sectors i.e. industry, buildings and transportation ("World Energy Perspectives: Energy Efficiency Technologies, 2018"). They consume comparatively less units of energy to produce the same output as compared to their inefficient counterparts and used to achieve energy efficiency in the system. They remove cost-ineffective, energy guzzling products from the markets and enhance economic growth and environmental protection.

Yang et al, (2013) explained energy efficiency gap using market failures, behavioral explanations and model and measurement errors. The market failures include asymmetrical and uncertain information problem, capital market failures, principal agent issues, and innovation market failures. Behavioral failures may arise due to inattentiveness, salience issues and bounded rationality. While modeling, error may emerge due to incorrect assumption of economic costs, energy use, usage profile and characteristics of consumers. The following sections will further discuss market failures and behavioral failures in more details.

a) Market Failures

In neo-classical economics, market failures are explained as the deviation from perfect market. In presence of market failures, free market may not be able to produce results that are socially optimal (Jaffe, Newell and stavins, 2004). The market failures include asymmetrical and uncertain information problem, principal agent issues[28], split incentive problem[29], capital market failures and innovation market failures (Yang et al., 2013). Whereas there might be some market barriers that are not market failures but related to energy efficiency paradox and therefore, does not require a policy response. On the other hand, some failures which are not related to paradox may require policy interventions. Most of the market failures are not unique to energy efficiency but requires broad policy responses to be addressed (Kenneth Gillingham et al., 2009). Discrepancy between optimal and actual implementation of cost effective energy measures is mainly explained by market failures as noted by (Backlund et al., 2012), while non-market failures is explained by high discount rate[30], optimal behavior of

[28] It is the situation, where one agent decides the level of energy efficiency of a building but does not use it while the principal i.e. purchaser or tenant uses the building and pays the bills. This situation is usually known as the **Principal-agent problem**. In this situation when agent is not able to make gain from the energy efficiency investments in the purchase price or rent charged for the building then agent will not or may under-invest in energy efficiency relative to social optimum leading to market failure conditions (refer Jaffe and Stavins, 1994). Murthishaw and Sathaye (2006) in their study quantified the magnitude of principal-agent problems for four end uses i.e. space heating, refrigerators, water heating and lighting and found that split incentive problem is relevant to 25 percent of refrigerators energy use, 2 per cent of lighting, 48 percent of space heating energy use and 66 percent of water heating energy use.

[29]**Split incentives** represent a market failure to adequately transmit the information related to energy efficiency to potential renter of these investments. In situation where agent is not able to make gain from the energy efficiency investments in the purchase price or rent charged for the building then agent will not or may under-invest in energy efficiency relative to social optimum leading to market failure conditions (Jaffe and Stavins, 1994). Murthishaw and Sathaye (2006) in their study quantified the magnitude of principal-agent problems for four end uses i.e. space heating, refrigerators, water heating and lighting and found that split incentive problem is relevant to 25 percent of refrigerators energy use, 2 per cent of lighting, 48 percent of space heating energy use and 66 percent of water heating energy use. Levinson and Niemann (2004) studied that tenants who don't pay their bills consumes more energy as compared to those pay their own electricity bills.

[30] Implicit Discount rates can be calculated on the basis of capital cost versus operating cost savings of buying a product. People assume high discount rates in case of efficient product (Hausman, 1979;Train, 1985).

consumer, future energy prices, risks and uncertainties and imperfections in capital markets may impede investments in energy efficiency (Koopmans and Te Velde, 2009).

b) Behavioral failures

Behavioral failures characterize consumer behavior that is not consistent with utility maximization or energy service cost minimization. The behavioral economics identifies systematic prejudices in consumer decision making that may be found relevant towards shaping energy efficient behaviour or investment. The behavioral economics is motivated by the evidence that consumers are not perfectly rational. It is assumed that a consumer minimizes present value cost for a given level of energy service provision. In context of energy efficiency, various themes emerge from behavioral economics i.e. bounded rationality, prospect theory, and heuristic decision making (Gillingham et al., 2009). Behavioural failures may arise due to salience issues (e.g. reputation), inattentiveness and bounded rationality (Yang et al., 2013). Prospect theory on the other hand describes how consumers make decision under uncertainties and put forwards the idea that welfare change from gains and losses is assessed with respect to a reference point usually status quo. Consumers treat gains differently from losses thus give greater weight to certain outcomes than uncertainties and want to minimize the risk. Hence, consumer favors status quo which results in loss aversion, status quo bias, anchoring, and abnormal behavior (Shogren and Taylor, 2008). Bounded rationality encompasses that consumers are not fully informed and will not include all possibilities in their deliberation for performing any behavioral or economic act. It posits that gathering all information is constrained by energy and time (Simon, 1957). It is simply impossible to collect all this information and usually agents rely on routines, heuristics and experience for their decision making (Kahneman, 2011). However, it is also argued that it is not even useful always to make fully informed economic decisions, as the actions based on limited information usually offers a more reasonable solution. Moreover sometimes individuals may not even know their preferences perfectly well (Andre De Palma, Myers, and Papageorgiou, 1994).

In energy policy, various studies have largely indicated that lack of information[31] about energy efficiency and energy efficient technologies results in adoption of non-efficient

[31] Information is "*data that has been given its meaning by way of relational connection*"(refer Bellinger, Castro, and Mills, 2004).

technologies and thus results into increased energy consumption in housheld sector (Jaffe and Stavins, 1994); *(*Golove and Eto, 1996). It is difficult to obtain accurate, affordable, reliable and easy information as people those who have information may have many reasons to manipulate the information to increase its value (Drichoutis, Lazaridi, and Nayga (2006). Therefore, to provide affordable, easy to understand and less time consuming information to consumers, policy makers have advocated for standard and labeling in households sector especially concerning those technology which consumes more electricity. The next section therefore, discusses about standards and labels in end-use household appliances.

2.6 Standards and Labels: Reducing Energy Efficiency Gap

To provide the information about energy efficient technology, its future energy cost and its impact on environment to the consumers various policies have been introduced which aim to provide them easy to understand, affordable and reliable information. These informational policies includes different labeling program for energy efficient technologies. Energy labels usually works along with standards in the form of standards and labeling (S&L) programs. Most of the nations have adopted the energy standards and labeling program for their household products. S&L programs treat all manufacturers, distributors and retailers on equal front (Weil and McMahon, 2005). It certifies and rank technology according to their efficiency levels and removes inefficient technologies from the market (S. de la Rue du Can et al., 2014). Moreover, standards have been found successful in inducing innovation, growing existing market and providing new and better market opportunities. Studies indicate that innovation is more prevalent in deployment, commercialization and diffusion of innovative energy efficient technology which can be observed by market entry of efficient product (IEA, 2015). Energy efficient standards shift the distribution of energy efficient models of products sold in the market upwards by removing inefficient models while labels shift the distribution of energy efficient models in upward direction by providing information to consumers which helps consumer to have rational decision while manufactures are forced to design products of higher efficiency that achieve higher ratings than the minimum standards (IEA, 2007).

Labels and minimum quality standards share many similar features and differences as well. Minimum quality standards impose withdrawal of product that fail to meet the standards (refer Figure 2.1 of annexure I) and is usually restricted to regulating basic quality while

labeling represents a soft form of regulating high quality. To reduce the cost of individual certification and to increase efficiency and credibility in certification process, rather than certifying exact attribute of every single product, the certifying agency defines the standards and certifies the product that meets the standards and thus only certified products receive the label. These labels allow consumers to distinguish one product from other product which has not followed the standard or have undergone inspection (Bonroy and Constantatos, 2015). Therefore, this study aims to examine and understand the role of standards and labels in reducing energy efficiency gap in Indian households. The following section gives an overview of standards and labels and situates them in the study as source of information to consumers.

2.7 Understanding Standards

Standards are generally the rules set by certain standard setting organization to achieve minimum energy efficiency of machinery, equipment and other technology. They are observed as a mechanism to share knowledge about a product; its design, its characteristics, and its impact (Brown, Pyke and Steenhoff, 2010). This study considers standards as:

> *"[A]document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context* (SS-EN45020, 1999)*".*

While standardization is defined as

> *"[A]n activity of establishing, with regard to actual or potential problems, provisions for common and repeated use, aimed at the achievement of the optimum degree of order in a given context".* (ISO/IEC Guide 2:1996, definition 1.1)

Brunsson and Jacobsson (2000) in their book, '*world of standards*' gave an interesting view about standards and standardization. According to them, standards generate a strong element of global order in modern world; they create control, homogeneity among producers, people and organisation. They are instruments of control and help in classifying things in

standardized manner (p.4). Standards are form of rules similar to laws, documented in some manner but are voluntary in nature (Brunsson and Jacobsson, 2000). While, default rules are also argued to be similar to standards as they are voluntary and make non adherence difficult but at the same time they are different as they are invisible and users have lack of awareness surrounding them (Kerwer, 2005). Even though standards are voluntary in nature, they are considered as significant governance mechanisms (Thevenot, 2009; Brunsson and Jacobsson, 2000). Moreover, they are powerful tool to challenge and alter institutionalized behavior and identities (Brunsson et al., 2012). Standards are directed at those actors i.e. individual or organisers who are able to decide for themselves, whether to act according to standards or not. They act as actor only when they have choice to take a decision. When they have capacity to act and choose, the propensity to choose particular standard will depend on who they are and what is the situation (Brunsson and Jacobsson, 2000, p.131).

Standards can also be seen as knowledge, generated by certain group (usually expert) or certain type of knowledge can readily be considered as standards. This knowledge is aimed generally to some categories and is directed towards potential adopters who have defined identity and situation (Brunsson and Jacobsson, 2000, p.133). The standards can be *product standard* (specification and criteria for the characteristics of products) and *process standard* (criteria for the way the products are prepared) (FAO website)[32]. Standards can also be distinguished into *de-jure* and *de-facto* standards. *De jure* standards are "established through institutions involved in standards setting", while *de-facto* are selected by the market between competing technologies and are developed outside the traditional standardization framework. They are also called as non-consensus standards (Aurelie and Throne-Holst, 2012). This study would not be entering into the understanding of intricacies of abovementioned standards as it restricts itself to energy efficiency standards used for any equipment, machinery and other items used in the households i.e. end-use household technologies.

2.7.1 Energy Efficiency Standards

In context of Energy efficiency, standards are voluntary as well mandatory in nature. When they are voluntary, they are directed towards those consumers who can decide for themselves, whether to act according to standards or not. Whereas when they are mandatory,

[32] Standards accessed from http://www.fao.org/3/Y5136E/y5136e07.htm on 18th June 2019.

consumers can not decide for themselves but they can choose between the given alternatives. Standards are regulations and procedures that "prescribe the energy performance of manufactured products". They address issues concerning incomplete information, bounded rationality, technological diffusion externalities and also ensure efficiency (Stavins, Schatzki and Scott, 2019). Standards promote interoperability (development of shared protocols and the management of interfaces between one product and another) and protect collective welfare, therefore act as a public good (Shove and Moezzi, 2002). According to Waide and Buchner (2008) when standards are bounded with obligation to save energy, they are highly effective in relation to energy conservation. Energy efficient standards move the distribution of energy efficient models of products sold in the market upwards by eliminating inefficient models (Linares and labandeira, 2010). They are technical standards, which are not necessarily limited to measurement and definition of energy performances metrics. It may include means of testing, certifying, and labeling energy performance, other systems and approaches of energy management and also monitoring, identifying and verifying the energy savings through diverse applications and programs (IEA, 2007).

Energy efficiency standards used in any machinery, equipment and other items are of three types' i.e. 'prescriptive', 'minimum energy performance' and 'class average standards'. *Prescriptive standards* entail particular feature to be installed in all new products. *Minimum energy performance* standards lay down minimum efficiencies levels that should be achieved by manufacturers in each and every product and *class average standards* specify the average efficiency of manufactured product, which allows each manufacturer to select the level of efficiency for each model so that overall average is achieved (Wiel and McMahon, 2005). Energy efficiency standards for machinery, equipment and other technology can be determined by following methods (METI, 2015):

i. **Minimum standard value system**: Under this all equipment, machinery and other items covered under this program should surpass standard values. Most widely accepted minimum standard value system is Minimum Energy Performance Standards (MEPS). MEPS are specified minimum energy efficiency levels products must meet before being sold. They are set at limit that balances the technical innovation with economic viability and competitive forces within a particular market (NAECC, 2005). If product does not exceed the minimum value it is subjected to scrutiny and penalty. To establish efficiency standard limits that all products must

exceed, an economic validity evaluation is done very cautiously. It is highly time taking and long process to establish standards and coordination with manufacturers. They are revised with time to incorporate the technical improvement achieved by a technology with time and are based on test procedures (often termed as test standards). Test procedures establish appliance performance and energy consumption of any appliance (Harrington, 2004).

ii. **Average standard value system**: The target values are decided randomly after considering various factors i.e. potential technical improvement and potential impact of categorical improvements which is based on the information provided by manufacturers. Under this average value of all equipment, machinery and other items should exceed average value of the shipment volume by manufacturer and by product category and also by target fiscal year. Under this system, manufacturer can attain the standard value on average basis by delivering a product with higher efficiency than standard value in the same group. It caters well to facilitate manufacturer's voluntary activities (METI, 2015).

iii. **Maximum standard value system (Top Runner Program):** In this targets are set based on the values of most energy efficient equipment, machinery and other items in market at the time of standard value development process and define standard values by considering potential technological improvements as efficiency improvements and thus, target values are very high. Manufacturers can attain target values by exceeding target values by weighted average values using shipment volume. Weighted average values provides manufacturers incentive for developing product with higher energy consumption efficiency. As target standard values to be set in this system is clearly known, the process of standard value establishment can be done quickly and easily as compared to other systems. On the other hand manufactures are burdened with the technological and economic burdens (METI, 2015).

Most countries standardize their electrical appliance, equipment or any other item to reduce the energy consumption by using MEPS (Harrington, 2004). MEPS address variety of market barriers and imperfections and also tend to reduce the risk and uncertainty by developing a market for energy efficient technologies. At times, reduced cost of technology and experience with new technologies tends to reduce the need of information and split incentives effect which is said to help in overcoming the inertia of habit and routine. Thus, standards are

helpful in reducing energy efficiency gap only if they are well designed, properly enforced and continuously updated (Cooper, 2013). On one hand standards are widely accepted for its ability to maintain harmony, being able to govern, and to alter institutional behavior and identity. They also have filtering effect on commercial practice, removing some aspects and adding other dimension which has huge impact on economic and environmental consequences. They are stabilizing factor and provide a reliable and consistent point of reference and also reduce complex market relations (Shove and Moezzi, 2002). It is further highlighted that on one hand, standards are found helpful in regularizing skills, patterns of knowledge, division of labour and reducing effort and cost in describing, specifying and dealing with non-standardized products (Shove and Moezzi, 2002). On the other hand, standards as entity, face criticism for being less effective as policy and accused for legitimizing unsustainable habits, practices and conventions. The critiques of standards will be further discussed in next section.

2.7.2 Standards and Its Critique

As a policy instrument, standards are noted to be inferior in reducing environmental externalities when compared to taxes. Taxes are considered as superior based on neo-classical model of rational consumer choice according to which when consumers face proper price signals[33], they will make efficient choices. Studies (Linares ad Labandeiras, 2010; Parry et al., 2010; Anderson et al., 2011) have emphasized on advantages of implementation of energy taxes over energy standards as it lead to rebound effect and other inefficiencies. Tsvetan and Segerson (2014) analysed energy policies based on behavioral model of temptation and self control and found that in presence of temptation (i.e. lower prices for non-efficient products), pigovian taxes[34] alone cannot yield the best outcome and therefore, standards might dominate pigovian taxes. However, pigovian tax and standards can be considered as complementary instruments for higher social welfare rather than substitutes (Tsvetanov and Segerson, 2014). However, when welfare effect of energy efficiency

[33] Price signal is the information provided to consumers and producers, which is reflected through price charged from consumer or producers which in turn gives a signal about the quantity of product to be produced or demanded.

[34] A Pigouvian tax is a "government cost on activities that create socially harmful externalities. An externality is an activity that creates a negative effect on others in a society but not necessarily the person who does that activity". (Definition of Pigouvian taxes is accessed from https://www.thebalance.com/pigouvian-tax-definition-and-examples-4157479 on 20th June 2019.

standards and pricing policies are compared, standards were found to costly when there is no misperception over energy saving (Parry et al., 2014).

Another critique about standards comes from Shove and Moezzi (2002) who examined the role of energy efficiency standards in shaping markets, expectations, culture and conventions. According to them, standards often favour dominant designs which assume high levels of consumption of energy and its services despite for higher technical efficiency. It brings expectation and convention in their wake. It is recognized that adopting minimum energy efficiency standards may not be practical for developing countries but harmonization in general is found to be beneficial (Shove and Moezzi, 2002). The authors further suggest that international energy standards may have negative impact on socio-technical diversity and can foster a global monoculture of increasingly intense consumption. Moreover, energy policy initiatives may have unplanned consequence of stimulating energy consumption through legitimizing unsustainable habits, practices and conventions related to more efficient technologies that they promote. As most of critiques are given from the perspective of developed countries, it is crucial to analyse how it shapes in different context i.e. developing nations where energy consumption patterns are different from their developed counterparts. However, in terms of energy efficiency, the end-use technologies have clearly witnessed the innovation in the technology in last few decades which have resulted into more robust and efficient technologies when compared to older technologies. To reduce energy efficiency gap, having standards does not fulfill the goal as standards are expert knowledge. This expert knowledge needs to disseminate to end-users through various informational programs e.g. Labeling programs. The next section will discuss more about the labeling programs and how it shapes the decision making of end-users.

2.8 Understanding Labels

Labeling have always shape the way we think, look at things, people and societies and perceive world around us. Various labels have emerged with time and few have lost their value and use. Labels are usually used to categorize things and people, inform about the properties of the product which were not visible, to warn, and also to make status. They are used to educate consumers and allow them to take informed decision about the concerned product. For the government, it is considered as a tool to encourage changing consumption and production patterns of consumers and manufacturers respectively towards sustainability

("Eco-labeling", 2018)[35]. They can be found attached to a thing through a string, sometimes embossed, somewhere engraved, sometimes sewed and somewhere pasted.

Labels are not recent depiction or presentation of information. Different labels emerged at different time frames for different objectives. The earliest label affixed to a product appears to be those for bales of cotton in 16th century. During 1700s, labels were also found on medical containers. Labels on medicines were used to inform about the content, its seller, give directive about its usage and also warning[36]. For the medicines, earthen ware and lead vessels were labelled with name of extract, followed by name of seller or originator by early Greeks. The pharmaceuticals which were to be taken in dosage forms were labelled by Romans. The early apothecary jars were generally not labelled to allow their continuous reuse for variety of drugs but by the 16th century, concerns of correctly labelling the contents of all apothecary vessels grew stronger and thus emerged more dedicated labelling of such vessels. Until 17th century, physicians used to write the prescription order in a book in the pharmacy kept for that purpose and pharmacist used to inscribe a label made up of parchment, leather, or a wooden chip that used to be tied around the neck of bottle. Labels of different colors were also used i.e. green bordered labels were used for internal medicines and yellow labels with orange borders were used for external medicines. Later, tied-on labels were replaced with labels affixed to bottles which are still surviving with emergence of printing (Griffenhagen and Bogard, 1999).

Other labels which found its use all around the world was food labels. Earlier food used to be locally made and consumed and thus does not require labelling. Later in nineteenth century, with the emergence of processed foods in the market, more consumers started seeking more information about the food they purchased. Food labels[37] were thus direct means of communicating the information about ingredients, quality and nutritional value to the consumers. It may include information about the way food is produced (e.g. organic food or GMOs), gives information about the nutritional content (nutritional labelling) and also warns

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[35] Eco-labeling from https://www.unenvironment.org/explore-topics/resource-efficiency/what-we-do/responsible-industry/eco-labelling accessed on 12 March 2018

[36] Warning labels aims to inform people about the presence of hazard, the consequences of the exposure of hazard and also provide guidance how it can be avoided (Rousseau and Wogalter, 2006) and can be found in food, medicines, poison, insecticides and chemicals. Warning labels are increasingly used in various products i.e. cigarettes, tobacco, alcohol, toys etc.

[37] As per Food and Agricultural organisation (FAO), Food label is *"any tag, brand, mark, pictorial or other descriptive matter, written, printed, stencilled, marked, embossed or impressed on, or attached to a container of food or food product".* Accessed from http://www.fao.org/food-labelling/en/ on 13th April 2019.

about amount and time of usage (i.e. expiry date)[38]. The early food labels included basic information like weight, name of food, information about producer which later evolved to be more specific, scientific and informative. Trademarks were also used to provide partial quality assurance to consumers (Moore, 2001). The evidence of labelling of food can be traced back in 1203 in England, where regulatory labeling of bread was done, when King John ratified the "Assize of bread" which was later codified in 1266. It stated "*upon every measure, Bushel and weight and also upon every loaf, name of owner distinctly written*". For this every baker was required to put a mark of his own for his bread which with time became a key regulatory mechanism and prices were set for different grades of bread and any bread not in fulfilling the standards were regarded as illegal. Other food material like wine was also regulated and labeled (Moore, 2001). During 18th century most of respectable winery also had printed labels on handmade paper made by wooden press and glued to the product ("History of labeling", n.d). With the food labeling, the idea of standardizing and labeling the product started garnering more interest from different domains.

During 1980's and early 1990's there was increased interest about other types of labels called as '*eco-labels'*. The demand of eco-labels among consumers coincided with command and control measures by governments towards a model of market-governance, self regulation and new environmental policy instruments (Jordan et al., 2003). Eco-labels aimed to provide information about the world behind the product i.e. how it has been produced, does it include environment friendly processes or not, how it can be used, inform about the impact of product on the environment. Specifically they provide information regarding environmental characteristics and impact of labeled products and services to consumers, retailers, policymakers, and other interested parties which help in making informed and rational choices about the goods and services and also indicate the preference of consumers to manufacturers and service providers (World Bank, 2005, p.2) which will be discussed in the next section.

2.8.1 Labels as Source of Information

As noted above, the major idea behind having labels was to inform consumer about the product and help them in decision making of whether they want to buy that product or not,

[38] Food labelling accessed from http://www.fao.org/food-labelling/en/ on 13th April 2019.

how to use the product and even give directions about how to dispose it off. Information about product quality is difficult to acquire and for that tailor made certifications are deemed ideal but it is not a feasible and workable option as tailor made certification faces issues of credibility and efficiency and it is a costly affair to the organization (Perez-Lombard et al., 2009). Therefore, instead to certifying exact characteristics of any product, certifying agency rather defines a 'standard' and certifies the product when it meets the standard. Certified product therefore receives a 'label' to inform the consumers about the product on the basis which consumers can distinguish that product from other variants that do not comply with standard or have not been inspected (Bonroy and Constantatos, 2015). In conditions when consumers' do not have access to complete information about the prices of goods and quality of a product due to cost, time and understanding constraints (Nelson, 1970), labels play an important role, along with raising consumer awareness, ensuring product quality, and preventing fraudulent practices and also support consumers' right to know (World Bank, 2005, p. 2).

Labels are useful only if consumers use it during decision making. One can use the labels as tools only if they are noticed, understood, trusted and valued. A consumer will use a label during decision making only if she trust the message conveyed by the label (Hansen and Kull, 1994). Sometimes consumers who trust the label and its information are also not able to fully use it due to information overload and lack of attention. This attention is given to a label only if they know that labels will help him or her to attain certain goals (Nilsson et al., 1999) e.g. if a person is aiming to purchase an organic produce, she will look for the label which will say 'organic' and will pay attention to related information presented on these labels (Thogerson, 2002).

The information creation for the use of public is found to be limited as information has 'public good qualities'. The creator may not be able to capture all benefits of dissemination or transfer of information as cost of production and distribution of the information can be high which can reduce the incentive to generate the information which otherwise have important value (Gillingham et al., 2009). It is also difficult to obtain accurate information as people those who have information have many reasons to manipulate the information to increase its value. As noted by Akerlof (1970) if one party has more information than other party of the transaction then it may lead to adverse selection of product. Self interest is another incentive for manipulating the information for profit which in turn increases the cost

of obtaining information. Even if information is created, there are various bottlenecks which prevent consumers from being exposed to information include information unavailability, inappropriate timing of messages, targeted problems and attention deficit. Mazis and Staelin, (1982) used a framework proposed by Mc Guire (1976) to understand the journey of consumer in acquiring, processing and using information and proposed five major steps. These include exposure, attention, comprehension, retention/retrievel and decision making:

i. Exposure: data comes in contact with consumer
ii. Attention: the consumer selects certain incentives for further processing.
iii. Comprehension: the consumer understands and designate meaning to the message conveyed.
iv. Retention/ retrieval: information is stored in memory for later use when decision is made.
v. Decision making: Consumers select and synthesize the information for decision making.

These stages are not discrete but continuous and provide a useful framework for understanding the bottlenecks of information dissemination. When consumers receive the data, they allocate their own subjective meaning to it. When information is encoded, it may remain as it is or may be substantially modified or distorted or re-written into more generalizable forms. Therefore if during encoding process, if data is presented in confusing form, its meaning may be distorted by recipient leading to poor decision making (Mazis and Staelin, 1982).

However, mere possession of information is not adequate for making decision because personal decisions are shaped by bounded rationality[39]. Thus label help in providing information to consumer but how this information on labels is presented, processed and used still needs to be studied in a more systematic manner. Moreover, role of various stakeholders i.e. government, NGOs, manufacturers, consumer organization also needs to examined to study the motivations behind the label formulation. Bonroy and Constantatos (2015) have raised the concern about consumers' misperception about labels and its information and asks for its more and better understanding. Misunderstanding of label's information may arise

[39] The concept of bounded rationality implies that agents are not fully informed and will not include all possibilities in their consideration for performing any behavioral or economic act. Much often, agents rely on routine, heuristics and experience (Kahneman, 2011).

from three sources i.e. if the message is complex (e.g. nutritional labels), if there are large number of closely-related labels (eco-labels) and due to over or under-estimation of true risks/benefits associated to the label which is related to the product attribute. Other important attribute about labels is cost attached to it and also cost attached to information, which shapes the quality and quantity of information to be disseminated. The following section will discuss the economic aspect of labeling.

2.8.2 Labels and Its Economics

The economic theory suggests that information flow among the participants of market plays an important role in increasing the efficiency of markets but information has a cost attached to it. Consumers pay the cost to search the information while manufacturers and government pay the cost to generate the information. Even there is a cost related to collecting, verifying, monitoring and administrating the labeling program. Thus Labeling is economically justified as it improves the efficiency of market by easy and cheap flow of information from firms to consumers. The consumers are benefited from the information symmetry and reduced cost of information as it helps them to take informed decisions majorly in line with the preferences. Moreover, information also reduces the uncertainty about the product attributes during decision making. It also help manufacturers and firms as they get awarded for marginal improvements in the quality of various characteristics (Teisl and Roe, 1998).

As noted by Nelson (1970, 1974) and Darby and Karni (1973) there are various attributes of a product. These attributes are search, experience and credence. *Search* attributes is observed prior to purchase through research and inspection, *experience* attributes are assessed after purchase and use of the product and *credence* attributes cannot be easily verified even after purchase and use. The importance of labeling in product increases as attributes progresses along the spectrum of *search* to *experience* to *credence* (Caswell and Mojduszka,1996). It is noted that movement along this continuum increases the cost and difficulty in acquiring the information. While on the other side, for government and third party organization, it becomes more advantageous to provide information along the spectrum of attributes as organization experience economies of scale in verifying, monitoring, and disseminating information and can also penalize the firms which provide mis-information or mis-representation of information (Teisl and Roe, 1998).

Labeling policy varies with three major continua i.e. compulsoriness, explicitness and standardization. Compulsoriness is the "degree to which firms are required to provide information" and it can vary from being voluntary to intermediary to mandatory. Some labeling can be voluntary, while others can be mandatory. Few labeling can fall into category of intermediary labeling as they are claim based labeling. The labeling policies are also seen to have component of explicitness which is the "degree of information presented to consumers". e.g. as per ISO 14000, two types of labels has been identified on the basis of explicitness. It include Type 1 label, which provide least amount of detail related to attribute values and Type III provide most detailed information. The other component is standardization which is "the degree to which the regulation requires the information to be provided in a presentation format that is standardized and uniform across product". In some cases information can be quite implicit and other cases it can be explicit (Teisl and Roe, 1998). However the benefits of labeling majorly depend on the type of attributes being considered.

Various studies have discussed economics of labels and have resulted into dissimilar and contradictory results (Bonroy and constantatos, 2015) therefore; higher degree of research is warranted to understand the impact of labeling on firms, third party organization, government and also consumers. Each label will have different impact on firms and consumers depending on the objective of the labeling. In this study, all the labels are not discussed in general; rather author has chosen environmental labels[40] to examine how public understands the label and its impact on decision making specially energy labels.

2.8.3 Types of labeling

Recently, consumers are becoming more interested in buying ecologically sustainable products that has resulted into increased focus on environmental labeling as well (Ibanez and Grolleau, 2008). Last 40 years have seen rise in various Environment Labeling and

[40] Environmental label is a "claim by firm that it has employed environmentally sensitive production or distribution methods" and these claims often appears as labels fixed to products, advertisements or any other representation (Bruce and Laroiya, 2007). They intends to convey information to consumers about the steps the firm has taken to protect the environment and supports a valid purchase behavior (Thogersen et al, 2010[40]; Wang et al., 2014). It can "*take the form of statement, symbol or graphic on a product or package label, in product literature, in technical bulletins, in advertising or in publicity, amongst other things" (ISO 14040:1997)*.It should be noted that environmental labels raise consumer awareness about the environmental effects of product and also help in product differentiation and reducing the informational asymmetries. These labels represent a license granted to a product after completion of comprehensive assessment[40]. It also helps the consumer in making their purchase decision by providing information about the 'world' behind the product and for businesses, it also enables measurement of performance and communicating and marketing the environmental credentials of the products. ISO 14000 series establishes guiding principles for the development and use of environmental labels and declarations.

Information Schemes (ELIS) across the world. Majority of them operate at national level and uses third-party verification (Gruere, 2015). For promoting sustainable consumption and production practices '*environmental labeling*' can play a major role as it is designed to influence consumers. Environmental labeling is defined as (US EPA, 1998):

> *"The practice of labeling products based on a wide range of environmental consideration i.e. hazard warnings, certified marketing claims and information disclosure labels*".

Agenda 21 of UNCED (1992) has also highlighted the need to encourage government with industry and other significant groups for development of environmental labeling and other environment related information programs prepared to assist consumers to make informed decisions (UNCED, 1992; 4.21). Manufacturers or producers use labeling strategies for vertical product differentiation by providing required information about the environmental advantages of a product (Schumacher, 2010). As outlined in the definition, under environmental labeling various environmental attributes can be considered and they have been categorized into different categories as per their formulation process, their enforcement, and the attributes they present (Figure 2.7). Environmental labeling programs[41] are categorized into positive, negative or neutral labeling (US EPA, 1998) as per the attributes possessed by product.

Positive labeling programs endorses that concerned products possess environmentally preferable characteristics. This may include seal-of-approval and single-attribute certification program

a. **Seal-of-approval programs** give the license for the use of a logo to products that the program finds to be less harmful to environment compared to other products, based

[41] Labeling program differs in its mandate, operations, organizational affiliation and its role in market place. These programs encompass the consumer demand, competition among producers, and leadership of the concerned organization. The important aspect of labeling program is the verification. It can be first-party or third-party verification. The first party verification is done by marketers on their own behalf to promote positive environmental attributes of their products whereas, third party verification is done by independent agency based on some environmental criteria or standards (US EPA, 1998). One type of Voluntary Eco-label identified by (Galarraga Gallastegui, 2002); (D'Souza, Taghian, Lamb, and Peretiatko, 2007) uses pre-set indices and provide information about products based on independent verification. In this, performance against the environmental indices is testified by an independent third party, who collects life cycle inventory data and analyze the product rating in terms environmental indicators like natural resource use, energy use, water discharge, air emissions and solid waste generation.

on specific set of award criteria. In this product is chosen on the basis of category suggested by either manufacturers or program officials and criteria are laid down for receiving a label within the concerned category (US EPA, 1998). The examples of seal-of-approval program are Blue Angel (Germany), Eco-label (Canada) and Green seal (US).

b. **The single-attribute Certification program** certifies the "claims made for single-attribute of a product meet a specified definition" e.g. 'recycled' or 'biodegradable'. In this marketers have to verify that their product characteristics meet the program definition. It defines the definitions of claims and manufacturers must fulfill the concerned requirements e.g. US's Energy Star program (US EPA, 1998, p. 12).

Negative labeling program cautions the consumers about the harmful or hazardous components contained in the labeled products while neutral programs provide the information about the product that can be easily understood by consumers. In negative and neutral labeling, producers are dominant player (US EPA, 1998, p. 51) in shaping the direction of labeling program. It aims to point out the negative attributes of the product and thus ensure safe usage of potentially dangerous products. They are usually mandatory labels initiated by third party which requires information to be disclosed for public for health and safety concerns or manufacturers may give warning information on their products for liability reasons (US EPA, 1998, p. 12).

Neutral Labeling program discloses information about the product and the interpretation of information is dependent on the consumer for decision making. They are usually mandatory and the presentation of information is neutral and simple which can make comparison feasible. The information disclosure labels are developed because it is believed that consumers have "right to know" about the product. e.g. US FDA's nutrition label, Energy Guide Program, automobile fuel economy information program (US EPA, 1998, p. 12).

Another classification is given by International Standardization Organization (ISO) which provides globally recognized and credible sets of international benchmarks against which businesses can prepare their environmental labeling (as per ISO 14020 series). According to this, Environmental Labeling Programs can be categorized into two i.e. Type I and Type II environmental labeling program.

a) Type I labeling program

It "awards their environmental label to products that meet a set of predetermined requirement by public or private agencies". ISO 14024:2018 relates to type 1 voluntary environmental labeling program. It is voluntary, multiple- criteria based third party program that awards a license, which authorizes the use of environmental labels on products and indicates overall environmental preferability of a product within a particular product category based on life cycle assessment ("Environmental labels and declarations" n.d.). Products qualify for the labels when they reach or exceed a set threshold limit. They are product of third party certification and usually supported by the government. There is considerable increase in third party labeling of consumer products with an ecological, sustainability or social responsibility background (Mason, 2006). In this, stakeholders set the criteria using the consultative process including industry and consumers (Galarraga Gallastegui, 2002); (D'Souza, Taghian, Lamb, and Peretiatko, 2007). It is a costly process and aims to encourage consumers to shift towards environmental friendly consumption habits e.g. EU eco-labels, Nordic Swan, Germany's Blue Angel and India's Star labeling.

b) Type II environmental labeling program

It includes self declared environmental claims which are "*statement, symbols or graphic that indicates an environmental aspect of a product or packaging".* ISO 14021:2016 relates to this environmental labeling program. It is made without independent third party certification by manufacturers, importers, distributors, retailers or anyone who is likely to be benefit from this label (3.1.15). They often provide one sided informative environmental claims and signifies specific attributes of products such as 'organic food', 'CFC free' products and 'recyclable' (Galarraga Gallastegui, 2002); (D'Souza, Taghian, Lamb, and Peretiatko, 2007).

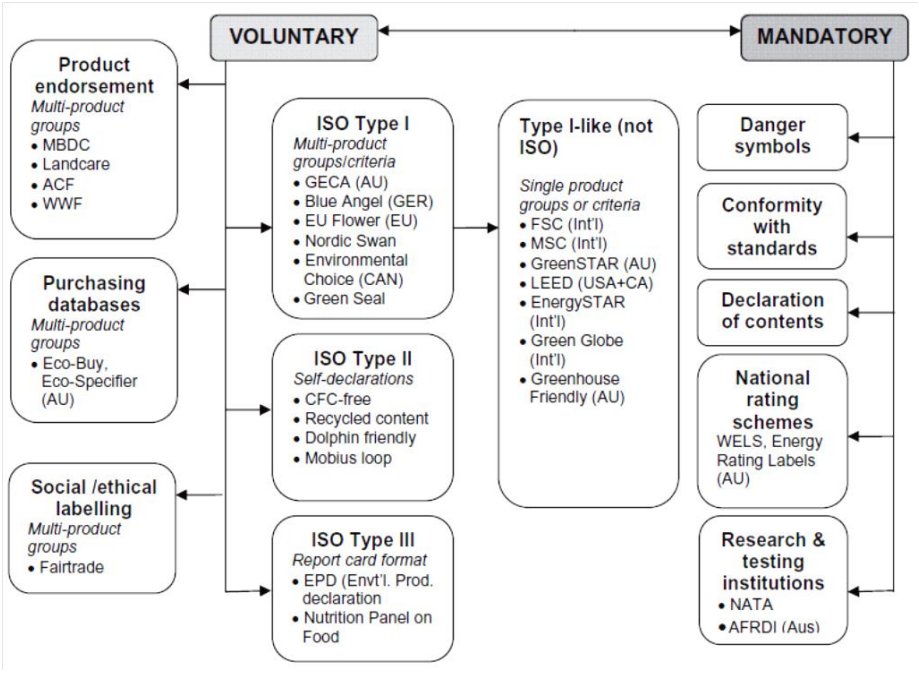

Figure 2.7 Classification of product environmental labels by type.

Source: Rubik and Frankl, (2005).

The literature related to acceptance of environmental labels has shown that there is a sharp increase in uptake of labeled products. Consumers (Green) are interested in buying ecologically sustainable products that corresponds their view on environmental issues and green consumerism[42] which resulted into increased focus on environmental labeling (Ibanez and Grolleau, 2008). Consumers showed increased willingness to buy products which concerns matters of justice, fairness, ecological sustainability, well being, ethical and political assessment. They are also willing to pay (WTP) more if they think that particular product suffice the cause which concerns them (Baksi and Bose, 2007). The next section will delve more deep into eco-labels.

2.8.4 Eco-Labels: Concepts and Critique

Environmental labels and eco-labels together form a group of labels that caters to environmental performance but eco-labels are part of environmental labels. They highlight overall preference of a product or service on the basis of life-cycle assessments and they

[42] Green consumerism is the "purchasing and non-purchasing decisions made by the consumers based on environmental or social characteristics" (peattie, 1995).

counter the criteria of comprehensiveness, independence and reliability. They are voluntary in nature and do not replace existing legislation rather they provide recognition and competitive advantage to products that have achieved high standards of environmental protection than minimum limit forced by law. A reliable eco-label is always based on effective scientific evidence and also provides 'technical information' about environmental performance to the consumers. The eco-labels are mainly certified by third-party and independent organization to ensure technical credibility and certification process is strengthened and monitored by large number of stakeholders i.e. representatives of industry, government, retailers, consumer organization and non-government organizations. Product categories for example food, appliances, paper products, and housecleaning products mainly have eco-labels on them (UNOPS, 2009).

Worlds' first eco-label was developed in 1978 and was named as Blue Angel[43] by German Federal Ministry for interiors. The product with blue angel label ensures high environmental standards and standards of serviceability and health and occupational protection for a large variety of products and services ("worlds' first eco-label goes international", n.d.). Later various other environmental labels were formulated and used in developed and developing nations e.g. *Eco-mark* (Japan), *Thai Green Label Scheme* (Thailand), *Environmental choice* (New Zealand), *Ten Circle Mark* (China), *Green Mark* (China), *Eco-Mark* (India), *Green label* (Singapore), *Energy Star* (US), *Nordic Swan* (Scandinavian countries), *China Environmental Labeling Plan* (China), *Korea Eco-labeling Program* (South Korea), *Eco-leaf* (Japan), *Energy Conservation Certificate* (China), *BEE star rating* (India) *etc* ("Environmental label", n.d.).

Eco-labels and its critiques

Studies have indicated that in few cases eco-labeling programs can rather increase the environmental degradation or investment in brown goods and can also develop tendency to certify those products which are easy to certify or which leads to reduced changes in production practices or environmental improvements (Bougherara, Grolleau, and Thiébaut,

[43] In 1993 European community introduced eco-label as a sort of green seal of approval throughout 12 community countries to signal consumer about the low impact of product on environment. It intended to remove dubious and unregulated advertisements of products which claim to be ecologically benevolent ("Malise, 1993)".

