Analytical Framework to Study Energy Efficiency Policy Portfolios across Countries/States

by

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Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Environmental Design and Planning

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July 22nd, 2010
Blacksburg, Virginia

Keywords: Energy Efficiency, Energy Efficiency Policies, Energy Efficiency Policy Evaluation, Energy Consumption Factor

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ABSTRACT

Energy conservation and implementation of effective energy efficiency policies have become imperative to curbing the escalating consumption of energy. The imbalance in the supply and demand of a country's energy has increased the importance of implementing energy efficiency policies. Proper replication of strategic energy efficiency policies that are known to be successful in one country, along with development of new approaches, can be helpful in developing the energy policy portfolio of another country. Some OECD (Organization of Economic Cooperation and Development) countries like Denmark, Finland, France, Germany, Italy, the United Kingdom and the United States have benefited from their energy policies during the most recent energy crisis. The motivation of this research is to provide a tool for developing countries, which are still in the stage of formulating their energy efficiency policies, to compare energy efficiency policy portfolios across countries. These countries can improve their energy efficiency policy portfolios based on lessons learned from the developed countries.

The research develops a framework to compare energy efficiency policy portfolios across countries / states. Although this framework can be adopted for any type of energy policy, targeting any sector with few modifications, the current focus is on policies that target the residential building sector to reduce energy consumption. The research begins with identification of the functional domains that influence human behavior—people, economy, environment and technology—followed by identification of the factors affecting household energy consumption. It uses the four functional domains as the

evaluation framework's four axes. The various factors affecting household energy consumption are positioned in the framework based on association with the functional domains. The energy efficiency policies implemented in a country are positioned in the same framework based on the pattern of diffusion of each type of policy. In addition, a prototype method is developed to identify the factors targeted by each energy efficiency policy implemented in a country. This evaluation method allows for a uniform assessment process of how energy efficiency policies target specific socio-economic factors that are known to affect energy consumption. The proposed framework will facilitate the work of policy makers and other decision makers with a powerful tool for evaluating and comparing their individual policies, or their complete portfolio of energy efficiency policies, to those from other states or countries, and to benefit from the lessons learned.

ACKNOWLEDGEMENT

Writing through these final pages of my dissertation I realize that my time at Virginia Tech is approaching towards end. Looking retrospectively to the journey which started three years back when I came to Virginia Tech with loads of aspiration, time has passed away unperceived and left me at the threshold of realizing my dream. This could not have been accomplished without the help and co-operation of my professors, friends and family members. Without them this experience definitely would not have been as rewarding and exciting as it is.

Firstly I would like to thank my advisor Dr. Georg Reichard for his continuous guidance, support and inspiration. Our weekly meetings were of immense value towards the accomplishment of this research. The discussions and dialogues with Dr. Reichard during those sessions provided me with many research ideas to consider. Other than the scheduled meetings his door was always open for me to walk in for a discussion. I still remember those days when I walked into his office not knowing what step I need to take next to progress in my research. To my amazement he always had a solution which helped me move on to the next level. He taught me how to be persistent to accomplish any goal. He has inspired me to dream big and think positive. I feel fortunate enough for getting the opportunity to work with him.

I would like to express my deepest appreciations to my committee members Dr Andrew McCoy, Dr. Annie Pearce and Dr. Yvan Beliveau for their insightful comments and advice. Their positive criticism, invaluable insights and inspiring ideas has helped me shape my research and complete it successfully. The research method course offered by Dr. Pearce and Dr. Fiori in my first semester at Virginia Tech provided me the initial idea of how to put down a research idea on paper and share it with other people. At that time I always wondered why they made us write a mini proposal almost every alternate week. I never liked the idea then, but today I realize it was those mini proposals which gave me the initial training to put together this two hundred page document. I am also indebted to

Dr. Fiori for helping me in the process of performing inter rater reliability study as one of the observers. My special thanks to all the other faculty of the department of building construction who had taught and advised me along the way.

Thanks to my colleagues and close friends, Prasun, Pardis, Kathlene, Liang, Sandeep, Saurabh, and others for all the good time they shared with me and for making this a great experience.

This long journey wouldn’t have been possible without the encouragement of my husband, who has stood beside me throughout and given me support whenever I needed it. I would also like to thank my parents, in-laws, brother, and sister-in-law who encouraged and supported me through tough times. A special appreciation to my mother for inspiring me to pursue doctoral studies. Coming from a conservative society where girls were not encouraged towards higher education, she had her own dreams and could not fulfill it to her satisfaction. She always wanted me to achieve her unfulfilled dreams. I hope I have lived to her expectation and will continue to do so.

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Energy Efficiency in this research refers to reduction in the consumption of energy by individuals or households.

Energy Efficient Equipment refers to equipment that consumes less input energy to give the same output as compared to similar equipments of its kind.

Energy Efficiency Policy is a deliberate plan of action to guide the creation of the necessary conditions to speed up the development and the deployment of energy efficient equipment and make people use energy more efficiently (i.e., get the maximum output from minimum input of energy) (World Energy Council 2008).

Demand Side Energy Efficiency Policies are that set of policies involving actions that control the amount and patterns of use of energy consumed by an individual or a household.

Energy Efficiency Policy Portfolio of a country is the collection of energy efficiency policies implemented in that country.

Evaluation of Energy Efficiency Policies is a method to assess the effects of already implemented policies with respect to necessity, efficiency, validity, and cost effectiveness and also improve the planning and implementation of new policies/measures.

Human Behavior as used in this research means the collection of activities performed by human beings, which is influenced by parameters such as culture, values, ethics, economic condition, education, climate, etc.

Functional Domains are categories for which a change in the value of a domain causes a change in behavior pattern. Typical examples of the environmental domains are culture, economy condition, ecology, available technology, etc.

Energy Consumption Factors in this research refers to the physical and behavioral factors that directly influence the amount of energy consumed by an individual or group.

Control Elements influence the energy consumption factors. They are identified from the subfactors or minor causes of energy consumption in this research.

OECD Countries in this research refers to all the 31 countries that are members of the Organization for Economic Cooperation and Development (OECD). It is an international organization of developed countries, which are committed to the principles of democracy and a free market economy. It provides a platform for sharing experiences and working towards solutions to common crises or problems.

Supply Push Policies are those policies that stimulate technological innovation in a country or region. These are the typical research and development grants that are given by government to the industry to develop new energy efficient technologies.

Demand Pull Policies are those policies create a market for emerging technologies. A typical example of such policies is financial incentives that help towards diffusion of technologies.

Chapter 1. Introduction

Chapter 1 provides the background information for this research including an overview of cross country/state energy policy evaluation problems, research efforts in this area, and definition of energy policies and energy policy evaluation. This chapter also presents the goal, objectives and methodology adopted for this research. Finally, the chapter concludes with the organization of this dissertation.

1.1 Background and Problem Statement

Energy conservation and the use of renewable energy sources have become important since the oil crisis of 1973. A fundamental imbalance between supply and demand defines a country's energy crisis. According to some experts, this imbalance can be ameliorated at a minimal cost by implementing demand-side energy efficiency policies in conjunction with using alternative fuels and restricting carbon emissions (Gillingham et al. 2004).

Proper implementation of strategic energy policies that are known to be successful for other countries, along with the development of new approaches, can improve the situation for any country. Many of the OECD countries like Denmark, Finland, France, Germany, Italy, and the United Kingdom have been successful in implementing energy efficiency policies to curb the growing demand for energy in the building sector (Jollands and Ellis 2009). Europe is often perceived as being a leader in energy efficiency. However, the European approach has its origin in a different, economic need for efficiency due to higher taxes and energy prices, thus providing a shorter payback period for various measurements that cannot be directly mapped to other parts of the world.

From past research of the OECD and other developing countries it is evident that cross country comparison of energy efficiency policies is difficult (Bosseboeuf et al. 1997b; IEA 1994; Jollands and Ellis 2009; Lee Schipper 1995). The reason for this as mentioned by Bosseboeuf(1997) is the heterogeneous nature of the data used for definition and measurement; efficiencies are different from one country to another and interpretation of similar ratios diverge considerably. Literature review shows instances of attempts made to summarize lessons learned from the evaluations of the policies of several European countries and the United States (Gillingham et al. 2004; Gillingham et al. 2006; Harmelink et al. 2008; Jollands and Ellis 2009).

Very few researchers have attempted such analysis on a global scale (Jollands and Ellis 2009; Lund 2007). In this attempt previous literature has been divided into five major categories:

i. Evaluation of effectiveness of different types of energy efficiency policies

ii. Calculation of estimated energy savings by energy efficiency policies

iii. Evaluation of energy efficiency policy portfolios of countries/states

iv. Evaluation of particular types of energy efficiency policies across countries/states

v. Evaluation of energy efficiency policy portfolios across countries/states

Many research initiatives are found in the first four categories, which are discussed in Chapter 2. In contrast, only one ongoing research initiative, by the International Council for Research and Innovation in Building and Construction, has been found under category five.

Since the research is focused on evaluation of energy efficiency policy portfolios across countries/states, it is important to define the term energy efficiency at the beginning, followed by a brief discussion about the requirement of energy efficiency policy evaluation.

1.1.1 <u>Definition of Energy Efficiency</u>

Efficient energy use or, in simple terms, energy efficiency, refers to utilizing less energy to provide the same amount of energy service. For instance, use of insulation in homebuilding enables reduction of the heating and cooling load, thus achieving a comfortable temperature with less use of energy. Similarly, fluorescent lights and/or skylights help to attain same level of illumination as that from incandescent light, but with less energy. The output amount of visible light from a 13-watt fluorescent light bulb and a 60-watt incandescent light bulb are the same; thus in the case of the fluorescent bulb the user is getting the same amount of light for less energy.

The World Energy Council (2004) defines energy efficiency as a reduction in the energy used for a given energy service of a level or activity. These reductions in energy consumption can change with better organization and management or improved economic efficiency in the sector rather than being just a result of technical change.

1.1.2 Energy Efficiency Policies

The goal of energy efficiency policies is creation of the necessary conditions to speed up the development and deployment of energy efficient equipment and make people use energy more efficiently (i.e., get the maximum output from the minimum input of energy). It fulfills its objectives through information for and communication with final consumers, sharing risks with producers and distributors, improvement in the research and development process in the field of energy efficiency, deployment of specific financing mechanism, regulation of appliances and equipment for consumers, and more (World Energy Council 2008).

1.1.3 Energy Efficiency Policy Evaluation

Policy evaluation checks the effectiveness of the policies in action with respect to necessity, efficiency, validity, and cost effectiveness. It provides the much needed impetus to improve the planning and implementation of policies. Constantinescu and Janssen (2007) suggested conducting energy policy evaluation to monitor the efficacy of energy policies to reduce energy use. Other benefits of energy policy evaluation include regulatory impact assessment, cost benefit analyses, and environmental consequence analyses prior to any action, and assistance in maintaining a balance between the demand side measures and supply side measures.

Due to the different types of policies implemented in different countries and the varying assumptions made by evaluation experts, identifying a generalizable method of evaluating the effectiveness of energy efficiency policies across countries/states is difficult. But such studies are immediately needed if countries want to learn from the experiences of other countries. Development of such a generalized evaluation method will be of utmost importance for non-OECD countries who are in the early stages of developing energy efficiency policy portfolios. Such cross country energy policy evaluation methods can also assist countries with a longer history of energy efficiency in fine tuning their energy efficiency policy portfolio by studying the experiences of other countries (Jollands and Ellis 2009).

1.2 Goal

As outlined above, the policies implemented in one country, for example in the United Kingdom, cannot be mapped directly to another country like the United States, as the United States' socio-economic system is balanced differently. However, if brought into context, the lessons learned by these countries could be very valuable and of high importance for policy makers and evaluators of the developing countries, to support their efforts in increasing the effectiveness of existing portfolios and planned incentives or policies targeting more efficient use of energy.

The overall goal of this dissertation is to develop a framework for analyzing the energy efficiency policy portfolios of a country/state. The research focuses on energy efficiency policies that target the residential building sector. The methods can later be adapted for the commercial building sector or energy efficiency policy portfolios as a whole. The main reason for selecting the residential sector is its homogeneity (mainly due to the large number of consumers with similar equipment) and assumed simplicity in the demand structure of this sector. This is a grounded theory research adopting a flexible design strategy and qualitative methods.

1.2.1 Grounded Theory Research

A grounded theory research is a type of systematic qualitative research methodology where a theory is generated based on data discovered in the process of conducting the research (Glaser and Strauss 1980). In this research the theory, that cross-country comparison of energy policy portfolios is possible, is generated based on the data collected and analyzed. The process used in grounded theory research method operates in a fashion opposite to traditional research methods. Instead of testing a hypothesis it aims to understand the research situation. It starts with data collection, unlike the other methods which are based on a hypothesis. The data collected are categorized initially, which later forms the basis for the creation of the theory. This is in contrast to traditional research methods where the researcher starts with choosing a theoretical framework and then applies the method to the studied phenomenon (Allan 2003).

Though interviews are the most common data collection method, other methods such as observation and analysis of documents are also used (Robson 2002). According to Glaser and Strauss (1967) “different kinds of data give the analyst different views or vantage points from which to understand a category and to develop its properties; these different views we have called slices of data”. The research is carried out in a back and forth process where first the data collected from the field is analyzed, and then back to the field to collect more data and analyze them. This process of data collection and analysis continues until certain categories are identified. According to Robson (2002) the research is carried out in three steps:

- Find the conceptual categories in the data
- Find relationships between the categories
- Conceptualize and account for these relationships through finding core categories

This research method was primarily used by sociologists but later spread to other related disciplines (Buchanan and Bryman 2009). Presently this method is used globally among the disciplines of nursing, business and education. The advantages of this theory are that it presents a strategy for doing the research that is systematic and coordinated, and it provides clear procedures for the analysis of qualitative data. The major drawbacks when adopting this kind of methodology are, first, that it is not possible to start a research study without some pre-existing theoretical idea and assumptions, and, second, it is difficult to decide when the categories are sufficient and the theory is developed sufficiently.

1.3 Research Question

The broad research goal presented above cannot be answered by one dissertation; rather it can only be approached. One way to approach this goal is to answer the following question: *How can the portfolio of energy efficiency policies targeting the residential building sector of one country or state be compared with that of another?* Looking into the energy policy portfolio of a country like United States it is visible that even within the group of policies targeting the residential sector, there are various sub targetable categories. The various subcategories that the individual policies target to reach the ultimate goal of energy efficiency and environmental protection are reduction in energy use by the industry, reduction in energy use by people through changes in behavior, introducing more innovative energy efficient products through research and development, and so on.

Thus the questions that are answered in this research are formulated as follows:

i. What strategies do energy efficiency policies follow to fulfill their goal? Can energy efficiency policies be grouped based on the strategies followed?

ii. How can the effectiveness of energy efficiency policies targeting human behaviors within specific markets be studied to improve energy efficiency?

iii. What are the main functional domains that influence human behavior?

iv. *What are the main factors that affect residential energy consumption?*

v. *Are all the factors that affect energy consumption by residential users being targeted by a country's energy efficiency policy portfolio?*

To find an answer to the above described research question the following objectives were identified.

1.4 Objectives

The evaluation framework developed in this research provides means and methods to evaluate how successfully energy efficiency policies address various factors that are known to influence energy consumption in a socio-economic context. Another aspect of the framework allows policymakers of one country to compare their existing energy efficiency policy portfolio and learn from the experience of other countries with similar socio-economic conditions.

The following objectives helped in the development of the framework:

i. Identifying the factors affecting energy consumption by residential users.

ii. Studying the types and patterns of energy efficiency policies implemented in the OECD countries, which target energy consumption of the residential sector.

iii. Understanding how successfully the energy efficiency policy portfolio of a country targets the factors identified in the first objective.

iv. Creating a framework to analyze energy efficiency policy portfolios, and identifying the transferable policies across countries/states.

v. Validating the proposed framework.

1.5 Research Methodology

1.5.1 <u>**Objective 1: Identifying the factors affecting energy consumption by residential users from a human behavior perspective.**</u>

This objective involves the following steps:

- Identifying the functional domains that influence human behavior and the relationships between them
- Identifying the factors that affect energy consumption
- Identifying control elements influencing energy consumption factors

<u>*Objective # 1.1: Identifying the functional domains that influence human behavior*</u>

Task 1.1: General literature on energy consumption and human behavior were reviewed and a list of functional domains that influence human behavior was generated.