2005). Hence, firms can green wash the consumers about their product and its environmental performance (Delmas and Burbano, 2011). There are also speculations that labeling may lead to 'excess inertia' or 'lock-in' as it may include certain attributes or may use a specific criterion for awarding seal-of-approval (Teisl and Roe, 1998). In terms of international trade, eco-labels were seen as barriers to trade as they were assumed to be used by various governments for protectionist agenda. Developing eco-labels schemes in developing nations was difficult as they fear facing various financial, scientific and technical barriers for establishing thresholds. Moreover, there were special concerns regarding the use of eco-labels which can reduce their accessibility of markets for their products and services in other countries that are following the eco-labeling. Labeling programs has also been opposed by various manufacturers and trade officials for the fear of loss of their competitive positions, added cost of certification and use of Life Cycle Assessment based product standards. Manufacturers even consider eco-labeling programs as a form of protectionism for domestically manufactured goods (US EPA, 1998). WTO committee on Trade and Environment (CTE) and Committee on Technical Barriers to Trade (CTBT) have extensively discussed various barriers related to trade due to eco-labels and developed agreements[44] which includes rules potentially applicable to eco-labels (World Bank, 2005, p.3).

Eco-labels in India

Despite various barriers and slow uptake of eco-labels, labeling schemes have started creating a niche market of certain products (World Bank, 2005, p. 3). In India, Eco-labels were introduced after the establishment of Indian Standards Institute (ISI) in 1947 with the support of government and private sector as a registered society under the Societies Registration Act 1860 (XXI of 1860) (Agrawal, 1987). A certification mark scheme was

[44]The various agreements includes General Agreement on Tariffs and Trade 1994 (GATT 1994 or GATT), the General Agreement on Trade in Services (GATS), the Agreement on Technical Barriers to Trade (TBT), and the Agreement on Sanitary or Phytosanitary Measures (SPS). Each agreement contains its own set of rules, some of which overlap with rules in other agreements. According to the general interpretive note for the WTO Annex 1A Agreements (which include GATT, TBT, and SPS), in case of a conflict between a provision of the GATT and a provision of another Annex 1A Agreement, the latter prevails to the extent of the conflict. In the absence of a conflict, case law points toward concurrent application of Annex 1A Agreements. (for further details refer General Agreement on Tariffs and Trade 1994, Annex 1A to the Marrakesh Agreement Establishing the World Trade Organization (Apr. 15, 1994), in The Legal Texts: The Results of the Uruguay Round of Multilateral Trade Negotiations, 33 I.L.M. 1125 (1999) , General Agreement on Trade in Services, Annex 1B to the Marrakesh Agreement Establishing the World Trade Organization (Apr. 15, 1994), in The Legal Texts: The Results of the Uruguay Round of Multilateral Trade Negotiations, 33 I.L.M. 1125 (1999) , Agreement on Technical Barriers to Trade, Annex 1A to the Marrakesh Agreement Establishing the World Trade Organization (Apr. 15, 1994), in The Legal Texts: The Results of the Uruguay Round of Multilateral Trade Negotiations, 33 I.L.M. 1125 (1999) , Agreement on Sanitary and Phytosanitary Measures, Annex 1A to the Marrakesh Agreement Establishing the World Trade Organization (Apr. 15, 1994), in The Legal Texts: The Results of the Uruguay Round of Multilateral Trade Negotiations, 33 I.L.M. 1125 (1999) , WTO Appellate Body Report, European Communities—Measures Affecting Asbestos and Asbestos containing Products, 80, WT/DS135/AB/R (Mar. 12, 2001).

introduced by an act of parliament (1952) to enable consumers to identify products of daily use of acceptable quality (Lal, 1991) and Indian parliament introduced a voluntary eco-labeling program known as **Eco-Mark** in February 1991. Eco-mark used an earthen pot as a label to symbolize that the product uses sustainable resource, reduces the hazardous waste production or reduces energy consumption. It was launched by Ministry of Environment and Forest to assist consumer to become environmentally conscious by providing them required information to consider environmental factors in their purchase decisions, encourage them to purchase products with less harmful environment impacts and thus ultimately encourage them to sustainable management of resources ("Ecomark to begin with cosmetics",1991). Eco-mark was type II Eco-labeling as per ISO 14021 as it is a claim made by the company regarding its product and services which is based on principles of ISO 14020[45] and did not involved any third party to certify their product ("Eco-label", n.d.).

The Eco-Mark[46] label was one of the first programs on environmental labeling in India but failed due to myriad of reasons (T.B, 2013). Reports indicated that the program in its initial phases targeted 132 sub-categories of products which was a huge number for a new policy. Till 2013, only 20 eco-marks were granted to 15 companies across four product categories i.e. paper, wood substitutes, finished leather and electrical/electronic goods (Suneja, 2013). One of the major reasons for failure of the Eco-label was delay in organization and bureaucratic set up. There was also lack of awareness about environmental labeling amongst consumers, manufacturers, industries and producers and thus demand from consumers was also not visible and manufactures didn't had any incentive to get their product labeled as it was self financing program ("Indian Ecolabeling Scheme: The Eco-Mark", n.d.). Despite of failure of one eco-labeling program, other programs i.e. energy labels were introduced which will be discussed later in next section.

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[45]ISO 14020 gave various principles to be followed during self-claiming a eco-product i.e. the declaration should be accurate, verifiable, relevant and non-deceptive, should be based on scientific methodology and on life cycle. The declaration should promote innovation for improved performance and should develop consensus with interested parties and the relevant information regarding procedure, methodology and any other criterion should be used to support environmental declaration to all interested parties.

[46] 16 products i.e. soap, detergents, paper, food items, lubricating oils, packaging, architectural paints, electronics goods, food additives, wood substitute, cosmetics, aerosol propellents, cosmetics, plastic products, textiles, fire extinguisher and leather were chosen to be labeled. Ministry of Environment and Forest (MoEF) and Central Pollution Control Board (CPCB) regulate the program along with Bureau of India Standard (BIS) product quality standards. BIS assessed and certified products and made contracts with manufacturers to allow the use of labels on payment of required fee. BIS also had power to withdraw license of the manufacturers in case of misleading information. Under this, a product was required to fulfill product quality standards and product –specific environmental criteria to be an Eco-mark product. After two decades of existence of Eco-Mark, only 12 companies secured Eco-Mark from BIS and 17 Licenses have been issued under product category of paper, wood substitute and finished leather products. Manufacturers of Commonly used item i.e. Soaps, and Electronics did not apply for license. In Initial cases, it was even suggested that government should give incentive for having Eco-Mark to manufacturers and also provide subsidy to Eco-labeled products.

2.8.5 Energy Labels

Energy labels are seen as one of the means to provide the information to consumers to remove information asymmetry and help them in making the informed decisions. Ben Youssef and Abderrazak (2009) pointed out that in absence of credible and reliable information disclosure mechanisms, consumers will fail to identify the true environmental characteristics of any environmental friendly product. On the basis of information presented on energy labels, they are classified into endorsement and comparative energy labels (refer Figure 2.8. and 2.9).

a) **Endorsement label** are labels which indicates that concerned product is energy efficient and meets a pre-determined standards or eligibility criteria e.g. ENERGY STAR. The product generally display a logo or mark which informs consumers that product meets a required standard or benchmark and mostly voluntary in nature. It endorses products that are supposedly having less impact on environment and energy consumption levels are under set limits (DoI, 2014)
b) **Comparative label** are labels which allows consumers to decide about the appliance by comparing it with other variants with relative rankings e.g. the energy rating label. They are mostly mandatory in nature but can be voluntary in some cases. It provides consumers to assess the comparative efficiency of a product through simple ranking and numerical system (DoI, 2014). Endorsement and comparative labeling can co-exist (Harrington, 2004). The comparison labels can have different designs and format for information representation i.e. Dial label, bar label and linear label.
    I. Dial label has 'dial' in which increased efficiency is linked to advancement along the dial (more efficient represented by clockwise arc) as used in Australia, Thailand, Korea and India. The number of stars or grades depends on highest present threshold for energy performance that the model is able to meet.
    II. Bar label mainly uses grids or bar chart with a grading from lowest to highest. All grade bars are visible on every label with a marker indicating the grade of concerned model e.g. Europe and South America uses this format.
    III. Linear label gives linear scale indicating the highest and lowest energy use of models in the market pointing out the specific model within that scale. North America uses such representation (Harrington, 2004).

(a) (b) (c) (d)

(e) (f) (g) (h)

Figure 2.8: Endorsement labels (a) Energy Star (USA), (b) Green seal (USA), (C) GreenMark (Chinese Taipei), (d) Energy Winner (korea), (e) Eco-Mark Scheme (India), (f) Blue Eco-Angel (Germany), (g) China Energy Conservation label (China), (h) Energy Smart product label (Australia)

Source: Harrington (2004)

(a) (b) (c)

Figure 2.9: Comparative energy labels (a) Australia (Dial), (b) China (Bar), (C) US (Linear)

Source: Harrington (2004)

Labels can be used stand-alone or along with energy standards. Along with the information about the product, they also provide energy-efficiency benchmark that work with other policy

measures such as procurement programs, financial incentives etc. ("Energy efficiency standards and label" n.d.). Studies related to energy labels have majorly focused on attentiveness of consumers, willingness to pay for labeled products, the value they attach to energy efficiency of product. But the interaction between energy label and public has not been systematically assessed (Sharma and Gupta, 2013). The energy labels can only be of use when consumers can correctly interpret information and allow them to make more informed decisions to reduce the energy consumption. There is little evidence whether consumers use the information correctly or not (Waechter et al., 2015). Studies reveal that providing information is important but not necessary (Grolleau, Ibanez, Mzoughi, and Teisl., 2016). As when consumers are provided with information in the form of labels, only few consumers may read and process all the information presented on the labels. The information affects those individuals more than others who are already sensitive and involved in solving some concerns (Thøgersen, Haugaard, and Olesen, 2010).

It is also indicated that even if consumers identify the label, it is difficult for them to understand what label intends to communicate. The uncertainty associated with understanding the meaning is also found to be linked to mistrust (Thøgersen, 2000). Sometimes, consumer suffers from information overload and their decision making is highly affected by framing and presentation of information (Banerjee and Solomon, 2003) or due to lack of motivation or ability (Thøgersen et al., 2010). hence information can lead to higher levels of knowledge but may not necessarily lead to change in behavior towards certain concerns (Abrahamse, Steg, Vlek, and Rothengatter, 2005). Moreover, lack of label credibility or lack of understanding of information conveyed by the labels can also cause negative reactions towards labels (Ibanez and Grolleau, 2008). Energy Labels are also found to be negatively correlated with the purchase intention and therefore there is a need to disseminate clear information about technology to increase consumer knowledge (Zainudin, Siwar, Choy, and Chamhuri, 2014). Therefore, to understand the consumer behavior, it becomes relevant to understand how consumers take the information, interpret it and use it.

2.9 Summary

For ensuring energy security[47], energy efficiency and conservation practices intensified with time but also raised the questions about uncertainties about its use on demand side (Yergin, 1988). This chapter presents the overall current scenario of Indian electricity consumption and production followed by underlining the reasons of steady rise of electricity demand in domestic sector and its consumption pattern. It highlights that Indian household sector is bound swell in coming years and so its energy demand. Therefore to cater to climate change and increasing air pollution, pace for moving towards energy efficiency should increase. Energy efficiency is seen as a "low cost-no regret"(Wirl, 2017) and thus can be opted in Indian household sector. The chapter also gave an overview about present scenario of energy efficiency research globally as well as in India. It discussed about the presence of energy efficiency gap in household sector and also outlined the reasons for the same. It was indicated that lack of affordable, clear and easy information is leading to energy efficiency gap in household sector. This is a market failure which can be removed through intervention i.e. standard and labeling programs. S&L programs provides a common energy efficiency benchmark which makes it easy for utilities, companies, and various agencies and encourages consumers to buy energy efficient products and also encourage manufacturers to bring more efficient products into the market. They provide information regarding energy consumption attributes and impact of labeled products and services to consumers, retailers, policymakers, and other interested parties which help in making informed choices about the products and services and also indicate the preference of consumers to manufacturers and service providers. It is further highlighted that the relation of end-users and information is crucial to be understood to shape more effective policy making.

[47] Energy security aims to assure adequate, reliable supplies of energy at reasonable prices and in ways that do not jeopardize major national values and objectives (Yergin, 1988).

Chapter 3
Public understanding of energy efficient technologies: A conceptual framework

3.1 Situating Energy Standards and Labels: An Introduction

Boundaries are 'conversational phenomena' as potential learning mechanisms i.e. identification, coordination, reflection and transformation' take place at these boundaries (Akkerman and Aurthur, 2011). Whereas boundary objects are "*entities that enhances the capacity of an idea, theory or practice to translate across culturally defined boundaries*" (Fox, 2011, p.70). In one of the pioneering study, Star and Griesemer (1989) used example of natural history work in which boundary objects[48] are produced when sponsors, theorist and amateurs collaborate to produce representations of nature. Fox (2011) used the case study of innovation in surgical sterility to understand how boundary objects work and their relation to social meanings within communities of practice. Boundary objects are adaptable to varied viewpoints and can also maintain identity across them. They can be classified into repositories, ideal types, coincident boundaries and standardized forms (Star and Griesemer, 1989). They can also help in overcoming different types of knowledge boundary through repositories, standardized forms and methods, models and maps (Carlile, 2002). For facilitating group work, boundary objects has been classified by Dirckinck-Holmfeld (2006) into ideal types of frameworks, group products, models, standards, concepts and guidelines and communication infrastructure. Not all the elements, standards, concepts, tools, artifacts and process that support educational process serve as boundary objects (Fominykh, Prasolova-Førland, Divitini, and Petersen, 2016). Moreover, it is not even necessary to expand the idea of boundary objects to explain everything to such an extent that it fails anything (Nicolini, Mengis, and Swan, 2012).

Boundary objects have capacities to serve as connection between intersecting social and cultural worlds. They act as bridge to provide meanings across the boundaries of individual

[48] "*boundary objects is an analytical concept of those of scientific objects which both inhabit several intersecting social worlds and satisfy informational requirements of each of them…these objects are both plastic enough to adapt to local needs and constraints of several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use and become strongly structured in individual site use…they have different meaning in different social worlds but structure is common…its creation and management is key process in developing and maintaining coherence across intersecting social worlds*" (Star and Griesemer, 1989, p.393).

knowledge systems, groups or sub-groups that are formed for same purpose. They also serve people when the knowledge is not complete and there is no full control over interpretation of an object (Fominykh et al., 2016). These objects create conditions for collaboration by their interpretive flexibility and not requiring deep sharing (Nicolini et al., 2012). They also facilitate communication and understanding across disciplines, actors or stakeholders and build consensus around particular policy issues (Baggio, Brown, and Hellebrandt, 2015).

In present case, author reiterates that energy standard and labels can be considered as boundary objects as they are used to understand and predict the energy efficient technology adoption. It is important to note that formulation of standards and label takes time, expertise and other technical efforts. Standards and labels helps in distinguishing relevant from irrelevant, reliable from unreliable information and express ethical positions and expert judgments on the basis of political, social, technical and economic consideration which is intrinsically linked with them. Standards are powerful as they work at an infrastructural level, almost invisible into the background but can be visualized during controversies related to it. They bridge boundaries between research communities as they help in coordinating the scientific work across various groups, making it useful to understand for others and thus remove heterogeneity of individual research sites and communities (Star and Griesemer, 1989). Standards also help in regulating boundaries by establishing expert authority in order to produce authoritative knowledge.

For the present study, energy labels and standards can be considered as boundary objects as author see them as artifacts which are understood by different groups and communities differently and act as a bridge by dissemination of information from one group (experts) to another group (end-users). This study is an attempt to understand what public in general understands about these boundary objects i.e. standards and labels. Public understanding is not only shaped by the science itself rather their understanding is deeply interwoven and shaped by broad social, political and economic worlds in which they are (Edwards, 2002). Therefore, various contextual factors are also considered to be important to understand their understanding about energy standards and labels which is shaping their decision making and energy consumption behavior as well. The study draws conceptual insights from Public Understanding of Science (PUS) and discusses the conceptual approaches that provide a framework in which this study is situated. Most of the studies focussing on understanding labels have used food labels or eco-labels as their area of study and are majorly focused in

developed countries. In Indian context, author is not aware of any study which primarily focuses on examining the understanding of energy labels by end users. The chapter provides a conceptual framework which tries to explain the role of energy standards and label in shaping decision making among the Indian consumers. Section 3.2 identifies the 'Public' involved in the study. Section 3.3 examines the relevance of 'public understanding of science' in energy efficiency context. Section 3.4 discusses the role of information in the form energy standards and labels in shaping the decision making of (non) adoption of energy efficient technology among public. Section 3.5 proposes a theoretical framework which explains the role of information in decision making.

3.2 Identifying 'Public'

Before understanding the "public understanding", it is more appropriate to understand the 'Public' referred in this study. In Merriam-Webster dictionary, public is a term "*of, relating to, or affecting all the people or whole area of a nation or state*". Michael (2009) note the term 'Public' covers a variety of terms for example, citizens, collectives, lay groups, communities and movements. They can be restricted to a group of people in specific or in general. The term has tendency to homogenize (lumping diversity together e.g. public may include individuals from different socio-economic conditions) as well as to divide (separating one group from another e.g. highly educated public includes people who have gain certain level of education) (Edwards, 2002).

The Royal Society of London published a report titled "*The Public Understanding of Science*" in 1985 and underlined 'public' as majorly '*non-scientific public'* and defined public in different ways depending on the need to understand science and different ways to achieve it. The report gave five overlapping functional types of 'public' as:

i. Private individuals for individual satisfaction and well being,
ii. Individual citizen for participating in civic responsibility as member of a democratic society,
iii. People employed in skilled and semi-skilled professions,
iv. People employed in professional and trade unions associations
v. Decision makers of society (Industry and government).

Use of publics has been associated with the proposal of a contextual model of communication according to which "communicators inform themselves about, and are attentive to, the different understandings, beliefs and attitudes within the public" (Bucchi and Trench, 2016). In this study, the author is not restricting herself to any of the above classification but refer '*public*' to all population, who are buying and/or using the end-use household appliances and are energy service consumers. They can be expert or lay person, skilled or unskilled and does not restrict to specific part of population.

3.3 Public Understanding of Science: Does It Matter?

> ***"****We live in an age when all manner of scientific knowledge—from the safety of fluoride and vaccines to the reality of climate change—faces organized and often furious opposition. Empowered by their own sources of information and their own interpretations of research, doubters have declared war on the consensus of experts. There are so many of these controversies these days, you'd think a diabolical agency had put something in the water to make people argumentative. And there's so much talk about the trend these days—in books, articles, and academic conferences—that science doubt itself has become a pop-culture meme."*
>
> *- Joel Achenbach (2015)*

In 2015, an article titled '*A giant leap for doubters*' by Joel Achenbach was published in National Geographic Magazine[49] which raised questions on the population who does not believe in science or its understanding in present age. The author gave numerous examples from different fields i.e. climate science, energy, biotechnology and biomedical science to point towards the negligence of understanding of processes and technologies based on science. And finally urged people to use scientific methods or trust a person using scientific methods to validate their viewpoints especially which concerns the global population and the future generations. The idea of urging people to understand, participate, question, engage in science and science related activities have been widely discussed by academicians and researchers in last 60 years. The public was majorly accepted as 'ignorant' about science and thus various measures were taken to nudge people to think and act in a certain way (scientific way).

In last few decades, academicians have examined the relationships of lay-person and experts and how their institutions were managed and negotiated (Bernal, 1983). How their

[49] Joel Achenbach (2015) A giant Leap for Doubters, National Geographic Magazine, accessed from https://www.nationalgeographic.com/magazine/2015/03/science-doubters-climate-change-vaccinations-gmos/ on 1st May 2019.

understanding is improving (are they factually correct about science?) and how they are appreciating and accepting the science and technologies (Gregory and Lock, 2008). The nature of this discussion has changed with time and is still changing (Raza, Singh and Dutta, 2002). The presence and shift of various paradigms of science understanding in last 60 years i.e. from "Science literacy", to "Public understanding of Science", to "science and society" has been widely debated and discussed various deficits in different paradigms (Bauer, 2009).

Science literacy paradigm (1960s-80s) reiterated that there is presence of information deficit among public and called for increased efforts in science education by various means. Scientific literacy paradigm was observed as "*a positive appreciation of outcomes of science*" (As cited in Bauer et al., 2007). It encouraged people to have knowledge of basic textbook facts of science, have understanding of methods, and appreciate positive outcomes of science and technology and also reject superstitious beliefs. Many attempts to measure science literacy among public (through quiz type questions) was undertaken by various countries, but could not conclusively say anything about the awareness level of science and scientific facts among public. Concerns like science biasness, methods of data collection, reasons of measuring knowledge, analysis of the results, portrayal of public and expert-scientist divide emerged in this paradigm (Bauer, 2003; p.223) which further shaped the direction of deliberations concerning understanding of science and technology among the public.

Public understanding of Science (PUS) paradigm shares the idea of 'deficit' public who don't understand science. Royal society report of 1985 declared public as deficient in understanding the scientific information and ask for measures to correct it through science education at all levels. During this time, it was believed that public does not support science because they don't understand it. If they will know about science, it will be helpful for them to change their attitudes towards science and make them more positive towards it. Therefore the research agenda shifted from knowledge to attitudes (Bauer, 2003; p.224). In report the term 'science' included "*mathematics, technology, engineering and medicines and anything which comprised the systematic investigation of the natural world and practical application of knowledge derived from such investigation*" (Royal Society Report, 1985, p.7). The 'understanding' includes "*comprehension of the nature of scientific activity and enquiry and the level of understanding depends upon the purpose it*

is needed for". The report was of view that "*a sensible and balanced public view about science education is dependent on the development of much greater awareness and enlightenment about science and its role in society*" (ibid, p.2). The report emphasized that PUS can result in national well being by enhancing the quality of public and private decision making. It further noted that PUS will improve the public decision making as it will be taken in the light of enough understanding of the issues and science behind it. Moreover, aspect of scientific literacy was also raised in the same to counter the ignorance about science, risks and uncertainty around science and technology.

During PUS paradigm, experts were seen as people doing right and taking right decisions while others were deemed wrong due to their undesired attitudes towards science and technology. However, it was underlined that PUS can strengthen economy and can help in making correct public and private decisions. Bauer (2003) noted that PUS had a "rationalist" and a "realist agenda". For rationalists, attitudes can be changed in positive direction, if all information is provided and can be assimilated by the public with rational core. For realists, attitudes are shaped through emotional relations with the world which they approach through advertisements. The science literacy and PUS paradigms were criticized for heavily blaming public for being 'deficit' about scientific information.

In Science-in-society paradigm, deficit was noted with in scientific institutions and expert actors rather than public. Scientific and technological institutions and their experts were labeled as 'deficit' about societal role in science and technology which operate in the society. Bauer et al, (2008) put the situation as "*the implicit and explicit views of the public held by scientific experts come under scrutiny; they explain part of trust crises. False conceptions of public operate in science policy making and misguide communication efforts of scientific institutions which alienate public further*". For the protagonist of this paradigm, public participation and 'angelic[50]' mediation became the priority while empirical social research became outdated pre-occupation (Table 3.1).

[50] As public engagement takes time and needs know-how, civil servants and public academics are overwhelmed by this managerial task. Here, "angels" steps in. "Angels" are age-old go-betweens that mediate, here not between heaven and earth, but between a disenchanted public and the institutions of science, industry and policy making (Refer Bauer et al., 2007).

Period	Attribution diagnosis	Strategy research
Science literacy (1960s-80s)	Public deficit knowledge	Measurement of literacy education
Public Understanding (1985-1990s)	Public deficit Attitudes	Know X attitude Attitude change Education Public relation
Science-in-Society (1990s-present)	Trust deficit Expert deficit Notions of Public Crises of confidence	Participation deliberations 'Angels' mediators Impact evaluation

Table 3.1: Different paradigms, problems and solutions

Source: Bauer (2009), p.222

These paradigms were transitioning from one to another, opening new questions about the public, experts, science knowledge, lay knowledge, their interaction in society and also how society shaped science. Various criticisms were laid down in each phase, pointing towards the inability to point towards the right question. Moreover, how to get the correct answer for a flawed question was also noted. The concerns and debates in above mentioned paradigms are still changing and will keep on changing with change in equation between science and society. It is further reiterated that till the time, science and society will not appear identical, the public understanding of science and expert's understanding of public will remain an important issue (Bauer et al., 2007). Also the need to understand 'deficit' is recommended to understand what needs to be understood. Next section tries to engage with 'deficit' in understanding the public understanding of science.

3.3.1 Deficit in Understanding

In an attempt to examine public understanding of Science and Technology (S&T), deficit of knowledge is pointed out again and again giving rise to deficit model (Lewenstein, 2003).The deficit model was one of the accepted and highly debated model of Public understanding of science since its inception. It argues that provision of sufficient information to consumers about science and technology can fill the knowledge gap and public can change their mind. The term *deficit* reflects that public is relatively ignorant of science and the scientists are required to transfer the information to improve their understanding of scientific facts and artifacts (Scheufele, 2013).

> "This model has emphasized the public's inability to understand and appreciate the achievements of science…owing to prejudicial public hostility as well as to misrepresentation by the mass media…and adopted a linear, pedagogical and paternalistic view of communication to argue that the quantity and quality of the public communication of science should be improved" *(*Bucchi and Trench, 2008, p.450).

In pursuance of this belief of Bucchi and Trench (2008), the proponents of deficit models emphasize on communication and suggest that public misunderstanding and oppositions may be minimized by communicating the views of expert to general public. In context of energy efficiency also, standards and labeling programs are introduced to reduce the information gap of consumers about energy efficiency and efficient technology which can shape consumer behavior towards a positive direction (adopting energy efficient technology). In general, consumers are expected to know about energy efficiency and related technologies and are expected to take the rational decision of buying the most efficient product and reduce their energy consumption. The information about energy efficiency is provided through standards and labels. The labels focus only on information aspect and assume that provision of information can change the way consumers consume or take rational decision. As traditional view gives the experts/ scientists sole authority to take decision on technical matters and it also assumed that consumers will/ should trust the knowledge produced by the experts involved in standard making and will/have to accept it as it is because the expert knows the best. Even though lay people are capable in understanding and participating in the expert science, the barriers to truly democratize science and technology are formidable (Kleinman, 1998).Therefore, trust on experts and systems responsible for construction and maintenance of infrastructure is crucial and also to understand the relationship between laypersons and experts/expert systems is required.

The difference of understanding of science exists amongst the science experts and general population. It is important to acknowledge the existing difference for enhancing the quality of science understanding, decision making and argument shaping on various scientific and socio-technical issues (Bromme and Goldman, 2014). The information comprehended by an expert or lay person from same source differs from each other due to difference in relevant knowledge and its organization and the other reasons (Bromme and Goldman, 2014) quoted (Goldman and Bisanz, 2002). It is noted that the effect of scientific knowledge is outweighed by the influence of social trust on perceptions of new technologies (Sturgis andAllum, 2004)

and the public respond in certain way not because of lack of information rather there is lack of 'epistemological trust'.

Deficit model has been criticized for oversimplifying the relationship of information and attitude. Various scholars has greatly condemned this on theoretical and empirical grounds (Wynne 1991; Ziman 1991; Evans and Durant, 1995; Sturgis, Cooper and Fife-Schaw, 2005, 33-34; Sturgis and Allum, 2004). Gross (1994) finds it to be an asymmetrical model as it allow communication to flow from one direction only i.e. from science (expert) to public. Its practitioners do not persuade or attempt to build trust among the public. Deficit model also fails to take into account the importance of context in which scientific information is communicated and the way people receive, interpret and assimilate scientific knowledge or integrate them with their personal values and beliefs (Naylor and Keogh, 1999). It is significant to note that scientific knowledge does not assure positive thinking about any technology or reduced chances of fears and risk related to it. It is more of "social construction than a set of objective facts" (Latour (1987).

The deficit model attracted criticism due to its linearity and oversimplification of understanding. These criticisms gave way to other model which was supposed to be an alternative to deficit model. This model was contextual model "which acknowledges that individuals are not empty vessels to information, but rather process the information according to social and psychological schemas that have been shaped by their previous experiences, cultural context, and personal circumstances" (Lewenstein, 2003). However, it seeks critical engagement with science and its role in society (Miller, 2001). The model includes that the knowledge of 'the formal contents of scientific knowledge; the methods and processes of science' along with "its forms of institutional embedding, patronage, organization and control" (Wynne, 1992) to be considered. It recognizes that individuals receive information in particular context which shapes the response to the information, which is also dependent on public trust on scientific expertise (Sturgis and Allum, 2004). Different factors like personal (age, education, lifestyle), psychological (what is understood), social context (cultural values), and external contexts (media) shape the way people take an information, perceive it and understand it. Social systems and media also play a vital role in augmenting or diminishing the public concern about specific issues (Lewenstein, 2003).

The contextual model was criticized for being more like deficit model as it focus on the response of public to information. Moreover, it is seen as a tool for manipulation of messages to achieve particular goals and fails to address various contexts in which institutions of science use 'science literacy' as a tool to influence funding and policy decisions due to their vested interests (Lewenstein, 2003). As deficit and contextual model was criticized for being information-centric, scientist community oriented and allowing one-sided representation of society, new models of science communications were proposed to fill the gaps of the deficit and contextual models. These models were lay-expertise model and public participation model. Lay-expertise model appreciate the local knowledge held by the lay population, which is used by them in diverse fields to make things happens (also called as "lay knowledge" or "lay expertise" by Wynne, 1989). This knowledge is majorly shaped by the life experience and historical legacies of lay population. The model argues that scientists often ignore the value of lay knowledge and count very high of their own level of knowledge. It was criticized for giving more importance to local knowledge over the reliable knowledge formed by recent scientific systems and also fails to answer how this model can provide assistance for practical activities that enhances public understanding about particular issue (Brossard and Lewenstein, 2009). It has supposedly raised ontological gap between expert and public in which experts are seen as unreflexive and lay person as reflexive (Durant, 2008).

Public participation model was another model which emerged due to criticisms from earlier models which failed to acknowledge trust as a major issue in policy debates around scientific and technical issues. This model aimed to enhance public participation (in the form of various activities i.e. consensus conferences, science shop, deliberative technology assessments, citizen juries, deliberative polling etc.) for increasing trust in science policy (Lewenstein, 2003). The above activities aimed at shifting control of science from scientist and policymakers towards public through various form of empowerment and political engagement (Sclove, 1995). Even though, the model had intention to engage public in policymaking but failed to gain much attention around energy policymaking. The next section examines the energy efficiency in light of the abovementioned models.

3.4 Information and energy efficiency

To nudge end-users to change the way they consume and reduce the energy demand in households, policy makers emphasized on providing more information about energy efficiency and energy efficient technology to public. Therefore, information provision through various informational programs i.e. standards and labels and advertisements were made. It is important to note that energy efficiency of an energy efficient technology can not be known until the technology is used and its reduced energy is measured. Before using the technology, an end-user has to buy one. During the adoption process of an efficient technology, one has to know about its energy efficiency and its impact on environment and economy. Therefore, information about the energy efficiency and efficient technology is important to be disseminated at the point of sale to the end-users. Information integration theory[51] (1971) reiterates that new information will shape the attitude of public whereas this attitude is shaped by the scale of value[52] and weight[53] of the new information[54]. Information with high value and weight will have more influence on people's attitudes when compared to the information which have low weight and value (Anderson, 1971). This information can be provided to receiver through written information and advertisements so that they can change or strengthen attitudes (Lindén, Carlsson-Kanyama, and Eriksson, 2006). It is evident that attitude formation and change undergoes a process of integration of new information along with existing cognitions and thoughts.

The information is found to be related to attitude formation and shaping but does not have higher impact on consumption behavior. Owens S. and Drifill L., (2008) have cited (Mc Keinzie-Mohr, 2000) have proposed that *"Providing information may influence attitudes on issues like energy and the environment but necessary not have impact on behavior".*

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[51] Hovland and colleagues in 1950s proposed source-communication-issue pathway to understand various issues. In this, a source of information provides that information which is relevant to shape people's attitude about certain issue. Norman Anderson and colleagues used source-communication-issue pathway to understand shaping of attitudes and proposed information integration theory in 1971. This theory was further tested by him and his colleagues and other researchers in the following years.. It states Thus new information integrates itself in various ways to existing information to create new attitude[51]. In modeling terms, valuation and integration are two fundamental operations are used in integration theory. Valuation involves determinants and measurements of scale and value parameters while integration comprises the way in which several stimuli are combined. This theory majorly concerns with situations which requires putting together various pieces of information. The integration of Information involves learning, perception, judgment and decision making and further this theory ask for development of unified general theory for better understanding of consumers(Refer Anderson, 1971).

[52]The scale value (s) is the location of informational stimulus along the dimension of judgment

[53]The Weight (w) is the psychological importance of information.

[54]Value and weight will depend on the dimension of judgment as well as individual. The same information may have different value and importance on different dimensions, or for different individuals on the same dimension.

During examination of adoption process of Compact Fluorescent Lamps (CFLs), Bertoldi and Atanasiu (2006) found that many citizens are aware of lighting as major electricity consumers but are unaware or reluctant to install energy efficient lighting due to lack of knowledge about the actual energy savings. The correlation between information programs and adoption of CFLs was not found to be strong. In other study Delmas and Lessem (2014), found that public information led to reduced consumption but information was found to be useful only if people are motivated to conserve. Motivations i.e. Intrinsic, Extrinsic and Reputational were found to be related to energy conservation behavior. Intrinsic motivation includes warm glow and pure altruism. Warm glow altruism is motivated by increase in self esteem which is associated with improving wellbeing of others whereas pure altruism is motivated by an interest in the sole wellbeing of others. On the other hand extrinsic motivation is for pecuniary rewards and personal goal settings. While, reputational motivation occurs when pro-social action acts as a signal of virtue leading to positive reputation.

The present study acknowledges the fact that energy conservation behavior is shaped by awareness about the environmental related concerns, energy related issues, energy price signaling, conceptualization of energy efficiency, level of trust among consumers, and amount of information present about energy efficient technologies available in market. If people know about labels, how they conceptualize and does this conceptualization is reflected in their decision making? The centre point of this study is energy labels which depicts certain data in the form of information i.e. information related to energy consumption, energy efficiency, price, brand, type, size etc. Moreover, standards and labelling literature often mention that standards allows to move efficient technology in market and labels help consumers to attain certain goals i.e. energy saving, saving environment and saving money etc. Therefore, this study takes energy labels as a source of major information about energy efficient technologies. The information presented on the labels needs to be properly understood to make a decision about buying an appliance.

3.5 Understanding Energy Efficiency Information

In context of energy conservation and efficiency, Constanzo et al., (1986) suggested that energy conservation behavior can be improved through dissemination of information. The study developed a model to understand energy conservation behavior and consisted of

psychological and positional factors. Psychological variables include how an individual perceive the information, evaluate it, understands it and remember it during making a choice. While positional variables include disposable income, home ownership, home repair skills, own home technologies *etc.* (Costanzo, Archer, and …, 1986).

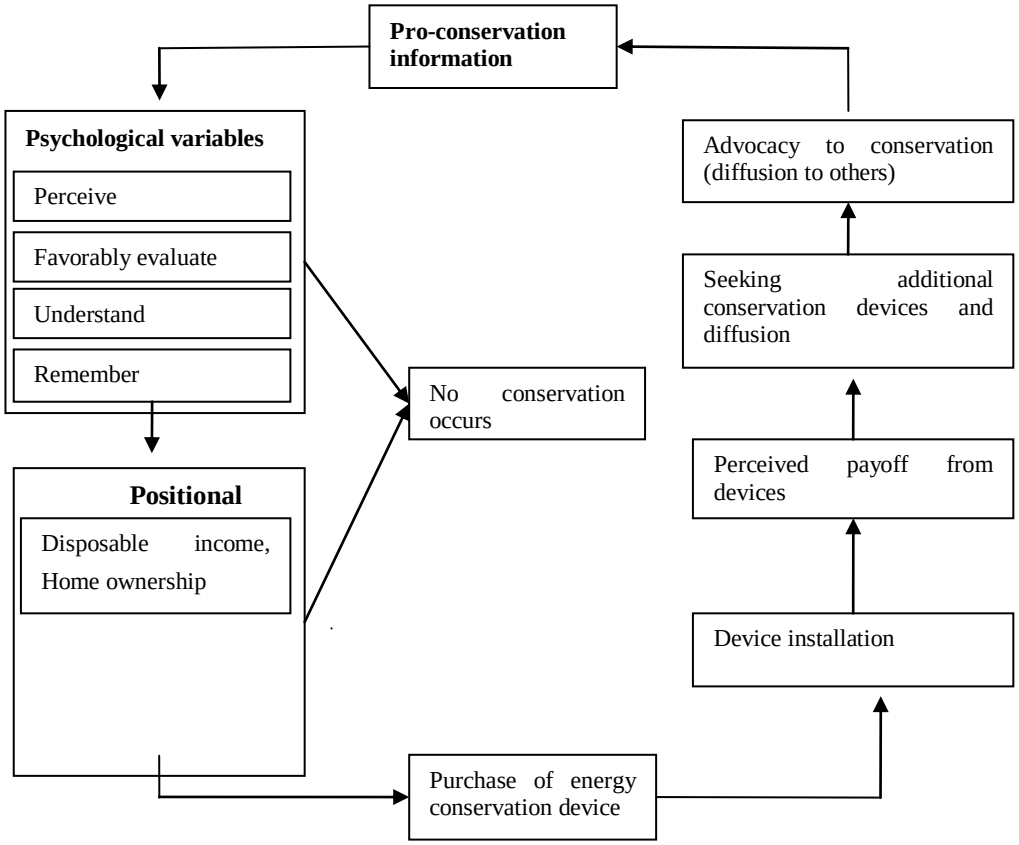

Figure 3.1 Social and Psychological factors for energy conservation behaviour

Source: Constanzo et al., (1986)

Before buying a product, consumer undergo various decision making dilemmas and after an energy conservation device is purchased, installed, the individual perceive some pay off, which forces him/ her to seek more information about conservation devices and also recommend the conservation device to others as well. However, the way information is presented also influences the decision making e.g. dull information is less appealing to consumers (Costanzo et al., 1986). Therefore, easy-to-understand, reliable and affordable information is required during decision making. When information is at place, many positional and psychological play their role in decision making of buying an appliance and

also shape future conservation behavior. Moreover, consumers already have some knowledge which they gain with experience which also shapes the way new information is understood.

The information about energy efficiency and conservation is useful only if people are motivated to conserve to energy and give high importance to it. There can be many motivations to conserve energy in households e.g. environmental concerns (save energy to save environment), economic concerns (saving on energy bills by reducing energy consumption), and social concerns (green reputation and role model playing (Delmas and Lessem, 2014). With the information also consumer may not change their attitude towards energy consumption and this inconsistency between expected rational behavior and actual behavior can arise due to many internal and external factors. It is important to note that individual's behavior, values and basic assumptions are embedded in ongoing social systems, his/her behavior may have unintended impacts on social and individual world views (Pedersen and Neergaard, 2006). There is limited understanding of how values are related to energy consumption (Mirosa, Lawson and Gnoth, 2013). However, few studies does indicate that that people with strong egoistic values may develop negative attitudes towards environmental protection easily and develop positive attitudes towards individual inconvenience associated with purchase of energy efficient appliances. Whereas people with biospheric and altruistic values encourage their behavior towards environmental protection and reduce positive attitudes towards individual inconvenience. And hence people with more knowledge about energy efficiency and energy efficient appliances opt for environment protection and do not bother much about the inconvenience related to purchase (Ngyugen, Lobo and Greenland, 2017). It is often argued that when public endorses certain values, normative goals grow stronger and these values are especially influential when they are activated and also supported by various contextual cues. On the other hand, people with strong hedonic and gain goals may purchase energy efficient appliance if they find it profitable and good but as those actions become costly, effortful, or time consuming, people may not be encouraged to buy that energy efficient appliance (Steg et al., 2014).