Zabel (2005) found that human behavior is the product of "three constituting components: cultural shaping (cultural artifacts, education, socialization, and enculturation), genetic predisposition (pattern recognition based on instincts, needs, drives, etc.), and situational correctives". In other words, the cultural setting in which a human being is brought up plays a fundamental role in shaping an individual's behavior, and thus also the individual's energy consumption. Other than cultural setting, economic condition is another functional domain influencing human behavior. Zabel (2005) in his research mentions economic systems now decide the consumption of technology which in turn affects the consumption of energy. Similar other research papers will be studied.

<u>*Objective # 1.2: Identifying the factors that affect energy consumption*</u>

Task 1.2: Through literature review, the various factors that affect energy consumption are identified. The energy demand is shaped by a variety of factors, including type of housing unit, location, and climate (EIA 1995).

Task 1.3: The Cause and Effect (C&E) diagram method is employed to analyze the root cause of each of the identified factors. The cause and effect diagram is a kind of graphical analysis tool that helps to sort and identify the control elements which are the possible causes of the factor.

Objective # 1:3: Identification of control elements influencing energy consumption factors

Task 1.4: The control elements influencing the energy consumption factors are generated and sorted using the affinity diagram method. An affinity diagram is used as a tool to gather large amounts of data and organize them into groups based on their natural relationship. The affinity diagram method helps to sift through large volumes of data and summarize the findings.

1.5.2 Objective 2: Studying types and patterns of energy efficiency policies implemented by OECD countries targeting the energy consumption of the residential sector.

This objective addresses the following questions:

- What types of policies have the OECD countries implemented in the past?
- What patterns of diffusion do various types of policies follow to achieve energy efficiency?

The tasks listed under this objective provide a descriptive overview of types of energy efficiency policies and categorize the findings representing various perspectives and patterns on this issue. This objective involves the following steps:

Task 2.1: Identifying the list of policies targeting the energy efficiency of residential buildings implemented in the OECD countries.

Task 2.2 Studying and listing the possible diffusion patterns that are applied by the different energy efficiency policies.

Through this objective, how the energy efficiency policies influence the people or the industry to reduce energy consumption is studied. The government with all its elected representatives is the central entity implementing the environmental protection measures (increasing energy efficiency is considered as one type of the many environmental protection measures taken throughout the world) either directly through people or through industry. Sometimes the government even uses the economy to influence people/industry to protect the environment. When the people/industry are directly approached by the government it is referred to as Direct Energy Efficiency Strategies; a typical example would be building codes, mandatory standards, etc. The other way is referred to as Indirect Energy Efficiency Strategies, which includes grants or subsidies, fiscal measures, preferential loans, and general soft instruments (non-regulatory measures). Through this objective the various patterns of reaching this goal (e.g., bottom-up or top-down approaches for the different actors in this scenario, and how different types of policies make use of these patterns) are studied.

1.5.3 Objective 3: Understanding how successfully the energy efficiency policy portfolio of a country targets the factors identified in Objective 1.

Within the scope of this objective a prototype method is developed to understand the accomplishment of energy efficiency policies in addressing the factors known to influence residential energy consumption.

Task 3.1 Using the method of content analysis, the energy consumption factors targeted by each of the energy efficiency policies are identified.

"Content analysis came to prominence in the social science at the start of the twentieth century, in a series of quantitative analyses of newspapers, primarily in the United States" (Robson 2002). Content analysis has been defined in many researches as an orderly, replicable method to pack together a set of data into fewer selected categories based on a clear set of rules. It is a useful technique to sift through large volumes of data and categorize them in a more methodological and systematic manner (Robson 2002). According to Robson (2002) a content analysis can be developed through the following steps:

- Start with a research question
- Decide on a sampling strategy
- Define the recording unit
- Construct categories for analysis
- Test the code on samples of text and assess reliability
- Carry out the analysis

Weber (1985) says that to reach a valid conclusion from the data analyzed it is important that the classification procedure adopted be reliable and consistent, i.e., different people should code the same document in the same way. In order to maintain a consistency in the method followed to group the policies based on the type and diffusion pattern, a reliability measure needs to be performed. This helps to bring consistency in the measuring or grouping methods used by different participants, thus eliminating bias. Reliability is measured by Stemler (2001) in the following way:

- Stability: The same methodology gives the same result in every try or intra-rater reliability.
- Reproducibility: Different participants reach the same conclusion after adopting the same methodology or inter-rater reliability.

1.5.4 <u>**Objective 4: Creating a framework to analyze the energy efficiency policy portfolio targeting the human behavior factors affecting energy consumption.**</u>

This objective involves the following steps:

Task 4.1: The relationship between the functional domains that influence human behavior is determined and placed on a graphical analysis diagram.

Task 4.2: The human behavior factors affecting residential energy consumption are plotted in the graphical analysis diagram based on its identified association with the functional domains in Objective 1.

Task 4.3: The energy efficiency policies targeting each of the factors are plotted on the same graphical analysis diagram. The result of these mappings is expected to visualize possible gaps that might exist between factors affecting energy consumption and policies trying to target these factors.

1.5.5 Objective 5: Validating the proposed framework.

The process of validating the evaluation framework is a critical step in this research. Although some of the methodologies used in this research were already validated and published, the overall framework, including the design methods adopted and the assumptions, needs to be validated for its appropriateness and comprehensiveness.

The evaluation framework is validated in the following ways:

- **Reliability:** Reliability checks whether the tool developed in this research produces consistent results. To check the reliability of the process the research used more than one analyzer to identify the factors targeted by individual policies. Agreement between the analyzers is checked using Krippendorff's alpha method.

- **Construct Validity**: To check the construct validity, the evaluation framework at an early development phase was submitted for an international conference and peer reviewed by experts in the area of energy efficiency policies.

- **Generalizability:** This term refers to the extent to which the developed evaluation framework is more generally applicable. To check the generalizability the policies of three EU countries and three US states were mapped on the evaluation framework. The successful demonstration of the above-mentioned cases proved the generalizability of the evaluation framework. Other than the above-mentioned two methods of validating the framework, a reliability check has been performed at the different methodological step.

1.6 Research Methods and Process

Grounded theory was most appropriate for this study as it allows conceptions to emerge from the data rather than imposing preconceived notions upon them (Strauss and Corbin 1990). Following the grounded theory methodology this research employs a method for accessing of literature throughout the whole research process as a major part of the data collection procedure. Thus, the analysis of the literature leads to the generation of the evaluation framework. Initially the research begins with identification of the factors affecting energy consumption through literature review, followed by analysis of these factors and identification of the control elements under each of them. The process is called note-taking or coding. At a later stage these control elements help to identify the energy consumption factors targeted by the energy efficiency policies implemented by a country, which provide the means by which the theory can be integrated. As factors affecting energy consumption are identified from the literature review, the research seeks to further increase diversity to strengthen the emerging theory by finding the relationship between them. Concept mapping is used for this purpose. At this stage, identified connections between the factors are recorded (referred to as memo in grounded theory methodology). Based on the relationships, the energy consumption factors are subsequently sequenced in a certain order to clarify the theory. This order of the sorted memos provides the skeleton of the framework. A similar method is again adopted to study energy efficiency policies already implemented, which further adds to the skeleton of the evaluation framework.

Figure 1-1 below shows the different methods that have been adopted at the different steps to develop the framework. The overall research comprised four steps: data collection, data analysis, creation of framework, and validation. Data collected in this research were focused on two categories: data related to human behavior (determine the functional domains and the factors affecting energy consumption by residential users) and data related to energy efficiency policies implemented in the three selected EU countries and three US states. The methods adopted for the process of data analysis were content analysis, cause and effect diagram, and affinity. Finally, the created framework was validated for reliability, construct validity and generalizability.

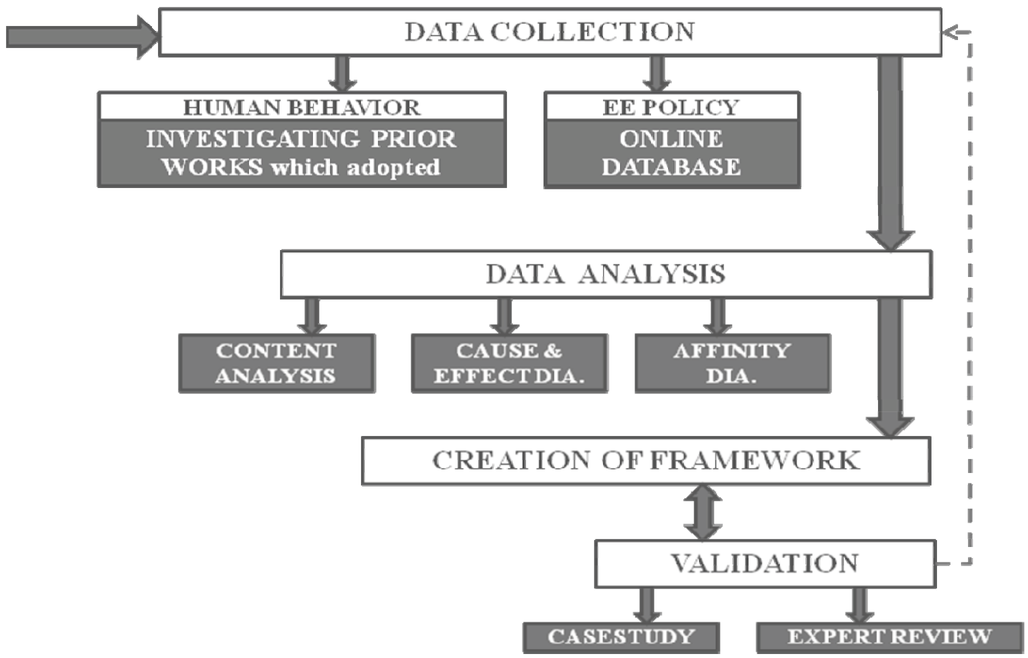

Figure 1-1 Flowchart representing the research methods used

Through literature review the functional domains and the energy consumption factors were identified and the control elements, which govern the energy consumption factors, were generated in Objective 1. In Objective 2 the different energy efficiency policy types and their working principles were studied. These identified working principles of the energy efficiency policies were later used in Objective 4 to implement the policies in the created evaluation framework. The control elements generated in Objective 1 are used in Objective 3 where a prototype method is developed to identify the energy consumption factors targeted by the individual energy efficiency policy of a country. In order to create the framework in Objective 4 the research uses the functional domains and energy consumption factors identified in Objective 1, the control elements generated in Objective 1 and the working principle of the policies identified in Objective 2. Figure 1-2 below represents the overall research process.

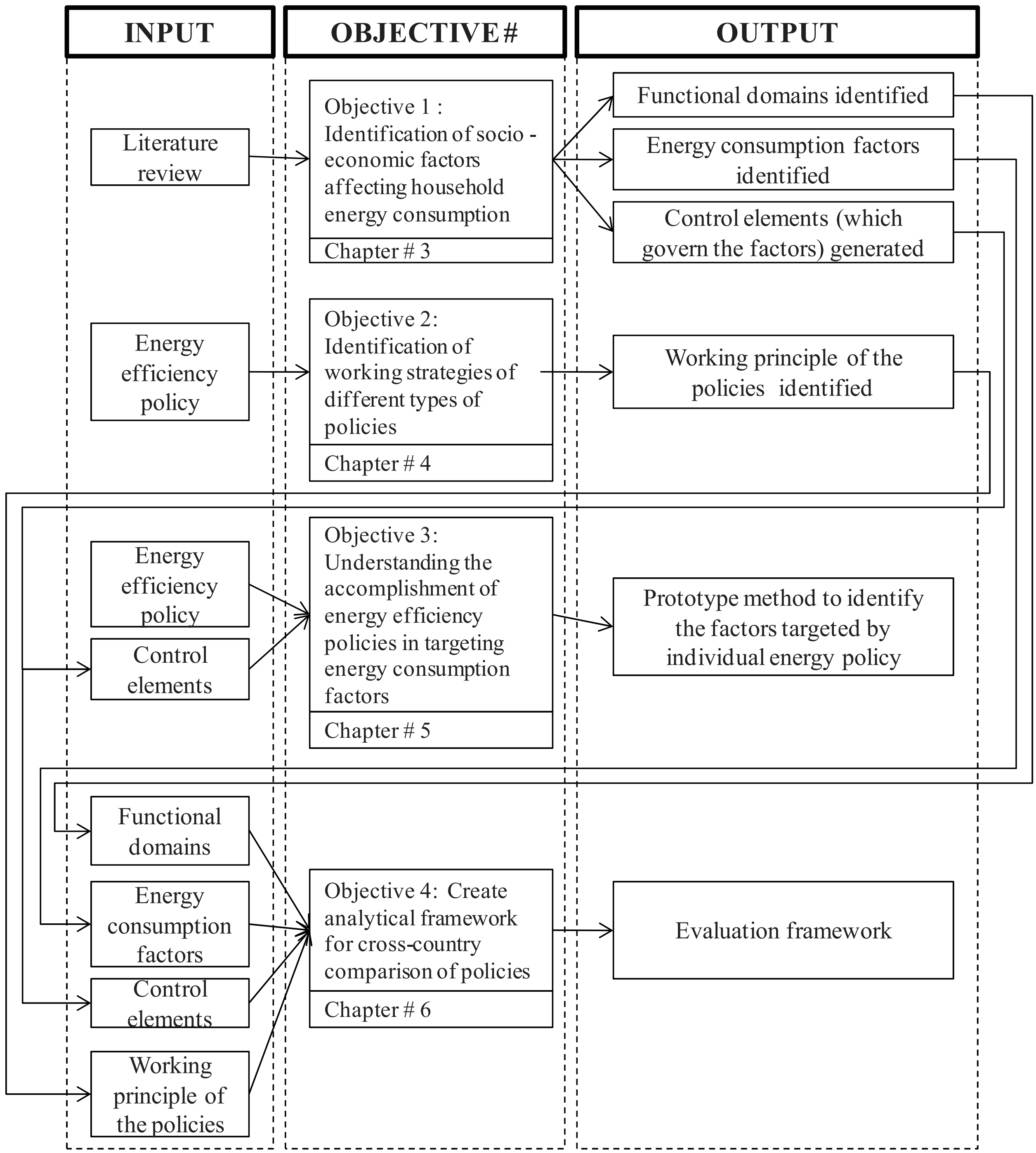

Figure 1-2 Flowchart representing the research process

1.7 Research Contributions

The method shown in this research is a first step for an exploratory framework that will help policy makers and other decision makers to understand the main factors influencing energy consumption and efficiency. This will assist policy makers in evaluating their current policy portfolios towards these factors and creating a mix of strategies that will address a majority of them. The framework created in this research can be used by a country to compare their portfolios to those from other countries with similar context and identify the gaps in their portfolio. This will provide policy makers and other decision makers a framework to evaluate and compare their individual policies or their complete portfolio to those from other states or countries and benefit from lessons learned by mapping various policies towards their own specific context. The framework provides an excellent means for policy makers and researchers to find new ways of implementing and evaluating effective energy efficiency policies from other countries/states in their own community. The framework can be used by local municipalities as a tool to compare their portfolios to those of other municipalities or local level policy portfolios.

1.8 Research Organization

This dissertation will have 8 chapters organized as follows:

Chapter 1: Introduction

This chapter provides background information to the study, describes the problem, defines the research scope objective and methodology, and explains the broader impact of the research. This chapter also explains the typical research methodologies and decision making tools that will be used in the research. In short, this chapter outlines the goal and organization of the research.

Chapter 2: Literature Review

This chapter reviews literatures on policy evaluation and cross-country comparison in the field of energy efficiency policy. It looks for the most used methodologies to assess the effectiveness of policies. Previous research attempts made for cross-country comparison of energy efficiency and energy efficiency indicators are studied.

Chapter 3: Identifying Socio-economic Factors Affecting Household Energy Consumption

This chapter discusses the process of identifying functional domains that influence human behavior in terms of energy consumption. It further illustrates the procedure of identifying the factors that cause the changes in human behavior that result in increased or decreased energy consumption. Each of the identified factors is further analyzed and lists of control elements are generated.

Chapter 4: Identifying the Working Strategies of Different Types of Energy Efficiency Policies

This chapter studies how the policies implemented in the OECD countries influence the people or the industry to reduce energy consumption, and group them into categories. The research studies various patterns of diffusion followed by the energy efficiency policies to reach their goal, e.g., bottom-up or top-down approaches for the different actors in the scenario.

Chapter 5: Understanding the Success of Energy Efficiency Policies in Addressing the Factors Known to Influence Residential Energy Consumption

This chapter presents the process of development of a prototype method to understand the accomplishment of energy efficiency policies in addressing the factors known to influence residential energy consumption.