3.5.1 Understanding energy saving behaviour

Understanding behavior of energy consumers is highly complex. Few researchers have tried to disentangle this complex system and have given numerous perspectives (for overview Jackson, 2005) which include microeconomics (e.g. rational choice models, pricing, market

structure); behavioral economics (e.g. bounded rationality, utility maximization, decision heuristics); technology adoption models (e.g. diffusion theories, theory of planned behavior); social and environmental psychology (e.g. the influences of information, pro-environmental attitudes, value-belief-norm characteristics, habits and external conditions); and sociological theories (e.g. social constructs, organizational behavior, embeddedness, socio- technical systems and the energy decision-makers cultural and social context). No single analytical approach explains a framework for analysing more than a small portion of behavior, or for providing reliable successful interventions (Keirstead, 2006); (Wilson and Dowlatabadi, 2007). Various conceptual theories like *Information Integration Theory* (Anderson, 1971), *Theory of Reasoned Action*[55] (Ajzen and Fishbein, 1975), *Theory of Planned Action*[56] (Beck and Azen, 1991), *Norm Activation Theory*[57] (Schwartz, 1977) and *Value- Belief-Norm Theory*[58] (Stern et al., 1999) has been used very often to describe a decision and corresponding behavior.

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[55] Other piece of research which explains the behavior of individuals was given by Icek Ajzen and Martin Fishbein proposed Theory of Reasoned Action (TRA) in 1975, which assume that individuals make rational decisions with use of information available to them. The studies showed that TRA was successful model of its time in predicting consumer intentions and behavior within their defined constraints. It is frequently applied to following situations: (a) the target behavior is not completely under the subjects' volitional control, (b) choice problems not addressed by Fishbein and Ajzen and (c) Subjects' intentions are assessed when it is not possible to have necessary information to form a completely confident intention. Fishbein and Ajzen have specifically acknowledged that their model was developed to deal with the behavior and not the outcomes or incidences resulting from behavior. Therefore, it deals with only those behaviors that are under a person's volitional control. If the action requires some external help which is beyond the models' boundary, then in such cases, the persons may not be able to perform the action even when intentions are strong. Moreover, it focuses only on the determinants and performance of a single behavior and does not cater to possibility of choosing from the given alternatives (Sheppard, …, and 1988). The model proposes that people consider the consequences of alternative behaviors before engaging in them and they choose to perform behaviors that they associate with desirable outcomes. In this model, person's behavior is determined by his/her intention to perform behavior and behavioral intent is derived from attitude towards behavior ad subjective norms (Bang, Ellinger, Hadjimarcou, and Traichal, 2000). The model proposes that people consider the consequences of alternative behaviors before engaging in them and they choose to perform behaviors that they associate with desirable outcomes. In this model, person's behavior is determined by his/her intention to perform behavior and behavioral intent is derived from attitude towards behavior ad subjective norms (Bang et al., 2000).

[56] To address the limitations of TRA, Ajzen and Fishbein proposed Theory of Planned Behavior (TPB) to deal with the behavior wherein an individual does not have full volitional control (Ajzen, 1985). Theory of Planned Behavior adds *perceived control* over the behavior considering situation where one may not have complete volitional control on behavior. In this, attitude is determined by individuals' beliefs about outcomes and attributes of performing behavior, weighted by evaluation of those outcomes or attributes. A person's subjective norm is determined by his/her normative beliefs, weighted by motivation to comply with the other person (referants) (Montano and Kaspryk, 2015).

[57] Norm activation theory given by Shalom Schwartz (1977) is a framework for understanding pro-social, altruistic behaviours. The basic premise of this theory is that personal norms are only a direct determinant of pro-social behaivour. He conceived personal norms as feelings of strong moral obligation that people experience themselves to engage in pro-social behavior. Norm activation happens when an individual become aware of potential consequences of any action. And by taking responsibility of those consequences, he/she can change his behavior accordingly as per his personal norms (Adam Faiers, Cook, and Neame, 2007). He rejected the idea that intentions mediate this relationship. Theory regards internalized personal norms of having two direct psychological antecedents, namely awareness of consequences of one's actions and an acceptance of personal responsibility that one holds for those of consequences. Relationship between personal norms and behavior is stronger in the case, where one is aware of negative consequences of not engaging in pro-social behavior and where one accepts responsibilities for these consequences and denies responsibility. It assumes altruistic behavior as important for pro-environmental behavior and this behaviour is depended on personal norms. Consumers with greater personal responsibility will be motivated to reduce their energy consumption (Abrahamse et al., 2009).

[58] Stern, (1999) gave 'value-belief-norm theory' of pro-environment behavior which links Schwartz's norm activation theory to ecological value theory. They defined values of three type's namely biospheric values, altruistic values and egoistic values (Yan and Lifang, 2011). The Value-Belief-Norms theory explained that individual's acceptance of key values shared by the movement (for pro-environmentalism) on holding their beliefs that particular conditions of environmental degradation threatens these values and on their holding beliefs further

In energy efficiency context, behavior is usually motivated by 'conviction' rather than 'economics'(Claudy and O'Driscoll, 2008). The adoption of energy efficient technology is influenced by various contextual factors and personal sphere variables. Claudy and O'Driscoll, (2008) integrated stern's theory and Ajzen's theory of planned behavior to formulate an integrated framework for adoption of sustainable energy systems. In this framework, Theory of Planned Behavior (TPB) assumes that technology fulfils some functions and satisfies some of need. This utility explains attitude formation related to green technologies. Subjective norms provide motivation for householders to adopt technology while normative beliefs i.e. pressure from society can lead them to adopt or not adopt in energy efficient technology. Personal motivation to adopt efficient technology depends on householders' perceived behavioral control and TPB also allows examining people's perceived behavioral control by measuring subjective importance and availability of various factors i.e. time, money or skills (Figure 3.2).

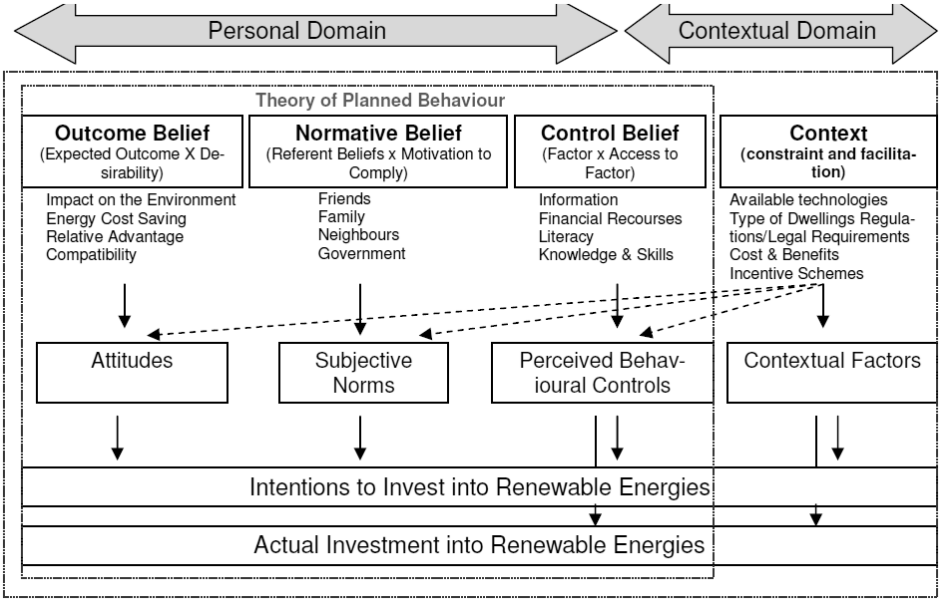

Figure 3.2: Integrated model to evaluate the factors determining the energy efficient technology adoption
Source: Claudy and O'Driscoll (2008)

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that something they can do would directly or indirectly help ameliorate these conditions and preserve the values. Anyone who holds these values and beliefs experiences a sense of personal moral obligation to take appropriate action.

The factor of adoption or non-adoption of efficient technology depends on personal and contextual factors which may vary across countries, regions and people. Contextual factors will be different for people with different attitudes or beliefs and personal factors will be facilitated or constrained by various contextual or external factors, which lead people or avoid them to adopt efficient technology. Contextual or external factors may include regulations, institutional constraints, unavailability of information, monetary incentives, public policies, capabilities and constraints provided by technology. Information campaigns might be proved useless if contextual constraints may not allow personal factors to affect behavior. This integrated model suggest that stronger the contextual influences then less likely the personal factors to explain the behavior (Claudy and O'Driscoll, 2008).

3.6 A Framework towards understanding energy labels

There can be many motivations for seeking information about energy efficiency and efficient behaviour. The stronger the motivation, the more the chance of looking for information and making a decision which suffice the goal for which consumer is motivated for (Thogerson, 2002). Motivations can be of various kinds i.e. *Intrinsic, Extrinsic and Reputational* motivations. *Intrinsic motivation* includes warm glow altruism[59] and pure altruism. On the other hand *extrinsic motivation* is for pecuniary rewards and personal goal settings. While, *reputational motivation* occurs when pro-social action acts as a signal of virtue creating positive reputation (Delmas and Lessem, 2014). When consumers have any of the above motivations to save energy, they search for information related to energy conservation and efficiency. The information about a product and its energy efficiency is usually depicted through energy labels.

When consumer knows about the existence of label they recognise it, read it, understand[60] it and finally take an informed decision. Labels can be used as tools only if they are noticed, understood, trusted and valued by the consumer (Hansen and Kull, 1994). It is also important to note that recognising a label is not same as understanding the precise meaning of label, as often consumers fails to understand what labels intent to communicate (Thogerson,

[59] Warm glow altruism is kind of altruism in which people sometimes wants to win prestige, respect, friendship, and other social and psychological objectives (Andreoni (1990) cited Oslon (1965)). For more refer Andreoni, J. (1990). Impure Altruism and Donations to Public Goods: A Theory of Warm-Glow Giving. *The Economic Journal*,*100*(401), 464-477. doi:10.2307/2234133

[60] Understanding is an interpolative and probabilistic process in which new knowledge is taken to synthesize new knowledge from previously held knowledge (refer www.coursehero.com).

2002). Understanding a label implies that individuals know about its existence, know what it looks like and what it means (Grankvist, Dahlstrand and Biel (2004). Studies also support that consumers may not be always capable of fully understanding of "label" information and often requires "technical" competency to understand (Proto, Malandrino, and Supino, 2007). Information processing theories also suggest that people cannot understand every single thing in stipulated time period (Jacoby, Speller and Kohn, 1974). In some cases, where products are provided with more than one label and each label indicates different aspect of product, it is even more difficult to understand the information fully and assess the comparable advantages of different products (Borin, Cerf and Krishan (2011). Although more information increases satisfaction level of consumer but in various cases it decreases their decision making activities (Jacoby et al., 1974). In real time buying situations, if there are many labels, consumers may experience information overload and even fail to notice relevant information (Thogerson, 2000). In such cases, attention given to label is important to analyse.

Waechter et al., (2015) noted that energy labels triggers attention towards energy information but its effect on consumers' actual product choices is low[61]. Although the research about what kind of information consumers seek related to environmental relevant characteristics is still limited. Studies related to decision making note that while making any decision, consumer try to maximize their utility. According to Lancaster's choice model, "*consumers make choice that maximizes their perceived utility and within their buying capacity*" (Lancaster, 1966)[62]. Generally consumers buy a product for private utility they provide however, consumers with pro-environment attitude would also be interested in reducing environmental impacts as well. Individuals receive utility through consumption of goods per se and it is most appropriate when individuals' subjective evaluation of goods' attribute corresponds to objectively measured attributes of goods. The characteristics of goods can be differentiated into search, experience and credence. The product with search and experience characteristics are able to produce this information easily while the credence attribute which is difficult to identify even after its use, needs information to be provided to consumers. In terms of a product's energy consumption, it cannot be identified or quantified during its use

[61] Waechter S, Sütterlin B, Siegrist M (2015) Desired and Undesired Effects of Energy Labels—An Eye-Tracking Study, PLoS ONE 10(7): e0134132. doi:10.1371/journal.pone.0134132

[62] Kelvin J. Lancaster (1966) A New Approach to Consumer Theory, Journal of Political Economy, Vol. 74, no. 2, pp. 132-157.

but energy labels change its credence attribute (energy consumption) to search attributes as labels inform about the amount of energy used and saved (Sammer and Wustenhagen, 2015).

Taking cue from various studies mentioned above in literature, the author has proposed a framework explaining the understanding of energy labels and factors shaping it. During literature review, it was noted before taking any decision about (not)/buying an efficient appliance, consumers follow series of steps. If consumers are motivated to save energy for environmental concern or economic concern or any other concerns, they usually seek the information to fulfil the goal. When they encounter the information, they recognise it and pay attention to it. After paying attention to an energy label, they comprehend it and finally take a decision according to their need and utility. Various internal and external factors affect each step of their decision making in different degrees (Figure 3.3).

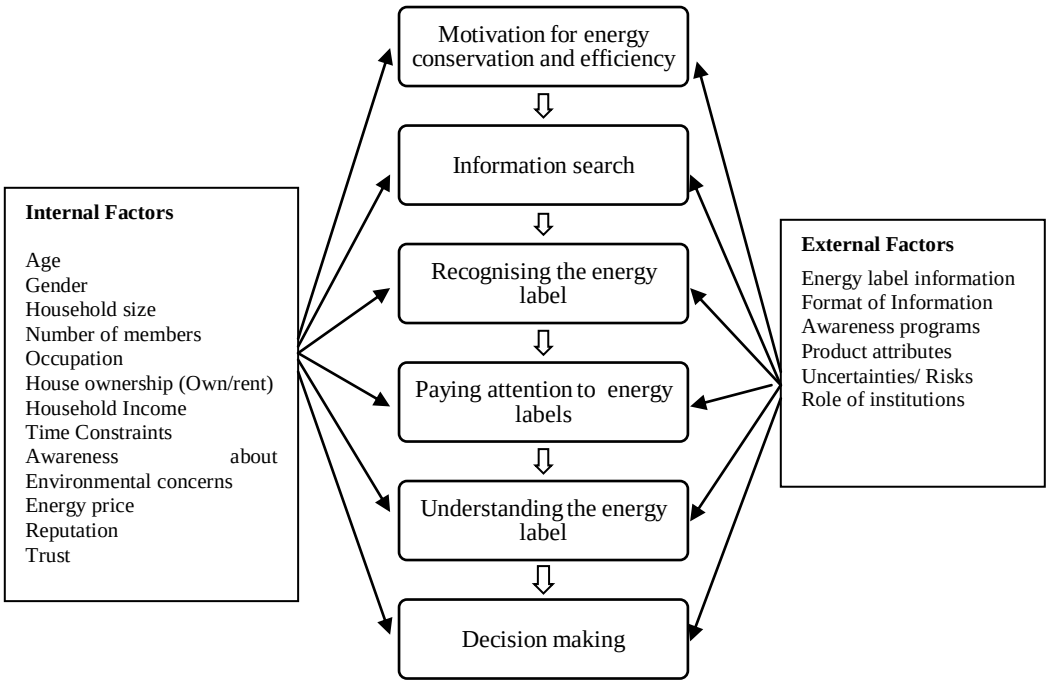

Figure 3.3: Understanding the energy labels

Source: Author's adaptation

a) Internal factors

Various internal factor included in the study are size of households, number of members, educational qualification, house ownership, awareness levels, trust, reputational concerns etc. Studies have noted that consumers are sceptical about the claims made by the eco-labels (Peattie, 1995). Moreover, consumer will use the information on energy labels in decision making only if they trust the message conveyed by the label (Hansen and Kull, 1994). If consumers trust the information providers, they will also trust the information generated by them. Information provided by public or independent source is often more trusted than information provided by manufacturers or retailers (Thogerson, 2000). This trust acts as a mediator of the relationship between pro-environmental attitude and paying attention towards eco-label. Therefore, it is important to use labels that consumers feel they can trust and promote the labels in a manner that builds trust amongst them. Research noting the relationship of level of trust and consumer's decision about energy labels is not very rich. Ownership of house is other factor which affects adoption of energy efficient technologies. Studies have indicated that renting a house is linked to decline in adoption of energy efficient technologies as owners does not find any incentive to invest in efficient technologies because energy bills are paid by tenants (Jaffe and Stavins, 1994; Sutherland, 1996). Moreover, renters are found to be significantly less likely to have energy efficient refrigerators, clothes washers, dishwashers and lighting (Davis, 2011) , Size of residence is directly related to investing in energy efficient technologies as large residences generally have more number of appliances and higher energy consumption. Therefore, owners of large residence have more incentives to invest in such technologies (Mills and Schleich, 2008).

Family size and presence of children in family also shapes the decision making as more consumers results in higher energy consumption. Households with 2-4 members show higher energy saving activity (Curtis, simpson-Housley and Drever, 1984). In one study, Dupont, (2004) noted that parent with children are more concerned about various environmental issues and thus more aware about energy saving mechanisms. Head of the household or main household income earner affects the energy savings. Studies suggests that older households heads have lower level of awareness and knowledge about energy efficient technologies and thus low preference of such technologies (Linden, Carlsson-kanyama and Eriksson, 2006; Carlsson-kanyama, Linden and Eriksson, 2005; Torgler et al., 2008). Education is another very factor affecting search, acquisition and understanding the energy

related issues. It is found to be positively related to adoption of energy efficient technologies (Hirst and Goeltz, 1982; Scott, 1997). Moreover it also reduces the cost of information acquisition and makes it easy to understand the information on labels (Schultz, 1975). Household income is found to be positively related to energy conservation and efficiency investments (Mills and Schleich, 2008). Job profile of consumers and adoption of energy efficient technology is not a well established relationship.

b) External Factors

External factors included in the study are format of information, informational programs, product attributes, institutions and risks and uncertainties. Mills and Schleich (2009) in their study assessed the factors affecting high efficiency appliance buying through simulations and noted that choice is not a dependent on socio-demographic characteristics to a large extent. The other factors, like who produce the labels, how information is produced, what information is presented also shapes the process of understanding energy labels. In some cases, information creators are public institutions, and in other cases, information is produced by manufacturers or private firms. In case of energy labeling in India, labels are produced government institution along with other stakeholders. At times creators may not be able to capture all benefits of information dissemination (Gillingham et al., 2009). Moreover, adverse selection can results is information is not properly transmitted to buyers (Akerlof, 1970).

Format of how information is presented varies across the world making it very important factor to be analysed. McNeil and Wilkie (1979) in their study discussed impacts of various formats of information expressed in kWh/Year, dollar/Years, or dollars/month on consumer's choice of freezers. They found that disclosure format in physical or monetary units and annual or monthly information did not have any impact on consumer's appliance choices. In rather a recent study by Rohling and Schubert (2013) analysed which label format (either Monetary vs. Physical units or annual Vs. Monthly) is better for decision making. The study noted that which label format is better for better decision making is still disputable but impact of labelling was found to positive when information provided was accumulated over the product's expected lifetime. Other studies have largely focussed on relationship of different format of information presentation with consumer behaviour (Allcott and Taubinsky, 2015). In some cases, pictorial representation of information is found to be more superior technique

in capturing attention in direct proportion to its surface size (Peters and Wedel, 2004). In other cases, information in numerical format about quantity of physical energy usage had incremental value in directing decision but is found to be less effective than monetary information (Newell and Siikamaki, 2013). Davis and Metcalf (2014) in their study examined the quality of information presented by the mandatory labels for energy efficient appliances in US using an online choice experiment. They found that state specific labels lead to improved choices but also showed that consumers do not completely understand the information displayed in the label. Studies have suggested that people have difficulty in understanding energy consumption figures of household appliances into contexts. The preferences for energy efficient appliances actually decrease when information on energy consumption is presented in annual operating cost than in physical units in watts (Heinzle, 2012). While Allcott and Knittel (2018), did not found any effect of information disclosure on actual purchase decisions when consumers are provided with electricity cost information.

As outlined in earlier sections, different fields of study have proposed various theoretical perspectives to understand and solve the issues related to energy conservation and efficiency energy. Each field has given useful insights towards energy demand reduction but none have been completely successful in this task. Therefore, integration approach towards looking at this concern has garnered much attention. Present study is identifies factors for (non)adopting energy efficient technology and also proposes a framework which explains the public understand of information on the energy labels.

3.7 Summary

This chapter explores the need for public understanding of energy labels. It traces the evolution of PUS and models around it. As energy consumers were considered as deficit in information about energy conservation and efficiency, the energy labels were noted as one of the methods to provide required information to consumers. Understanding energy labels is a prerequisite to adopt energy efficient technologies for reducing energy consumption. Energylabels provides information about product characteristics, energy consumption and efficiency and shape the decision making of public. Various frameworks have tried to understand why people behave in a certain way especially when they have to take a decision of adopting an efficient technology. The study proposes a framework explaining the process of understanding energy labels and factors shaping the understanding. The proposed

framework indicates that various internal and external factors shape the process of understanding of energy labels which are in turn shaped by values, beliefs and norms of the consumers.

Chapter 4
Standards and Labeling: Policies and Programs in different countries

> "*Achieving the goals of environmental quality and sustainable development will require efficiency in production and changes in consumption patterns in order to emphasize optimization of resource use and minimization of waste" (Agenda 21-b).*

4.1 Introduction

In recent times, the policy makers have highlighted the need for promoting sustainable consumption and production[63] practices to improve resource efficiency and reduce the overall consumption (Wang, Liu, and Qi, 2014; Jackson, 2005). Agenda 21 of United Nations Convention of Environment and Development (UNCED,1992) has highlighted the need to change consumption patterns and asked for development of national policies and strategies to promote changes in unsustainable consumption patterns (UNCED, 1992:4.8). Special emphasis is given to developing nations to achieve sustainable consumption patterns in their development process through enhanced technological development and assistance from industrialized countries and also encourage the usage of environmentally sound consumer products (UNCED, 1992:4.20). Moreover, United Nations Sustainable Developmental Goals (UN SDGs) also calls for responsible consumption and production and targets to implement the 10 year framework of programs on sustainable consumption and production with participation from developed and developing nations ("SDGs", n.d.).

Being efficient in terms of production, distribution and use of energy ensures sustainable consumption and production for long term. Various policies and programs across the world have been introduced to maintain the same in different sectors. Promoting energy efficiency is one of the agenda in ensuring sustainable consumption and production and therefore various policies and programs have been introduced to ensure energy is being used in efficient manner. Section 4.2 provides a brief overview of various important energy

[63] Sustainable Consumption and Production (SCP) as defined by Oslo Symposium[63] (1994) is "*the use of services and related products, which respond to basic needs and brings a better quality of life while minimizing the use of natural resources and toxic material as well as emissions of waste and pollutant over the life cycle of service or product so not to jeopardize the needs of future generation*".

efficiency policies in domestic sector of US, China, Japan, EU and India. The list of various energy efficiency policies and programs was accessed from IEA database. Section 4.3 will emphasize on S&L program to understand the process involved in it and section 4.4 presents a comparative analysis of these programs in select nations i.e. China, European Union, United States of America, Japan and India. For the present study, China, India, US, Japan were chosen for the analysis as they are top most electricity consuming nations in 2018[64] While, EU was selected due to its historical relevance in the field of energy efficiency. It is important to note that China, US and EU accounts for 100, 86 and 77 energy standards and label measures respectively (DoI, 2014) which makes inclusion of these countries in this study more relevant.

4.2 Energy Efficiency Policies and Programs

Policymakers maintains that dynamic use of energy efficiency policies encourage consumers and manufacturers to reduce their energy consumption at reasonable costs. At the demand side various plans and programs are being introduced at the state and national level e.g. utility based demand side management programs, financial incentives for promoting consumer purchase (tax, rebates, subsidy etc.), appliance standards and labels program, information dissemination programs (award, campaigns, advertisements etc.) and educational and Research and Development (R&D) programs (Gillingham, Newell and Palmer, 2006). Most of the nation follows combination of all of the above programs in their energy efficiency policies. Table 4.1 gives a brief overview of various energy efficiency policies and programs in US, China, EU, Japan and India. The table has highlighted the objectives and policy contexts of the important energy efficiency policies pertaining to domestic sector in these nations. The policies given in the table 4.1 have been accessed from IEA energy efficiency policy and measures database. The database provides information on policies and measures taken or planned to improve energy efficiency.

[64] Global Energy Statistical Yearbook 2018 accessed from https://yearbook.enerdata.net/electricity/electricity-domestic-consumption-data.html on 25th March 2019.

Plan/program	Year	Target area	Implementing agency	Objectives	Policy context
UNITED STATES					
Energy Efficiency Enforcement regulations[65]	2009	Residential sector	U.S. Department of Energy (DoE)	-Provides for manufacturer submission of compliance statements and certification reports to DoE, -Maintenance of compliance records by manufacturers, -Availability of enforcement actions for improper certification or upon determination of non-compliance.	Regulatory
National Action plan for Energy Efficiency[66]	2006	Multi-Sectoral	U.S. Energy Protection Agency	-Private-public initiative -Making long-term commitment to implement cost-effective EE -Communicate benefits and opportunities for EE - provide funding to deliver energy efficiency - modify policies to align utility	Informational, Economic,
Appliances and commercial equipment standards program[67]	2006	Residential and commercial sector	U.S. Department of Energy (DoE)	-information for help in decision making - Issues regulations for appliance and equipment standards and test procedure and for implementation, certification and enforcement - information on public participation - supports voluntary Energy Star Program	Informational, Regulatory, Economic, Social
ENERGY STAR National Campaign[68]	2005	Residential Sector	U.S. Energy Protection Agency	-Sponsors various campaigns which seek to encourage energy efficiency and energy savings by consumers - encourage to change behavior /actions	Informational, Social
ENERGY SAVERS[69]	2004	Multi-Sectoral	U.S. Department of Energy (DoE)	- Educates consumers, homeowners and business on reducing energy consumption and bills.	Informational
Appliances and equipment energy efficiency program[70]	1988	Multi-Sectoral	U.S. Department of Energy (DoE)	- Manages, develops, promulgates and enforces test procdures and minimum energy efficiency standards (MEES) for residential standards for residential appliances and commercial equipment. - projected to save a 75 quadrillion Btus (quads) of energy by 2045.	Informational, Regulatory,
CHINA					
13th Five year Plan (2016-20)[71]	2017	Multi-sectoral Policy	National Peoples congress and National Development and Reform Commission (NDRC)	-To achieve an accurate and international understanding of profound changes in domestic and international environments and circumstances - To adapt, understand and guide the new economic development.	Regulatory

[65] Energy efficiency enforcement regulation accessed from https://www.federalregister.gov/documents/2009/10/14/E9-24666/guidance-on-energy-efficiency-enforcement-regulations on 18th June 2019.

[66] National Action plan for Energy Efficiency accessed from https://www.epa.gov/energy/national-action-plan-energy-efficiency on 18th June 2019.

[67] Appliances and commercial equipment standards programs accessed from https://www.energy.gov/eere/buildings/appliance-and-equipment-standards-program on 18th June 2019.

[68] ENERGY STAR Campaign accessed from https://www.iea.org/policiesandmeasures/pams/unitedstates/name-22815-en.php?s=dHlwZT1lZSZzdGF0dXM9T2s,andreturn=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy9lbmVyZ3llZmZpY2llbmN5LyI-RW5lcmd5IEVmZmljaWVuY3k8L2E-PC9uYXY- on 18th June 2019.

[69] Energy Savers accessed from http://energy.gov/energysaver/energy-saver on 18th June 2019.

[70] Appliances and equipment energy efficiency program accessed from https://www.iea.org/policiesandmeasures/pams/unitedstates/name-24940-en.php?s=dHlwZT1lZSZzdGF0dXM9T2s,andreturn=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy9lbmVyZ3llZmZpY2llbmN5LyI-RW5lcmd5IEVmZmljaWVuY3k8L2E-PC9uYXY- on 18th June 2019.

[71] 13th Five Year Plan of China accessed from http://en.ndrc.gov.cn/newsrelease/201612/P020161207645765233498.pdf on 18th June 2019.

Energy Efficiency Leader Scheme[72]	2014	Multi-sectoral Policy	NDRC, Ministry of Finance, Industry and Information Technology, National Energy Administration, General administration of quality supervision, Inspection and Quarantine, and Standardization Administration.	-To designate and incentivize energy efficient leaders i.e. manufacturers and brands that meet or exceed specific energy efficiency benchmarks. -To be leader, proposed energy efficiency standards should be higher than those currently set by China Energy Label	Informational
Medium and Long term Plan of Energy Conservation[73]	2004	Multi-sectoral Policy	National Development and Reform Commission (NDRC)	-To improve energy utilization efficiency, energy conservation, alleviate energy constrains and environmental pressures during 2005-10 and 2010-20 period. -Provides directive with principles and objectives for energy conservation with various programs for different sectors i.e. optimizing energy systems in various industries, adopt energy conservation standards for buildings, promote energy conservation in government agencies, monitoring and technical services, replacement of Incandescent lamps with efficient lights.	Regulatory
Minimum Energy Performance Standards (MEPS)	1989	Multi-sectoral Policy	China National Institute of Standardisation (CNIS)	-The MEPS includes household appliances and industrial appliances. -aims to eliminate the bottom 20per cent of efficiency in market.	Regulatory
JAPAN					
Top Runner Program[74]	2013	Multi-sectoral Policy	Ministry of Economy, Trade and Industry (METI)	-Mandatory standards program and its targets are set based on the value of most energy efficient machinery and other items on the market at the time of standard value establishment. -The program was prescribed under law concerning the rational use of Energy (Energy Conservation law). - In 2015, it aimed to provide an effective measure to achieve energy conservation in residential sector, commercial and transportation sector, also improvements in the energy consumption efficiency of machinery and appliances.	Regulatory, Informational
Unified Energy Saving Labeling Program[75]	2006	Residential Appliances	Ministry of Economy, Trade and Industry (METI)	-mandatory labeling according to Energy Conservation Law -provides for labels with product information i.e. name, model, energy consumption, efficiency ratio, and fuel consumption	Informational
Stand-by power reduction Policy	2000	Residential Appliances	Ministry of Economy, Trade and Industry (METI)	-To reduce standby power on electricity appliance. - Industrial associations like Japan Electronics and Information Technology Industries Association (JEITA), The Japan Electrical Manufacturers Association (JEMA), The Japan Refrigeration and Air Conditioning Industry Association (JRAIA) agreed with voluntary commitments to lower the standy-by power consumption to 1W or lower. -expected to replace household appliances with new currently-in-market ones, per household standby power consumption would be 201kWh/year.	Regulatory
INDIA					

[72] Energy Efficiency Leader scheme accessed from https://news.ihsmarkit.com/press-release/technology/new-leader-program-aims-promote-energy-efficiency-chinas-home-appliances on 18th June 2019.
[73] Medium and long term plan for Energy conservation accessed from http://fourfact.com/images/uploads/China_Energy_Saving_Plan.pdf on 18th June 2019.
[74] Top Runner Program Accessed accessed from https://policy.asiapacificenergy.org/sites/default/files/toprunner2015e.pdf on 18th June 2019.

[75] Energy saveing labelling Program accessed from http://www.ecolabelindex.com/ecolabel/energy-saving-labeling-program-japan on 18th June 2019.

Unnat Jyoti by Affordable LEDs for All (UJALA) Yojana[76]	2015	Residential lighting	Energy Efficiency Standards and Labels (EESL)	-Aimed to replace the 200 million incandascenet bulbs to LED light bulbs by providing it to consumers at subsidized rates and saving 10.5 billion kWh of electricity	Regulatory, Financial
National Mission of Enhanced Energy Efficiency (NMEEE)	2009	Multi sectoral	Bureau of Energy Efficiency (BEE) under Ministry of Power (MoP)	-To strenthen market for energy efficiency with the provision of conducive regulatory and policy regime.	Regulatory, financial, informational
Standard and Labeling Program	2006	Multi sectoral	Bureau of Energy Efficiency (BEE) under Ministry of Power (MoP)	Launched S&L program under the framework of Energy Conservation Act (2001) which shifts the market towards efficient appliances and labeling provides transparency to end-users on energy saving and cost saving potential.	Regulatory, Informational,
EUROPEAN UNION (EU)					
Energy Efficiency Directive (2012/27/EU)[77]	2012	Multi-sectoral	Member states Government	-Establishes a set of binding measures to reach 20per cent energy efficiency target of EU by 2020. - All EU member countries are required to use energy efficiently at all stages of energy chain. -In 2018, directive was amended (2018/2002) to increase energy efficiency target to 32.5per cent by 2030 along with other measures.	Regulatory, Informational
ECO-Design directive (2009/125/EC)[78]	2009	Multi-sectoral	Member states Government	-Provides consistent EU wide rules for improving environmental performance of products i.e. household appliances, information and communication technologies. -sets out minimum mandatory requirements for energy efficiency of these products. -prevents trade barriers, improve product quality and environment protection.	Regulatory, Informational
EU Energy Efficiency Labels[79]	1992	Residential sector	Member states Government	-EU wide labeling activities comes from a framework directive (Council Directive 92/75/EEC) agreed to 1992. -The labeling specifications are spelled out in individual implementing directive, for refrigerators issued in 1994 and took effect in January, 1995. - The labeling requirement become mandatory in member states only when the government have transposed the directive from national law. -Member states holds the responsibility to translate directives into law and take necessary measures to ensure all suppliers and dealers fulfill obligation in their territory. - Ensure labeling scheme is accompanied by educational and promotional information campaigns to encourage consumers. **EU Directive (2003/66/EC)** extended A to G labeling scheme to electric refrigerators, freezers and their combination from 2004 while best performing refrigerators and freezers will carry labels showing efficiency to A+ or A++. In 2019, the efficiency labels having A+ or A++ was scrapped.	Regulatory, Informational,

Table 4.1: Energy efficiency policies in residential sector

[76] Ujala Scheme accessed accessed from http://pmjandhanyojana.co.in/ujala-free-led-bulb-scheme-9-price/ on 15th June 2019.
[77] Energy Efficiency Directive (2012/27/EU) accessed from https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive on 18th June 2019.
[78] ECO-Design directive (2009/125/EC) accessed fromhttps://www.eea.europa.eu/policy-documents/2009-125-ec-erp-directive on 18th June 2019.

[79] EU Energy Efficiency Labels accessed from https://www.iea.org/policiesandmeasures/pams/europeanunion/name-21940-en.php?s=dHlwZT1lZSZzdGF0dXM9T2s,andreturn=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy9lbmVyZ3llZmZpY2llbmN5LyI-RW5lcmd5IEVmZmljaWVuY3k8L2E-PC9uYXY- on 18th June 2019.

Source: IEA databas

4.3 Energy Standard and Labeling Programs

The history of energy efficiency standards goes back to early 1960s. First mandatory minimum energy efficiency standards were introduced in Poland for a range of industrial appliances in 1962. Later French government established standards for refrigerators and freezers in 1966 and 1978 respectively. Mandatory labeling programs developed along with the standards. In 1976, mandatory labeling of heating appliances, boilers, refrigerators, washers, televisions and ventilation equipments was also introduced. Della Cava, Wiel, and Constantine (1997) quoted Waide, Lebot and Hinnells (1997) who noted that early legislation for standards was weak and poorly implemented and did not have any implication on energy consumption which was revoked during 1970-1980s to harmonize European trading conditions. In 1974, California State mandated energy efficiency standard which became effective in 1977 and also resulted into significant reduction of energy consumption. In 1987, Australian Government implemented its labeling program to cover major household appliances.

Standards and labeling (S&L) program is one of the most favorable programs for the residential sector among all the given countries. They push average efficiency of appliances from present average efficiency towards standard average efficiency after the standards have been implemented. And introduction of labels leads to increased availability of efficient products in market as manufacturers' competites to have more efficient product to win over market (Mahila, 2004). Historical analysis of standards and labeling programs indicated that some countries have greatly widened and updated their programs and starting standard level for each product varies country to country with increased stringency over time (Della Cava, Wiel, and Constantine, 1997). A report commissioned by Department of Industry (DoI), Australia (2014) indicates the number of countries with standards and labeling has grown to 81 countries and products subjected to mandatory energy performance standard measures has increased to 55 in 2006 from 42 in 2004. It further points towards the increase in standards and labels measures[80] in different countries across the world from 1220 in 2004 to 3604 in 2013. Majorly regulated product types were refrigerators (185 measures), room air conditioners (152 measures), lamp or ballasts (358

[80] "Energy efficiency measures includes energy –using appliance, equipment, control system or practice whose implementation results in reduced energy use while maintaining a comparable or higher level of service" (Definition of energy measure accessed from https://energy.ces.ncsu.edu/energy-efficiency-measure-eem-defined/ on 05th June 2019).

measures across all lamp types) and television (135 measures). China, USA, Korea and EU countries accounts for 100, 86, 78 and 77 measures respectively (DoI, 2014) which makes them countries with highest energy efficiency measures.

4.3.1 Underlining the process

The energy efficiency labels and standards development includes various steps. The whole process of standard and labeling program vary from one country to another and takes different timeline. The stakeholder's involvement also varies in the process. The following figure explains the step-wise process of standard and labeling program. The development program of standards and labeling programs is given in Figure 4.1.

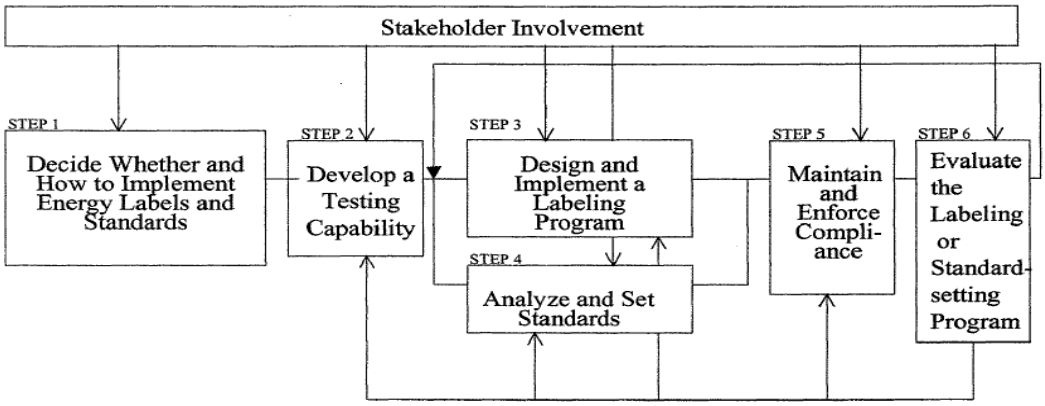

Figure 4.1: Steps to develop the product energy efficiency standards and labeling program
Source: Della Cava et al., (2000)

a) Identification of need of implementation of energy labels and standards

Government of any nation decides the need of these programs according to their national requirements and assessing various factors i.e. cultural, institutional and political factors which can affect their implementation and the effectiveness of such programs. The government decides the extent to which they have to rely on existing test facilities, test procedures and label designs. The standards already set by international organizations and neighboring countries can also be adopted with some changes. Institutional, constitutional, legislative and administrative authority is also established for undertaking standards and label setting process. In this, training of

personnel is major requirement. Once decision has been taken to adopt energy efficiency labeling requirements and standards, the implementing institution establishes rules for the process of standard and label setting.

b) Assessing the requirement of data and selection of products to be labeled

After assessing the need of standard and labeling program, cost benefit analysis is important to conduct before implementing the energy standards in any nation. The assessment of technical potential of labels and standards will require data on current levels and forecasted trends for efficiency of products in the market place. Data regarding the existence and characteristics of domestically manufactured products, imported products, and standards in other countries is also collected.

c) Setting of testing capability

Collection of various data is followed by process of setting the testing capability. Testing capability is pre-requisite for development of any standards and labels for any product to have uniformity of standards among the manufacturers and their products. It ensures conformity with testing requirements. Testing capabilities can be formed within a country or outside the country so that manufacturers and private laboratories can be accredited and recognized in transparent manner. The concerned nation can decide whether they have to adopt existing test protocols for assessing product energy efficiency or not. In most case, adoption of existing test protocols for assessing product energy efficiency is highly preferable as it is beneficial to they have known repeatability and reproducibility along the facility needs and defined benefits and issues. Moreover, it allows consistent decision criteria and standardization among the various models allowing economies of scale in manufacturing and reduces the expenses.

d) Design and Implementation of labeling program

Labels requirements are usually established using consumer research. After designing of labeling, a testing agenda must be created to ensure the accuracy and confidence in the information depicted on the label and harmonization of labels needs to be considered in two parts i.e. harmonization of technical foundation and label format and its presentation.

e) Standard Setting process

Standard levels are assessed based on national situations and should integrate factor i.e. user habits, the use environment, technological and financial situations of affected producers and estimated impact on national economy. S&L program includes promulgation and enforcement of standards. During promulgation, the steps and schedule for establishing energy efficiency labels and standards is clearly prescribed. Producers must have adequate time to create, test and distribute new models and dispose of old inventory. The government agencies responsible for promulgation labeling requirements and standards must find an appropriate balance between consensus building and unilateral government action. It should be open, transparent and flexible (Weil and McMohan, 2003).