Chapter 6: Analytical Framework for Cross Country Comparison of Energy Efficiency Policy Portfolios

This chapter describes the steps involved in creating an evaluation framework to analyze the energy efficiency policy portfolio targeting the human behavior factors affecting energy consumption and identifies the transferable policies across countries/states.

Chapter 7: Establishing Trustworthiness of the Framework

This chapter presents the processes that will be adopted to check the validity and the generalizability of the framework designed in the previous chapter. Validity refers to the accuracy of the result obtained and generalizability refers to the extent to which the framework is generally applicable such as in other contexts, situations and times (Robson 2002).

Chapter 8: Conclusion and Recommendations

The chapter summarizes the research findings, which include categorization of the policies, the factors affecting energy consumption, and the effectiveness of the policy portfolio of a country in addressing the factors known to influence energy consumption. The chapter further describes guidelines and tasks for future research.

Chapter 2. Literature Review

The development of a framework to compare the energy efficiency policy portfolio across countries/states should begin with a good understanding of energy efficiency, and energy efficiency policies. This chapter starts with the review of the definition of energy efficiency and energy efficiency policies and is followed by a study of the factors affecting residential energy consumption. Potential causes of residential energy consumption have been investigated in previous studies. This research summarizes the results of about 50 prominent research studies and generates a comprehensive list of factors affecting residential energy consumption. It is important to study the factors that affect residential energy consumption because the energy efficiency policies are designed to work against these factors.

Furthermore, this chapter discusses the importance of energy efficiency policy evaluation and addresses the research efforts that have been made on a global scale in this area. The potential scope and limitations of cross country comparisons of energy efficiency policies or policy portfolios are also discussed in this chapter.

2.1 Energy Efficiency

Energy efficiency refers to reduction in energy usage to achieve a given level of output. Since the oil crisis of 1973 people have become more aware of the efficient use of energy. Lovins (1976) described in his seminal paper the alternative sources of energy that were available in abundance, and were renewable and more environmental friendly than fossil fuels. The development of the concept of energy efficiency is found in past research which is described as "maintaining or increasing the level of useful output or outcome delivered, while reducing energy consumption" (ACG 2004).

Reducing the consumption of individual household energy by using more energy efficient equipment and better insulation of a house is obviously an energy efficiency improvement step from the engineering point of view. This improvement at the micro-level will not be visible at the macro-level unless every individual homeowner starts to consume energy more efficiently. Sometimes, for example due to an extreme increase in fuel prices, consumers decrease their consumption by changing their day to day activities such as driving less, or by adjusting their thermostat. These changes cannot necessarily be counted as energy efficiency improvements, as they may be reversed at any time with decreases in energy prices. The World Energy Council (2008) considers energy efficiency a matter of individual behavior reflecting the rationale of energy consumers, and of using the appropriate technology, such as thermal regulation of room temperatures or automatic standby mode for idle equipment.

Now the question rises whether this energy efficiency will substantially reduce the consumption of energy. This introduces the term energy efficiency gap. Many authors describe it in many different ways. A study describes energy efficiency gap as the difference between the actual energy efficiency of many purchased products and the level of energy efficiency that can be provided cost effectively for the same period (Levine et al. 1994). Energy efficiency gap is also described as the difference between the most energy efficient processes and technologies available and those actually in use (ACG 2004). Jaffe (1999) sees energy efficiency from the perspective of the use of energy efficient technologies. According to him the energy efficiency gap is the gap between the most energy efficient technologies available at some point in time and those that are actually in use. Synthesizing the ideas of many authors, this paper defines energy efficiency gap as the difference between the targeted energy savings by some new energy efficient product and the actual savings with the use of that product.

There is a wide range of viewpoints about this thought of energy efficiency. Some economists believe that there cannot be any cost effective solution associated with energy efficiency. In contrast, certain other people think that there are certain market barriers which affect the proper implementation of energy efficient technological solutions (Levine et al. 1994). The question remains as to how much energy efficiency can be achieved after overcoming the market barriers.

In a bid to quantify the effect of energy efficiency policies, Anderson (1993) mentioned four major rationales for increased energy efficiency, namely 'saving money', 'energy dependence', 'greenhouse effect', and 'sustainable economy'. The 'saving money' rationale is based on the concept of cost effectiveness where expenditure by government to promote energy efficiency policies is compared with the financial savings achieved due to reduction in energy use. Similarly, the 'energy dependence' rationale proposes to measure the effectiveness of energy efficiency policies by the actual reduction in energy consumption (as a whole, or of imported oil, or of nuclear energy, depending on the version of argument). The 'greenhouse effect' and 'sustainable economy' rationales include contribution made towards reducing carbon dioxide emission as a criterion to evaluate energy efficiency policies. Within the paradigm of the last two rationales, cost effectiveness should be measured in terms of carbon emissions (in tones) prevented per amount spent (dollar or pound) on the policies.

In order to achieve energy efficiency it is important to understand the factors that affect residential energy consumption. The following section summarizes the conclusion of previous research and generates a comprehensive list of factors that affect residential energy consumption.

2.2 Factors Affecting Energy Consumption

Following a literature search of the prominent research on residential energy consumption, factors were identified. Various social, environmental, psychological journals (e.g., Journal of Applied Psychology, Journal of Environmental Psychology, The Journal of Consumer Affairs, Energy Policy, etc.) were consulted. Further, reference lists of the articles were reviewed to locate additional published materials. This process was repeated till saturation. The search resulted in a total of 52 researches. In order to be selected for the review each study should not talk about the energy consumption factors associated with specific problems but rather comment on broader perspectives.

Each of the individual literature items was studied to answer the following questions:

1. What is the target group of the study?

2. What factors were concluded to affect energy consumption?

The answers to the above question are represented in tabular form in Table 2 1.

Table 2-1 Factors affecting energy consumption as identified from previous literature

No.	Research Title	Author	Year	Study Target Area	Factor Identified
1	Factors affecting residential heating energy consumption	J. Donovan, W. Fischer	1976	Household energy consumption	Dwelling size, age of dwelling, income, energy price, eco consciousness, technological improvement
2	Energy and Families: The Crisis and the Response	B. Morrison P. Gladhart	1976	Household energy consumption	Income, householder age, household size, dwelling size, housing type, equipments used, eco consciousness
3	Residential energy use and conservation in Denmark, 1965-1980	L. Schipper	1983	Residential energy consumption for heating home and water in Denmark	Energy price, income

No.	Research Title	Author	Year	Study Target Area	Factor Identified
4	Home energy use in nine OECD countries	L. Schipper, A. Ketoff	1983	Comparison between home energy consumption	Income, energy price, dwelling size, weather, dwelling characteristics
5	A behavioral model of residential energy use	W. Van Raaij, T. Verhallen	1983	Household energy consumption	Technological improvement, lifestyle, housing type (S/M), dwelling characteristics, income, household size, age, eco consciousness, weather, urbanization, energy price
6	An Update on Econometric Studies of Energy Deman Behavior	D. Bohi, M. Zimmerman	1984	Energy consumption vs. energy price	Energy price
7	Energy in American Homes: Change and Prospects	S. Meyers, L. Schipper	1984	Household energy consumption	Weather, housing type
8	Residential energy use and conservation in Sweden	L. Schipper	1984	Household energy consumption in Sweden	Energy price, income, dwelling size, household size, lifestyle(indoor temperature), equipments used, housing type (S/M)
9	Personal and Contextual Influences on Household Energy Adaptations	J. Black, P. Stern, J. Elworth	1985	Household Energy Consumption	Attitudes, culture, indoor temperature setting, dwelling characteristics, energy price
10	Residential energy consumption in low-income and elderly households: how nondiscretionary is it	M. Brown, P. Rollinson	1985	Low income and elderly household energy consumption	Household size, eco consciousness
11	Explaining Residential Energy use by International Bottom-Up Comparisons	L. Schipper, A. Ketoff, A. Kahane	1985	Household energy consumption	Lifestyle, dwelling characteristics, equipment availability, indoor temperature, energy price, household size, type of fuels, dwelling size, technology improvement
12	Impacts of energy audits on home energy consumption	V. Junk, W. Junk, J. Jones	1987	Household energy consumption	Eco consciousness, income, dwelling characteristics, type of fuel used, age, dwelling age, housing type (s/m)
13	Personality Variables and Environmental Attitudes as Predictors of Ecologically Responsible Consumption Patterns	I. Balderjahn	1988	Household Energy Consumption	Attitude, education, dwelling characteristics, household expenditure
14	Linking Lifestyle and Energy Use : A matter of time?	L. Schipper, S. Bartlett, D. Hawk, E. Vine	1989	Household energy consumption	Income, energy price, dwelling size, dwelling characteristics, dwelling age, household size, equipment ownership
15	Influence of Income on Energy Beliefs and Behaviors of Urban Elderly	C. Mileham J. Brandt	1990	Household energy consumption of elderly	Income, dwelling size, household size, age of dwelling
16	The Structure and Intensity of Energy Use: Trends in Five OECD Nations	R. Howarth, L. Schipper, B. Andersson	1992	Overall energy consumption	Lifestyle, income, technology available
17	Effect of Thermal Improvements in Housing on Residential Energy Demand	L. Hsueh, J. Gerner	1993	Energy savings from home improvement	Weather, income, dwelling size