Nations	Product types	Saving accrual period	Saving (TWH)	Savings (USD)	Savings (MTCO2)
EU	Ecodesign/labeling directives	1990-2010	213	N/A	N/A
EU	Ecodesign/labeling directives	2010-2020	17191	120bn[2]	320[3]
USA	Federal Energy and Water Conservation standards[4]	1987-2013	10,753	N/A	2113
USA	Federal Energy and Water Conservation standards[4]	In 2013	1,1876	56bn[6]	218[7]
USA	Energy Star- Voluntary Programs	1992-2013	2,700	295bn	2,198
USA	Energy Star- Voluntary Programs	In 2013	380	32bn[8]	294
China	All Program	To 2020	1143[9]	N/A	N/A
Australia	Air Conditioner Program	2003-2020	65	0.8bn	N/A
Australia	Refrigerator/Freezers	1986-2009	5.9	N/A	6
Fiji	Refrigerator/Freezers	2012-2014	0.005	085m	0.002
India	All Program	2012-2030	70	N/A	N/A

Table 4.2: Savings reported by various studies[81] (Scale of these savings depends upon the scope and maturity of national S&L programs).

Source: Armand and Tarascon (2015)

[81] 1. On average the energy saving is 19per cent for the products included in the accounting; 2. This represents the net benefit from a €170 bn. gross saving on running costs (87per cent energy) compared with €60 bn. in extra
acquisition costs associated with the more efficient products; 3. This is 18per cent of the included products and 6.7per cent of the EU total (4721 MtCO2e); 4. Includes the impacts of energy and water conservation standards that have been adopted from 1987 through 2013 covering a total of 43 product categories.;5. This is equivalent to 4per cent of total USA energy consumption and 4per cent of national CO2e emissions. The implied carbon/cost conversion factors for the "USA - All Federal programs" is significantly different to that reported for the "USA Energy Star Program" because Federal Programs report primary energy savings whereas the Energy Star program reports delivered energy savings. There will also be some other differences relating to aspects such as coverage, fuels, time periods and evaluation methodologies;6. This represents an average household saving of USA $361 in operating costs in 2013.;7. This is equivalent to 4per cent of national CO2e emissions.
8. In addition to direct reductions in energy costs the study estimates that more than $11billion in benefits to society due to reducing damage from climate change were also realised in 2013.;9. By 2020, annual savings are expected to be equivalent to 11per cent of residential electricity use.;10. This analysis included an accurate ex-post analysis of data between 2003 and 2008.
11. Most of the savings (around 4.1 TWh/year) is attributed to energy labels introduced from 1986, thus policies from the late 1990s onwards will have realised an estimated energy savings of around 1.8 TWh/year per annum by 2009.

After standard setting and label design, concerned authority certifies, monitor and enforce compliance. And finally labeling and standard setting program are evaluated (Weil and McMohan, 2003). The effectiveness of labels depends on how the information about energy efficiency of a product is presented to the consumers and also on format of labels, market supports and credibility of labeling program. The evaluation of standard and labeling program in various countries have noted that it does have positive impact on energy saving and reducing carbon emissions. The summary of various studies is given in table 4.2. Next section will focus more on energy labels of US, China, Japan, EU and India.

4.4 Energy standards and Labeling programs: A Comparative analysis

In this section, S&L programs of few select nations have been analyzed. The S&L programs of China, Japan, United States, European Union and India were chosen because of increased electricity demands in these countries and also due to their historical role in shaping energy efficiency policy across the world. It is important to note that each and every country has different S&L programs and the information on labels also varies, from country to country and from appliance to appliance.

4.4.1 China

China has one of the most comprehensive Standard and Labeling Program amongst the developing nations. It includes Minimum Energy Efficiency Standards (MEES) which are mandatory, a voluntary endorsement label and information labels. The appliance energy efficiency standards were introduced in 1988 after standardization law of china. In 1997, Chinese National Energy Conservation Law was introduced to ensure regulatory basis of mandatory energy efficiency standards for energy consuming products and equipments and motivate program improvements[82]. The first energy efficiency standards in China was published in 1989 which included minimum efficiency standards for refrigerators, Room ACs, clothes washers, television sets, rice cookers, radio receivers, electric fans and electric irons by China's State Bureau of Technical Supervision (SBTS). It is a government agency authorized to issue all

[82] Article 14 of the law asks for formulation of national standards by administrative department for standardization under state council in which manufacturers are bound to comply with under Article 24. In case of violation of standards by manufacturers, administrative department may submit a proposal to suspend production by manufacturers or its closure (Article 43).

standards except those related to environmental safety and selected petroleum products. This was structured and renamed as the State General Administration for Quality Supervision, Inspection and Quarantine (AQSIQ). State Economic and Trade Commission (SETC) is responsible for supervision of development of energy efficiency standards and labels.

The China National Institute of standardization (CNIS) under aegis of AQSIQ provides technical support for development of mandatory minimum energy efficiency standards and is also responsible for development of China's energy information labeling program under supervision of State Economic and Trade Commission (SETC) and AQSIQ. In China, SETC and AQSIQ set national agenda while CNIS and CECP develop and implement relevant program components (Lin, 2011). CECP formalized a comprehensive system of certification requirements and procedures in 1998, under which an endorsement label would be granted to products that meet both the quality assurance and energy performance specifications. Later in 1999, CECP granted its energy conservation label (Lin, 2011). In 1999, China Standards Certification Center launched a new voluntary energy efficiency endorsement labeling program targeting top 25per cent most efficient products. In 2005, mandatory categorical energy information labels were established (Zhou, Khanne, Fridley, and Romankiewicz, 2013).

China use similar principles as U.S, Australia, EU and Japan to choose target products for their S&L Program. In China, after the selection of products, standards are drafted and reviewed by drafting organization and draft is circulated among the key organization involved in the production, distribution, use, technical development and testing of given products. Further, the draft standard is open to comments and feedbacks for nearly 2 months. The comments and suggestions are collected, analysed and synthesized by drafting organization and the summary of comments and suggestion are sent to secretariat of technical committee for review. China does not follow a specific legally prescribed process for standard setting. The whole process for standard development and revisions takes approximately 1.5 years and within 6 months, standards comes into effect. Within five year, standards are reviewed by either the technical committee or SAC to maintain the pace of technical and efficiency improvements. In the process of revision of mandatory energy efficiency standards, China use techno-economic analysis and market impact analysis for evaluating efficiency levels which are found to be consistent with tools used in US standard setting process (Zhou et al., 2013). Various loopholes in standard and labeling program of China have noted by studies, which includes the lack of formalized

regulatory process for standard setting and absence of legal or regulatory guidance on this program. Moreover, stakeholder[83] participation in standards development process is also found to be limited (Zhou et al., 2013).

4.4.1.1 Understanding Energy Label of China

The energy label of China has information in Chinese language (Mandrin) and information in the labels includes manufacturer's name, product model, efficiency grade, energy consumption or energy efficiency index and adopted energy efficiency code.

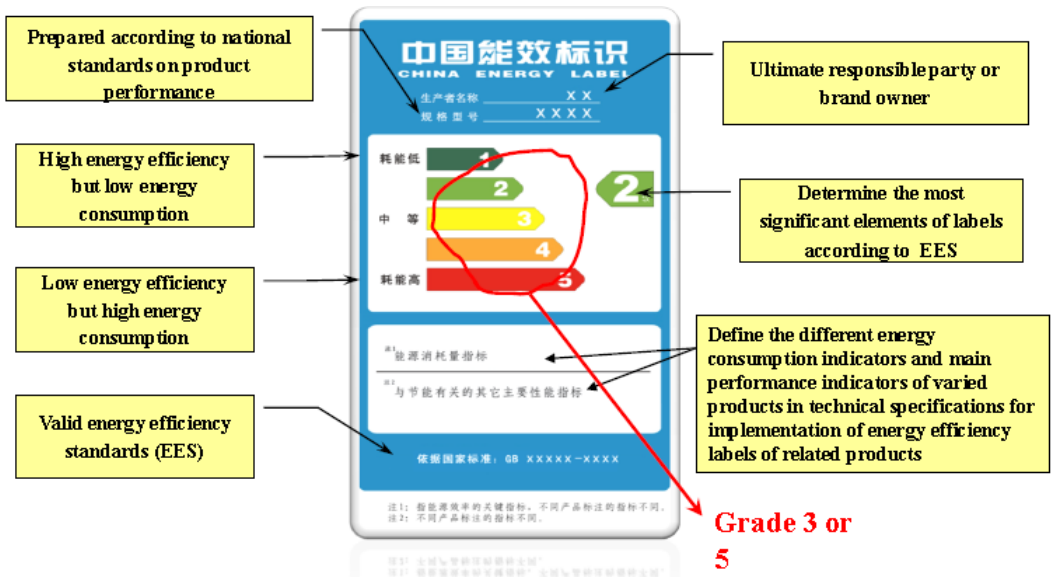

Figure 4.2: Energy Label of China

Source: Jianhong (2011)

The Chinese energy label has color representation ranging from dark green to light green to red where green color signifies more efficient while red denotes less efficiency and more energy consumption. The energy label has two varieties i.e. labels with three efficiency level and five efficiency levels. Level 1 is most efficient, level 2 (3and4) represents average energy efficiency level and level 3 (or 5 level) represents minimum requirement of mandatory minimum energy efficiency standards (Zeng and Eide, 2011). 10 categories of appliances (i.e. refrigerator,

[83] Stakeholders are members of technical committees formed for development and revision of standards and do not include environmental groups, consumer associations, utilities and NGOs.

washing machine, self contained air conditioners, water chilling unit, variable frequency air conditioner, multi connected air conditioner, electric water heater, household electromagnetism stove and microwave oven) follows 5 grade energy efficiency labels. Grade 1 is most efficient and refer that product has reached the advanced international level with lowest energy consumption. Grade 2 is for better energy conservation, grade 3 showcase average energy efficiency of domestic market, grade 4 is below average market level and grade 5 is for high energy consumption and is an indicator for market access. For 13 categories of appliances (i.e. room AC, high pressure sodium lamp, self ballasted fluorescent lamp, small and medium three phase synchronous motor, gas water heater, heating stove, photocopier, computer monitor and flat part TV) 3 grade energy efficiency labels is used. In this grade 1 is most efficient and shows that it has reached advanced international level, grade 2 is for better energy conservation and grade 3 is an indicator for market access and stands for high energy consumption (Jianhong, 2011). Energy label provided the information about the valid energy efficiency standards and also defined different energy consumption indicators and main performance indicators of varied products in technical specifications for implementation of energy efficiency labels of related products. The colour coding and comparative ratings makes it easy for consumers to understand the efficiency of label.

4.4.2 Japan

In Japan, Energy Conservation law was introduced in 1979, which acts as a basis for Standards and labeling program. Japan do not follow traditional MEPS but has an aggressive efficiency target program that encourages manufacturers to reach specified level of efficiency and called this program as Top Runner Program. The energy efficiency policy division of Agency of Natural Resources and Energy of Ministry of Economy Trade and Industry (METI) administer the program. In the top runner program, target products are selected by Energy Efficiency Standards Subcommittee (EESS) under METI. The EESS constitutes members from academia, manufacturing units, labor unions and various consumer organizations. A proposal of standard value level is examined by Evaluation Standard Subcommittee (ESS) under EESS for each machinery and equipment. Manufacturer measure and collect data used to develop a standard value proposal and submitted to ESS. After the data analysis, the efficiency level of Top Runner products in the markets is examined. The examination focuses on future technical development possibilities an influence of standard proposal on the price of appliances. After above

examination, potential for further technical development and efficiency of Top Runner products is analyzed to determine top runner standard proposal. The draft standard is opened for public comments and suggestion. After accepting feedbacks from general public, final standard value proposal is determined by evaluation standard subcommittee. After approval in Japanese Parliament, top runner standard is formally approved. Standards conformity is maintained by mutual surveillance among manufacturers and by consumer organizations, researchers and mass media. Government also conducts shop front investigation to assess whether labels are affixed on products. In Japanese Top Runner Program, existing energy efficiency targets can be replaced with efficiency level of most efficient products currently on the market which makes standards revision an easy task. In 2000, a comparative labeling program was introduced which allow consumers to distinguish more efficient models. Since 2003, the labeling program is voluntary in nature but 100per cent of manufacturers are using energy labels in catalogues (Harrington and Damnics, 2001).

In top runner program, targets are set based on the value of most energy efficient products on the market at the time of value setting process. The Japan's energy conservation policies are shaped by Advisory Committee for Natural Resources and Energy. The committee is advisory body to METI. For the eligibility in Top Runner Program, three requirements were main i.e. extensive use of that appliance, that appliance consume considerable amount of energy and lastly the appliance requires particular efforts to improve energy consumption performance along with market place trends for machinery, equipments and other factors. For standards development, the target scope of target machinery, equipments and other methods of energy consumption efficiency are deliberated and determined. The energy consumption efficiency of all products is measured and recent and updated maximum efficiency is determined. During standards establishment, draft Top Runner Standard values are reported to WTO/TBT to avoid trade barriers to imported products. After these procedures, governments and other ordinances are amended to formally add the standard values to the range of top runner target machinery, equipment and other items. The whole process of top runner program takes around one and a half year.

The standards are set by identifying the most efficient model in each size and type of products as benchmark. There is no minimum level of efficiency which needs to be acquired but manufacturers can invite penalties in the form of public announcements about the company

which failed to meet the target by the government if average efficiency target are not met. New target levels are reviewed and established when target year is reached (Geller et al., 2006). As standards are categorized by size for most appliances, manufacturers do not find incentive to manufacture smaller and less energy consuming appliances which creates a serious concerns in terms of total energy consumption especially in case for television and automobiles. To overcome this concern, imposing an obligation for each manufacturer to report average appliance efficiency could be effective. Kimura (2010) have noted that variation in standard by volume created an inverse relationship between size and energy use in case of refrigerators *i.e.* small refrigerators use more energy as compared to larger ones as small sized refrigerators are cheap and does not include efficient and expensive technologies making it difficult to merge categories despite of efficient technologies for refrigerators. The author on a positive note emphasize that high efficiency target will reduce costs of efficient technologies and therefore, these technologies can be included in small sized refrigerators in future. After the standard formation and finalization, information is provided to consumers through labeling program.

4.4.2.1 Understanding Energy Labels of Japan

In Japan, Energy Efficiency Standards Subcommittee of Advisory Committee for Natural Resources and Energy decided to include four items in label i.e. symbol used to show degree that energy saving standards have been achieved, energy saving standard achievement rate, energy consumption efficiency and target fiscal year. In year 2000, labeling program was established as Japanese standard and energy saving labeling program was launched. Initially the program targeted five product categories i.e. Air Conditioners, Lighting Equipments, TV sets, Refrigerators, and Freezers and further in 2003, five more products were added to list i.e. space heaters, gas cooking appliances, gas water heaters, oil water heater and electric toilet seats. Presently, the labeling program covers 21 products. Labeling program is a voluntary scheme based on JIS system and required to be indicated on the participant's catalogues and product themselves. The Japanese Energy Label includes Energy Saving symbol, energy saving standard achievement rate, target fiscal year and energy consumption efficiency (Figure 4.3).

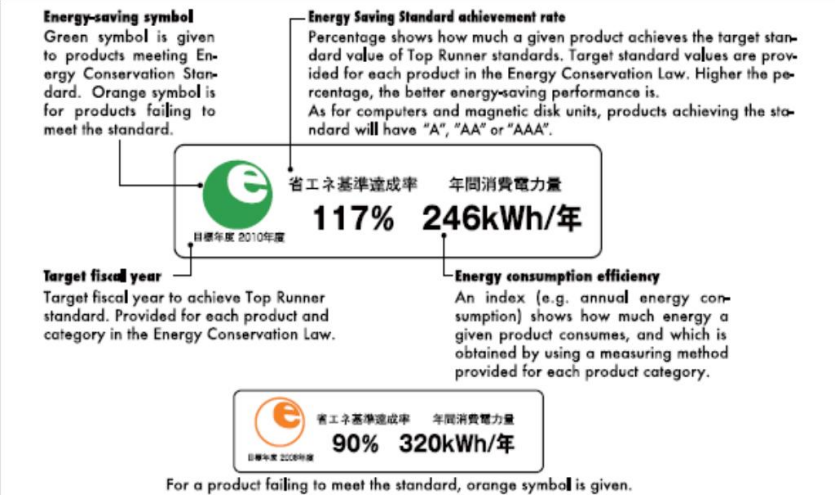

Figure 4.3: Japan's energy Label

Source: METI (2013)

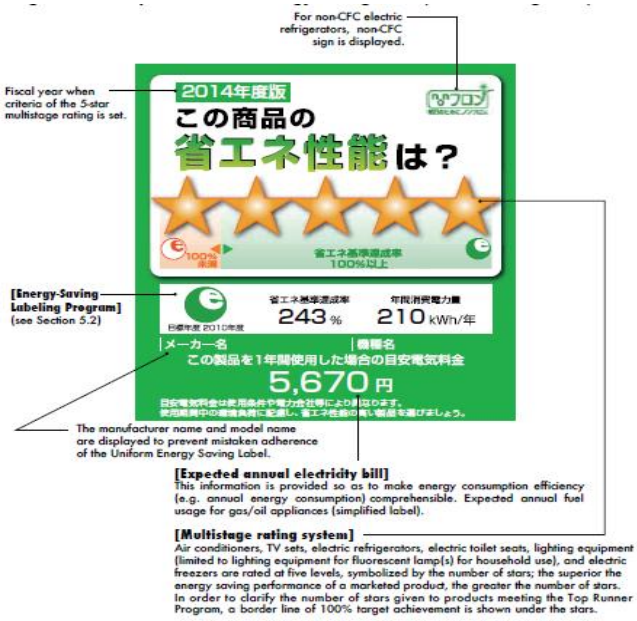

Figure 4.4: Uniform Energy Saving Label of Japan

Source: METI (2013)

Retailers are also asked to provide information of products displayed at their shops with the use of Uniform Energy Saving Label since 2006 that present multi stage rating, expected electricity bill and other information (Figure 4.4). The multi stage rating use 5 star mark to represent relative position of a given product in market with respect to energy-saving performance (METI,

2013). This label has been applied to air conditioners, electric refrigerators and TV sets. It includes energy saving label, fiscal year when criteria of 5 Star multi stage rating is set, non-CFC indication, expected annual electricity bill (METI, 2013).

4.4.3 United States of America (USA)

The US Federal government has passed four major pieces of legislation which makes a solid framework for standard and labeling program. Energy Policy and Conservation Act (1975) required Federal Trade Commission (FTC) to establish labeling program and Department of Energy (DoE) to set voluntary efficiency targets. In 1978, National Energy Policy and Conservation Act asked to change efficiency targets to mandatory standards. During late 1970s, states began prescribing MEPS to manufacturers which had to meet varying criteria. Since 1980, the labeling program termed as Energy Guide became effective when manufacturers were obliged to place energy labels indicating energy consumption on their appliances. The additional standards were included into law in Energy Policy Act (1992). Department of Energy (DoE) is required to set MEPS for a wide range of selected products after a prescribed process of research and consultation. MEPS level are reviewed by Department of Energy with due time and revise the standards with higher levels. Federal MEPS levels dominate over state level and if the federal government determines that no standards are warranted for a particular product then states are free to set local MEPS rules. Canada and Mexico have harmonized their MEPS regimes with US for many products. NIST is responsible for establishing test procedures for Energy Labeling Program (Harrington and Damnics, 2001).

In US, DoE carry out decision of U.S. Energy Efficiency Standard. Energy Guide Label (Comparison label) is managed by Federal Trade Commission (FTC) and Energy Star Program Label is managed by DoE and US Environmental Protection Act (US EPA). Standard formulation and implementation is a lengthy process and numerous entities involved in the whole process. During the selection of products to be involved in standard making process, target products are examined by Department of Energy and manufacturer trade associations collect the basic data from member companies which can be used in standard development process. Research institutes i.e. Lawrence Berkeley National Laboratory (LBNL) undertakes technical and economic validity based on collected data. Standard must be technically feasible and economically beneficial. After economic analysis, opinions are exchanged between

manufacturers and industrial groups on one side and NGOs, energy related organizations, consumer organization on the other side. US DoE accepts and adopts results which are collected as a result of deliberations. The final outcome from standards development process is published in official government gazette and is reexamined after receiving public comments. The whole process may take 3-12 years. In recent times, development of new standards of two or more items is turning difficult due to budget and resource constraint. For energy efficiency standards compliance, manufacturers are responsible to measure their own products and self authorization is admitted. Government is not actively involved in conformity checking or monitoring of standards.

4.4.3.1 Understanding Energy label of USA

ENERGY GUIDE Label includes the information about energy consumption, yearly operating cost and also Energy Star Logo. ENERGY GUIDE Label is a mandatory system while ENERGY STAR label is a voluntary labeling system. It is yellow and black label which help to estimate the product's energy consumption or energy efficiency. EPA ensures that each appliance earn the label based on independent certification to deliver quality, performance and savings to consumers. Manufacturers of most home appliances are required to attach the label to their appliances under FTC's appliance labeling program. This label indicate features about the product, manufacturer's details, estimated yearly operating cost, energy usage, a scale to compare the energy use of different models by showing range of operating cost for models with similar features, and ENERGY STAR logo (Figure 4.5).Appliances with updated energy efficiency test have Energy Guide Labels with bright yellow numbers and other appliances have original labels with black numbers. They are appliance specific and vary from appliance to appliance.

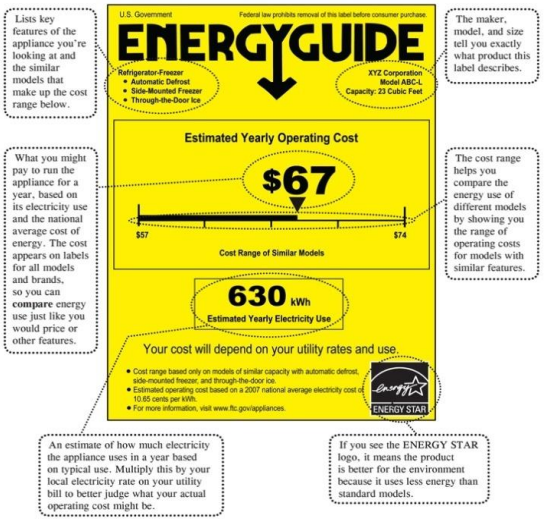

Figure 4.5: Energy Guide of USA

Source: Consumer FTC website.

4.4.4 European Union (EU)

In European Union, the Directorate General of Energy and Transport (TREN) is main governing body in managing energy policy. New Energies and Demand Management Unit holds the responsibility of managing Standard and Labeling program. Prior to EU labeling program, many countries had their own standards and labeling program. For the interest of various countries in Europe the commission developed the directive for mandatory energy labeling of household appliances (Directive 92/75/EEC) which made comparative labeling compulsory in all countries of EU in 1992 which came into force and became effective from 1995. Under this directive, new appliances can be added in the program without seeking political approval. Another directive allowed the introduction of Eco-Labeling scheme in 1992. This labeling program covers several appliances which must meet energy efficiency criteria. The Framework directive on energy labeling (Council Directive 92/42/EEC) was amended in 2003 to include Eco-design requirements for energy using products (Hirayama et al., 2008).

In EU, there are only three products with mandatory MEPS due to legislative complexity and need for separate approval for each appliance. European commission (EC) is also working towards improved efficiency through voluntary negotiated agreements for a range of products. It negotiates with manufacturing associations to reduce overall energy consumption by setting

target efficiency level for an appliance and by elimination of those products which consumes most energy. To revise or introduce MEPS, European Union members take approval from EC and parliament as there is no framework directive for MEPS (Harrington and Damnics, 2001).

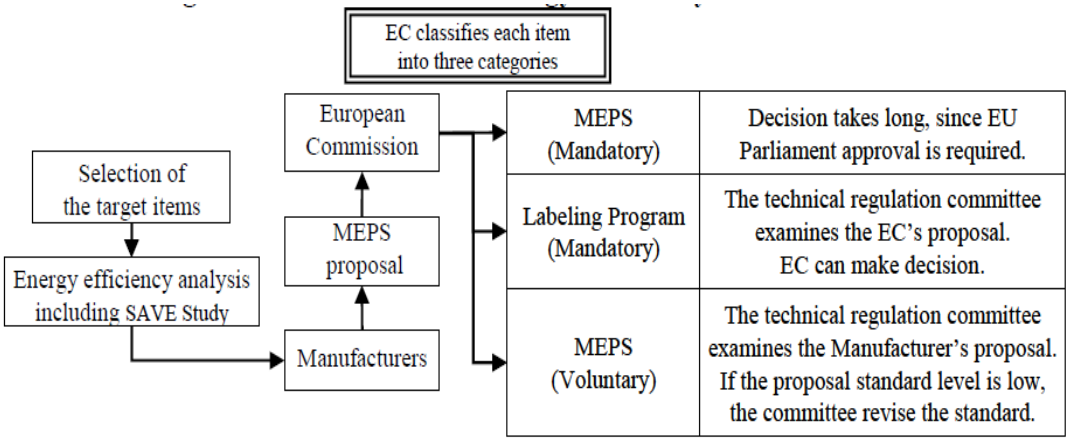

Figure 4.6: Standard and labeling program in EU

Source: Hirayama et al., (2008).

During standard development, the Directorate General Energy and Transport (DG TREN) of the European Commission manages and take charge of development of MEPS and labeling standards. In EU, only products i.e. domestic gas or oil fired hot water service, refrigerator and Fluorescent Lighting Ballasts have MEPS (Harrington and Damnics, 2001). For selecting target products, priority is given to those products that have large potential for improvement of efficiency. In order to speed up the standard development procedure in recent years, 'comitology'[84] procedure was introduced. In this EC forms a technical regulation committee consisting of representative of member nations which takes decision on each product and adopts tense EC directives which can help in reducing deliberation process of parliament or an executive board. Energy efficiency standards are imposed on manufacturers through regulation and manufacturers are responsible for conducting measurements and application of standard is based on self authorization. Manufacturers are mandated to supply labels in packaging at the

[84]Comitology refers to set of procedures, including meetings of representative committees that provide EU countries a voice in implementing acts. When EU laws sometimes authorize the European Commission to adopt implementing acts, which set conditions that ensure a given law is applied uniformly. Comitology applies when the Commission has been granted implementing powers in the text of a law. The same law also stipulates that the Commission is to be assisted by a committee when defining the measures contained in the resulting implementing act. Comitology is not compulsory for all implementing acts – some of which the Commission can adopt without consulting a committee (for example, when allocating grants under a certain amount). For more refer https://ec.europa.eu/info/implementing-and-delegated-acts/comitology_en .

time of shipment and retailers are obliged to affix labels on products exhibited at retail outlets. To cross check the efficiency and conformity to the standards competitors will examine the product and test the conformity (Hirayama et al., 2008).

4.4.4.1 Understanding Energy Labels of EU

EU Energy label presents information about energy efficiency of a product through grading scale ranging from A+++ to G and also color gradients are used to indicate the same. Energy label also includes information like electricity consumption, water consumption, noise levels (for washing machines), and size. These labels are mandatory for all appliances sold in EU for which regulation exist and must be clearly displayed at the point of sale. These labels show how a product ranks on a scale from A+++ to G as per energy consumption. Class A+++ (dark green) is most energy efficient and Class G (red) is the least.

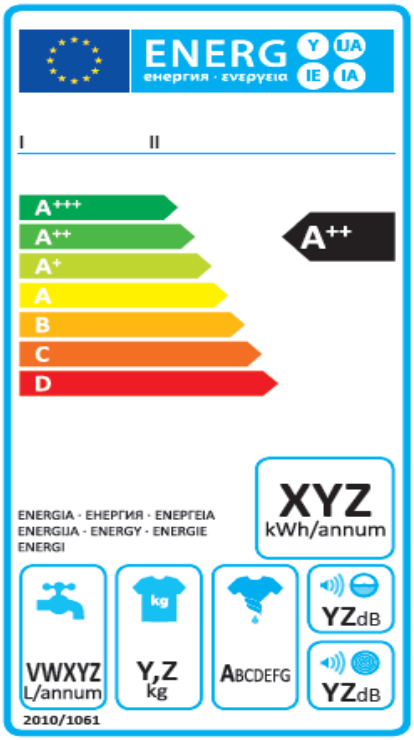

Figure 4.7: EU Energy label

Source: EU energy label[85]

Present labels have ranks i.e. A+, A++, A+++ which indicates better efficiency and this ranking was motivated by appliance makers as they didn't want to give a 'C' label to an average energy efficient product. Therefore, they nudged the idea of inflating the grades which led to the inclusion of A+, A++, A+++ in the labels and thus other categories became obsolete to consumers. Moreover, there was continuous confusion among consumers about this grading scale therefore; from 2019 this grading scale will revert back to A to G ranking with time ("Energy labels in EU", n.d.).

4.4.5 India

In 2001, Energy Conservation Act was passed which was landmark legislation for Indian power sector as it laid legislative and institutional framework for Energy efficiency and conservation in various sectors[86]. This Act proposed to set Bureau of Energy Efficiency to implement and monitor EC Act (2001). Later, Bureau of Energy Efficiency (BEE)[87] was set up in 2002 as a nodal agency at central level to regulate and promote energy efficiency in various sectors. For this, S&L program was introduced in May, 2006 (Figure 4.8). BEE works under the aegis of Ministry of Power (MoP) for promoting energy efficiency in different sectors and has the mandate to implement S&L program. It plays a facilitator in complete process of program design, process and procedures, implementation and enforcement mechanisms. In this a permittee provides information regarding energy efficiency of the product on label as prescribed in respective product regulation, statutory order or by Bureau of Energy Efficiency. In this, manufactures are expected to test their equipment and self declare the rating level based on standards evolved by Bureau of Energy Efficiency (BEE) and affixing appropriate label (Chitrodia, 2006).

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[85]EU energy label accessed from http://www.come-on-labels.eu/download/new-energy-label-retailers-suppliers on 3rd februray 2019.

[86] Under this, central government under energy (Conservation) Act, 2001 has power to display labels on specified appliances (14.d) and enforce minimum efficiency by prohibiting manufacturers, sale and import of product not meeting standards (14.c)[86].

[87] The Bureau of Energy Efficiency is the nodal agency at central level and state designated agencies (SDAs) at state level. India has 32 SDAs at state/UT level working at regulatory, developmental, facilitation and promotional level. Energy Efficiency Services Limited (EESL) is a joint venture company promoted by four Central Public Sector Undertakings (CPSUs), namely National Thermal Power Corporation Limited (NTPC Limited), Power Grid Corporation of India Limited (PGCIL), Power Finance Corporation Limited (PFC Limited) and Rural Electrification Corporation (REC). This company is expected to promote energy efficiency market in India and attract private sector investment. It is also considered as an implementation arm of the National Mission for Enhanced Energy Efficiency (NMEEE) and to open up the market opportunities for energy efficiency in India which is estimated to be over USD 18 billion (Sengupta, Undated)

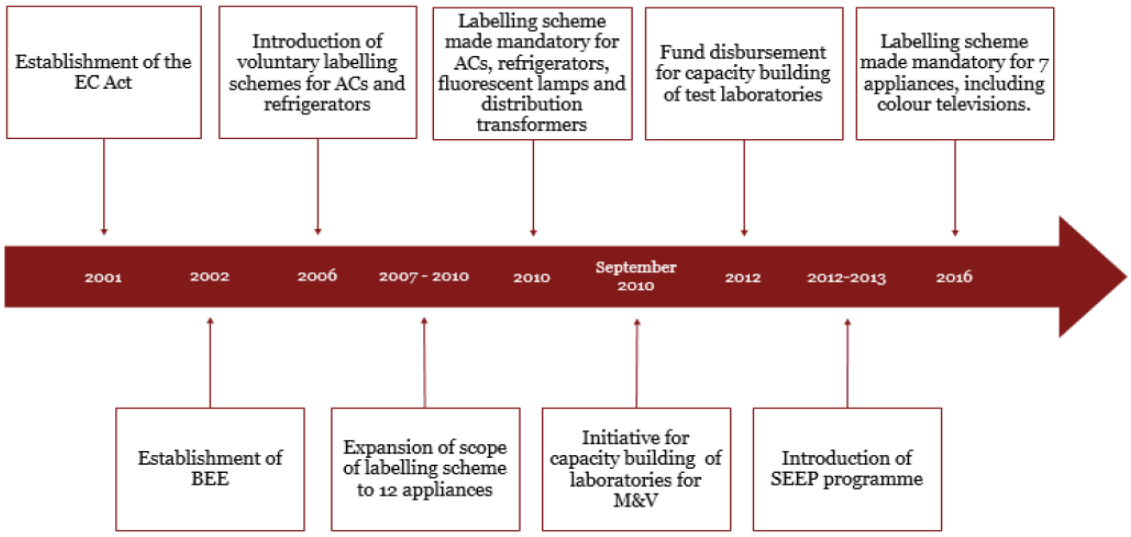

Figure 4.8: Standard and Labeling program in India

Source: Development of standard and labeling inspection guidelines for state designated agencies (2016)

For the development of standards for electrical appliances, Bureau of Indian Standards[88] (BIS) and Bureau of Energy Efficiency (BEE) work together. BIS is involved in setting overall voluntary quality standards for appliances and products. It establishes standards for any article, process and amends, revises or cancels the standards with a consultation of consumers, manufacturers, technologists, scientists and officials through duly constituted committees i.e. technical committees and steering committees under Bureau of Indian Standards Act (1986). Being a signatory to WTO agreement on Technical barriers to trade (1995) BIS has aligned its standards formulation procedure to the 'code of Good Practices for the preparation, adoption and application of Standards'. Technical committees (TC) are formed for different appliance and equipment include technical persons from BEE, BIS, manufactures, and other manufacturing associations to deal with technical details related to appliances and products. BIS also sets up steering committee (SC) to coordinate with the manufacturers and Government. The TC discusses and decides about the technical basis involved in setting up of standards and assists the SC in formulating the strategy for their execution. The standards development process is shown graphically below in Figure 4.9.

[88] According to BIS website, BIS is the "National Standard Body of India established under the BIS Act 2016 for the harmonious development of the activities of standardization, marking and quality certification of goods and for matters connected therewith or incidental thereto". It provides traceability and tangability benefits to the national economy in terms of maintaining quality, minimizing health hazards, promoting exports and imports substitute, control over proliferation through standardization, certification and testing.

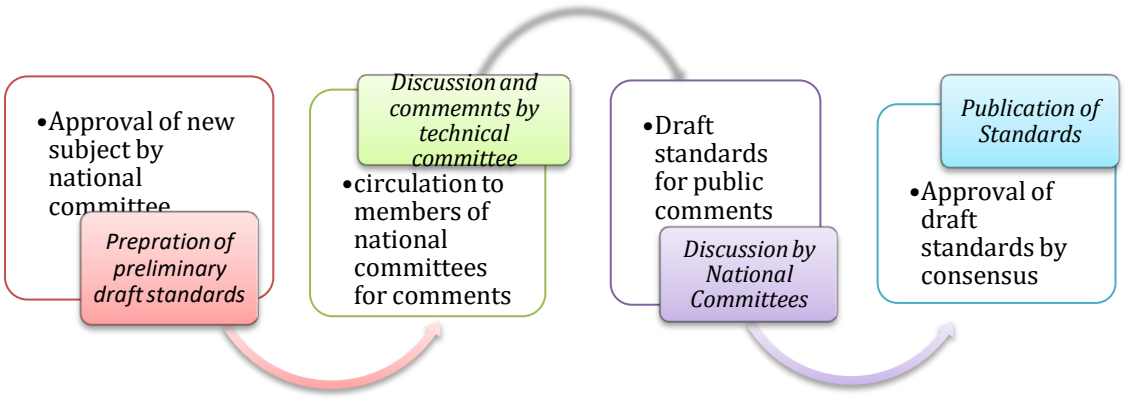

Figure 4.9: Standards development process in India

Source: National standards and labels in India (2012)

In labeling process, BEE forms steering committee and product specific technical committees from BEE, BIS, manufacturers, manufacturing associations, consumer organizations, technical experts, NGOs. The technical committees take care of the technical issues including the test procedures, data collection, data analysis, standard settings and label design. This label is further sent to Ministry of Power (MoP) for perusal and finalization. After 2-3 years of introduction of voluntary labeling program of any appliance, BEE conducts a market assessment to evaluate the market transformation and study the need to enhance the technology and other institutional requirements for transition from voluntary to mandatory program. After the assessment of need for transitioning, BEE sends the draft proposal to Ministry of Power (MoP) and after its approval from MoP, the draft is sent to Ministry of Law (MoL) for legal vetting. MoL sends this draft back to MoP after vetting and approval and finally draft regulations is published in official gazette for seeking public comments. After incorporating all the required changes in the documents, it is again sent to MoP and MoL which after approval is notified in official gazette[89]. After the regulation is notified in official gazette, it becomes mandatory to display to star rating label on the concerned appliance. If the equipment is not correctly labeled and manufacturer does not rectify the errors as per BEE norms, then BEE can inform consumer about the same through wide publicity (BEE website). States through SDAs have penal power under section 26, 27 of Energy (Conservation) Act (2001) for enforcement ("Standard and Labeling Program", 2008).

[89] The process of standard and labelling in India was discussed in detail with the officials of BEE and MoP during the field work.

For random testing of refrigerators, BEE worked with Intertek India (Delhi), CPRI (Bangalore) and ERDA (Vadodara) (Chitrodia, 2006).The credibility of labels is monitored by BEE through random verification test by an independent agency i.e. M/S Rites ("Standard and Labeling Program", 2008).

The labeling program started with tube light and frost free refrigerator in India. These products were selected on the basis of their market share and power consumption. Rating criteria for star ratings have been prepared as per BIS (Chitrodia, 2006). Standards and Labeling program in India was initially started for 19 appliances i.e. Room AC, Fluorescent tube lights, Frost free refrigerators, Distribution transformers, Induction motors, Direct cool refrigerator, electric storage type geysers, ceiling fans, Color TVs, Agricultural pump sets, LPG stoves, Washing Machines, Laptops, ballast, floor standing ACs, office automation products, Diesel generating sets and Diesel operating pump sets. From the above appliances, Room ACs, Fluorescent tube lights, Frost free refrigerators, distribution transformers were notified under mandatory labeling from 7th January 2010 while others were under voluntary labeling phase. The standards and labels for refrigerators and ACs are periodically revised and enforced to incorporate innovation in the technology ("Energy efficiency", MoP press release, n.d.). In 2018, India had mandatory labeling for 10 appliances. They are frost-free refrigerator[90], distribution transformers (DT)[91], Room AC[92], Room AC (Cassettes, floor/ standing), variable capacity inverter AC, Tubular

[90] Every Frost Free Refrigerator (FFR henceforth) being manufactured, commercially purchased or sold in India shall meet all compliance requirements as specified in clause 5 of IS 15750:2006, performance requirements of pull down temperature as per clause 5.2.2 of IS 15750:2006. All FFR should either carry a BIS certification mark or should be certified against ISO 9000 or above. The energy label on FFR should have energy star ranging from one to five stars based on their relative efficiencies. The star level shall be determined on the basis of star level parameters constant multiplier (KWh/l/yr) and constant fixed allowances (KWH/yr). Comparative energy Consumption (CEC) and total adjusted storage volume for FRR should be used to determine the star rating band and star rating of the model. The model variant may use common label with comparative energy consumption (CEC) not less than highest projected annual energy consumption (PAEC) of those variant. The energy consumption and performance for household FFR is determined as per clause 14 of IS 15750:2006 and volume is tested as per clause 6 of IS 15750:2006 with all amendments, tolerance limit for volume should be as per clause 5.1 of IS 15750:2006 and pull down temperature should be as per clause 5.2.2 of IS 15750:2006. For the display of energy labels the BEE draft notification no. 2/11(5)103-BEE.4 was published. The notification outlined various definitions and specification of labels of FFR (accessed from BEE website).