No.	Research Title	Author	Year	Study Target Area	Factor Identified
18	Measuring Energy Efficiency in the United States' Economy: A Beginning	DOE	1995	Household energy consumption in US	Housing type (S/M), dwelling size, dwelling characteristics, weather
19	The direct and indirect energy requirements of households in the Netherlands	K. Vringer, K. Blok	1995	Household energy consumption in Netherland	Income, education, leisure
20	Lifestyle change and energy use in Japan: household equipment and energy consumption	H. Nakagami	1996	Household energy consumption	Income, lifestyle, dwelling size
21	A cross-cultural analysis of household energy use behaviour in Japan and Norway	H. Wilhite, H. Nakagami, T. Masuda, Y. Yamaga, H. Haneda	1996	Household energy consumption	Dwelling size, eco consciousness, lifestyle, weather, cultural attitudes, income
22	Energy efficiency indicators in the residential sector: What do we know and what has to be ensured?	R. Haas	1997	Household energy consumption	Household size, householder age, energy price, equipment price, income, eco consciousness, equipments used, dwelling size, weather
23	Some reflections on barriers to the efficient use of energy	L. Weber	1997	Household energy consumption	Eco consciousness
24	Rural household energy consumption : The effects of access to electricity--evidence from South Africa	M. Davis	1998	Rural household energy consumption	Income
25	The impact of consumer behavior on residential energy demand for space heating	R. Haas, H. Auer, P. Biermayr	1998	Household energy consumption	Availability of fuel, energy price, indoor temperature, weather
26	Climatic and economic influences on residential electricity consumption	J. Lam	1998	Household electricity consumption	Income, household size, weather, energy price
27	Reducing Household Energy Consumption: A Qualitative and Quantitative Field Study	G. Brandon, A. Lewis	1999	Household Energy Consumption	Income, socio-demographics, environmental attitudes, information
28	Trends in Consumption and Production: Household Energy Consumption	O. Dzioubinski, R. Chipman	1999	Household energy consumption	Energy price, equipment price, income, availability of fuel, availability of equipments
29	Estimating the electricity savings effect of ceiling insulation	E. Mathews, M. Kleingeld, P. Taylor	1999	Household energy consumption	Dwelling characteristics
30	Energy consumption in the Islamic Republic of Iran	A.Bakhtiari, F. Shahbudaghlou	2000	Energy consumption in Iran	Income, household size, urbanization, energy price
31	Factors Influencing Water Heating Energy Use and Peak Demand in a Large Scale Residential Monitoring Study	M. Bouchelle, D. Parker M. Anello	2000	Household water heating energy use	Weather, household size

No.	Research Title	Author	Year	Study Target Area	Factor Identified
32	Domestic energy consumption patterns in Uttara Kannada District, Karnataka State, India	T. Ramachandra, D. Subramanian, N. Joshi, S. Gunaga, R. Harikantra	2000	Household energy consumption in India	Income, weather
33	Architectural, Demographic, and Economic Causes of Electricity Consumption in Bombay	P. Tiwari	2000	Household energy consumption in Bombay, India	Income, energy price, dwelling size, dwelling characteristics, dwelling age, household size
34	The uses of energy in the domestic sector	J. Andrade	2001	Household energy consumption	Time spend at home, dwelling characteristics, information and knowledge, household size, householders age
35	Norwegian residential electricity demand--a microeconomic assessment of the growth from 1976 to 1993	B. Halvorsen, B. Larsen	2001	Household electricity consumption in Norway	Household size, equipments used, income, dwelling size, energy price
36	Behavioral factors study of residential users which influence the energy consumption	I. Blasco Lucas, E. Hidalgo, G. Gomez, R. Rosés	2001	Household Energy Consumption	Household size, householder age, time spend at home
37	Demographic Determinants of Household Energy Use in the United States	B. O'Neill, B. Chen	2002	Household energy consumption in US	Householder age, household size
38	The direct and indirect energy requirement of households in the European Union	A. Reinders, K. Vringer, K. Blok	2003	Household energy consumption in EU countries	Lifestyle, weather, culture, dwelling characteristics
39	A study of domestic energy usage patterns in Hong Kong	G. Tso, K. Yau	2003	Household energy consumption	Weather, dwelling characteristics, dwelling size, income, household size, equipments used
40	Household consumption: Influences of aspiration level, social comparison, and money management	N. Karlsson, P. Dellgran, B. Klingander, T. Gärling	2004	Household energy consumption	Income, eco consciousness
41	Energy requirements of Sydney households	M. Lenzen, C. Dey, B. Foran	2004	Household energy consumption in Sydney	Household size, income, household age and urbanization
42	An analysis of crosssectional variation in total household energy requirement in India using micro survey data	S. Pachauri	2004	Household energy consumption	Income, Weather, urbanization, household size, lifestyle, householder age
43	Energy requirements of households in Brazil	C. Cohen, M. Lenzen, R. Schaeffer	2005	Household energy consumption in Brazil	Income
44	Study on affecting factors and standard of rural household energy consumption in China	W. Xiaohua, F. Zhenmin	2005	Rural household energy consumption in China	Income, annual temperature
45	The Effects of Household Characteristics and Energy Use Consciousness on the Effectiveness of Real-	D. Allen, K. Janda	2006	Household energy consumption	Income, energy monitoring system, eco-consciousness

No.	Research Title	Author	Year	Study Target Area	Factor Identified
	Time Energy Use Feedback: A Pilot Study				
46	A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan	M. Lenzen, M. Wier, C. Cohen, H. Hayami, S. Pachauri, R. Schaeffer	2006	Household energy consumption	Income, household size, housing type (S/M), urbanization
47	Socioeconomic Factors Affecting Household Energy Consumption in Qom, Iran	E. Mehrzad, A. Masoud, E. Mansour	2007	Household energy consumption in Iran	Eco consciousness, urbanization
48	Household energy requirement and value patterns	K. Vringer, T. Aalbers, K. Blok	2007	Household energy consumption	Eco-consciousness
40	Energy-related intervention success factors: a literature review	D.Uitdenbogerd, C. Egmond, R. Jonkers, G. Kok	2007	Household energy consumption	Household size, income, householder age, dwelling characteristics, technological improvement, eco consciousness, lifestyle
50	Short-term prediction of household electricity consumption: Assessing weather sensitivity in a Mediterranean area	M. Beccali, M. Cellura, V. Lo Brano, A. Marvuglia	2008	Household electricity consumption	Weather
51	Changing of energy consumption pattern from rural households to urban households in China: An example from Shaanxi Province, China	J. Cai, Z. Jiang	2008	Rural and urban household energy consumption	Urbanization
52	The household energy transition in India and China	S. Pachauri, L. Jiang	2008	Rural and urban household energy consumption	Income, energy price, urbanization

2.3 Energy Efficiency Policies

Energy efficiency is often guided by individual human behavior, such as avoiding the misuse of energy and using the appropriate equipment. On the other hand, it also depends upon the availability of technology or simply proper decision making for investments regarding domestic appliances or devices (World Energy Council 2004). Cost related energy efficiency decisions are mainly based on the tradeoff between the present cost of the product and future savings in terms of energy expenses.

The common offers of energy savings tend to look more lucrative when energy prices are high. The goal of energy efficiency policies is the creation of necessary conditions to speed up the development and the deployment of energy efficient equipment, and to make people use energy more efficiently (i.e., get the maximum output from minimum input of energy). The objectives are fulfilled through dispersion of information and communication with the final consumers. Other approaches involve sharing risks with producers and distributors, improvement in the research and development process in the field of energy efficiency, deployment of specific financing mechanism, regulations of appliances and equipment for consumers, and more (World Energy Council 2008).