[91] Every Distribution Transformers (DT henceforth) being manufactured, commercially purchased or sold in India should meet compliance requirements given by BEE as per IS 2026. The DT should carry either BIS certification mark or should be certified against IS/ISO 9000 or above. It is mandatory to display energy labels on DT with star ranging from one to five. It should be rated from star one to star five on basis of relative energy efficiencies or loss of standards which is the total losses at 50per cent and 100per cent loading of DT. The highest loss segment is defined as star one and lowest loss segment is star five. The star level is determined on basis testing as per testing code and procedure as per IS 1180 (part 1): 1989. BEE notification no. 2/11(5)/03-BEE-3 give the details about the display of labels on DT. For publishing and displaying energy labels on DT every permittee shall conform to energy consumption standards for distribution transformer notified under clause (a) of section 14 of Act (accessed from BEE website).

[92] The room AC of vapour compression type which are unitary and split AC upto a rated cooling capacity of 10,465 W being manufactured, commercially purchased or sold in India should meet the compliance requirements in accordance with IS 1391 (part 1) for unitary AC and IS 1391 (part 2) for split AC. further it shall be certified against IS/ISO 9000 or above. The AC should have energy star label ranging from one to five stars based on their relative energy efficiencies. the label should include logo of BEE, name of manufacturer or importer or brand, model and year of manufacturing or import, cooling capacity at 50 and 100 per cent, electricity consumption, variable speed compressor, heat pump, Energy Efficiency Ratio, label period, star level, and unique series code.

Fluorescent Lamps[93] (TFLs) and Ceiling fans, LED lamps[94], direct cool refrigerators, Electric Geysers, and Color TV[95].

In 2010, The Energy Conservation (Amendment) Bill 2010 was introduced which amends the Energy Conservation Act, 2001. The Bill expands the scope of energy conservation norms for buildings and tightens the applicability of energy efficiency norms for appliances and equipment. The Bill reduces the time frame of prohibition of manufacture, sale, purchase or import of notified equipment for not conforming to norms to six months, extendable by a further six months which can be liable to penalty, if not fulfilled the terms and conditions ("The Energy Conservation (Amendment) Bill 2010"). BEE along with CLASP developed world's first standards for LEDs in 2012 and developed standard and labeling for LEDs in 2016[96].

4.4.5.1 Understanding Energy label of India

Labels describe energy performance and provide consumers necessary information to make informed decisions. There are two types of energy labels used in India at present: smaller and bigger label. Smaller one is meant for ceiling fans, tube lights, computers/ laptops and television. Bigger labels are used in refrigerators, air conditioners, geysers and washing machine (Jain, 2014). Both the labels have comparative 1-5 star ratings. 1 star is least efficient while 5 star is most efficient. The bigger label include logo of BEE, name of manufacturer or importer and brand, gross volume, storage volume, model and year of manufacturing or import, authority number, electricity consumption (units/year) and star level of FFR.

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[93] tubular fluorescent lamp means a low pressure mercury discharge lamp of tubular form either straight or curved in which most of the light is emitted by a layer of fluorescent material excited by the ultra-violet radiation from the discharge.

[94] BEE notification dated December 27th, 2017 specified energy consumption standards for star labeled self- ballasted LED lamps[94]. it states that every self ballasted LED lamp upto 250V, 50Hz to be used for general lighting purposes that works on single phase alternating current supply which is manufactured, commercially purchased or sold in India should meet compliance requirements in section 16.1 and 16.2 of Indian Standard 16102 (part 1) with all amendments and should also comply with performance requirements as specified in Indian Standard 16102 (part 2) with all amendments. every label on self ballasted lamp should have logo of BEE, name of manufacturer or importer and brand, trade name and its number, model and year of manufacturing or import, unique series code, power consumption, luminous flux (in Lumens), luminous efficacy (lm/W), star level of self- ballasted LED lamps and label period. The star ratings are continuously revised after every to years.

[95] color TV is commercially available electronic appliance designed primarily for the display or direct view and reception of audio visual signals from terrestrial, cable, satellite, Internet Protocol TV (IPTV), or other transmission of analog and digital signals, consisting of a tuner or receiver and a display encased in a single housing; and the appliance covers colour television with Cathode Ray Tube (CRT), Liquid Crystal Display (LCD) with Cold Cathode Fluorescent Lamp (CCFL) backlight, Liquid Crystal Display (LCD) with Light Emitting Diode (LED) backlight and Plasma technologies type, which also includes TV combination unit and analog TV.

[96] The emergence of LED standards helped Government of India to successfully launch Unnat Jyoti by Affordable LEDs for all (UJALA) program. Under this program, 800 million units of LED will be provided to residents in the entire country. It uses public-private partnership to deploy energy efficient lighting, by designing and implementing standards for LED lighting(source:Illuminating India, efficiently (2016) accessed from https://clasp.ngo/updates/2016/illuminating-india-efficiently on 25th March 2018).

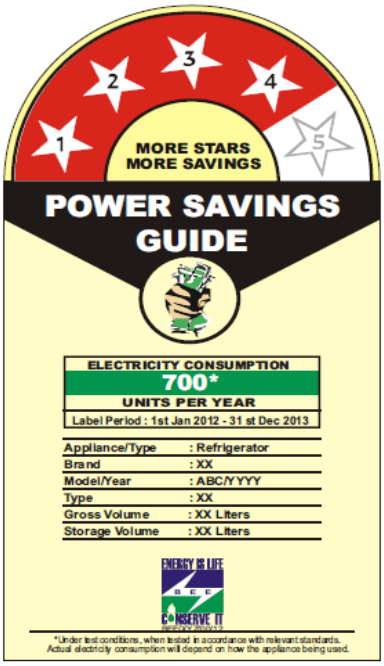

Figure 4.10: Energy label for bigger appliance

Source: BEE website

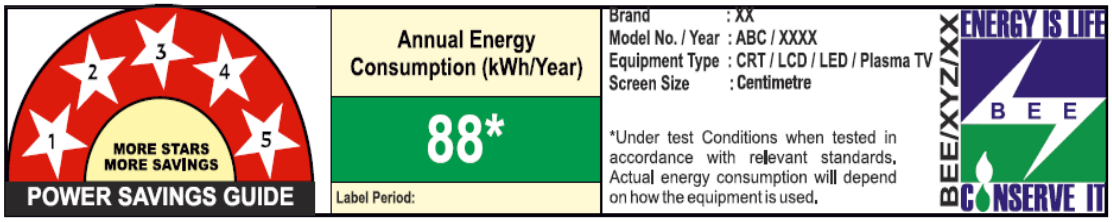

Figure 4.11: Energy efficiency label for smaller appliances

Source: BEE website

Smaller label also have comparative star labeling, logo of BEE, name of manufacturer or importer and brand, size (screen size in case of TV), model number and year of manufacturing or import, equipment type, electricity consumption, label period and unique series code.

It is important to note that all the concerned countries have comparative labels for their energy efficient technologies while US and India also uses endorsement labels for some of its appliances. For US and China, energy labeling is mandatory while for EU and India, appliances can have voluntary labeling as well. Japan is exceptional case, where labeling is voluntary in nature but there 100 per cent of appliances are found to be labeled. The energy efficiency is

denoted by either by comparative scale (as in China, Japan, EU and India) or using simple text or numerical information (e.g. US). This information is the most crucial information in the label for those seeking the information about reducing energy consumption. Therefore, most of the labels have interactive grading scale along with color gradations. China has used 3 and 5-point scale while India and Japan used only 5-star rating. In an exceptional case, EU used 7 point scale from A+++ to G which made it difficult for consumer to take decision as usually A stands for best and G stands for worst but in this case, consumers have to choose from A+, A++, A+++ ,A, B, C, D, E, F, G. Now this rating system is being reverted to A to G rating scale from 2019 onwards. EU energy labels make it a point that unnecessary information can have negative impact on consumers.

	China	**Japan**	**US**	**EU**	**India**
Type of Label	Comparative	Comparative	Comparative and Endorsement	Comparative	Comparative
Mandatory or voluntary	Mandatory	Voluntary	Mandatory	Mandatory and voluntary	Mandatory and voluntary
Energy efficiency information	3 and 5 point grade scale	5 star rating	N/A	7 point scale	5 Star rating
Language	Chinese	Japanese	English	Different languages	English
MEPS/MEES	MEES	Top Runner program	MEPS	MEPS	MEPS
Presence of any eco label	N/A	Yes	Yes	Yes	N/A
Information about standard used	Yes	Yes	N/A	Yes	Yes
Colour ranking	Yes	Yes	N/A	Yes	Yes
Annual Electricity consumption information	Yes	Yes	Yes	Yes	Yes
Money saving information	N/A	Yes (expected bill)	Yes (yearly operating cost)	Yes	N/A
Validity of label	Yes	Yes	N/A	N/A	Yes
Logo/Name of authority involved	Yes	Yes	Yes	Yes	Yes
Size	Yes	Yes	Yes	Yes	Yes
Model no.	Yes	Yes	Yes	Yes	Yes

Table 4.3: Comparative analysis of energy labels

Source: Author's analysis

China, Japan, US and EU uses their commonly used language to give information and India uses its official language i.e. English. Other important information to note is that energy labels of EU and Japan not only provide information about energy efficiency but also presents other information e.g. non-CFC (Japan) and water conservation (EU). This makes a label more

informative about other environmental concerns and also allows consumers to choose more environment friendly information.

4.5 Summary

This chapter gave an overview of energy standards and labeling process as whole and also presented a comparative analysis of various programs. Effectiveness of S&L programs is ensured when these programs are well formulated, properly enforced and regularly updated. It is important to note that S&L programs are highly successful when it caters to cultural and social need of the country. This chapter gives an analysis of energy standard and labeling program of select nations to understand the underlying differences of each programs and energy labels. It is noted that even though, the energy label of select nations appear to be similar in its presentation but the way the information is presented in each label vary to make it easy for consumers to understand and change their behavior towards energy consumption. The labels are effective when the information presented on them is clear, easy to understand and appropriate information to end-users. Unclear and complex information discourage the end-users to seek the information and they usually suffer from informational overall load.

Chapter 5
Methodology

5.1 Introduction

The chapter discusses the research strategy used to understand the public understanding of energy efficiency, energy efficient technology and energy standards and labels in Indian households. It is an exploratory study to understand what role does information in the form of energy standards and labels play in shaping understanding of energy efficient technology and to make a decision for adopting an efficient technology in Indian households. The chapter describes the method used in designing of questionnaire, conducting survey and collection of data for the study. Section 5.2 discusses the research strategy used in this study i.e. preliminary research, questionnaire formation and data collection. Section 5.3 underlines the limitations of the study.

5.2 Research strategy

For this study, quantitative and qualitative research methods (termed as *mixed methods or multi-method*) were found to be important to justify the research objectives. Mixed method research involves collection, analysis and interpretation of quantitative and qualitative data in a single study or in series of study. Under this, researcher can use qualitative research methods for one phase of study and other method i.e. quantitative research method for other stage of research study either simultaneously or sequentially. Pure *qualitative research* is exploratory, inductive, unstructured, open-ended, naturalistic and free-flowing that results in qualitative data where as pure *quantitative research* is observed as confirmatory, deductive, structured, close-ended, controlled and linear research that results in quantitative data (Johnson and Turner, 2003, p.297). When these methods are used together, it results in better understanding of research problem. Johnson and Onwuegbuzie (2004) noted that methodological pluralism or eclecticism of mixed methods results in superior research and can give better picture of research context and can be used for validation purpose. For better understanding of research problem, mixed method design should follow the rule of complementary strengths and non-over lapping weakness i.e. both the methods should strengthen the understanding of research aims and results (Johnson and turner, 2003).

Since 1960's there is steady growth in the mixed methods research in various disciples including Education, Psychology, Nursing, Health science, Library and Information Science research and program evaluation (Leech and Onwuegbuzie, 2009). In recent times, mixed method research is increasingly recognized as third major research paradigm along with qualitative and quantitative research. It is considered as evolving approach to knowledge that attempts to consider multiple viewpoints, perspective, and positions and stand points (Johnson, Onwuegbuzie and Turner, 2007). Mixed methods can include mono-method designs, fully mixed methods and partially mixed methods. In fully mixed methods, qualitative and quantitative methods are mixed within one or more stages of research process or across these stages while in partially mixed methods, the quantitative and qualitative phases are not mixed within or across various stages. In this, both are conducted either simultaneously or sequentially (Onwuegbuzie and Johnson, 2004). Major purpose for using mixed methods is exploration, explanation, triangulation and complementarity (Creswell and Tashakkori, 2007). Exploration is meant for "*understanding a phenomenon and test propositions from qualitative phase*" while complementarity is applied when one method complements the result from other method. It helps to clarify, explain and to capture some levels of analysis different from the objects of research. Further its objective "*is not to corroborate the results, but to apprehend a supplementary facet of reality*". Triangulation is "*combination of methodologies in the study of same population*". It permits scholars to corroborate and support outcomes relative to same phenomenon with different methods and also to improve internal as well as external validity. Transformation is "*converting qualitative data into numerical codes to analyse it statistically or convert quantitative data into narrative data for ease of analyses*" (Bentahar and Cameron, 2015).

Leech and Onwuegbuzie (2009) classified mixed methods on the basis of three dimensions i.e. Level of mixing (fully or partially mixed), time orientation (concurrent or sequential) and emphasis of approaches (equal status or dominant status) and proposed following eight types of mixed research designs (a) partially mixed concurrent equal status designs, (b) partially mixed concurrent dominant status designs (c) partially mixed sequential equal status designs (d) partially mixed sequential dominant status designs, (e) fully mixed concurrent equal status designs (f) fully mixed concurrent dominant status designs, (g) fully mixed sequential equal status designs (h) fully mixed sequential dominant status designs

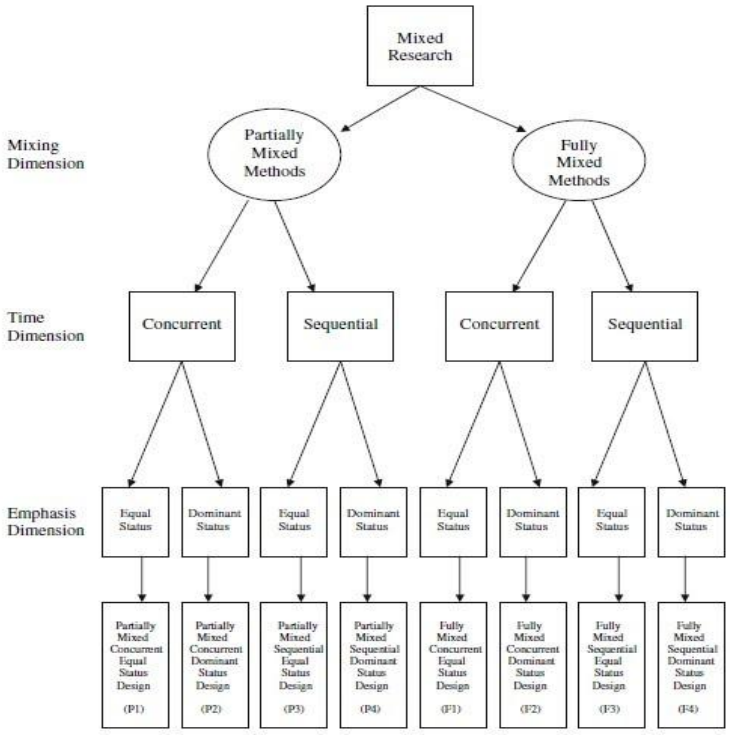

Figure 5.1: Typology of mixed methods

Source: Leech and Onwuegbuzie (2007)

For this study, the author used *partially mixed concurrent equal status design* as it involved conducting a research study which involved qualitative as well quantitative method concurrently and equal weight is given to both of them. Further research strategy is divided into various phases which will be outlined in the following sections.

5.2.1 Literature review

The study revolves around the idea that information is important to shape the understanding of energy efficiency and also the decisions making. To situate the central idea around PUS, a detailed review of literature was conducted. Secondary literature from journals, books, newspapers and magazines around energy efficiency, energy efficient technology and energy efficiency gap was done to understand the present scenario. Libraries of Bureau of Energy Efficiency, and Ministry of Power were accessed to understand the policy making around standards and labels in India.

To examine the current scenario of energy consumption and energy efficiency, detailed literature review was conducted since 1947. The secondary literature was accessed from newspaper repository (times of India), annual reports from various ministries and organization e.g. International Energy Agengy (IEA) and also used other online sources. Data from NSSO (2011-12) was accessed to examine the appliance ownership in Indian households. To underline the research around energy efficiency, bibliometric analysis was conducted using SCOPUS database with the key words 'energy efficiency' and 'energy efficiencies'. To understand the conceptualization of energy efficiency a content analysis was conducted using the response from the respondents and lastly, to analyze the role of information in decision making logit regression model was used.

5.2.2 Preliminary research for qualitative and quantitative analysis

As noted in earlier chapter, literature around energy efficiency gap has widely highlighted the need to fill the information gap among energy consumers to reduce the energy demands from Indian households. As there is not much literature available around understanding of energy efficiency and energy efficient technologies among the Indian consumers, it was important to observe the existence of the information gap among consumers. To observe the gap in real life situation, visits to appliance shop was conducted at various different places i.e. Mohan Singh electronics market, R.K puram, Vijay Sales, Reliance digital and Croma, and Reliance fresh limited digital xpress during January' 2017- May' 2017.

	Shop names	Address
1	Reliance Digital	- Vasant Kunj
2	Croma	- Vasant Kunj
3	Mohan singh shops (5)	-Rama Krishna Puram
4	Vijay sales	-Shadhara.
5	Reliance Fresh Limited Digital Xpress	- Sahibabad, Ghaziabad

Table 5.1: Shops selected for preliminary research

Source: Author's field work

The main motive to visit these shops was to identify the buying behavior of consumers and to note the extent of emphasis they provide to energy efficiency while making decisions, what factor do they keep in consideration while making decision, their attention towards energy labels,

support from shop keepers and other staff and role of information in decision making etc. The shops were chosen to capture understanding of consumers of all socio-economic backgrounds. Reliance Digital and Croma, vasant kunj was chosen because they are electronics showroom located in southern part of Delhi and majorly catering to high income groups. While Vijay sales and Reliance Digital, Ghaziabad caters to middle class (Business standard, 2015)[97] and lower middle class. Mohan Singh market was chosen because it is small hub of electronic shops (around 10-12 shops) of varying size which is catering consumers of middle class, lower middle class and anyone who can afford to buy a new electronic appliance as it has appliances in varied price range.

Shops for second hand appliances were not selected for the study as these shops majorly caters to young students, short-term consumers (consumers who want to own appliance for small period of time), low income groups consumers and lastly who cannot afford to buy a new appliance for their household. For them major concern before buying an appliance will be price as they would not like to spend much on these appliances. Moreover, students, short-term renters, and consumers from low income groups often do not pay their electricity bill. Therefore, they do not even have incentive to conserve energy or use energy efficient technologies.

The author went to these shops posing as customer (who is willing to buy a refrigerator) and interacted with other customers as well as shopkeepers as a customer only. The author did not reveal the intention to customers while discussing with them because it would have made them conscious about their decision making. While interaction and observation, it was noted that in different shops and places, consumers and shopkeepers and helpers behaved and worked differently. Moreover, there was difference in set of appliances in terms of brand and price in each place. Consumers who were found shopping in high-end shops were majorly found to be focusing on brand and size whereas, consumers from middle class or low middle class emphasized on price, quality and size. Most of appliances found in high-end shops were 4 and 5 starred (most efficient) appliances whereas in other shops, appliance ranging from 1 to 5 stars (least efficient to most efficient) can be found. In these shops, buyers were continuously found

[97] Business Standard (2015), Indian middle class is 24 million: credit sussie (highlights that lowest threshold for a person to be considered middle class with annual wealth of $13,662 (Rs 737,748 or Rs 61,480 per month)) in 2015 (accessed from https://www.business-standard.com/article/current-affairs/indian-middle-class-is-24-million-not-264-million-credit-suisse-115102900181_1.html retrieved on 24th October 2017).

engaged with shop keepers /helpers enquiring about the different appliances. Most of the enquiries were about size, product specifications, models, price and brands. The electricity consumption information was majorly provided by the shop keepers/helpers to consumers. In few instances, consumers did ask about the meaning of stars on the energy labels. When author tried to know about their information search pattern, most of them indicated that they have researched online especially for Refrigerator, Television and Air Conditioners. With respect to price, in malls consumers do not have any option of bargaining the price of appliances therefore no discussion of this sort was observed. In small shops consumers were found to be bargaining on the price of appliance with the shopkeepers.

After the interaction with potential buyers, author did mention about the research work to shopkeepers and ask them about the kind of information potential buyers seek from them. Most of the shopkeepers did not give much time to interact after they get to know about the real motive for being there in the shop. Shopkeepers/helpers from the malls did mention that they help consumers to buy the best product in terms of price and energy efficiency. Whereas shopkeepers/helpers in Mohan Singh market and Vijay sales were highly cooperative and interacted with author about how different kind of buyers ask for different information. They highlighted that the buyers emphasize on seeking information about price of appliance, size, how appliance work and how much electricity bills will be increased on the usage of an appliance (especially in case of ACs). They also indicated that while making decision, energy labels are seen by most of the potential buyers but their decision is not based on the information of the energy labels.

The author interacted with the two officials of Bureau of Energy Efficiency (BEE) and one official of Ministry of Power (MoP) with prior informed consent. The interaction was informal and no recording of any sort was done by author. The interaction majorly focused on relevance of energy efficiency in Indian households, Standards and labeling (S&L) program launched by BEE, the impact of S&L program on appliance ownership, and need for mandatory labeling. The officials underlined the importance of energy efficiency and energy conservation in Indian households in wake of increasing emissions and climate change. When asked about the relevance of energy labels, all the officials stated that energy labels are helpful in decision making and discussed about the information campaign “Bachat ke Sitare” by BEE to raise more awareness about the energy efficiency among the consumers.

Taking cue from above interactions with shop keepers, consumers and officials, it was noted that consumers do register the information about energy consumption through energy labels but it is not reflected in their decision making. Therefore, to understand more about public understanding of energy efficiency, efficient technology and role of information in decision making of purchasing an efficient technology, questionnaire was designed and analysed. The designing of questionnaire is further discussed in next section in detail.

5.2.3 Questionnaire designing

This questionnaire aimed to understand the public understanding of energy efficiency, energy efficient technologies and energy labels. The questionnaire formation used intra-method mixing as it included variety of questions i.e. multiple choice questions, likert scale multiple choice question, dichotomous question, checklist type multiple choice questions and open-ended questions to get a clear picture of public understanding. Although, Wynne and other scholars have strongly argued that quantitative approach based on survey is not suitable for understand the public understanding as it cannot shed any useful light on understanding public's knowledge and their interactions with science (Wynne, 1995). He further argue that "survey take the respondents out of their social context and are intrinsically unable to examine or control analytically for the potentially variable, socially rooted meanings that key terms have for social actors"(Wynne, 1995). Thus, not only quantitative but qualitative approach was also taken in this survey. It is not based on yes/no format rather tries to engage with respondents by asking their opinions.

To make the analysis rich, author has included open ended questionnaire in her survey. In this respondents were asked to write about their understanding of energy efficiency, efficient technologies and energy labels. Open ended questions results in better, more and heterogeneous set of perspectives when compared to closed- ended questions. They are typically used to collect new information about an experience or subject matter, to understand various quantitative findings and to discover various dimensions of respondents' experiences (Sproull, 1988). Moreover, they are appropriate to measure knowledge as they minimize the likelihood of getting 'guess' responses and also elicit more 'Don't know' responses (Krosnick and Presser, 2010). Major drawback related to analysis of responses from open ended questions is that it is time consuming and can lead to confusion related to result interpretation (Krippendorff, 1980).

Moreover, the responses from open ended survey are complex and difficult to analyze as removal of contexts is problematic for coder understanding. But it allows respondents to "use his or her own frame of reference in determining a response, even if this might seem inappropriate or irrational to survey designers" (Stoneman, Sturgis and Alum, 2013). Even though open ended questions have many advantages, it is not widely used in survey research as it costly, time consuming and requires resources to transliterate and analyze. The biggest setback of using open ended questions is that it favors educated population who is able to articulate properly and are able provide responses and thus exert an unequal influence on public policy.

5.2.4 Structure of questionnaire

The questionnaire was divided into 3 major sections. First section included questions related to awareness and public understanding about energy consumption, energy efficiency and energy efficient technologies. Second section consisted of three stated choice experiment to understand the energy efficiency gap among the respondents and also to measure the willingness to pay (WTP) for most efficient technology. Third and last section included respondent's socio-economic characteristics (table 5.2). Following is the detailed description about the structure of questionnaire.

Section	**Question asked**	**Type of question**
Public awareness related to energy efficiency and energy efficient technology	average electricity consumption	Dichotomous
	average monthly electricity bill	Multiple choice
	decision of buying any electrical appliance in your family	Multiple choice
	Average time to make purchase decision of electrical appliances	Multiple choice
	Understanding of the term "Energy efficiency"	Open ended
	Awareness about energy efficient appliance	Dichotomous
	Understanding of energy labels	Dichotomous
	Ownership of energy efficient appliance	Dichotomous
	Motivation to buy efficient appliance	Multiple choice
	Rating characteristics of energy labels	Likert scale
	Rating the factors to be considered before buying electrical appliance	Likert scale
	Rate the sources of information	Likert scale
	Knowledge about Standard andLabeling (S&L) program in India	Dichotomous
	Requirement of rebate/subsidies on Energy Efficient Appliances	Multiple choice
Understanding the choice of efficient technology	Choice Experiment 1 (to examine energy efficiency gap)	Dichotomous and open-ended.
	Choice Experiment 2 (to examine energy efficiency fallacy)	
	Choice Experiment 3 (to examine WTP)	

Socio-economic characteristics	Age Monthly Income of household place of stay (last one year) Educational qualification gender head of the family Type of house Employment (Last one year)	Multiple choice Multiple choice Dichotomous Multiple choice Multiple choice Multiple choice Multiple choice Multiple choice Multiple choice

Table 5.2: Structure of questionnaire

Source: Author's work

One of the research objectives of this study is to understand what people think about the energy efficiency and energy efficient technology. To get a clearer picture, what shape their understanding about energy efficiency and conservation, the author first enquired about their energy consumption pattern and their awareness about the units of electricity consumed in the respondents' household and amount paid as their electricity bills. They were also asked about who makes the decision of buying any electrical appliance in a household and how much time is taken for making such decision. For this study, it was found relevant to ask the about energy consumption pattern as it shapes the consumer behavior towards energy saving and out of this behavior, consumers take the decision of buying an efficient technology or not buying that technology. Apart from behavior various other factors also shapes the decision making i.e. who takes the decision of buying any technology, age, gender, education and buying capacity of decision maker. In one of the questions, respondents were asked to write about their understanding of energy efficiency. Their awareness about energy efficient technology and its understanding was also examined in other question in this section. In last question of this section, respondents were shown some labels and were asked to identify it and rate the characteristics attached to these label on a 5-point likert scale.

First part of the questionnaire also attempts to examine the public understanding about energy use, efficiency and conservation. In the questionnaire, an open ended question was included to understand the public understanding of term *'energy efficiency'*. Respondents were asked to give their views about the term 'energy efficiency'. For analyzing the views given by respondents, content analysis was used. Content analysis is a "*research technique for making replicable and valid inferences from texts to the contexts of their use*" (Krippendroff, 2004, p.18). It is one the

most used methodology in text analysis and uses a systematic rigorous approach for text developed or generated during research. The main aim for content analysis is organizing and eliciting meaningful conclusion from the data collected (Bengtsson, 2016). Taking cue from (Krippendroff, 2004) content analysis is considered as best method for understanding the public understanding. Many research domains like anthropology, library and Information Studies, Management, Psychology, Nursing Business Studies and Sociology have used content analysis (Graneheim and Lundman, 2004).

Content analysis can be used in all types of written and visual matter. It can follow various methods i.e. interviews (Golsäter, Sidenvall, Lingfors and Enskär, 2011), written questions (Bengtsson, Ohlsson and Ulander, 2007), or open ended question in a questionnaire (Donath, Winkler, Graessel, and Luttenberger, 2011; Jacob et al., 2014). It is completely dependent on researcher to which kind of method of data collection is to be used. It is also a highly flexible method for qualitative analysis (White and Marsh, 2006) but study by (Hsieh and Shannon, 2005) underlined three approaches of content analysis which are used to understand the meaning from the content of text data. These approaches are conventional[98], directed[99] and summative content analysis[100]. Jackson and Trochim (2002) proposed the concept mapping methodology for open- ended survey data as it combine the strengths of word-based and 'code based methodologies. In this study, author has coded the open responses on the basis of a predefined categorization scheme as also used by (zull, 2016).

In the same section respondents' understanding and perception about energy efficient appliance was also examined through various questions e.g. did they own any efficient appliance? Is there any reduction in their energy bills? If No, why it has not decreased even after using efficient appliance? What factors are considered by them while making a purchase and what source of information is used by them to know about these electrical appliances?

In second section of the questionnaire, three Stated Choice (SC) questions along with open ended questions were asked to understand the energy efficiency gap and their willingness to pay to more efficient technology. Stated Choice Experiment (SCE) has potential to provide rich

[98] In conventional content analysis, coding categories are derived directly from the text data.
[99] In directed, analysis starts with a theory or relevant research findings as guidance for initial codes.
[100] In summative content analysis involves counting and comparisons, usually of keywords or content, followed by the interpretation of the underlying context.

information on preferences as it is usually collected in a tightly controlled choice experiments. In this consumers are given series of choice sets with competing options and asked to choose an option that they are most likely to purchase. This method relies heavily on appropriate identification of attributes, designs of choice sets, sample collection and mode of data collection for collection of data. For this study, the attributes are chosen directly from energy labels provided by BEE.

5.2.5 Selection of attributes

Energy labels provided by BEE on various electrical appliances provides information i.e. energy star, energy efficiency, label period, Appliance type, Brand, Model, Year of manufacturing, electricity consumption and type of standard used. For every appliance, some information varies i.e. In Air Conditioners energy efficiency is given in term of ISEER, while in refrigerator it is not present. To reduce confusion among the respondents, label of refrigerator was used for stated choice experiment as refrigerators are one of the commonly found appliances in Indian households. As noted by NSS consumption expenditure survey (2011-12) ownership of refrigerator is 44.75 per cent and 19.12 per cent in urban and rural areas respectively which is highest among large appliances and also have considerable share in electricity consumption in households. The other reason for choosing refrigerator for stated choice experiments is that it is available in varied price ranges, brands and sizes in India. The price range in 2019 varied from INR 9449 to INR 3,22,000. The refrigerators have variety of 16 brands and size also varies from 170L to 351 L[101].

The energy labels were also chosen from various websites i.e. Flipkart, Amazon, BEE app, Snap deal etc. The energy labels used in this study indicate real time information after extensive literature review, online and offline market research, discussion with shopkeepers and consumers. The attributes selected for choice experiments includes energy efficiency star rating, energy consumption, price, storage capacity, year of manufacturing, label period were selected for this study. In market conditions, price of appliance is not mentioned on the energy label but for studying the Willingness to Pay (WTP) of a given appliance, the price of appliance was added on the label. The price given on the labels was real time price accessed from online

[101] The brand variety, price range and size was noted from flipkart. https://www.flipkart.com/refrigerators/pr?sid=j9eper cent2Cabmper cent2Chzgandsort=price_desc (retrieved on 28th June 2019).

platforms during May-June 2017.The energy labels of various brands were used to develop the stated choice experiment although the name of brand is not indicated in the questionnaire (Table 5.3). The selection of labels was based on market demand, size and type sold in Indian markets.

Attributes	**Experiment 1**		**Experiment 2**		**Experiment 3**		
Energy Star	5	3	4	4	1	3	5
Price	17,520	14,250	21,499	14,250	7,000	10,490	15,000
Electricity consumption (Units)	130	150	167	164	335	212	122
Size (gross Vol. in lts)	185	185	215	190	190	190	190
Brand	A	A	A	A	A	B	C

Table 5.3: attributes selected for various stated choice experiment

Source: Author's analysis

5.2.4.1 Experiment 1

In first experiment, respondents were asked to choose an option from given alternatives. This stated choice experiment aimed to understand the role of energy efficiency information in shaping consumer's decision making. Labels of direct cool refrigerators of same capacity i.e. 185 lts and storage capacity of 170 lts was chosen. The BEE app was also used for comparative analysis in initial phases of the study but later due to insufficient information about price and other attributes it was decided to use online marketing sites i.e. Amazon, Flipkart and snapdeal.

Attributes	**Experiment 1**	
Energy Star	5	3
Price	17,520	14,250
Electricity consumption (Units)	130	150
Size (gross Vol. in lts)	185	185
Brand	A	A
Label period	1 Jan 2017 to 30 Dec 2018	1 Jan 2017 to 30 Dec 2018

Table 5.4 : attributes selected for experiment 1

Source: Author's analysis

Most of the information about the appliance was collected from the bijlibacho website. This experiment examines the presence of energy efficiency gap among the consumers. In this, 2 options were made available in the form of energy labels with varied star rating, pricing, and electricity consumption. While the size and brand and label time period was same (Table 5.4). This experiment tries to observe which kind of information consumers look into the energy label. Is it only the price which matters to them? Or energy star rating and electricity consumption is

also area of interest to them. If consumers did not wanted to choose any of the two given options, they were free to choose “none of the above” option.

5.2.4.2 Experiment 2

This experiment aimed to identify energy efficiency fallacy among respondents. For the experiment labels of direct cool refrigerators of same efficiency i.e. 4 stars was chosen. In this choice experiment, 2 options were made available in the form of energy labels with varied pricing, electricity consumption and size. While the star rating and brand and label time period was same this time. This experiment tries to observe whether people try to analyse the information in critical manner or not? With respect to provided information on energy labels, will they buy a bigger refrigerator if its electricity consumption is not very high? If consumers did not want to choose any of the two given options, they were free to choose “none of the above” option (Table 5.5).

Attributes	Experiment 2	
Energy Star	4	4
Price	21,499	14,250
Electricity consumption (Units)	167	164
Size (gross Vol. in lts)	215	190
Brand	A	A
Label period	1 Jan 2017 to 30 Dec 2018	1 Jan 2017 to 30 Dec 2018

Table 5.5: attributes selected for Experiment 2

Source: Author’s analysis

5.2.4.3 Experiment 3

This experiment aimed to observe the consumers’ Willingness-to-Pay (WTP) for an efficient product when they are provided with limited information on energy labels. WTP aims to identify the inclination of consumers towards energy efficient product and how much are they willing to pay more for more efficient product. Studies surrounding energy efficient product have largely noted that consumers are willing to pay more for product which are energy efficient but how this WTP is related to real time buying behavior is largely under researched. This experiment aimed to observe the consumers’ Willingness-to-Pay (WTP) for efficient appliance. In this, 3 options with different star ratings, price and electricity consumption were provided to consumers to choose from (Table 5.6).

Attributes	Experiment 3		
Energy Star	1	3	5
Price	7,000	10,490	15,000
Electricity consumption (Units)	335	212	122
Size (gross Vol. in lts)	190	190	190
Brand	A	B	C

Table 5.6: attributes selected for experiment 3

Source: Author's analysis

5.2.6 Conducting a survey

After the pilot survey with 10 individuals and discussion with other researchers, required changes were made and final questionnaire was prepared in Hindi as well as English language. It was prepared and hosted by online software named as *Survey Monkey*. It is online survey development cloud based software which provides a platform for researchers for undertaking online surveys.

The study used online survey as they are less costly, time saving, have flexibility of including visuals and media as well (Kellner, 2004). Other option for conducting this research was at shopping areas, where buyers buy the appliance but this option was discarded due to following reasons which was observed in earlier visits to these appliance shops:

- Buyers become highly conscious about their decision when approached to ask about the reason for selecting a product.
- Their decision gets altered when they know they are being observed.
- They don't like to be judged on their reasons of making any choice.
- Shopkeepers do not cooperate much, if they know they can lose their customers.
- Buyers found the questionnaire to be lengthy for the time they have.
- Buyers were rather interested to answer the questionnaire online.

For the above reasons, online method data collection method was selected. Moreover, it also provides access to a large and varied population in short span of time (Mertler, 2002) and ensures a potentially better response rate (Matz, 1999). Even though, it relies on initiatives from respondents to complete the survey which introduces the non-response bias (Couper, 2011) making it flexible but also inculcates the postponing attitude among them, (At times, they forget about it).

The online samples are considered as representative of population sub-groups only (Hoogendorn and Daalmans, 2009) and thus not considered as representative of general population. On comparison of online research and face-to-face survey, it was noted that online research using part members gave more qualified and viewpoint-oriented sample than face-to-face surveys. Moreover, the face-to-face interviews are more susceptible to social desirability bias as interviewer is present at the time interview (Duffey et al., 2005). There is no convincing evidence that indicates the difference in quality of responses between self-completed mail survey and online surveys (Ilieva et al., 2002). However, studies indicate that participant response in email survey can be more illustrative than paper-and-pencil survey (Schaerfer and Dillman, 1998). Studies comparing response rate from online and face-to-face surveys indicate that web-based survey produce more 'don't Know' response, more non-differentiation on rating scale and higher non-response rate (Heerwegh and Loosveldt, 2008), while study by (Lindhjem and Navrud, 2011) noted no such difference in 'don't know' response rate.

The only limitation for administering web based survey is that the respondents should possess minimum basic computer skills and should be connected to internet although technical issues related to handling of computer/ laptop/ mobiles or internet connection may have arisen during survey which may have affecte the response rate. For the study questionnaire included 3 sections and 30 questions. The estimated time to completely answer the questionnaire was 20-25 minutes. The questionnaire was sent through links on email-IDs and whatsapp groups to the population of age above 18 years, who have access to internet and able to read and write either in English or Hindi. As income and education plays a very important role, it was aimed that this survey should reach to respondents of above 18 years of each income group and education qualification. Hence, various organization, universities and institutes were selected to answer the survey. For capturing young and educated population, various *colleges of Delhi Universities* were targeted. For reaching to medium aged and highly educated population, *Jawaharlal Nehru University, IIT Delhi, Delhi University, IISERs* were targeted. This questionnaire was also sent to various NGOs like *Hazards centre, Climate Change Research Institute, Vatavaran* and *Ama Prayas.* To capture working class an IT firms from Noida was approached and to capture government sector employees, teachers at school level, professors at undergraduate and post graduate level, employees from various ministries were requested to answer the survey. And one researcher also volunteered to send the questionnaire to various farmers and marginal groups who have access to smart phones.

In the beginning of survey, respondents were informed about the aim of survey and were assured that the information provided by them will be used only for research purposes. They were also asked to forward the questionnaire to their friends and relatives so that general population of various socio-economic characteristics can be captured. The study follow snow ball sampling which is a form of non-probability sampling and commonly used in sociological studies which involve sensitive issues or illegal activities thus used in medical services and in various social sciences including sociology, anthropology, political science, and Human geography (Noy, 2009). It is commonly defined as method in which "one interviewee provides the researcher the name of at least one more potential interviewee and then interview provides a name of an at least one more potential interviewee, and so on" (Patton, 1990). With sample size not fixed, and is determined according to mathematical decisions on the basis of information yielded as survey response grows. Even though it is preferred to follow random sampling to reduce bias and for estimation of sampling error, purposive sampling is considered desirable when universe is small and characteristics of it is to be studied deeply, also for convenience and reduction of cost involved in sampling (Etikan, Alkassim, Abubakar, 2016).

The scholars from qualitative research has opposed the notion of 'lack of generalisability' attached with snow ball sampling stating that "the intent is not to generalize to a population, but to develop an in-depth exploration of central phenomenon" (Creswell, 2005, p.203). Kirchherr and Charles (2018) gave key recommendation to inform researchers on how to do research using snow ball sampling. It includes that prior contacts of the examiner are required, sample seed diversity is crucial (initial set of respondents should be sufficiently varied), maintaining contact to win trust of respondents is important, persistence is also crucial to secure interviews, and lastly snow ball sampling should be pursued with multiple waves to increased response rate.

For this study, data collection started in April, 2018 and lasted till June, 2018. The questionnaire was sent through links to selected public and those people were asked to send this questionnaire to their friends and relatives who are above 18 years of age. The total numbers of valid responses collected were 307.

5.2.7 Regression Analysis

After collection of data, regression analysis was conducted. Regression analysis use the cause and effect relationship of dependent variable on one or more independent variables for estimating or predicting the population mean or average value of dependent variable in terms of the fixed variables in repeated sampling. It shows statistical relationship among variables and not that of deterministic one (Gujurati et al., 2009).

The general form of a linear probability model is as follows

$$Y_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + u_i \quad \ldots(1)$$

Where Y_i is a dependent variable, and
X variables are known as explanatory variables or predictors.
'u' is known as a random or stochastic or error term.

'Y' is a random variable and can take shape of four different scales such as ratio scale, interval scale, ordinal scale and nominal scale. Ratio scale has three distinct properties of variables such as ratio of two variables, distance between two variables and ordering of variables. e.g. Gross Domestic Product (GDP) is a ratio scale variable. Interval scale variable does not satisfy the first property of ratio scale i.e. ratio of two scale e.g. time period 2007-2018. The ordinal scale satisfies the ordering property of the ratio scale but does not satisfy other two properties of ratio scale e.g. A, B, C grades for students in a class etc. Nominal scale variables do not satisfy any property of a ratio scale. The variables such as gender, marital status and religion are nominal scale variables. Such variables are often called dummy or categorical variables and they are often quantified as '1' or '0' where usually '1' shows the presence of an attribute and '0' indicates the absence of an attribute.

Linear regression model is easy way to identify relationship between two continuous variables. The 'X' and 'Y' variables can be logarithmic ln(x), reciprocal (1/X), or can be raised to a power $X^{3.}$ Linearity in the β coefficients means that they are not satisfying the above mentioned properties of 'X' and 'Y' variables. Linear regression or linear probability model is not a preferred choice for modeling dichotomous variables. In this study, the dependent variables are

dichotomous. E.g. when the respondent is asked about "*Do you know about energy efficient appliances*?", then reply comes in form of 'yes' (1) and 'no' (0) which could be studied in relation to various explanatory variables such as income, gender, education etc. As the answers from respondents come in binary values; author is opting for logistic regression.

$$\text{Logit } Y_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + u_i$$

where Y_i= 1(yes) or 0 (no)

The characteristics of respondents also vary as there are respondents of different level of qualification, income level, education level, place of stay, household size etc. which takes different properties of different variable and it is important to note that, many of variable are in the form of nominal scale.

5.3 Limitation of study

Before analyzing the results, it is important to highlight the limitations of the study which arises majorly due to human errors, lack of time and lack of funds. First limitation of the study is that it is based on web-based surveys and caters only to the population who has access to either smart phones or computers along with internet connectivity. Although the questionnaire was prepared in English and Hindi language but inability to properly read and comprehend would have played a major deterrent for respondents. While preparing the questionnaire, due care was undertaken to keep it simple and crisp but usage of technical terms like energy efficiency, appliance, conservation was inevitable and thus consumers would have felt intimidated by the questionnaire. Moreover, lack of incentive for responding discourages respondents to complete the questionnaire.

5.4 Summary

Even though, there are limitation to this study, the author has tried to include all major aspects in the questionnaire to examine how general public understands the concept of energy efficiency, what is their consumption pattern, how they make decision of buying an electronic appliance, how different information shapes their decision making. Moreover, this study is one of kind of study which has focused on analyzing the role of information in shaping decision making in

controlled scenario. This online stated choice experiment helps the researcher to weight the type of information usually observed by the consumers in the situations where they are making decision online. Another aspect of the study, which makes it a unique study, is that it includes open ended questions which aim to capture the reasons a decision making which highlights the underlying motivations and goals of respondents. It also helps in triangulate what people are saying and what they are doing.

Chapter 6

Public Understanding of Energy Efficient technology: an Empirical Analysis

6.1 Introduction

To understand energy efficiency, it is important to understand how energy is being used. Its understanding should not be restricted to technical aspect rather should also include its social aspect. Socio-technical understanding of energy can help shift energy policies of electrical systems toward sustainable system, by user involvement at different stages, strengthening socio-

technical system, providing spaces for learning and interaction, inculcating new cultures of experiment and keep other options open (Rohracher, 2008). It is emphasized that understanding of an issue, product or service is dependent on learning (Kaiser et al., 1999) as quoted by (Faiers et al., 2007) and learning can be tacit or explicit, depending on the issue, product or service. Public have skills and awareness that enable them to choose information from vast pool to carry out actions and evaluate facts and theories and finally allows understanding and decision making. However, general information, specific feedback on consumption and action contributes in shaping the knowledge (tacit) in a required direction and nudge the public to seek more information, analyse it and seek answers to their problems and also to encourage them to share knowledge with others (Darby, 2006). Understanding of energy efficiency is also tacit knowledge which is shaped by the how energy is perceived, used and understood. The section 6.2 discusses how energy efficiency is being conceptualized by public. Section 6.3 analyses the awareness of energy efficient technology within sample.

6.2 Understanding 'Energy Efficiency'

"Energy efficiency" is a term found frequently in the literature of energy policy and often used synonymously to energy conservation related behavior. With the growth of energy efficiency research over the last few decades (Du H et. al., 2012), it has become significant to gain better understanding about it. There are various definitions available in different literature but no well defined definition is accepted by everyone and everywhere and its understanding varies with context. Lawrence Berkeley National Laboratory (LBNL) defines energy efficiency simply as "*using less energy to provide same service*" ("Energy Efficiency" n.d.). American Council for an Energy Efficient Economy (ACEEE), defines energy efficiency as "*energy resource*" which results in energy savings ("Energy Efficiency as a Resource", n.d.). Patterson (1996) keeps the classic definition of energy efficiency as "*simple ratio of "useful output" of process and energy input in the process"* but, raises the issue of defining "useful output". Herring (2006) put energy efficiency as "*the ratio of energy services*[102] *out to energy input".*

In 1996, Energy Information Agency (EIA) conducted a workshop for defining energy efficiency in US and came out with different definitions for different sectors and different perspectives i.e.

[102]Energy services are defined based on content analysis and extensive literature review. He defined energy services as those functions performed using energy which are means to obtain or facilitate desired and services or states (Fell J.M, 2017).

physical perspective, thermodynamic perspective, mechanistic, economical or behavioral perspective. Physical perspective looks at efficiency as using less energy to produce same output. An economist perspective includes all changes that result in decreasing the amount of energy used to produce one unit of economic activity (e.g. the energy used per unit of GDP or value added). International Energy Agency (IEA) defined energy efficiency as the "*difference between the current and average practice energy consumption and best practices energy consumption".* They consider it as powerful and cost effective tool for achieving a sustainable energy future. Oikonomou et al., (2009) noted that energy efficiency concerns technical relationship between maximum quantity of obtainable service i.e. heating, lighting, cooling, mobility *etc*. and behavioral change and the quantity of end-use of energy consumed. Gillinghim et al., (2009) while examining the literature for consumer decision making in energy efficiency and conservation defined energy efficiency as energy service provided per unit of energy input. Barton et al., (2013) also use the classic definition of 'energy efficiency' as the ratio of function (services) or value provided, to the energy converted to provide it. The literature indicates that energy efficiency has different components i.e. physical, technological, social, behavioral, and economic *etc* to its understanding. Moreover, the idea of "Input" and "output" of the energy efficiency is still needs to be defined. This study attempts to examine the public understanding about energy use, efficiency and energy labels in India. In the questionnaire, an open ended question was included to understand the public understanding of term *'energy efficiency'*. Respondents were asked *"what do you understand about 'energy efficiency'?*". Out of total 307 responses, 107 respondents skipped the question and therefore only 200 valid responses were available for analysis. It is evident that 34 per cent of respondents refrained from answering the question and this can be due to the fact that they are not aware about the term 'energy efficiency' or they are disinterested to respond the concerned question. From the given 200 responses, 11 respondents admitted that they don't know about energy efficiency and thus cannot answer it. For example, respondent ID.128 have mentioned that "*no idea, it should be using electricity efficiently*" while, respondent ID.167 have clearly mentioned that he "*does not know exact meaning*". This point towards the fact either the respondents do not know about the term 'energy efficiency' or they do not understand the meaning of the term.

To analyze the public understanding of term **'energy efficiency'** only 189 out of 200 responses were coded. The responses collected from the online questionnaire were not very lengthy and included 3-4 lines (i.e. 10-30 words). A comprehensive word count was done using MS excel

(Figure 6.1). The assumption behind word count is that words often mentioned are the words that reflect the greatest concerns. But it is seen that common words are commonly used and if respondents have used synonymous word for different reasons (e.g. stylistic reason) then it lead to bias and under estimation of results. Moreover, each word may not represent a category equally well and can also have multiple meanings (Stemler, 2001). To avoid the above inaccuracy, the definitions given by the respondents were manually looked upon and any response which didn't make sense was stuck down from the list.

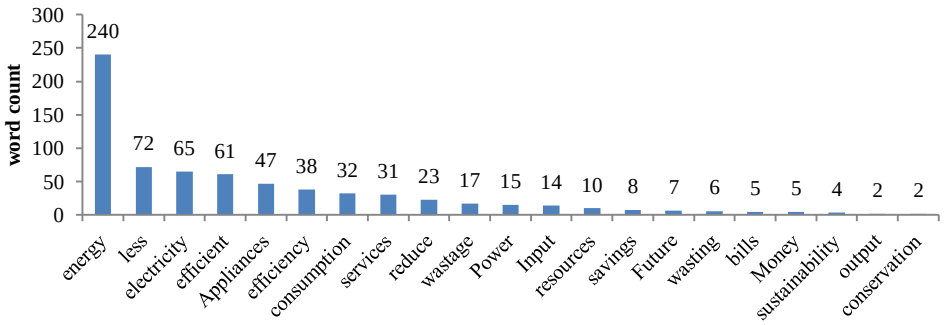

Figure 6.1 word count of the given responses

Source: Author's analysis

The word count gave the frequency of words used by the respondents. 'Energy' was obviously the most used word (with word count of 240). The word '***energy***' was used by the respondents along with other words e.g. '***efficiency***', '***efficient***', '***conservation***' *etc*. to elucidate the context. It is evident that most of the responses revolves around the term '***energy use***', '***electricity use***', '***energy saving***', '***input-output ratio***', '***energy services***', '***energy wastage***', '***consumption***' and '***efficient appliance***'. It clearly shows that respondents understand energy efficiency in the context of using less energy, less energy consumption, using energy efficiently, using energy efficient appliances, reducing wastage, and energy input. While the words like '***sustainability***', '***bills***', '***output***' have considerably low word count. From word count, it can be understood that respondents do not relate to idea of sustainability, environmental resource conservation and reducing energy bills to their understanding of energy efficiency. But for clearer understanding, manual examination of the narratives of respondents was conducted. After the analysis of all definitions, specific contexts were chosen as labels i.e. for a simple one line definition, one label was provided. If the definition talks about two or more ideas, two or more labels were provided to them. The labeling process can be better understood with the given examples:

Response ID: 4 stated that energy efficiency is "*Prudent use of electricity*". The definition was labeled as '**Efficient use of electricity'.**

Response ID: 53 stated that: "*Usage of energy in such a way that the least amount of it gets wasted and the maximum is used for the desired purpose"*. The author chose to label this definition as '**reduced wastage**' and '**Efficient use of Energy**'.

Response ID: 13 stated that: "*It is the use of energy in an efficient manner so that no waste of energy would occur and we can save much energy for future needs. It is the management of energy in an efficient manner that would come of need for future generations as well*". As this definition includes various dimensions, therefore different labels i.e. '**reduced wastage**'; '**efficient use of Energy**' and **'sustainable use'** was used for analysis.

Using the above method, all the valid 189 definitions were labeled under particular code. During coding, it was identified that many definitions had overlapping codes. Therefore, 24 major codes were identified. Most of the responses indicated that they understand 'energy efficiency' as efficient use of energy (32), efficient use of electricity (24), using less energy for same service (22) and less energy used by appliance (23). Respondents also understand energy efficiency as reducing wastage related to energy use (20) and saving energy (10).

After labeling of definition under identified codes, various categories were given under which these codes falls. For the analysis, 9 categories were formed i.e. Economic aspect, electricity consumption, energy use, energy resource conservation, environmental concern, input-output relations, sustainability aspect, technological aspect and miscellaneous definition were collected under 'other' theme (Figure 6.2).

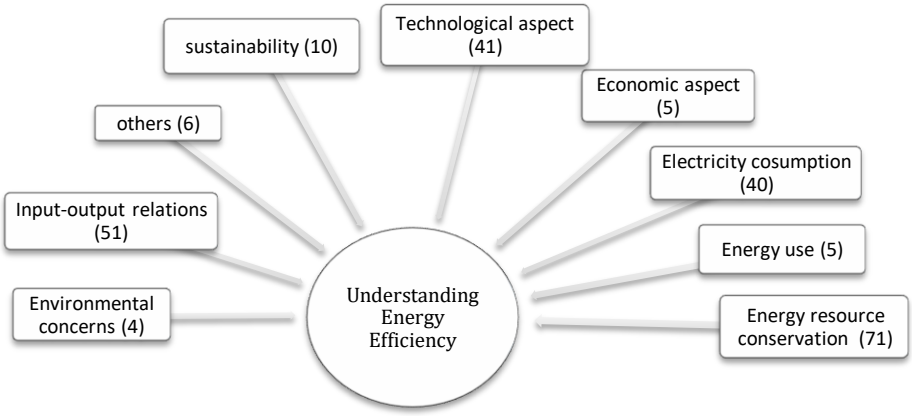

Figure 6.2: Major identified categories[103]*[104]

Source:: Author's analysis

During the analysis of definitions, it was identified that most of the respondents understood energy efficiency as energy resource consumption and its conservation, while a group of respondents described energy efficiency as electricity consumption and using electricity efficiently. The respondents also discussed energy efficiency through an input-output relation in which they highlight the need of reducing input for the same output or better output. The output can be seen as services or end-use. The input is in the form of energy or electricity. The findings of the questionnaire reflect that respondents do understands that energy efficient technology or energy efficient appliance are crucial for reducing energy consumption and helps in achieving energy efficiency. That is why, a large chunk of respondents indicate that using energy efficient appliance is energy efficiency. Few examples of how energy efficiency is understood from technological perspectives are given below:

[103] "A code can be thought of as a label; a name that most exactly describes what this particular condensed meaning unit is about. Usually one or two words long". And "A category is formed by grouping together those codes that are related to each other through their content or context. In other words, codes are organised into a category when they are describing different aspects, similarities or differences, of the text's content that belong together" (Erlingsson and Brysiewicz, 2017).

*Number in bracket denotes number of respondents.

Response ID. 73: "*It means reduce your bill by using the product like LED bulbs and solar energy products*".

Response ID. 130: "*Energy efficiency implies rationalizing energy consumption for utilization of electrical product(s) and appliances".*

Response ID. 155: "*How much less energy an electrical appliance use energy as compare to its previous model or modeled which are available in market instead of this segment "in short how much less energy it use to for its operation*".

Response ID. 175: "*it is the efficiency in electricity consumption of an appliance, that is, how much it can achieve while limiting the total electricity it consumes".*

Response ID. 194: "*From the perspective of electrical appliances, energy efficiency means, out of the amount of electrical energy they need, how efficiently that amount is converted into actual usage instead of getting lost in heat etc. The more efficient an appliance is, the less electricity it draws to perform a particular work".*

One of the respondents (Response ID. 12) specifically points out towards holistic idea of energy efficiency as:

> *"It is the use of energy in an efficient manner so that no waste of energy would be occur and we can save much energy for future needs. It is the management of energy in an efficient manner that would come of need for future generations as well".*

Other respondent (Response ID. 26) explains energy efficiency as "*sustainable consumption and production*", and does not talk about consumption and production of what. Very few respondents have noted the relationship of energy efficiency and environmental protection. i.e. Response ID.33 says:

> *"Energy efficiency, means using less energy to provide the same level of energy. It is therefore one method to reduce human greenhouse gas emissions".*

Even though, energy efficiency can seen as a means to reduce the environmental deterioration, very few respondents have directly pointed out towards this dimension (Figure 6.3)

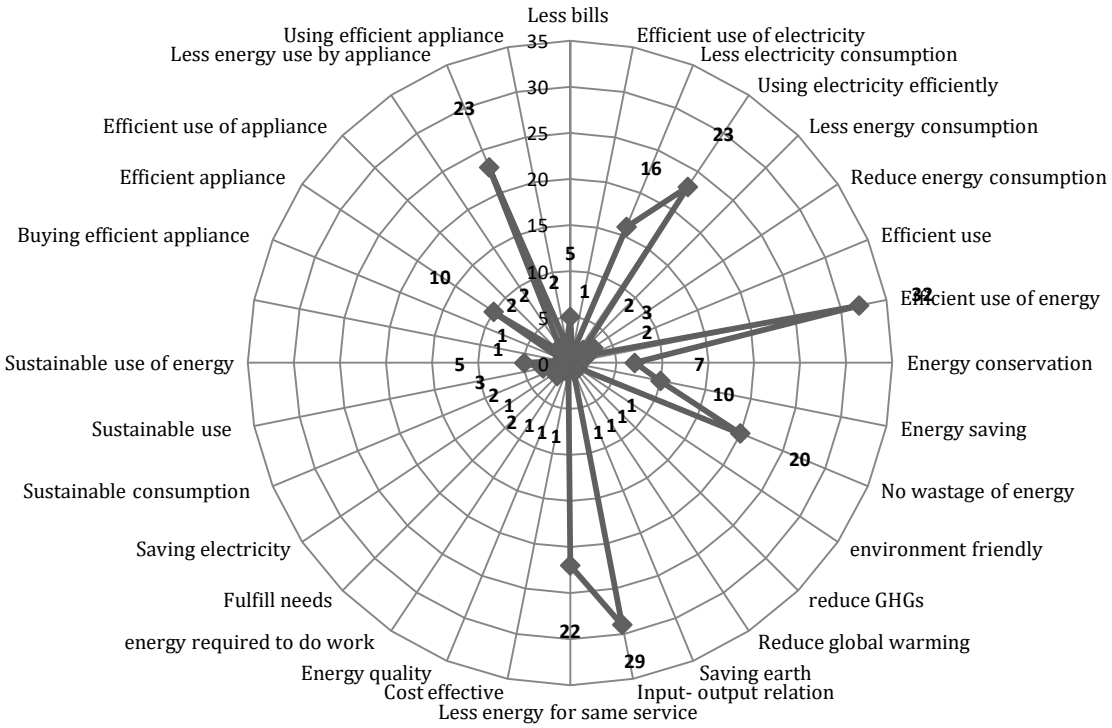

Figure 6.3: Understanding energy efficiency

Source: Author's analysis

It is important to note that for respondents' understanding of energy efficiency is not strongly related to sustainability, saving money on their energy bills and improving quality of energy. The above discussion is based on the views shared by 'public' who uses electricity to get services in their households. Their understanding about energy efficiency revolves around their understanding of related concerns and issues. Public (respondent) understands energy efficiency as something which allows them to use less energy for the same services. The notion of 'using less energy' is shaped by their implicit concerns i.e. high electricity bills, increasing environmental degradation, concern about future. It is crucial to know what and how people understand energy efficiency, so that energy policy can be nudged in a direction which can make adoption of efficient technology more effective in long run.

6.3 Knowing about energy efficient appliances

Before analyzing the awareness about energy efficient appliances, it is important to understand what various parameters are observed by consumers when they plan to purchase a refrigerator.

Therefore, respondents were asked to rate the factors considered by them before making a decision to adopt or not-adopt a refrigerator. The factors provided to them were brand (Rt_brand), energy consumption (Rt_EC), energy efficiency (Rt_EE), price (Rt_pr), suggestion by others (Rt_sug), exchange offers/ festive offers (Rt_Exc), Size (Rt_size) and features (GL). Most of respondents indicated that energy consumption (Rt_EC), energy efficiency (Rt_EE), price (Rt_pr) are most important factors which they look for while taking a decision. Exchange offers and festive offers are indicated to be least important factor (figure).

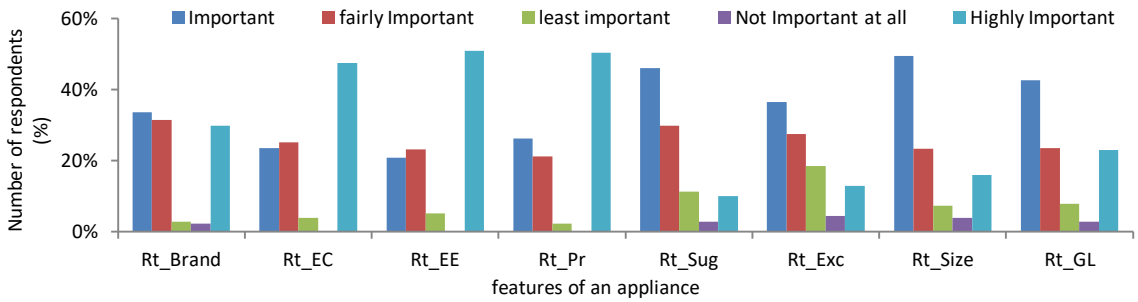

Figure 6.4 Factors considered when buying a refrigerator

Source: Author's findings

For the examining the understanding about energy efficient appliances and energy labels, following socio-economic characteristics of the respondents have been used. Most of the respondents are living in urban areas (89.9 per cent), are male (56.60 per cent), belongs to the age group 18-35 years (89. 3 per cent) and have monthly average below INR 60,000 (54.71 per cent), are students (51.57 per cent), live in their own home (53 per cent) and are graduate or post graduate (62.89 per cent).

	Frequency	Percent
Stay		
Rural	16	10.06
Urban	143	89.94
Gender		
Female	69	43.40
Male	90	56.60
Age		
18+ to 25 years	61	38.36
26 to 35 years	81	50.94
36 to 45 years	6	3.77
46 to 55 years	6	3.77
56 years and above	5	3.14
Monthly Income		
100,001 and above	23	14.47
Rs. 20,001-40,000	29	18.24
Rs. 40,001-60,000	31	19.50

Rs.60,001-80,000	29	18.24
Rs.80,001-100,000	20	12.58
Upto Rs. 20,000	27	16.98
Qualification		
12^{th}	12	7.55
Below 10^{th}	1	0.63
Graduation (Non-science)	21	13.21
Graduation/Diploma (science)	26	16.35
M.Phil and Above	46	28.93
Post-Graduation (Science)	32	20.13
Post-Graduation(non-science)	21	13.21
House		
Own	88	53.35
Rented	71	44.65
Employment		
Entrepreneur	3	1.86
Government sector	38	24
Other	8	5.03
Private Sector	10	6.29
Self –employed	12	7.55
Student	82	51.57

Table 6.1: Descriptive statistics

Source: Author's findings.

6.3.1 Analysing Awareness about EEA: A Logit Regression

For analyzing awareness about energy efficient appliances, logit regression analysis was used. As mentioned above, when the dependent variable is nominal i.e. they denote categories such as 'knowledge of an energy efficient appliance' or 'no knowledge of an energy efficient appliance'. The responses is in the form of 'yes' or 'no' and it won't be appropriate to find out cause of this responses from ordinary simple ordinary least square (OLS) method. Therefore, logistic regression analysis comes to play an important role when dependent variables are nominal. Logistic regression analysis is a predictive analysis and is conducted when the dependent variable is dichotomous (binary). It is used to describe data and to explain the statistical relationship between one dependent dichotomous variable and one or more ordinal, interval or ratio-level as well as nominal variables. It provides the probability of choosing energy efficient appliance with change in independent variables i.e. income, education and gender.

In one of the question, respondents were asked whether they know about energy efficient appliance or not. Therefore the logit model was used to analyze the awareness level of energy efficient appliances. The model estimated the probability (P_i) of "knowing about energy efficient

appliance (yes)" or "knowing about energy efficient appliance (no)" given the value of explanatory variables (X_i) like income, age, gender, qualification, place of stay, household size, type of employment, electricity consumption. In developing such a probability model, it should be noted that values of explanatory variable (X_i) changes and the estimated probabilities lie in between 0-1 interval and the relationship between (P_i) and (X_i) is nonlinear.

Let's assume that the knowledge of energy efficient appliances "yes" depends on an unobservable utility index I_i* which depends on explanatory variables such as age, education, gender etc. therefore, utlity index is given as:

$$I_i^* = \beta X + u_i \qquad ...(1)$$

where i= ith individual
and u= error term
and $\beta X = \beta_1 X_1 + \beta_1 X_1 + \ldots + \beta_n X_n$

But how is the unobservable index related to the actual knowledge of 'yes' energy efficient appliance or otherwise. It is reasonable to assume that $Y_i = 1$ ('yes' knowledge of energy efficient appliances) and utility index $I_i^* \geq 0$; $Y_i = 0$ ('no' knowledge of energy efficient appliances) $I_i^* < 0$. That is if a person's utility index 'I' exceeds the threshold level 'I*', he or she will have knowledge "yes" for energy efficient appliances, but if it is less than 'I*', that the knowledge for energy efficient appliances will otherwise. To make this choice operational, it can be thought of making a choice of "yes", say the knowledge of energy efficient appliance i.e.

$$(Y=1) \text{ and } P_r(Y_i = 1) = P_r(I_i^* \geq 0)$$

$$= P_r(\beta X + u_i) \geq 0$$

$$= P_r[(u_i \geq -(\beta X)] \qquad ...(2)$$

Now this probability depends on the probability distribution of Y_i which in turn depends on the probability distribution of error term u_i. The logit model assumes that the probability distribution of error term follows the logistic probability distribution.

$$P_i = 1/(1+e^{-Z_i}) \qquad ... (3)$$

Where, P_i is the probability of "yes" knowledge of energy efficient appliances, i.e. $Y_i = 1$

and $$z_i = \beta X + u_i \quad \text{... (4)}$$

The probability that the y=0. i.e the respondents knowledge "no" on energy efficient appliances is given as:

$$1 - P_i = 1/(1+e^{Zi}) \quad \text{...(5)}$$

The signs of Zi in equation (3) are different from equation (4).

Zi= ranges from $-\infty$ to $+\infty$
P_i = ranges between 0 and 1
and P_i is nonlinearly related to Zi.

Taking the ratios of $P_i / 1-P_i$ that is the probability that a respondent is having knowledge "yes" for knowledge about energy efficient appliance against the probability "no' knowledge of energy efficient appliances.

$$P_i / 1-P_i = [1/(1+e^{-Zi})]/ [1/(1+e^{Zi})] \quad \text{... (6)}$$

$P_i / 1-P_i$ is simply the odds ratio in favour of "yes" knowledge of energy efficient appliances against the probability of "no" knowledge of energy efficient appliances.

Taking the natural logs of eqn. (6)

$$L_i = \ln (P_i / 1-P_i) = z_i = \beta X + u_i ,$$

L_i is logit which is log natural of the odds ratio.

It is important to note that the logit model assume that the log of the odds ratio is linearly related to X_i . Although the logit model is linear, it cannot be estimated by usual ordinary least square method. It is because P_i is equal to 1 for "yes" and 0 for "no' for the knowledge of energy efficient appliances. We can put these variables directly in the logit model $L_i = \ln(1/0)$ or ln (0/1) for 'yes' and 'no' knowledge on energy efficient appliances respectively. But, these are undefined expressions. The most popular method with attractive statistical properties is the method of maximum likelihood (ML).

Pseudo R^2 : The conventional measure of goodness of fit **R^2,** is not very meaningful when the dependent variable takes the values of '0' and '1'. In the logit model, the similar measure is Pseudo R^2.

$$\text{Pseudo } R^2 = 1 - (\ln L_{fit} / \ln L_0) \quad \ldots(1)$$

Where, L_{fit} is likelihood ratio for the fitted model

and L_0 is likelihood ratio for the model without any explanatory variables.

It should be emphasized that in binary regression models, goodness of fit measure are of secondary importance.

Likelihood Ratio Statistic: Null hypothesis in our first model is "respondents have no knowledge on energy efficient appliances" can be tested with the likelihood ratio (LR) statistic which is the equivalent of the F-test in the linear regression model. Under the null hypothesis that none of the regressors are significant, the LR statistic follows the chi-square distribution with degrees of freedom (df) equals to the number of explanatory variable. When the model finds the explanatory variable are significant, it can be said that the explanatory variable included in the model (which are significant) are important determinants of knowledge on energy efficient appliances.

Logit model in this case has been refined though interaction among explanatory variables. In our model we have taken 11 explanatory variables such as youth, female, graduate, post graduate and to observe the interaction between the given variables i.e. knowledge level for youth with high income, female with high income, female with postgraduate and high income graduate, the model has been further refined and 4 more explanatory variables were included in the refined model.

Our model without interaction is as follows:

$$\text{Logit}Y_i = \alpha + \beta_1 \text{rural} + \beta_2 \text{highincome} + \beta_3 \text{youth} + \beta_4 \text{female} + \beta_5 \text{graduate} + \beta_6 \text{ postgraduate} + \beta_7 \text{govt\_emp} + \beta_8 \text{self\_emp} + \beta_9 \text{ownhouse} + \beta_{10} \text{bighh} + \beta_{11} \text{highunits} + u_i \quad \ldots(1)$$

Where Y is a dependent variable, and

X variables are known as explanatory variables or predictors.
'u' is known as a random or stochastic or error term.

The model after interaction among explanatory variables is as follows:

$$\text{Logit}Y_i = \alpha + \beta_1 \text{rural} + \beta_2 \text{highincome} + \beta_3 \text{youth} + \beta_4 \text{female} + \beta_5 \text{graduate} + \beta_6 \text{ postgraduate} + \beta_7 \text{govt\_emp} + \beta_8 \text{self\_emp} + \beta_9 \text{ownhouse} + \beta_{10} \text{bighh} + \beta_{11} \text{highunits} + \beta_{12} \text{youth\_hinc} + \beta_{13} \text{fem\_hinc} + \beta_{14} \text{fem\_postgrad} + \beta_{15} \text{hinc\_grad} + u_i \quad ...(2)$$

Where Y_i is a dependent variable but dichotomous, the responses for Y comes in the form of 1(yes), no (0), and
X variables such as rural, highincome etc. are known as explanatory variables or predictors.
'u' is known as a random or stochastic or error term.

Respondents were asked about the energy efficient appliance and their understanding about the same; only 135 respondents said that they do know about energy efficient appliance. Out of which, 56 per cent (76 respondents) were male and 44 per cent (59 respondents) were female. 91 per cent (123 respondents) of them live in urban area and only 9 per cent (12 respondents) belonged to rural area. 24 respondents denied about knowing about them. Out of these 24 respondents, 19 belonged to age group ranging from 18 to 35 years.

	variable	**Comparative group**	**Definition of Variables**	**Mean**	**Std. Dev.**
Place of stay	Rural	Urban area	"Rural area"	0.100	0.301
Monthly Income	High income	Below Rs. 60,000	"Rs. 60,001-80,000" "Rs. 80,001 -100,000"	0.452	0.499
Age (yrs)	Youth	age above 35 years	"18+ to 25 years" "26 to 35 years"	0.893	0.309
Gender	Female	Male	"Female"	0.433	0.497
Qualification	Graduate	Graduationand below	"below graduation"	0.295	0.457
Qualification	postgraduate	Graduationand below	"Post-Graduation (Science)" "Post-Graduation (non-science)"	0.622	0.486
Employment	gov_emp	private and non-workers	"Government sector"	0.238	0.427
Employment	self_emp	private and non-workers	"Entrepreneur" "Self –employed"	0.094	0.293
House ownership	ownhouse	rented house	"Own House"	0.553	0.498

Household size (no.)	Bighh	Family size more than 5	family size 5 and below	0.157	0.365
Electricity Units consumed	highunits	750 units and above	"501-750 Units"	0.176	0.382
	Youth_hinc		"Age 18-35 Yrs and income above 60,000"	0.396	0.49
	Fem_hinc		"Female and income above 60,000"	0.220	0.415
	Fem_postgrad		"Female and Post graduate"	0.289	0.454
	Hinc_grad		"Income above 60,000 and graduation"	0.106	0.309

Table 6.2: Variable definitions, sample mean and standard deviation (The total number of observations for each variable is 159; min=0 and max=1)

Source: Author's analysis

Most of the respondents (n=72) who know about the EEA belonged to age group 26-35 years while 51 respondents belonged to age group 18- 25 years. Very few (i.e. 12 respondents) who know about the EEA are above 36 years of age. Looking at the educational qualification clearly showed that respondents who know about EEA, belong to higher educational qualification (66 percent of respondents have qualification above post-graduation). Moreover, 68 per cent of respondents, who had knew about energy efficient appliance has their monthly income of their households is Rs.40, 000 and above. It is evident from the results that students have more knowledge about energy efficient appliance. The various explanatory variables used in the analysis are given in table 6.2. With logit model allowing for interaction between the explanatory variables, the author wants to examine how different variables interact. Interaction variables may give us insight on who is more aware about energy efficient technology. The results for logit regression are given in following table 6.3. The likelihood ratio of chi square 27.26 with a probability value 0.02, tells us that our model as a whole fits significantly better than the model with no predictors. In this model, the knowledge of energy efficient appliances is taken as binary value '1' while no knowledge of energy efficient appliances is taken as binary value '0'.

EE	Odds Ratio	Std. Err.	Z	P>|z|
Rural	.4761771	.3473382	-1.02	0.309
Highincome	5.138484	7.277291	1.16	0.248
Youth	8.389542	9.155582	1.95	**0.051**
Female	1.610072	1.612053	0.48	0.634
Graduate	13.94119	14.1177	2.60	**0.009**
Postgraduate	15.2658	14.70439	2.83	**0.005**
gov_emp	.2890268	.203425	-1.76	**0.078**
self_emp	.7561812	.7120771	-0.30	0.767
Ownhouse	1.081331	.6706114	0.13	0.900
Bighh	.3623274	.2355299	-1.56	0.118
Highunits	3.739483	3.244949	1.52	0.129
Youth_hinc	.3083657	.4423439	-0.82	0.412
Fem_hinc	.4167263	.4623606	-0.79	0.430

Fem_pg	.8057811	.877996	-0.20	0.843
Hinc_grad	.1224483	.1438721	-1.79	**0.074**
_cons	.1481361	.1931706	-1.46	0.143

Table 6.3: Logistic regression about awareness about energy efficient appliance (K_ee_a= 'yes')

Source: Author's analysis

Number of observations = 159
LR chi2(15) = 27.26
Prob > chi2 = **0.0267**
Log likelihood = -53.840341
Pseudo R2 = 0.2020

It is important to note that some of explanatory variables are showing the significant result for knowing the energy efficient appliances. Examining the independent explanatory variables, it is noted that youth, graduate, post graduate and employees in government sector are more aware about energy efficient appliances and showing statistically significant results. While respondents whose household monthly income are more than INR 60,000 and are graduates are also found to have more awareness about efficient appliances. For the female post graduate (fem_postgrad), probability of knowing about energy efficient appliances are 80 per cent higher against not knowing the energy efficient appliances. Similarly for high income graduate (hinc_grad), probability of knowing about energy efficient appliances is 12 per cent higher than not knowing about it. Amongst the youth with high income, this probability is 30 per cent higher.

In case of government employees (gov_emp), the odds ratio of knowing the energy efficient appliances 'yes" is 23 per cent. Overall, it could be inferred that all the explanatory variables are showing a positive relation towards the knowledge of energy efficient appliances. The odds ratio is more than 13 and 15 times for educated respondents (graduate and post graduate) respectively pointing towards high awareness among highly educated respondents. Examining the marginal effects indicates that probability of knowledge about energy efficient appliances increases by 17 points and 34 points respectively when respondents are graduates and post graduates. Hence, it can be noted that with more education, awareness about energy efficient appliances increases (for marginal effects result, refer table 2 in annexure II).

Likely Advantage of EEA

Respondents were also asked to rate likely advantage of energy efficient appliances (EEA) on the 5 point scale ranging from high significance to low significance. most of respondents, 46 per cent of respondents rated that EEA reduced air pollution (Rt_AP) as highly significant, while

ownership status (Rt_St_O) was found to be least significant for the consumers (by 23 per cent). Reduction in operating cost (Rt_OC) was also rated to be significant by 47 per cent of respondents. The figure clearly indicates that respondents relate EEA with reduction in carbon emission (Rt_Co2), reducing air pollution (Rt_AP) and climate change (Rt_CC) (Figure 6.5)

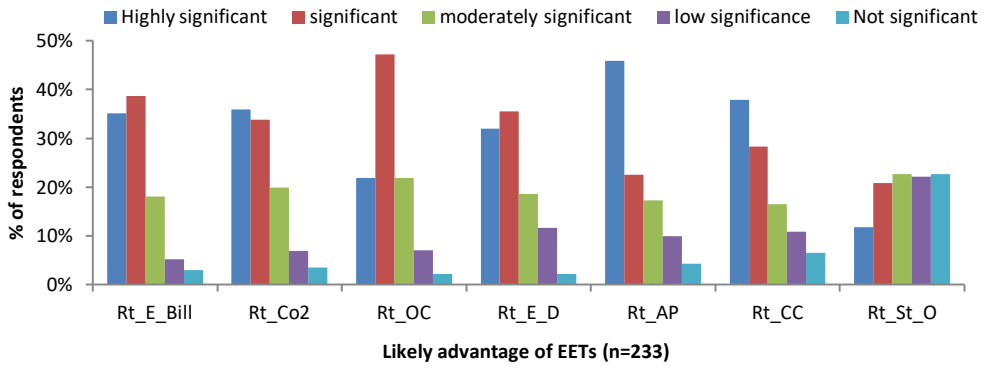

Figure 6.5: likely advantages of using energy efficient technologies/appliances

Source: Author's analysis

6.4 Analysing Awareness about Energy Labels

When asked about standards and labels, most of the respondents (67.2 per cent) did not know about such labels. Respondents who know about the energy labels are majorly young (18-35 years) and possess higher education (post graduation and above). Those respondents were further asked about who makes these standards and labels, and most of them (43.3 per cent) indicated that they are made by government experts while 22 per cent said they are made by industry representatives and manufacturers (Table1 in annexure II).

To know analyse the awareness about of energy labels on energy efficient appliances, respondents were asked to identify the images (energy labels in this case) given on their screens. The labels included the larger and smaller label. The respondents were asked which of the following images they have seen and are able to recognize (Figure 6.6 (a) and (b)).

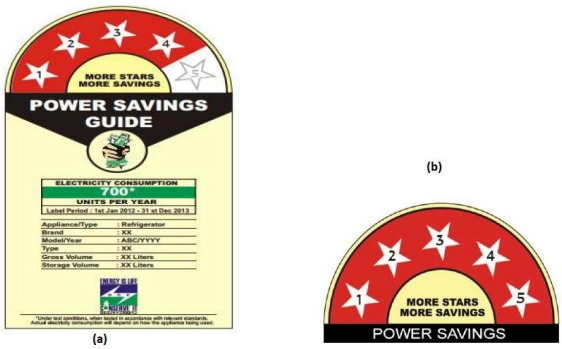

Figure 6.6: Images presented to consumers

Source: Images were accessed from website of Bureau of Energy Efficiency (BEE)

The respondents were free to choose any image i.e. either 'image A' or 'image B', 'both of them' or 'none of them'. Therefore, for the analysis the author treats responses as nominal variables and multinomial logit regression was run on STATA. The model used for the analysis can be explained as:

$$\text{logit } Y_{ij} = \alpha + \beta_1 \text{rural} + \beta_2 \text{highincome} + \beta_3 \text{youth} + \beta_4 \text{female} + \beta_5 \text{graduate} + \beta_6 \text{ postgraduate} + \beta_7 \text{govt\_emp} + \beta_8 \text{self\_emp} + \beta_9 \text{ownhouse} + \beta_{10} \text{bighh} + \beta_{11} \text{highunits} + \beta_{12} \text{youth\_hinc} + \beta_{13} \text{fem\_hinc} + \beta_{14} \text{fem\_postgrad} + \beta_{15} \text{hinc\_grad} + u_i$$

Where Y_{ij}= 1 (if the individual 'i' chooses "none of them" (base outcome) alternative to j (j= image A, image B and both of the them)

Or Y_{ij}= 0 otherwise, Further,

$$\pi_{ij} = \Pr(Y_{ij} = 1)$$

Where, π_{ij} stands for the probability of seeing "none of them" images.