Over the past 30 years several energy efficiency policies have been implemented in the OECD countries, which were guided mainly by three drivers. A first wave of policies followed the economical concerns that evolved during the oil embargos of the 1970s. Another driver was the environmental concerns that started in the early 1970s due to urban smog and acid rain and later in the more global context of climate change. The third driver was ever increasing energy prices (Norberg-Bohm 2000). Policy makers responded in two ways, through supply-push and demand-pull policies. Supply-push policies stimulated technological innovations while demand-pull policies created a market for emerging energy technologies. Supply push policies are mostly mandatory regulations, economic incentives and financial help for industries. Demand-pull policies are, for example, environmental regulations, regulations related to utilities, information and awareness programs, and subsidies for specific energy saving technologies. An example of a significant demand-pull policy was the Public Utilities Regulatory Policies Act (PURPA) of 1978 that was the first step to deregulate the vertically integrated industries. Following the PURPA Act, the Energy Policy Act of 1992 and the Energy Efficiency Improvement Act of 2007 were the next noteworthy steps towards energy efficiency in the United States.

The following section presents an overview of the different types of energy efficiency policies implemented in the OECD countries after the oil crisis of the 1970s. The policies tend to fall under the following general categories: mandatory regulations, financial incentives and subsidies, information and awareness programs, and voluntary agreement of the industry with the government.

2.3.1 Mandatory Regulations

Codes or Standards remove inefficient products from the market, leaving consumers to choose among a wide array of more efficient products (Nadel 1997). Although building codes can be traced back to Hammurabi's law (Hammurabi and Johns 2000) which was issued almost four thousand years ago, energy efficiency codes did not emerge before the late 1950s. Originally set up to improve comfort in Scandinavian countries, they were transformed into tight energy saving strategies in the early 1970s when the first oil shock rippled through these countries. The Kyoto protocol initiated a similar effect on building codes around the globe, as the building sector was identified as a major contributor to CO_2 emissions. Many countries try to put into practice minimum efficiency standards to reduce energy use. Implementing such standards help in achieving national and international objectives, such as reducing energy expenses, air pollution, emission of green house gases, and dependence on imported energy sources. In the United States, California was the first state to initiate appliance efficiency standards in 1974, and later, in 1978, the National Energy Policy and Conservation Act (NEPCA) directed the United States Department of Energy (DOE) to develop mandatory efficiency standards. The Japanese government has made it compulsory to submit an energy conservation plan as part of planning permission documents for large buildings. Mandatory standards help to get around problems caused by lack of knowledge and information on the part of the consumer (Anderson 1993).

2.3.2 Financial Incentives and Subsidies

Financial incentive programs are targeted towards consumers or companies by offering them direct financial motivation for reducing energy consumption as well as investing in energy efficient equipment (Gillingham et al. 2004). The financial incentive programs are of different types: incentives for consumer purchases, income tax credits or deduction programs, or emission allowance programs. The initial utility programs of the 1970s were often information and loan programs, with the goal to educate consumers about the cost effectiveness of energy efficiency measures and to provide subsidized financing to invest in those measures. Gradually it became evident that education alone produced limited energy savings and most consumers were interested in financial incentives (Stern et al. 1985). Rebates were one of the first financial incentive programs which were used extensively in the form of cash rebates given out to the consumers who purchased designated energy efficient equipment (Gillingham et al. 2004). Income tax credits or deductions are federal or state level policy instruments to encourage energy efficiency investments in the United States. Presently there are no federal level income tax credits or deductions for residential energy efficiency investments, but there is a federal income tax deduction for the purchase of hybrid vehicles. Though some of the literature finds this program to be effective (Durham et al. 1988; Williams and Poyer 1996) others draw the opposite conclusion that this program is ineffective (Carpenter and Chester 1984; Dubin and Henson 1988).

Some countries established subsidies or preferential loans through public-private partnerships between government and banks, which ultimately carry out the application and qualification process that is required in order to be eligible for these loans. Subsidies have been common instruments in many of the developed OECD countries. Usually the residential grants have been for insulation and weather stripping (Anderson 1993). Examples of this strategy are the Low Energy Building program in Austria, or the United States mortgage market influenced by the guidelines of Fannie Mae. Some of the energy efficiency policies implemented in the United States, as a part of which grants are given out to low income people (Low Income Weatherization Program), are very similar to the policies implemented in the Netherlands and Sweden where grants are given out for rented accommodations. Loans were given out by the government below the market interest rate to promote the widespread use of energy efficiency products. The Swedish government gives soft loans to promote energy efficient building construction and the Dutch government to promote combined heat and power (CHP) district heating schemes (Anderson 1993).

2.3.3 Information and Awareness Programs

The information and awareness programs consist of the entire attempt made by governments of the OECD countries to induce energy efficient investment by providing all information about potential energy savings. Energy Star is one of the effective energy efficient programs, encompassing a broad range of programs, all designed to encourage energy efficient investments in the United States. The program started with computer monitors and has in later years expanded to most other residential and official equipment commonly in use and, finally, residential heating and cooling equipment. Other notable efforts by DOE include Building America, The High Performance Building Initiative and Zero Energy Building Initiative. The Building America program offers technical assistance to homebuilders and assists in interaction between different segments of the home building industry. The High Performance Building Initiative is a program in which DOE works with architects, engineers, and building owners to improve the energy efficiency of new commercial buildings.

Similar efforts have also been implemented in other OECD countries. For example, the United Kingdom government declared 1986 Energy Efficiency Year to draw public attention to energy conservation and efficiency. This included large scale television advertising campaigns. Every year Japan has an Energy Conservation Month with large scale publicity. In addition to this Japan also has an Energy Managers Program where technical manuals and handbooks are provided along with technical advisory service and training programs.

Energy audits have proved to be efficient, where the customer is given a detailed analysis of their energy use combined with conservation advice (Anderson 1993). In some cases, for instance in Japan, the government itself provides the audit service; whereas in other countries like the United Kingdom the use of energy consultants is subsidized. The United States requires the gas and electricity utilities to provide the same audit service.

Furthermore, initiatives have been taken where consumers are provided with the details of their regular energy consumption through the help of energy metering. A energy policy in Spain mandates that consumers shift to a smart meter which gives detailed information about the energy used by different appliances and equipments hour by hour (Plan for the Progressive Replacement of Electricity Meters (Smart meters)). Similar efforts have been carried out in the United States at the state and local levels, where the state government or municipalities enter into a voluntary agreement with the utility companies to provide the consumer with detailed information. Literature found in this area suggests that information and awareness programs are successful in achieving energy efficiency by targeting the market failures associated with the problem of imperfect information (DeCanio 1998; Howarth et al. 2000).

2.3.4 Voluntary Agreements

Voluntary Agreements are programs where firms voluntarily agree to take on goals to improve efficiency or save energy. Some early examples of voluntary agreement programs implemented in the United States are Voluntary CO_2 Reductions, DOE Climate Challenge, and Partnership for Advanced Technology in Housing (PATH). As a mandate of the 1992 Energy Policy Act implemented in the United States, a national inventory of greenhouse gases and national database of voluntary reduction in greenhouse gas emission was created. The purpose behind this action was to persuade companies to voluntarily reduce their greenhouse gas emissions by making public commitments. This allowed companies to set noble goals and thereby improve their public image. Data shows that a large number of companies are investing their time and resources to register their emission reduction (Gillingham et al. 2004). The PATH program is a voluntary public–private partnership involving multiple stakeholders such as homebuilders, product manufacturers, insurance companies, and financial companies, and the United States Department of Housing and Urban Development (HUD). This program provides information about the latest improvements in residential housing technologies and promotes research on new housing technologies with the intent of improving energy efficiency, affordability, durability, environmental suitability, and resistance to natural disaster of residential housing. Little or no research has been performed to analyze the effectiveness of PATH (Gillingham et al. 2004).

2.4 Energy Efficiency Policy Evaluation

As discussed in Chapter 1, energy policy evaluation is required to improve the planning and implementation of policies and also to check the effects of already implemented policies with respect to necessity, efficiency, validity, and cost effectiveness. Constantinescu and Janssen (2007) list the major reasons for conducting energy policy evaluation as the need (1) to monitor progress in the reduction of energy use, (2) to perform a regulatory impact assessment and cost benefit analysis, (3) to assess the environmental consequences before any action is taken, and (4) to maintain a best overall mix of demand side measures and supply side measures. Their paper further mentions that energy policies can be improved by the assessment of issues, such as the amount of energy savings achieved by a typical measure, and the cost at which the impact has been achieved.