Therefore, πi_1 π_{i2} π_{i3} represent the probabilities that individual i chooses alternatives 'image A', 'image B' and 'both of them' respectively. It is should be noted that our model has more than one explanatory variable, "x" represents a vector of variables and then β represents a vector of coefficients. Therefore, in our model total explanatory variables including interaction variables is 15, hence the model will have 15 slope coefficients and these slope coefficients may differ from choice to choice. In other words, the four probabilities estimated from the equation mentioned

may have different coefficients from predictors. As it is noted before, the model cannot estimate all the four probabilities independently; the common practice in multinomial logit model is to choose one category or choice as the base reference or comparison category and set its coefficient values to zero. It is to note that in our model "recognising image on electrical appliance", the base outcome "none of them" is chosen for our output result. If the model chooses another category, the coefficients will change. But, no matter what the choice of the base category, the estimated probabilities of four choices will remain same. Therefore, coefficients are to be interpreted in relation to the base category "none of them" in this model.

Image 'A' (bigger label) was recognised by 28.3 per cent of respondents, Image 'B' (Smaller label) was recognised 19.4 per cent of respondents while both the images were recognised by the 42.7 per cent of respondents. In this model, the respondents were asked to recognize different images of energy labels to know about the awareness level about the energy standards and labels. The responses were in terms of 'image A' (bigger energy label), 'image B' (small energy label), 'both of them', and 'none of them'. The responses are treated as nominal scale variables, and the awareness about these images (energy labels) depends on the explanatory variables like place of stay, age, gender, education level etc. the results are represented in three parts. The result of multinomial logistic regression is divided into 3 parts. The first part (Table 6.4) give the values of the various coefficients for identifying 'image A' in relation to base outcome i.e. 'none of them'. The second part (Table 6.5) explains the variation in recognizing 'image B' over 'none of them' and third part (Table 6.7) gives the values of the various coefficients for "both the images" over "none of them". The overall model is found to be statistically significant. The output result of LR of 71.27 follows the chi-square distribution with the degrees of freedom equals to the number of coefficients.

Statistical significance of LR is showing that the overall model is good fit, although not every slope coefficient is statistically significant. In part 1, the log of the odds in favour of "image A" over "none of them" has significant positive coefficients for youth, female, and post graduate which suggest increased odds for 'image A' against 'none of them'. The odds of recognizing image A for youth is 19.29 times over none (Exponential of the coefficient is e^2.96= 19.29 coefficient in part 1 (Table 6.4) for youth which is significant with probability 0.07). The same is

11.58 times for female, 2.88 times for graduate, and 19.09 times for post graduate respectively. Likewise, negative coefficient of a regressor implies that the odds in favour of 'none' i.e. not recognizing the energy labels over recognizing 'image A'.

Number of obs=159
LR chi2(45)=71.27
Prob > chi2 = 0.0076
Log likelihood = -165.02068
Pseudo R2 = 0.1776

Image	Coef.	Std. Err.	Z	P>|z|
None		**Base outcome**		
		Image A		
Rural	.3128953	1.050913	0.30	0.766
highincome	34.25494	2608.324	0.01	0.990
Youth	2.962687	1.667392	1.78	**0.076**
Female	2.451623	1.374652	1.78	**0.075**
Graduate	1.064226	1.25159	0.85	0.395
postgraduate	2.948331	1.593857	1.85	**0.064**
gov_emp	-.3904959	.9271264	-0.42	0.674
self_emp	1.736803	1.729505	1.00	0.315
Ownhouse	-1.027235	.8051511	-1.28	0.202
Bighh	-.3883643	.8947687	-0.43	0.664
Highunits	16.17333	1543.195	0.01	0.992
Youth_hinc	-16.48433	2295.149	-0.01	0.994
Fem_hinc	-17.20424	1239.211	-0.01	0.989
Fem_postgra	-3.920285	1.843145	-2.13	**0.033**
Hinc_grad	-1.949175	2.137575	-0.91	0.362
_cons	-3.428066	2.016641	-1.70	0.089

Table 6.4: MLM regression about recognising energy labels (Image A)

Source: Author's analysis

Part 2 of the result (Table 6.5) indicates that the respondents with post-graduation have significantly recognized 'image B' over 'none of them' in their appliances. The probability of recognizing the image B is positive for high income group, youth, female, graduate, post graduate, high unit of electricity consumption respondent, however, it is only statistically significant for very higher levels of education i.e. post graduation. It was found that for the post graduate, the odds of recognizing 'image B' are 82 times higher over 'none'.

Image	Coef.	Std. Err.	Z	P>|z|
None	Base outcome			
Image B				
Rural	-.1348842	1.162897	-0.12	0.908
Highincome	34.38246	2608.324	0.01	0.989
Youth	.7512912	1.41255	0.53	0.595
Female	2.238595	1.454613	1.54	0.124
Graduate	2.525685	1.642391	1.54	0.124
Postgraduate	4.46616	1.981925	2.25	**0.024**
gov_emp	-.0611057	.9425028	-0.06	0.948
self_emp	.5463355	1.751125	0.31	0.755
Ownhouse	-.4561838	.8232402	-0.55	0.579
Bighh	-.0627713	.9324316	-0.07	0.946

Highunits	15.12307	1543.195	0.01	0.992
Youth_hinc	-16.34052	2295.149	-0.01	0.994
Fem_hinc	-15.6513	1239.211	-0.01	0.990
Fem_postgra	-4.148983	1.951629	-2.13	**0.034**
Hinc_grad	-4.953846	2.331666	-2.12	**0.034**
_cons	-3.447728	2.133536	-1.62	0.106

Table 6.5: MLM regression about recognising energy labels (Image B)

Source: Author's analysis

In part 3 (Table 6.6), the odds for recognizing 'both the images' are positive for respondents including high income, youth, graduate, post graduate, self-employment, and high units. The odds are statistically significant only in the case of youth in which the odds of recognizing 'both of the images' are 48 times over 'none'. Overall the results show that youth and post graduates are more aware about energy labels (bigger and smaller).

The result on the marginal effects (Table 3 of annexure II) reflects that probability of recognizing 'image A' over 'none' increases with 3 points in female respondents and 29 points among self-employed respondents. Moreover recognizing 'image B' over 'none of them' increases by 10 points in high income (highincome) groups, 16 points in female, 35 points for graduate and 25 points for post graduates (postgraduate), 4 points for own house (ownhouse) and 11 points for big households (bighh) keeping all other variables constant. However, the recognizing of 'image B' is found statistically significant only for youth (Table 4 of annexure II).

Image	**Coef.**	**Std. Err.**	**Z**	**P>|z|**
None	Base outcome			
Both the Images (A and B)				
Rural	-.6154186	1.04188	-0.59	0.555
Highincome	36.17484	2608.324	0.01	0.989
Youth	3.872948	1.752415	2.21	**0.027**
Female	-.011346	1.422722	-0.01	0.994
Graduate	.2634931	1.114617	0.24	0.813
postgraduate	2.277361	1.459761	1.56	0.119
gov_emp	-.4316923	.8915335	-0.48	0.628
self_emp	.5084237	1.748763	0.29	0.771
Ownhouse	.5661742	.7532605	-0.75	0.452
Bighh	-1.019576	.8699686	-1.17	0.241
Highunits	16.44514	1543.195	0.01	0.991
Youth_hinc	-18.94412	2295.149	-0.01	0.993
Fem_hinc	-15.82751	1239.211	-0.01	0.990
Fem_postgra	-1.900578	1.854342	-1.02	0.305
Hinc_grad	-2.381208	2.17634	-1.09	0.274
_cons	-2.786855	2.002646	-1.39	0.164

Table 6.6: MLM regression about recognising both energy labels (Image A and B)

Source: Author's analysis

The probability of recognizing 'image A and B' over 'none' increases by 42 points among youth, 46 points among female post graduates and 2.9 points among high income graduates keeping all

other things constant. The result also shows positive directional change recognizing both 'image A and B' in case of high income, youth, own house, high units, female post graduates and high income graduates. In the case of awareness about 'both the images' the awareness increases by 73 points in high income group, 42 points in young respondents and 6 points among respondents who are living in their own houses (Table 5 of annexure II).

Characteristics of energy labels

When respondents were also asked to rate the characteristics attached to energy label i.e. labels are reliable, easy to understand, cheap source of information, motivates energy conscious behavior among users etc. (Fgure 6.7).

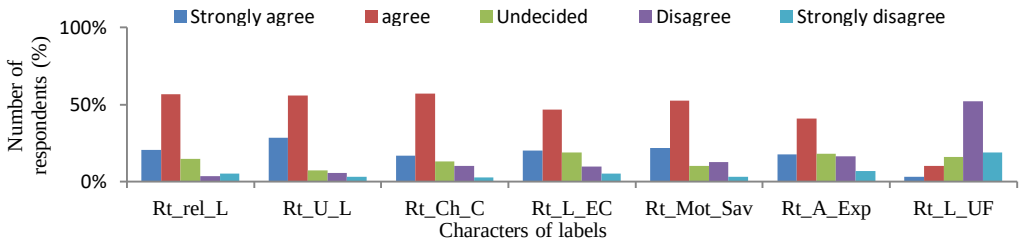

Figure 6.7: Rating the characteristics of energy labels [105]

Source: Author's analysis

Respondents majorly (56 per cent) agreed to most of the characteristics i.e. labels are reliable (56 per cent), they are easy to understand (56 per cent), they provide cheap and easy information (57 per cent), they motivates to save electricity (53 per cent) etc. the respondents also agree that labels make the appliance expensive (41 per cent) i.e. appliance which have these energy labels are expensive. Most of the respondents (52 per cent) disagreed with the fact that labels are not useful.

[105] (Rt_rel_L: labels are reliable, Rt_U_L: labels are easy to understand; Rt_ch_C: labels provide easy and cheap information about energy consumption; Rt_L_EC: labels promote environment conscious behaviour; Rt_Mot_sav: labels motivates to save energy; Rt_A_Exp: labels makes appliance expensie; Rt_L_UF: labels are not useful)

Identifying need of financial incentives of EEA

Respondents were further asked whether they require any financial incentive for adopting energy efficient appliances in their households. Most of respondents (74.9 per cent) out of 159 respondents raised the need of financial incentive in terms of subsidy, discounts and rebates. 60 per cent of total respondents who noted the need of financial assistance have their average monthly income below INR 60,000 and 57 per cent of them are male while 43 per cent of them are female respondents. It is evident from the result that respondents find high initial price of energy efficient appliance as a deterrent to adoption of high efficient appliance in their households and providing financial assistance in the form of subsidy, rebate, discounts or even provision of equated monthly installments (EMIs) to consumers may nudge consumers to buy more efficient appliance by removing the economic barriers.

6.5 Summary

This chapter analyses the understanding of energy efficiency among the respondents. The results of this open ended questions indicates that understanding of 'energy efficiency' is not woven around the sustainability and economic gains rather they are find it as something which reduces the energy consumption. However, they fail to highlight that goal of reducing energy consumption is shaped by certain concern and values attached to goal. These goals are implicitly motivated towards to reducing environmental degradation and reducing the economic burden however, they fail to explicitly mention about the same. It is also interesting to note that understanding of energy efficiency is found to be related to technology which can reduce the energy demand. Technologies are affected by users, regulators and others (Misa et al, 2003, p.52). Therefore, it is important to know technology and its relation with society.

When respondents were asked about energy efficient technology, it was noted that young, graduate, post graduate, government employees and high income graduates know about the technology. This explains that knowledge about energy efficient technology is present as public good but only that young, graduate, post graduate, government employees and high income graduates are able understand it. Whereas when asked about soft information i.e. energy labels, youth, female, and post graduate had higher probability of recognizing bigger energy label. Whereas in case of smaller labels, only highly qualified respondents have higher probability of

recognizing it. In case of both the labels i.e. smaller and bigger, only young respondents have higher odds of recognizing over 'none'. Studies have already mentioned in the literature review that various internal factors shape the understanding of information. Overall the present study, can conclude that young respondents know more about labels and energy efficient technology and this can be due to various factors i.e. education and exposure to information. Therefore, more information is sought which can reach to individuals for all socio-economic strata.

Chapter 7

Energy Labels and Adoption of Household Technology: An empirical Analysis

7.1 Introduction

Energy labels provide information about the credence characteristic i.e. energy consumption and energy efficiency of an energy consuming technology. Energy consumption is not visible to consumers and thus cannot be verified by the consumers. Similarly, energy efficiency of the product cannot be measured by consumers merely by seeing the product. Although electricity bills or meters can indicate the level of electricity consumption of the household, but fails to point out towards the electricity consumption of each electricity consuming technology. The only way to know about energy efficiency of a technology is to read the energy labels available on it. The information presented on the labels is a form of standardized information which is based on the standard/ test procedure followed by the particular product category and provides various information i.e. energy efficiency, energy consumption and size/volume of the product to the consumer. This chapter tries to examine the role of this information on the energy labels in decision making of consumers. Section 7.2 elucidates the data used for subsequent analysis. Section 7.3 discusses the results of Stated Choice Experiment 1. Section 7.4 discusses the results of Stated Choice Experiment 2. Section 7.5 discusses the results of Stated Choice Experiment 3 followed by conclusion (section 7.6)

7.2 Understanding energy labels: An analysis

To understand the role of information provided by energy labels in decision making of adopting or not adopting an energy efficient product, various stated choice experiments were formulated. The respondents were asked to choose one option out of the given options. In behavioral science,

choice experiments are conducted which include sample of choice sets selected from universal set of all possible choice sets that satisfy certain statistical properties (i.e. identification and precision). Stated choice data is generated after systematic and planned design process in which attributes and their levels are pre-defined without measurement of error and varied to generate preference or choice alternative (Louviere, 2003, p.83). It involves choice responses from same economic agents but evoked in hypothetical markets. It controls relationships between attributes and can also include existing and/ or proposed choice alternatives and seems reliable when respondents understand and respond to task and thus useful in forecasting change in behavior (Louviere, 2003, p.23). Stated choice methods are used to determine the individual's preferences for alternatives expressed in a survey context (Louviere et al., 2010).

For this study, respondents were asked to give their preference for 3 stated choice experiments. Before starting the experiments, respondents were informed that they have to buy a refrigerator for their home based on the information given on the energy labels. For stated choice experiment, refrigerators were chosen because they are very common appliance which people know and use. Its usage has increased in last few years in urban and rural areas, and also because it consumes high share of electricity after Air conditioners in an average household and is also available in different price ranges. Respondents were informed that all refrigerators are available in color and finish that they want and if any consumer did not wanted to choose any of the two given options, they were free to choose "none of the above" option. 307 respondents answered the questionnaire but only 159 samples were chosen for final analysis. Most of the respondents (89 per cent) belonged to urban areas. 56.06 per cent are males and 43.40 per cent are females. In terms of age, most of respondents (89 per cent) are below age 35 per cent and 52.21 per cent of respondents earns below INR 60, 000 and 53.35 per cent of respondents are living in their own houses. The following section will discuss more about the stated choice experiments and its analysis.

7.3 Stated Choice Experiment 1

This section is dedicated to analyse how consumers respond to the information presented on the energy labels. For this, labels of direct cool refrigerators of same capacity i.e. 185 lts and storage capacity of 170 lts was chosen. The experiment tried to understand which refrigerator will be chosen by consumer when they are provided with different information in terms of energy

efficiency and energy consumption. It also looks at what kind of consumers prefer more efficient refrigerator. The information about the attributes used in the choice experiment is given in Table 7.1.

Attributes	Refrigerator A	Refrigerator B
Energy Star	*****	***
Price (Rs.)	17,520	14,250
Electricity consumption (Units)	130	195
Size (gross Vol. in lts)	185	185
Brand	A	A
Label period	1 Jan 2017 to 30 Dec 2018	1 Jan 2017 to 30 Dec 2018

Table 7.1: Attributes for the label selected for stated choice experiment 1

Source: Author's analysis

For the given stated choice experiment, majority of respondents (88 per cent) out of 159 respondents chose 'refrigerator A' over 'B'. And 3 respondents didn't choose any of the given option. Out of the total respondents who opted for option A, 42.8 per cent of them are female and 57.2 per cent are male. When respondents asked about the reason of such choice i.e. 'refrigerator A', gave written explanation (approx.10-25 words) for the same. The major reasons for choosing option A over B was that it was found to be more efficient, economic, environment friendly, and less energy consuming. Narratives given by few respondents are as follows:

> **Respondent ID. 19 "***because it consumes less amount of units annually…Thus will reduce my power bill as well as it is less harmful for the environment".*

> **Respondent ID. 69 "***I would prefer refrigerator A because it's energy consumption is less although cost is bit high but energy consumption matters more so that electricity bills can be controlled too in future".*

> **Respondent ID. 139 "***The net price of product a after using for 4 to 5 years will be significantly less than actual price of product b. Because product a will consume less power"*

The arguments given by respondents around the energy labels indicate that most of the respondents, who chose 'refrigerator A', gave importance to the star rating and electricity consumption as well. In real buying situations, where the potential buyers are overloaded with different information about different characteristics usually give less importance to star rating (Newell and Siikamaki, 2014) but if the emphasis about star rating and electricity consumption is

increased by any external factor e.g. shopkeepers, helpers, websites (in case of online purchase), then respondents tends to opt for more efficient technology, if their economic conditions allow. In this case, 45.1 per cent of total respondents, who chose 'refrigerator A' have their average monthly income of more than INR 60,000 and respondents from age group of 18-35 years favored the efficiency over price.

The respondents who chose 'refrigerator B' over 'A' (n= 17) put more emphasis on the price of the refrigerator. Most of them found 'refrigerator A' as expensive. The respondents, who chose option B over A, majorly (n=10) have their average monthly income below INR 60,000 and live in their own houses (n=10). Various arguments by respondents gave a hint of distrust among the consumers but economic aspect emerges out to be stronger for not adopting a more efficient product. Few of the arguments are given below:

> **Respondent ID .94**: "*Labeling doesn't give us fair indicator whether the cost of usage of appliance is low or high. So as a customer I choose moderately fair labeled 3 and minimize my cost*".
>
> **Respondent ID .163**: "*Image b has 3 stars. Which are ok. And the price is cheaper*".
>
> **Respondent ID .191**: "*Economic feasibility. Higher price for option A may be equal to the money saved if buy option B. After a certain years, both A and B may have performance reduction so the energy efficiency after some years, say 5 years may not be the same as they offer. This is the personal opinion*".
>
> **Respondent ID .240**: "*B is cheaper and is a slightly energy efficient as well".*

7.3.1 Analyzing results of experiment 1

This experiment tries to understand which refrigerator consumer will choose when they are provided with different information in terms of energy efficiency and energy consumption. Following is the equation used in the logistic regression:

$$\text{Logit } Y_A = \alpha + \beta_1 \text{rural} + \beta_2 \text{highincome} + \beta_3 \text{youth} + \beta_4 \text{female} + \beta_5 \text{graduate} + \beta_6 \text{ postgraduate} + \beta_7 \text{govt\_emp} + \beta_8 \text{self\_emp} + \beta_9 \text{ownhouse} + \beta_{10} \text{bighh} + \beta_{11} \text{highunits} + \beta_{12} \text{youth\_hinc} + \beta_{13} \text{fem\_hinc} + \beta_{14} \text{fem\_postgrad} + \beta_{15} \text{hinc\_grad} + u_i$$

Where Y_A= Probability of choosing 'refrigerator A' over 'Refrigerator B and None'. For the analysis 'refrigerator B and None' are comparative groups or Y_A= 0 otherwise.

β=coefficient vector which is constant across the sample

u =random vector which captures unobservable factors that influence the choice of individuals

Odds ratio: $Y_A/1-Y_A$= (probability of choosing refrigerator A over Refrigerator B or None)/(probability of not choosing refrigerator A over Refrigerator B or None)

$$Logit(Y_a)= \ln(Y_a/1-Y_a)$$

Overall model does not fit very well in this case, but results of logistic regression indicates that odds of choosing 'refrigerator A' over 'refrigerator B and none' are significant in case of youth, graduate and post graduate. It is clear that explanatory variables explain the decision of choosing the efficient alternative i.e. 'image A' over 'image B and None'. It is important to note that when respondents were asked about 'whether they know about energy efficient appliance', explanatory variables like youth, graduate, post graduate, government employee, female with post graduation and high income graduate showed significant results for knowing the energy efficient appliances. But, when it comes to decision making only respondents who are graduates, post graduates and youth were able to make a decision of choosing the most efficient appliance i.e. 5 starred. It indicates that respondents know about the efficient technology but they are not able to take a decision out of the given information. The result of logistic regression is given in table 7.2.

EE	Odds Ratio	Std. Err.	Z	P>|z|
Rural	.874	.610	-0.19	0.847
Highincome	5.090863	7.771951	1.07	0.286
Youth	5.313646	5.20941	1.70	**0.088**
Female	1.694592	1.52636	0.59	0.558
Graduate	8.303976	7.426109	2.37	**0.018**
Postgraduate	7.089043	6.070743	2.29	**0.022**
gov_emp	1.525796	1.016922	0.63	0.526
self_emp	2.223632	2.408846	0.74	0.461
Ownhouse	.5640019	.2979078	-1.08	0.278
Bighh	1.009726	.6799959	0.01	0.989
Highunits	3.76449	3.269127	1.53	0.127
Youth_hinc	.2597239	.3981663	-0.88	0.37
Fem_hinc	1.553423	1.623417	0.42	0.673
Fem_pg	.3115771	.3238686	-1.12	0.262
Hinc_grad	.6522342	.7814006	-0.36	0.721
_cons	.1896801	.2299025	-1.37	0.170

Number of obs = 159
LR chi2(15) = 18.22
Prob> chi2 = 0.2512
Pseudo R2 =1286

Table 7.2: Result of logit regression for stated choice experiment 1

Source: Author's analysis

The result of the experiment indicates that the odds of taking a decision of buying 'refrigerator A' over other alternatives in case of graduates and post graduates are 8.3 and 7.08 times higher. Examining marginal effect after logistic regression indicates that probabilities of choosing 'refrigerator A' over 'refrigerator B and None' increase by 18 points for graduates and 11points for high consumption units (Table 6 in Annexure II). Therefore, it can be concluded that in the given sample, graduates, post graduates and youths are have more understanding about energy efficiency and their preference towards buying a efficient refrigerator is higher. Although, it is also worth noting that chances of buying a most efficient refrigerator increases with increase in consumption level.

7.4 Stated Choice Experiment 2

The second experiment tried to look at the decision making of respondents based on the provided information on the labels. In this, respondents were asked to choose a refrigerator based on the information on labels provided to them. For this experiment, labels of direct cool refrigerators of same energy efficiency i.e. 4 star but different price and capacity was chosen. This experiment tries to understand which refrigerator consumers will choose when they are provided with different information in terms of price and size only (Table 7.3). Whether the consumer will choose refrigerator A which is as efficient as refrigerator B but bigger in size? Moreover, this will also indicate whether consumer focuses more on other information i.e. price of refrigerator, if energy consumption is nearly same.

Attributes	Refrigerator A	Refrigerator B
Energy Star	****	****
Price	21,499	14,250
Electricity consumption (Units)	167	164
Size (gross Vol. in lts)	215	190
Brand	A	A

Table 7.3: Attributes for the label selected for stated choice experiment 2

Source: Author's analysis

In this choice experiment, three options were given to respondents to choose from. It included 'Refrigerator A', 'refrigerator 'B' and 'None of them'. This experiment tries to understand the decision of consumers when they face situation in which star rating is same and size and price is different. For this experiment, out of total 159 valid responses, 68.6 per cent of respondents

chose option ‘refrigerator B’ over ‘Refrigerator A’. 5.7 per cent of respondents didn’t choose any of the given option and 25.7 per cent of respondents chose ‘Refrigerator A’.

The respondents who chose ‘refrigerator A’ are found to be critically analyzing the information and majority of them were found to be willing to spend more for larger size of product, given its efficiency is similar to smaller one. Most of respondents (56 per cent) who opted for ‘refrigerator A’ have their average monthly income below INR 60,000. This indicates that when consumers find more efficient and larger refrigerator, they are willing to spend more as they find it to be energy saving and moneysaving on long run. As mentioned by a respondent ID.65: “*Although pricier, I'd save money on electricity”.* Other respondent also mentioned about their preference for larger refrigerator.

> **Respondent ID. 27:** “*I would choose refrigerator A. As there is no huge difference in electricity consumption units between both refrigerators, so we can prefer volume factor. Since volumes for refrigerator A is more, I would choose that”.*

Respondents who are choosing ‘refrigerator B’ were found to be focusing on price of refrigerator. Text analysis of the respondent’s explanations was conducted to note reasons behind their preferences. The respondent’s description was coded under various headings i.e. economic, size, energy consumption reduction, energy efficiency etc. Most of the respondents were focusing around price of product, energy consumption level and energy efficiency of the product. The trend of the analysis can be observed in following figure:

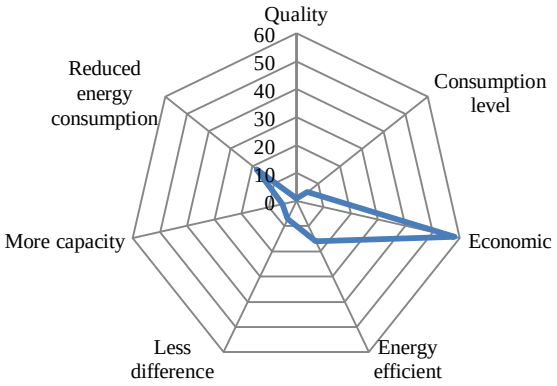

Figure 7.1: Reasons for choosing ‘Refrigerator B’

Source: author's analysis

7.4.1 Analyzing results of experiment 2

This experiment tries to understand which refrigerator consumer will choose when they are provided with different information in terms of size and price. Equation for Logistic regression for this stated choice experiment 2 is given below:

$$\text{Logit } Y_B = \alpha + \beta_1 \text{rural} + \beta_2 \text{highincome} + \beta_3 \text{youth} + \beta_4 \text{female} + \beta_5 \text{graduate} + \beta_6 \text{ postgraduate} + \beta_7 \text{govt\_emp} + \beta_8 \text{self\_emp} + \beta_9 \text{ownhouse} + \beta_{10} \text{bighh} + \beta_{11} \text{highunits} + \beta_{12} \text{youth\_hinc} + \beta_{13} \text{fem\_hinc} + \beta_{14} \text{fem\_postgrad} + \beta_{15} \text{hinc\_grad} + u_i$$

Where Y_B= Probability of choosing refrigerator B over Refrigerator A or None. For the analysis 'refrigerator A' or 'None' are comparative groups or Y_B= 0 otherwise.

β=coefficient vector which is constant across the sample

u=random vector which captures unobservable factors that influence the choice of individuals

Odds ratio: $Y_B/1\text{-}Y_B$= (probability of choosing refrigerator B over Refrigerator A or None)/(probability of not choosing refrigerator B over Refrigerator A or None)

$$\text{Logit}(Y_B) = \ln(Y_B/1\text{-}Y_B)$$

The result of logistic regression showed the odds of choosing 'refrigerator B' over 'refrigerator A and None' is significant among the respondents live in their own house and female post graduate. Although, overall model does not fit very well but odds for all the explanatory variables was found to be positive for choosing 'refrigerator B'. The results indicate that respondents who live in their own house and female post graduates were able to significantly understand and differentiate the information given on the labels and choose 'refrigerator B' over 'refrigerator A and None', even though size of 'refrigerator B' was comparatively smaller. All the coefficients are showing positive relation towards choosing 'refrigerator B'. This indicates that not only the information about energy efficiency rather, other information i.e. price and size also matters to the respondents (Table 7.4).

EE	Odds Ratio	Std. Err.	Z	P>|z|
Rural	1.699638	1.048062	0.86	0.390
Highincome	.1914858	.2285102	-1.39	0.166
Youth	.6139605	.580588	-0.52	0.606
Female	1.537724	1.04204	0.63	0.525
Graduate	1.290939	.9659762	0.34	0.733
Postgraduate	2.252957	1.715363	1.07	0.286
gov_emp	1.693392	.8411216	1.06	0.289
self_emp	.9882047	.6587562	-0.02	0.986
Ownhouse	.4517411	.1876846	-1.91	**0.056**
Bighh	.8693883	.4428428	-0.27	0.783
Highunits	1.331392	.6846878	0.56	0.578
Youth_hinc	4.180747	5.075526	1.18	0.239
Fem_hinc	2.335912	1.787483	1.11	0.268
Fem_pg	.2701993	.2144182	-1.65	**0.099**
Hinc_grad	1.644866	1.393968	0.59	0.557
_cons	2.900189	3.240838	0.95	0.341

Table 7.4: Result of logit regression for stated choice experiment 2

Source: Author' analysis

Number of obs = 159
LR chi2(15) = 11.45
Prob> chi2 = 0.7203
Pseudo R2 =.0578
Log likelihood= -93.274016

However, examining the marginal effect indicates that probabilities of choosing 'refrigerator A and None' over 'refrigerator B' (refer Table 7 in Annexure II) is 18 points higher amongst the respondents who are live in their own house. The result again indicates the females who are post graduates have higher probabilities of analyzing information on the labels and choosing 'refrigerator B' over 'refrigerator A and None'. Thus, it is important to note that information on price also shapes their decision making which is also supported by their justification of choosing a particular option.

7.5 Stated Choice Experiment 3

The third experiment tries to look at the decision making of respondents based on the provided information in tabular format. In this, respondents were asked to choose a refrigerator based on the information on labels provided to them. In this, 3 alternatives with different energy star ratings, price and electricity consumption were provided to consumers to choose from. This experiment tries to understand, whether consumer will give more preference to more efficient but expensive refrigerator of same size or not. Detailed information about the attributes used in Experiment 3 is given in Table 7.5.

Attributes	Refrigerator 1	Refrigerator 2	Refrigerator 3
Energy Star	*	***	*****
Price	7,000	10,490	15,000
Electricity consumption (Units)	335	212	122
Size (gross Vol. in lts)	190	190	190
Brand	A	B	C

Table 7.5: Attributes for the label selected for experiment 3

Source: Author's analysis

The 77.12 per cent of respondents chose 'refrigerator 3' over 'refrigerator 1' and 'refrigerator 2'. And 3.27 per cent of respondents didn't choose any of the given option. 54 female and 69 male respondents chose 'refrigerator 3' over 'refrigerator 1' and 'refrigerator 2'. From the given respondents who choose 'refrigerator 3' over 'refrigerator 1' and 'refrigerator 2', 91 per cent of them belong to age group of 18 years to 35 years and 52.8 per cent of them have their monthly household income below INR 60,000. Most of them (67.4 per cent) also belonged to the highly educated population (graduation and post graduation). When asked about the reason of choosing 'refrigerator 3', respondents shared their justifications for choosing such option. Few justifications given by respondents are:

> **Respondent Id. 145**: *Because of some better features like less energy consumption which is more important from future point of view*

> **Respondent Id. 45**:*it will help me in long run..both by cutting down my power bill plus less harming the environmen*t.

The arguments given by consumers were coded under different labels i.e. energy efficiency, energy ratings, energy saving and economic. After content analysis, it was noted that those who chose refrigerator 3 over other option were mainly concerned about energy efficiency and saving money for long term (figure 7.2) and improving energy efficiency derives their decision making.

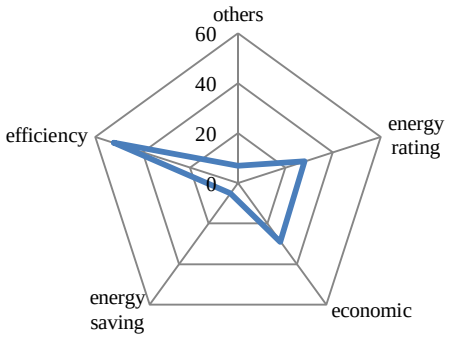

Figure 7.2: Reasons for choosing 'Refrigerator 3'

Source: author's analysis

7.5.1 Analyzing results of experiment 3

Multinomial logistic regression was run for this experiment as the respondents gave response as 'refrigerator 1', 'refrigerator 2', 'refrigerator 3' and 'none of the above'. The equation of the model is given as:

$$\text{Logit } Y_1 = \alpha + \beta_1 \text{rural} + \beta_2 \text{highincome} + \beta_3 \text{youth} + \beta_4 \text{female} + \beta_5 \text{graduate} + \beta_6 \text{ postgraduate} + \beta_7 \text{govt\_emp} + \beta_8 \text{self\_emp} + \beta_9 \text{ownhouse} + \beta_{10} \text{bighh} + \beta_{11} \text{highunits} + \beta_{12} \text{youth\_hinc} + \beta_{13} \text{fem\_hinc} + \beta_{14} \text{fem\_postgrad} + \beta_{15} \text{hinc\_grad} + u_i$$

Where Y_1= Probability of choosing refrigerator 1 over Refrigerator 2 or 3. For the analysis refrigerator 1 or 2 are comparative groups or Y_1= 0 otherwise.

β=coefficient vector which is constant across the sample

u =random vector which captures unobservable factors that influence the choice of individuals. Where,

Odds ratio = $Y_1/1\text{-}Y_1$= (probability of choosing refrigerator 1 over Refrigerator 2 or 3)/(probability of not choosing refrigerator 3 over Refrigerator 1 or 2)

$$\text{Logit}(Y_1) = \ln(Y_1/1\text{-}Y_1)$$

The results from multinomial logistic regression (Table 7.6) indicates that probability of choosing 'Refrigerator 3' over 'Refrigerator 2' and 'Refrigerator 1' is positive among high income, youth, graduate, government employees, big households, household consuming high electricity units, female post graduate and high income graduate. Whereas probability of choosing 'Refrigerator 2' over 'Refrigerator 3' and 'Refrigerator 1' is positive among youth, graduates and government employees, big households, high energy consumption units, high income female (fem_hinc), female post graduate (fem_postgrad), and high income graduate (hinc_grad). Overall the model does not fit very well but it was found that among rural respondents, coefficient was found to be statistically significant towards 'Refrigerator 1' (most inefficient but lowest cost) rather than 'Refrigerator 3'. The results of marginal effects are given in table 7 and 8 of annexure II.

Image	**Coef.**	**Std. Err.**	**Z**	**P>|z|**	**Coef.**	**Std. Err.**	**Z**	**P>|z|**
None	Base outcome							
	Refrigerator 2				**Refrigerator 3**			
Rural	-1.371	1.151	-1.19	0.233	-1.958	1.012	-1.93	0.053
Highincome	-.759	2.395	-0.32	0.751	1.432	2.005	0.71	0.475
Youth	1.278	1.511	0.85	0.398	1.986	1.329	1.49	0.135
Female	-2.411	1.670	-1.44	0.149	-.9382	1.465	-0.64	0.522
Graduate	.3929	1.557	0.25	0.801	.6534	1.395	0.47	0.640
Postgraduate	-1.697	1.580	-1.07	0.283	-1.367	1.443	-0.95	0.343
gov_emp	16.398	1549.358	0.01	0.992	16.237	1549.3	0.01	0.992
self_emp	-2.248	1.454388	-1.55	0.122	-1.324	1.008	-1.31	0.189
Ownhouse	-.1476	.898	-0.16	0.870	-.4063	.7886	-0.52	0.606
Bighh	.9298	1.404	0.66	0.508	1.557	1.267	1.23	0.219
Highunits	1.654	1.344	1.23	0.219	1.544	1.247	1.24	0.216
Youth_hinc	-.7512	2.403	-0.31	0.755	-1.203	2.076	-0.58	0.562
Fem_hinc	.9457	1.942	0.49	0.626	-1.786	1.670	-1.07	0.285
Fem_postgra	2.859	1.982	1.44	0.149	2.559	1.779	1.44	0.150
Hinc_grad	16.207	1997.9	0.01	0.994	16.064	1997.9	0.01	0.994
_cons	.9910	2.0121	0.49	0.622	1.234	1.766	0.70	0.484

Table 7.6: multinomial regression for stated choice experiment 3

Source: Author's analysis

The result of multinomial regression indicate that willingness to pay higher for a highly efficient appliance was found to positive among high income, youth, graduate, government employees, big households, household consuming high electricity units, female post graduate and high income graduate. Although none of the above variables is showing statistical significance in this experiment, but the results provide an indication towards the variables which may have strong relation, if the number of observation increases considerably.

7.6 Summary

Energy labels are helpful in influencing the potential buyers to opt for efficient technology by providing information about energy consumption and efficiency as providing specific information helps consumers in better decision making (Davis and Metcalf, 2014; Allcott and Taubinsky, 2015). This chapter examined the role of information in decision making using stated choice experiments. Online stated choice experiment was chosen for the study because it provides control experiment which is similar to real time situation. It is relevant to note how respondents assimilate the information and use it especially when they are trying to make online purchases. The experiments noted that respondents do look at information on energy labels, analyze it and then take the decision but this process is affected by various internal and external factors. It was noted that when easy and clear information is present to respondents, a decision making process becomes easy and they opt for energy efficient technology readily (experiment 1) whereas when respondents are provided with more detailed information and when they have to examine the information more minutely, respondents tends to make decision which satisfy their personal utility and also their reflects their underlying concerns (money or environment).

Chapter 8
Conclusion

Energy efficient technology is used to achieve energy efficiency in the system and consumes less units of energy to produce the same output as compared to their inefficient counterparts. Like another technology, they are embodiment of human desires and ambition and offers solution to complex problems (increasing energy demand and pollution in this case) by interacting with society and culture involving mutual influence, substantial uncertainty and acceptance (Misa et al., 2003, p.3). Efficient technology is affected by users, regulators and other institutions and also shapes the present social context in which they interact and shapes the future choices. Despite the presence of various energy efficient technologies to provide better services, people fail to invest in it, even when investment is economically justified (Jaffe and Stavins, 1994). Various reasons have been identified to explain this failure to invest in efficient technology and informational failure is one of the other failures. Informational failures include absence of cost effective, easy to understand and trust worthy information (Golove and Eto, 1996) to users which allows rational decision making. Policy makers have reiterated the importance of informational programs i.e. advertisements and standards and labeling programs in narrowing the information gap between producers and end-users.

Various studies have examined the role of energy labels in shaping decision making but most of research is restricted to developed countries. Due to presence of socio-economic and cultural differences between developed and developing countries, it becomes important to examine the role of energy labels in shaping decision making in developing countries as well. This is a one of its kind of study as it tries to understand how end-users conceptualize the energy efficiency and how they are reacting to information on energy labels in Indian Households. This study acknowledges that standards and labeling programs are established on the idea that energy users do not understand science behind energy efficiency and they require technical competency to understand it. And because of this lack of understanding, government along with other experts generate the information in the form of standards which allow certain type of technology to exist in the market as users may fail to observe the importance of energy efficiency and may not take rational decision. Therefore to nudge users to opt for energy efficient technology, information is provided to them in the form of energy labels.

Energy labels are not just graphics or information about a technology rather it symbolizes what society is seeking and getting. It inculcates practices and shapes the behavior towards energy consumption and conservation. They shape the way we see a technology and use it and acts as a boundary object for the experts for generating the information and also for public who are at receiving end of the information. Labels allow firms to credibly disclose the financial value of energy efficiency to consumers and helps consumers to make rational decisions (Allcott and Mullainathan, 2010). The information on energy labels are based on the standard which is acceptable to all the participants in given context, time and space. The standard followed for particular product makes a label unique and with the change in standard, the information depicted on the label also varies. Energy labels are quite helpful in influencing the decision making of the users, only if they see the label (attention), observe it (assimilation), understand it (understanding) and finally use the information in decision making keeping contextual factors in consideration (Claudy and O'Driscoll, 2008). Although it is evident that information affects those individuals more than others who are already sensitive and involved in solving some concerns (Thøgersen, Haugaard, and Olesen, 2010).

There is little evidence to know how labels shapes the decision making (Waechter et al., 2015) and what kind of information affects their decision making process. However, studies have suggested that simple information on economic value of energy saved is most important guiding factor for adopting energy efficient technology (Newell and Siikamaki, 2013) and reducing energy consumption (Deutsch, 2010) but this information is not possible to be produced on regular basis due spatio-temporal change in energy prices. On the other hand, studies indicate that preference for energy efficient appliances actually decrease when information on energy consumption is presented in annual operating cost than in physical unit watts (Allcott and Knittel, 2018; Stadelmann and Schbert, 2018). Moreover, people are also failing to conceptualize energy consumption figures of household appliances into required contexts (Heinzle, 2012). It is noted that energy labels triggers attention towards energy information but its effect on consumers' actual product choices is low (Waechter et al., 2015) but better when compared to 'no energy labels' scenario (Stadelmann and Schbert, 2018) especially when information is provided in pictorial form (Peters and Wedel, 2004).

This study tries to examine the public understanding of energy efficiency, energy efficient technology and energy labels using stated choice (SC) experiments among Indian Households.

SC experiments have been used in various studies (Newell and Siikamaki, 2013; Davis and Metcalf, 2014; Waechter, 2015; Shen and Saijo, 2009; Mills et al., 2009; mills and schleich, 2010; Allcott and Taubinsky, 2015) to examine the role of energy labels in adoption process of energy efficient technologies in various developed countries. The study used qualitative and quantitative analysis to analyze the understanding of energy efficiency among users and role of information in (non) adoption of energy efficient appliance in Indian households.

The study noted that public (respondents) understanding of energy efficiency revolves around their understanding of related concerns and issues around energy use. For them energy efficiency allows to get more services for the same energy, helps in saving energy and does not allow wastage of energy. Although it is interesting to note that when public relates energy efficiency to using less energy, their understanding is shaped by various underlying practices (wastage), concerns (environmental) and goals (reputational, altruistic, hedonic or economic). Therefore, advertisements and labeling programs should present information in such as way that target to reduce wasteful practices, caters to concerns and fulfill positive goals of the users.

The study tried to know about the awareness level of energy efficient technology and energy labels and analysed the results using logit and multi logit regression models. It was found that young, highly educated (graduate and post graduate) and government employees know about energy efficient appliances. However, it was also highlighted that female post graduate (fem_grad), high income graduate (hinc_grad) and youth with high income (you_hinc) have more probability of knowing about energy efficient technology when compared to other explanatory variables. The findings indicate that respondents who are young, highly educated (graduate and post graduate) and government employees have more awareness for EET compared to old, less educated and other employees. Therefore, it is proposed that information about energy efficient technology through various means should to those who are less educated and working in non-governmental sector. For other variables results were insignificant and this can due to less number of respondents used in analsyis.

Regarding the awareness about energy labels, respondent were asked to identify various energy labels and approximately half of respondents were able to identify both energy labels (bigger and smaller). It was found that respondents who are young, belong to high income category, highly educated (graduate and post graduate) and households using high units of electricity have higher

chances of knowing about the energy labels. Only young respondents showed statistically significant positive relations for identifying the both the energy labels.

When it came to decision making using the information from two energy labels that have different energy efficiency (experiment 1), only respondents who are graduates, post graduates and young were able to make a decision of choosing the most efficient appliance i.e. 5 starred. It indicates that most of the respondents know about the efficient technology but graduates, post graduates and young respondents are able take a decision out of the given information. In the Experiment 2, when respondents had to choose a refrigerator from two option of same energy efficiency and different sizes, they showed that odds of choosing 'refrigerator B' over 'refrigerator A and None' is significant among the respondents live in their own house and female post graduate. The results indicate that respondents who live in their own house and female post graduates were able to significantly understand and differentiate the information given on the labels and choose 'refrigerator B' over 'refrigerator A and None', even though size of 'refrigerator B' was comparatively smaller.

In the experiment 3, most of respondents (77 per cent) chose highly efficient but expensive refrigerator but the results from multinomial logistic regression indicates that probability of choosing 'Refrigerator 3' over 'Refrigerator 2' and 'Refrigerator 1' is positive among high income, youth, graduate, government employees, big households, household consuming high electricity units, female post graduate and high income graduate.

The results from these stated choice experiments cannot be generalized for all the population because of sample size given in the analyses is small and does not represent whole population, but it does give indication that energy labels play an important role only if it well understood by the users. Findings indicate that young, female, highly educated, high income respondents are more aware, know about energy efficient technology, understand energy labels and also choose efficient technologies during decision making. Therefore, it will be relevant to disseminate more energy efficiency information to old, less educated and males. Whereas for less income groups provision of financial incentives should be readily available to them to allow adoption of efficient appliances. As this study also identifies that most of respondents (74.9 per cent) raised the need of financial incentive in terms of subsidy, discounts and rebates. 60 per cent of total

respondents who noted the need of financial assistance have their average monthly income below INR 60,000.

It is evident from the results of the study that respondents want to reduce their energy consumption in their households, and with required information and adoption of energy efficient technology they can achieve the same. Therefore, more responsibility lies in the hand appliance manufacturers and advertisers to share more about energy efficiency aspect during the advertisements. So that public from every socio-economic can capture the idea of energy efficiency because, decision making solely does not depend upon the energy labels. Other factors like references from family members, relatives, shopkeepers and social media also play an important role in technology adoption. Therefore, on-site information provision can also help consumers.

This study has its own flaws due to human, time and economic constraints but tries to capture the public understanding of energy efficiency, energy efficient technology and energy standards and labels in an effective manner. It opens an arena of other research questions i.e. how consumers of different socio-economic understands the information on energy labels, how energy standards and labels changes the behavior of consumers towards energy consumption, how they shape the practices of energy consumption and energy conservation, how informational policies and programs can cater to different population, how these energy labels help users to fulfill their underlying goals (if they do), how manufactures and government institutions can build trust among consumers, how this gap of expert and public can be reduced and how public participation in energy policy making can be ensured.

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Annexure 1

Table 2. 1: Energy sources (2011-12) with 101662 observations

Items	Consuming households (%)	Rural consuming households (%)	Urban consuming households (%)	Average value per person (Rs.) in all households	Average value per person (Rs.) in consuming households
MPCE		**1278.4**	**2399.2**	**1627.13**	**1627.13**
Coke	0	0.48	0.80	0.28	47.53
Firewood	65.07	84.03	23.37	39.91	57.64
Electricity	80.99	74.12	96.11	44.29	55.39
Dung cake	30.58	41.25	7.12	9.42	26.60
Kerosene PDS	61.83	76.22	30.18	5.97	9.06
Kerosene others	20.15	22.00	16.07	4.02	18.94
Match box	95.88	97.39	92.56	1.53	1.57
Coal	1.76	1.64	2.04	0.81	42.16
LPG	36.87	21.68	70.32	24.65	67.69
Charcoal	0.28	0.24	0.37	0.09	29.52
Candle	30.04	24.53	42.18	1.02	3.44
Gobar gas	0.19	0.26	0.05	0.11	49.02
Petrol	0.07	0.07	0.08	0.09	96.45
Diesel	0.16	0.18	0.11	0.05	25.29
Others	99.77	99.81	99.68	136.63	136.70

Sources: NSSO (2011-12)

Table 2.2 Appliance ownership (2011-12) with 101662 observations

Items	Rural (%)	Urban (%)	Mean total (%)
Radio	25.07	23.67	24.49
TV	62.16	81.76	70.25
VCR	16.88	30.64	22.56
Camera	4.73	14.20	8.64
CD_VCD	15.24	28.25	20.61
Musical Instrument	3.17	5.78	4.25
other Entertainment	0.43	0.30	0.38
Electric fan	68.27	88.40	76.58
AC	8.89	22.21	14.39
Inverter	5.42	13.68	8.83
Lantern	1.62	0.88	1.31
Sewing machine	18.77	25.31	21.47
Washing Machine	6.52	22.98	13.31
Refrigerator	19.12	44.75	29.70
water Purifier	7.91	20.32	13.03
Iron	1.75	2.28	1.97
Other appliances	1.67	1.79	1.72

Sources: NSSO (2011-12)

Search query for bibliometric analysis

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Table 2.4: 20 most productive institutes in terms of publication on energy efficiency

	Name of institution	Country	N	%
1.	Chinese Academy of Sciences	China	522	(2)
2.	Lawrence Berkeley National Laboratory	United states	454	1.8
3.	Ministry of Education China	China	450	1.8
4.	Tsinghua University	China	436	1.7
5.	Tianjin University	China	263	1
6.	Hong Kong Polytechnic University	Hong kong	254	1
7.	Xi'an Jiaotong University	China	201	0.8
8.	National University of Singapore	Singapore	199	0.7
9.	University of Chinese Academy of Sciences	China	187	0.7
10.	North China Electric Power University	China	186	0.7
11.	University of California, Berkeley	United states	186	0.7
12.	Danmarks Tekniske Universitet	Denmark	182	0.7
13.	Shanghai Jiao Tong University	China	181	0.7
14.	City University of Hong Kong	Hong Kong	164	0.6
15.	Politecnico di Milano	Italy	164	0.6
16.	Ontario Tech University	Canada	155	0.6
17.	University of Malaya	Malaysia	154	0.6
18.	University of Cambridge	United Kingdom	154	0.6
19.	Aalto University	Finland	154	0.6
20.	The Royal Institute of Technology KTH	Sweden	151	0.6

Source: Data retrieved from Scopus

Table 2.5: 20 most productive journals in the field of energy efficiency in India during 1983-2018

	Source	N	%
1.	Energy	3471	14
2.	Applied Energy	2708	11
3.	Energy Policy	2084	8
4.	Energy And Buildings	1952	8
5.	Journal Of Cleaner Production	907	4
6.	Energy Conversion And Management	847	3
7.	Applied Thermal Engineering	793	3
8.	Renewable And Sustainable Energy Reviews	785	3
9.	Energies	581	2
10.	Energy And Environmental Science	550	2
11.	Building And Environment	536	2
12.	Energy Efficiency	491	2
13.	Sustainability Switzerland	439	2
14.	Journal Of Power Sources	414	2
15.	ASHRAE Journal	391	2
16.	Energy Economics	373	1
17.	Energy Engineering Journal Of The Association Of Energy	269	1

	Engineering		
18.	Environmental Science And Technology	262	1
19.	International Journal Of Energy Research	237	1
20.	International Journal Of Applied Engineering Research	227	1

Source: Data retrieved from Scopus

Table 2.6: Top 10 institutes publishing in the field of energy efficiency in India during 1983-2018

Name of Institute	**N**	**%**
Indian Institute of Technology, Delhi (IIT-D)	98	8
Indian Institute of Technology, Madras (IIT-M)	59	5
Anna University, Tamil Nadu (AU)	57	5
Indian Institute of Technology, Bombay (IIT- B)	37	3
Indian Institute of Science, Bengaluru (IISc)	36	3
Jadavpur University, Kolkata (JU)	36	3
Indian Institute of Technology, Kharagpur (IIT-kh)	33	3
Vellore Institute of Technology, Tamil Nadu (VIT)	30	3
Indian Institute of Technology, Roorkee ((IIT-R)	24	2
Indira Gandhi Institute of Development Research, Mumbai (IGIDR)	23	2

Source: Data retrived from Scopus

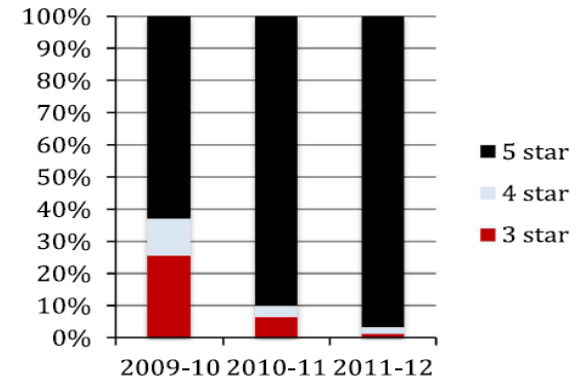
Table 2.7: Articles by source in the field of energy efficiency in India during 1983-2018

Name of Journals	**N**	**%**
Energy	174	15
International Journal Of Applied Engineering Research (IJAER)	164	14
Applied Energy	81	7
Renewable And Sustainable Energy Reviews (RSER)	61	5
Indian Journal Of Science And Technology (INDJST)	59	5
Energy Policy	53	4
Energy Conversion And Management	51	4
Applied Thermal Engineering	38	3
Energy And Buildings	35	3
Arpn Journal Of Engineering And Applied Sciences	32	3

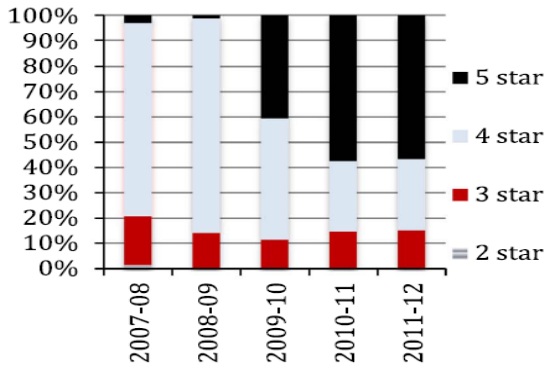
Source: Data retrived from Scopus

Figure 2.1: example of non-complaince of standard, advertised by nodal agency of energy efficiency in India

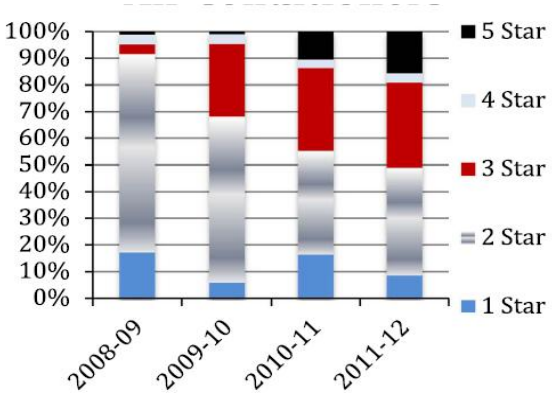
Source: BEE website



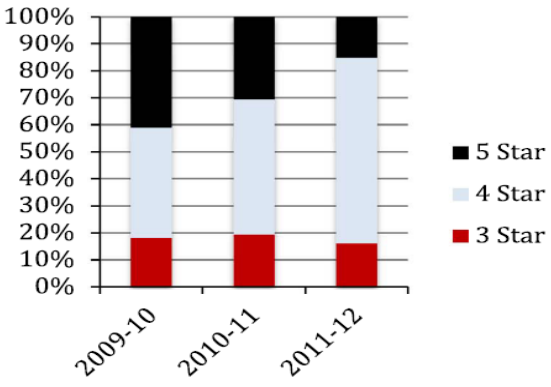
Electric fan



Refrigerators



Air conditioners



Television

Figure 2.2 Share of labeled appliances sold from 2007 to 2011 (Electric fan, refrigerature, Air conditioners, television)

Source: Parikh and Parikh (2016)

Questionnaire on "Public Understanding of Energy Efficient Household Technology in India"

Electricity related information

1. Do you know about your average electricity consumption?
   - Yes
   - No

2. how many Units of electricity your household consume monthly?

   - below 250 Units
   - 251-500 Units
   - 501-750 Units
   - and above

3 what is your average monthly bill?

   - Below 500
   - 501-1000
   - 1001-1500
   - 1501 and above
   - Fixed Tariff (how much)?
   - Don't remember

3. How you get to know about your electricity consumption (units consumed)?
   - Electricity bills
   - Meters
   - Smart meters
   - Electrician or any other expert
   - Other
   - App in the phone

4. Who makes the decision of buying an electrical appliance in your family?
   - Head of the family
   - Eldest earning male member
   - Eldest earning female member
   - Family members discuss among themselves
   - Children of the family
   - Others

5. Average time to make purchase decision of electrical appliances?
   - On-spot decision
   - Few days (10-15 days) before buying the appliance
   - One month average
   - Other

Information about energy efficiency

6. What do you understand by the term "Energy efficiency"?

7. Do you know about Energy Efficient Appliance?
   - Yes
   - No

8. If yes, how can you identify an Energy Efficient Appliance?

9. According to you, what are likely advantages of Energy Efficient Appliance (Energy efficient Appliance use less electricity to provide same service). Rate them from level of highly significance to least significance.

	Highly significant	Important	Moderate	low	Least significant
Reduces energy bills					
Reduces the co2 emissions					
Reduce the operating cost					

Reduces the energy demand					
Decrease pollution					
Reduce climate change					
Increase status of owner					

10. Rate the following practices which you think is important to follow to reduce your electricity consumption.

	Highly Important	Slightly Important	Important	least important	Not Important at all
Turn off light and appliance when not in use.					
Use Energy Efficient Appliance.					
Using less number of appliances.					
Doing major work during daytime.					

Understanding about standards and Labels

11. Which of the following images you have seen on your electrical appliances?
    a) Image a
    b) Image b
    c) both of them
    d) none of them

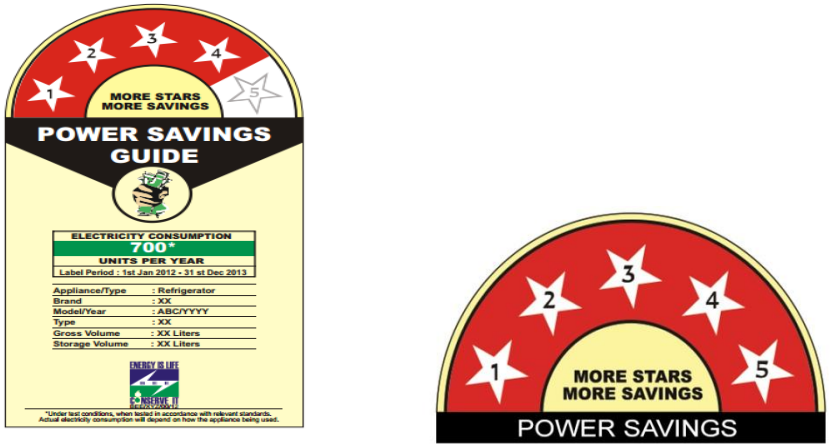


Image 1 (a and b)

12. What do you understand by such images?

13. Do you look for such image when buying an electrical appliance?
    a) Yes
    b) No
    c) Some times

14. Do you think such images provide good information about product and energy efficiency?
    a) Yes
    b) No

15. Do you own any energy efficient appliance?
    a) Yes
    b) No

16. What motivated you to buy an efficient appliance?
    a) To reduce energy bills
    b) To save money
    c) It is better technology
    d) It is right thing to do
    e) To save fossil fuel for future generation
    f) To reduce carbon footprints

g) You care for Environment
h) Others

17. Did you observed any reduction in your energy bills after using this efficient appliance
    a. Yes
    b. No

18. If No, why do you think your energy bills has not been reduced even after using an efficient appliance?
    - The appliance does not work properly
    - I use more that appliance for more number of hours.
    - Number of other appliance has increased in my household
    - Don't understand.
    - Other

19. Rate the following characteristics about energy Star labels (strongly agree to strongly disagree)

Characters	Strongly agree	agree	Undecided	Disagree	Strongly disagree
Labels are reliable					
Labels are easy to understand					
Labels provide easy and cheap information about energy consumption					
Labels promotes environment conscious behavior					
Labels motivates us to save energy					
Labels makes an appliance expensive					
Labels are not very useful					

20. Please rate the following factors you consider (from highly important to not important) while buying a **Refrigerator**?

Factors	Highly Important	Slightly Important	Important	least important	Not Important at all
Brand					
Electricity consumption					
Energy efficiency					
Price of product					
Suggestions by someone reliable					
Exchange offer/ festive offers					
Size of the appliance					
Good looks or features					

21. Before buying a household appliance, which **source of information** do you seek to get more information about that appliance?

22. Rate the following sources of information according to their reliability while purchasing an electrical appliance:

Source of Information	Highly reliable	reliable	moderately reliable	Little reliable	Not reliable
Social media (Face book, whatsapp, Instagram, Snapchat, pinterest etc.)					
Electronic media (T.V, Radio, Internet etc.)					
Print media (Books, magazines, pamphlets, leaflets, posters etc.)					
Shopkeepers /helpers					
Friends, family, neighbors					
Bureau of energy efficiency app					
Electricity suppliers					
Other sources					

23. Do you know who makes these Energy Star labels?
    - Yes

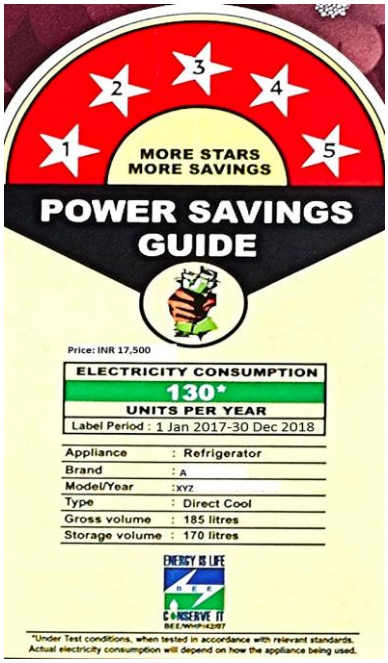
- No

24. If yes, Who they are

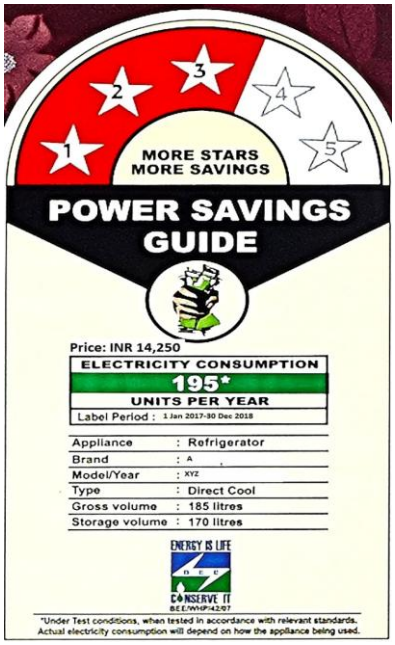
- Scientists with Government
- Social scientist / researcher
- Industry representatives/manufacturers
- NGOs
- Consumer organization
- Others

25. Do you know about Standard &Labeling (S&L) program in India?
    - Yes
    - No

Test 1: You have to buy a refrigerator for your home, which of the following refrigerators will you chose based on the given information in these labels? Both refrigerators are available in color and finish that you want.



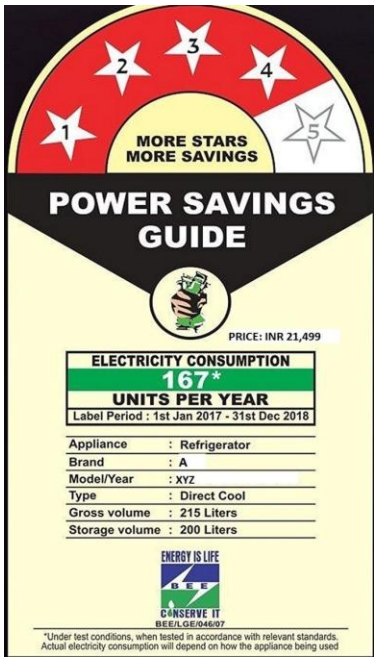
(a)

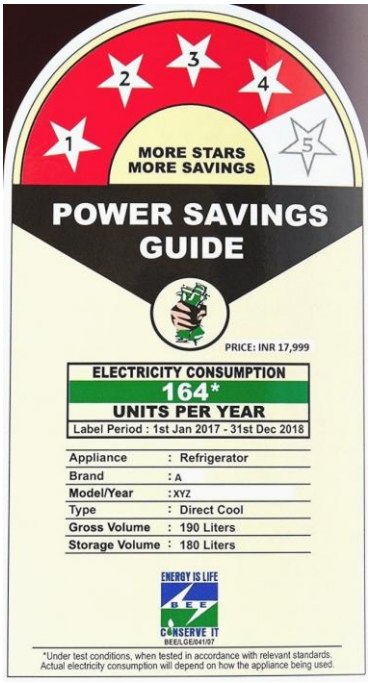


(b)

Your choice: (a), (b), 'None of above'

Test:2 You have to buy a refrigerator for your home, which of the following refrigerators will you chose based on the given information in these labels? Both refrigerators are available in color and finish that you want.





(A) (B)

Your choice: (a), (b) and 'none of the above'

Test 3: If you to buy a refrigerator for yourself and there are only three options available. Which of the following alternative you would like to choose?

- ❖ All the refrigerators are available in color and finish that you want.

Characteristics	*Refrigerator1*	*Refrigerator2*	*Refrigerator3*
Brand	**A**	**B**	**C**
Price	**7,000**	**10,490**	**15,000**
Size(in Litres)	**190**	**190**	**190**
Star ratings	*	***	*****
Cost savings/year	**1730**	**1730**	**1730**
Energy consumption(CEC in Kwh/Yr)	**335**	**212**	**122**

Your choice: (a), (b), (c) and 'None of the above'

Personal information

26. Your age:
    - Below 18 years
    - 18+ to 25 years
    - 25+ to 35 years
    - 35+ to 45 years
    - 45+ years and above

27. Monthly Income of your household:
    - Upto 20,000
    - 20,0001-40,000
    - 40,001-60,000
    - 60,001-80,000
    - 80,001 and above

28. Your place of stay (last one year)
    - Urban area
    - Rural area

29. Please specify the number of family members who stay with you:

30. Your Educational qualification:
    - Below 10th
    - 10^{th}
    - 12^{th}
    - Graduation/Diploma
    - Post graduation
    - Post graduation and above

31. Your gender
    - Male
    - Female

32. Who is the head of your family? Age?

33. Type of house you are living for last one year:
    - Rented
    - Own

34. Employment status (Last one year)
    - Students
    - Private Sector
    - Government sector
    - Entrepreneur
    - Self –employed
    - Home maker
    - others

35. Would you like to have rebate/subsidies on Energy Efficient Appliances?

a) Yes, very much required.
b) Not required
c) No opinion

Annexure II

Table 1: Awareness about developers of S&L

	Awareness about developers of S&L (%)		
Educational Qualification	**No**	**Yes**	**Total**
12th	8	3	7
Below 10th	0	2	1
Graduation (Non-science)	15	5	12
Graduation/Diploma (science)	16	10	14
M.Phil and Above	24	29	26
Post-Graduation (non science)	10	16	12
Post-Graduation (Science)	15	24	18
No Response			12
Grand Total	**100.00**	**100.00**	**100.00**

Figure 1 rating energy saving methods

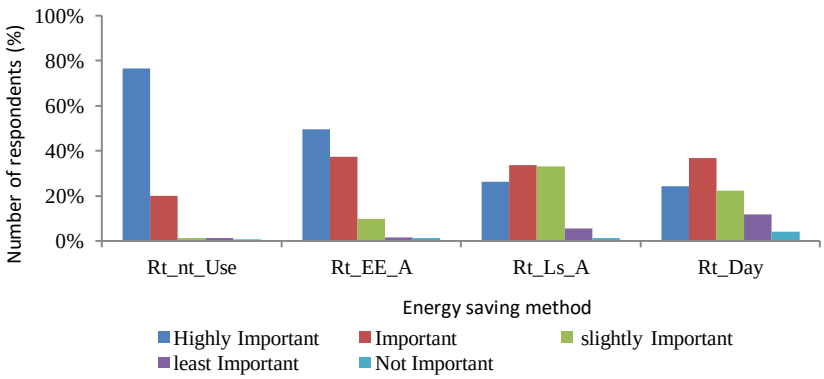


Table 2: marginal effect after logistic regression for 'knowledge of energy efficiency appliance'

y = Pr(eneeffic) (predict, p) = .89899875

variable	dy/dx	Std. Err.	z	P>|z|	[	95% C.I.	]	X
rural*	-.0852105	.10111	-0.84	0.399	-.283376		.112955	.100629
highin~e*	.146909	.13185	1.11	0.265	-.111507		.405325	.45283
youth*	.3466979	.2404	1.44	0.149	-.124472		.817868	.893082
female*	.0423565	.08686	0.49	0.626	-.127894		.212607	.433962
graduate*	.1794043	.06333	2.83	0.005	.055276		.303533	.295597
postgr~e*	.3414963	.1463	2.33	0.020	.054751		.628241	.622642
gov_emp*	-.1470914	.10056	-1.46	0.144	-.344195		.050012	.238994
self_emp*	-.0277822	.10224	-0.27	0.786	-.228177		.172612	.09434
ownhouse*	.0071244	.05674	0.13	0.900	-.10408		.118328	.553459
bighh*	-.1216634	.09682	-1.26	0.209	-.311429		.068102	.157233
highun~s*	.0876156	.04271	2.05	0.040	.003897		.171334	.176101
youth_~c*	-.1202108	.16578	-0.73	0.468	-.445143		.204721	.396226
fem_hinc*	-.0971021	.14667	-0.66	0.508	-.384575		.190371	.220126
fem_po~d*	-.0203459	.10623	-0.19	0.848	-.228553		.187861	.289308
hinc_g~d*	-.3406024	.25918	-1.31	0.189	-.848591		.167386	.106918

Source: Author's analysis

Table 3: marginal effect after MLM regression for 'recognising Image A'

y = Pr(image==ImageA) (predict, p outcome(2)) = .31694393

variable	dy/dx	Std. Err.	z	P>|z|	[	95% C.I.	]	X
rural*	.1827837	.16709	1.09	0.274	-.144705		.510272	.100629
highin~e*	.1624804	.99225	0.16	0.870	-1.7823		2.10726	.45283
youth*	.1440361	.18619	0.77	0.439	-.220898		.508971	.893082
female*	.3633113	.15292	2.38	0.018	.063589		.663034	.433962
graduate*	-.0134504	.20761	-0.06	0.948	-.420353		.393452	.295597
postgr~e*	.0304148	.19338	0.16	0.875	-.348605		.409435	.622642
gov_emp*	-.0143439	.11446	-0.13	0.900	-.238689		.210001	.238994
self_emp*	.2904316	.16811	1.73	0.084	-.039058		.619922	.09434
ownhouse*	-.1069198	.10456	-1.02	0.307	-.311853		.098014	.553459
bighh*	.0675342	.13155	0.51	0.608	-.190306		.325375	.157233
highun~s*	-.0007133	.15397	-0.00	0.996	-.302495		.301068	.176101
youth_~c*	-.0040378	148.42	-0.00	1.000	-290.905		290.897	.396226
fem_hinc*	-.3806821	5.34603	-0.07	0.943	-10.8587		10.0973	.220126
fem_po~d*	-.2765165	.12807	-2.16	0.031	-.52753		-.025503	.289308
hinc_g~d*	.1844173	.2449	0.75	0.451	-.295573		.664408	.106918

Source: Author's analysis

Table 4: marginal effect after MLM regression for 'recognising Image B'

y = Pr(image==ImageB) (predict, p outcome(3)) = .18521695

variable	dy/dx	Std. Err.	z	P>|z|	[	95% C.I.	]	X
rural*	.005259	.12342	0.04	0.966	-.236636		.247154	.100629
highin~e*	.1018877	.54679	0.19	0.852	-.969797		1.17357	.45283
youth*	-.5680053	.25223	-2.25	0.024	-1.06237		-.073643	.893082
female*	.1684073	.14249	1.18	0.237	-.110873		.447688	.433962
graduate*	.3509208	.2747	1.28	0.201	-.187485		.889327	.295597
postgr~e*	.2554348	.16635	1.54	0.125	-.070603		.581472	.622642
gov_emp*	.0566299	.09164	0.62	0.537	-.122984		.236243	.238994
self_emp*	-.0753977	.10567	-0.71	0.476	-.282505		.13171	.09434
ownhouse*	.0435083	.07606	0.57	0.567	-.105557		.192574	.553459
bighh*	.1168777	.11752	0.99	0.320	-.113454		.34721	.157233
highun~s*	-.1428747	.0949	-1.51	0.132	-.32887		.043121	.176101
youth_~c*	.0123674	94.603	0.00	1.000	-185.406		185.431	.396226
fem_hinc*	-.1462258	10.487	-0.01	0.989	-20.7006		20.4082	.220126
fem_po~d*	-.1884065	.10736	-1.75	0.079	-.398834		.022021	.289308
hinc_g~d*	-.2145739	.05301	-4.05	0.000	-.318472		-.110676	.106918

Source: Source: Author's analysis

Table 5: marginal effect after MLM regression for 'recognising both the Image'

y = Pr(image==Both) (predict, p outcome(4)) = .49778095

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
rural*	-.1880527	.14923	-1.26	0.208	-.480546	.104441	.100629
highin~e*	.7334285	.66759	1.10	0.272	-.575016	2.04187	.45283
youth*	.4243651	.15274	2.78	0.005	.125007	.723724	.893082
female*	-.5316571	.15052	-3.53	0.000	-.826665	-.236649	.433962
graduate*	-.3374204	.20655	-1.63	0.102	-.74226	.067419	.295597
postgr~e*	-.2855496	.22442	-1.27	0.203	-.725412	.154313	.622642
gov_emp*	-.042308	.11684	-0.36	0.717	-.271311	.186695	.238994
self_emp*	-.2149929	.15108	-1.42	0.155	-.511099	.081113	.09434
ownhouse*	.063372	.10683	0.59	0.553	-.146018	.272762	.553459
bighh*	-.184454	.12432	-1.48	0.138	-.428117	.059209	.157233
highun~s*	.1445766	.19235	0.75	0.452	-.232421	.521574	.176101
youth_~c*	-.667591	52.791	-0.01	0.990	-104.136	102.801	.396226
fem_hinc*	-.4153038	24.566	-0.02	0.987	-48.5633	47.7327	.220126
fem_po~d*	.4645791	.19622	2.37	0.018	.079997	.849162	.289308
hinc_g~d*	.0297035	.2499	0.12	0.905	-.460082	.519489	.106918

Source: Author's analysis

Table 6: marginal effect after logistic regression for experiment 1

y = Pr(test1) (predict, p = .8699903

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
rural*	-.0158232	.08535	-0.19	0.853	-.183104	.151457	.100629
highin~e*	.1801638	.16889	1.07	0.286	-.150848	.511176	.45283
youth*	.2879996	.21448	1.34	0.179	-.132374	.708373	.893082
female*	.0583579	.09751	0.60	0.549	-.132749	.249464	.433962
graduate*	.1858239	.06861	2.71	0.007	.051341	.320306	.295597
postgr~e*	.2693381	.13872	1.94	0.052	-.002557	.541233	.622642
gov_emp*	.044108	.06362	0.69	0.488	-.080593	.168809	.238994
self_emp*	.071207	.07244	0.98	0.326	-.070769	.213183	.09434
ownhouse*	-.0636068	.05751	-1.11	0.269	-.176324	.04911	.553459
bighh*	.0010921	.07579	0.01	0.989	-.147462	.149646	.157233
highun~s*	.1110258	.0505	2.20	0.028	.012057	.209994	.176101
youth_~c*	-.1716623	.21749	-0.79	0.430	-.597942	.254617	.396226
fem_hinc*	.0455395	.09872	0.46	0.645	-.147942	.239021	.220126
fem_po~d*	-.1586295	.16481	-0.96	0.336	-.481653	.164394	.289308
hinc_g~d*	-.054649	.17155	-0.32	0.750	-.390874	.281576	.106918

Source: Author's analysis

Table 7: marginal effect after logistic regression for experiment 2

y = Pr(test2) (predict, p)= .69919658

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
rural*	.1014146	.10554	0.96	0.337	-.105439	.308268	.100629
highin~e*	-.3461305	.23793	-1.45	0.146	-.812467	.120206	.45283
youth*	-.0941896	.16542	-0.57	0.569	-.418415	.230036	.893082
female*	.0892969	.13837	0.65	0.519	-.181901	.360495	.433962
graduate*	.0525407	.15044	0.35	0.727	-.242319	.347401	.295597
postgr~e*	.1758666	.16732	1.05	0.293	-.152074	.503807	.622642
gov_emp*	.1042396	.09148	1.14	0.255	-.075067	.283546	.238994
self_emp*	-.0025003	.14074	-0.02	0.986	-.278347	.273347	.09434
ownhouse*	-.1632231	.08221	-1.99	0.047	-.324347	-.0021	.553459
bighh*	-.0299841	.11106	-0.27	0.787	-.247653	.187685	.157233
highun~s*	.0578705	.09956	0.58	0.561	-.137261	.253002	.176101
youth_~c*	.2777371	.21279	1.31	0.192	-.139322	.694796	.396226
fem_hinc*	.159814	.12618	1.27	0.205	-.087499	.407127	.220126
fem_po~d*	-.2940461	.18011	-1.63	0.103	-.64705	.058958	.289308
hinc_g~d*	.0959073	.14742	0.65	0.515	-.193035	.38485	.106918

Source: Author's analysis

Table 8: marginal effect after mlogistic regression for experiment 3

```
y  = Pr(choice==Refrigerator2) (predict, p outcome(1))
         =  .13780991
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.      z    P>|z|  [    95% C.I.   ]       X
---------+--------------------------------------------------------------------
   rural*|   .0820081      .17663    0.46   0.642  -.264185  .428202   .100629
highin~e*|   -.255295       .1969   -1.30   0.195   -.64122   .13063    .45283
   youth*|  -.1019284      .21777   -0.47   0.640  -.528756  .324899   .893082
  female*|  -.1676516      .10609   -1.58   0.114  -.375588  .040285   .433962
graduate*|  -.0297685      .10284   -0.29   0.772  -.231325  .171788   .295597
postgr~e*|  -.0403802      .11893   -0.34   0.734  -.273471   .19271   .622642
 gov_emp*|   .0215172      .38683    0.06   0.956  -.736648  .779683   .238994
self_emp*|  -.0838181      .07795   -1.08   0.282  -.236591  .068955    .09434
ownhouse*|   .0304451      .06376    0.48   0.633   -.09453   .15542   .553459
   bighh*|  -.0638155      .06461   -0.99   0.323   -.19045  .062819   .157233
highun~s*|   .0134776      .08223    0.16   0.870  -.147693  .174648   .176101
youth_~c*|   .0556995      .20548    0.27   0.786  -.347042  .458441   .396226
fem_hinc*|   .4929491      .25661    1.92   0.055  -.009992   .99589   .220126
fem_po~d*|   .0373772      .14492    0.26   0.796  -.246655  .321409   .289308
hinc_g~d*|   .0178843      .17069    0.10   0.917  -.316659  .352427   .106918
------------------------------------------------------------------------------
```

Source: Author's analysis

```
Marginal effects after mlogit
      y  = Pr(choice==Refrigerator3) (predict, p outcome(2))=  .86190964
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.      z    P>|z|  [    95% C.I.   ]       X
---------+--------------------------------------------------------------------
   rural*|  -.0832643      .43275   -0.19   0.847  -.931432  .764904   .100629
highin~e*|   .2555879      .20277    1.26   0.207  -.141832  .653008    .45283
   youth*|   .1031719      .43374    0.24   0.812  -.746951  .953295   .893082
  female*|   .1673005      .18548    0.90   0.367  -.196232  .530833   .433962
graduate*|   .0299238      .11567    0.26   0.796  -.196778  .256625   .295597
postgr~e*|   .0400187      .18087    0.22   0.825  -.314479  .394516   .622642
 gov_emp*|  -.0080358     2.46349   -0.00   0.997  -4.83639  4.82031   .238994
self_emp*|   .0830536      .32333    0.26   0.797  -.550655  .716762    .09434
ownhouse*|  -.0305476      .07169   -0.43   0.670  -.171066  .109971   .553459
   bighh*|   .0640887      .11489    0.56   0.577  -.161092  .289269   .157233
highun~s*|  -.0131861      .13483   -0.10   0.922  -.277441  .251069   .176101
youth_~c*|  -.0560773      .24056   -0.23   0.816  -.527569  .415414   .396226
fem_hinc*|  -.4933054      .22223   -2.22   0.026  -.928874 -.057737   .220126
fem_po~d*|  -.0368265      .25008   -0.15   0.883  -.526966  .453313   .289308
hinc_g~d*|  -.0163206      .52191   -0.03   0.975  -1.03925  1.00661   .106918
------------------------------------------------------------------------------
```

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Source: Author's analysis