Before funding any energy program on a large scale, it is important to investigate whether or not such an environmental intervention will be successful in term of ecological efficacy and economic efficiency (Frondel and Schmidt 2005). An earlier typical way to approach this investigation process was to choose from certain possible considerations that are supported by explicit economic theory. According to Lovins (1985), "a kilowatt-hour saved is just like a kilowatt-hour generated" which confirms the efficacy of energy efficiency policies. In contrast, Wirl (1997) argues that with increase in technological efficiency demand increases.

As mentioned by some researchers, the major issue of energy efficiency policy is evaluation, which includes evaluation of the results achieved, evaluation of the targets, and evaluation of relative situations among countries (Bosseboeuf et al. 1997b). From past studies by the OECD and other developing countries it is evident that cross country comparison of energy efficiency policies is difficult (Bosseboeuf et al. 1997b; IEA 1994; Jollands and Ellis 2009; Lee Schipper 1995). According to Jollands and Ellis (2009) it is even more difficult to generalize the evaluation method for a whole class of policies across many countries of the world. This is due to different types implemented in different countries and the various assumptions made by evaluation experts; the heterogeneous nature of the data used for definition and measurement; and the fact that efficiencies are different from one country to another and interpretation of similar ratios diverge considerably (Bosseboeuf et al. 1997a). On the other hand, such studies are of immediate benefit, if countries want to learn from the experiences of other countries. The development of such a generalized evaluation method will be of utmost importance for non OECD countries, which are in the early stages of developing energy efficiency policy portfolios. According to Jolland and Ellis (2009) such cross country energy policy evaluation methods can also help countries with a longer history of energy efficiency policies to fine tune their energy efficiency policy portfolio by studying experiences of other countries.

Literature review shows instances of attempts made to summarize the lessons learned from evaluations for the policies of several European countries and the United States (Gillingham et al. 2004; Gillingham et al. 2006; Harmelink et al. 2008; Jollands and Ellis 2009). There are very few researchers who have attempted such analysis on a global scale (Jollands and Ellis 2009; Lund 2007). Figure 2-1 shows the analysis of the gap in the existing literature. In this attempt previous studies have been divided into five major categories:

i. Evaluation of effectiveness of different types of energy efficiency policies
ii. Calculation of estimated energy savings by energy efficiency policies
iii. Evaluation of energy efficiency policy portfolios of countries/states

iv. Evaluation of particular types of energy efficiency policies across countries/states

v. Evaluation of energy efficiency policy portfolios across countries/states

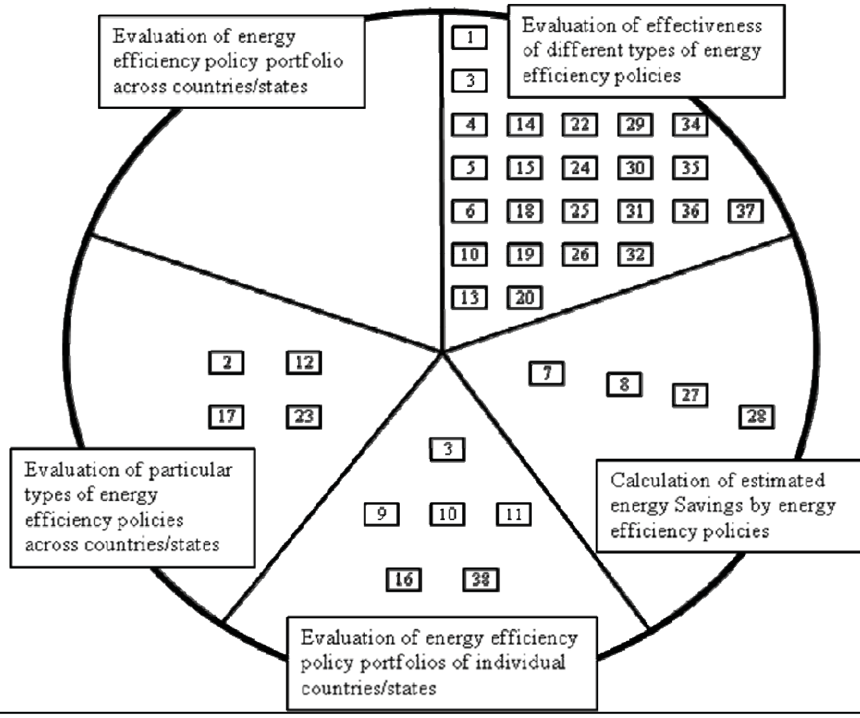

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Figure 2-1 Gap Analysis

Many research initiatives are found in the first four categories, which are discussed below. However, only one ongoing research initiative, by the International Council for Research and Innovation in Building and Construction, has been found under the fifth category (CIB 2010).

Research has been found evaluating the effectiveness of energy efficiency policies. These studies can be further subdivided based on the kinds of policies evaluated by the individual research. Gillingham (2006) has presented an exhaustive review of available literature evaluating the effectiveness of energy policies implemented in the United States.

Several studies have evaluated the effectiveness of appliances standards (Hausman and Joskow 1982; Soft 1993; Sutherland 2003). Lawrence Berkeley National Laboratory (LBNL) has been working as the primary contractor for engineering and economic analysis of appliance standards for the United States Department of Energy (USDOE) since 1982. LBNL has 20 full time analysts to produce technical and economic analyses of alternative standards. However, the final decision of selecting a standard to make it a mandate is upon the DOE (Sutherland 2003). A study by LBNL assesses the potential energy, dollar, and carbon impacts of energy efficiency standards implemented at the state and national levels. The research uses historical and projected shipments of equipment, a detailed stock accounting model, calculated and predicted unit energy savings involved with the standards, estimated growth in capital costs, demographic data, and fuel price data available and accounts for improvements in efficiency that are likely to occur in the absence of standards (Koomey et al. 1998). Another study investigates the effectiveness of the minimum standard on cold appliances using the British market as a case study (Schiellerup 2002). In this research "the timing and magnitude of market transformation as a result of the minimum standard is shown in the context of historical rates of change, the aspirations of Directive 96/57/EC and the development in price". Research has been found measuring the effectiveness of implementing appliance efficiency standards in developing countries such as Malaysia (Mahlia et al. 2001; Mahlia et al. 2004; Masjuki et al. 2001) and Hong Kong (Lam and Hui 1996).

Research has been found evaluating the effectiveness of the tax credits for residential energy improvements (Hassett and Metcalf 1995; Pearson and Smith 1991; Quinlan et al. 2001; Stern et al. 1986). A study by Hassett and Metcalf (1995) uses panel data on individual tax returns and variations in state tax policy to measure the impact of government tax policies in encouraging residential conservation investment. In a study on the impact of tax credits on adoption of solar energy systems, Durham et al (1988) econometrically determine that the level of state tax credits has a statistically significant effect on the probability of solar installation, with an elasticity of 0.76 with respect to the level of the tax credit. On the other hand, two other studies have also econometrically estimated the effect of tax credits on energy conservation investments but concluded that it is statistically insignificant (Dubin and Henson 1988; Walsh 1989). Another study evaluates the tax incentive as a policy tool for increasing research and development growth among private companies (Bozeman and Link 1984).

Efforts have also been found analyzing the effectiveness of information and voluntary programs (Alberini and Segerson 2002; Banerjee and Solomon 2003; Khanna 2002; Lee and Yik 2004). In a review, Howarth et al. (2000) suggest that information and awareness programs like Energy Star has successfully saved energy by reducing market failures related to imperfect information and bounded rationality. Performing an econometric analysis of the EPA's Green Light Program, DeCanio and Watkins (1998) conclude that such programs can induce energy-saving investment, improve corporate performance, and reduce pollution. An independent review analyses the voluntary Partnership for Advanced Technology in Housing (PATH) and concludes that the goal set by this program is not only laudable but largely unattainable (NAS 2000). Another research evaluating 56 PATH activities initiated between 1999 and 2001 recommended improvements for the program but did not provide any estimated energy or cost savings resulting from the energy efficiency component of the program (NAS 2000).

It is not an easy job to measure the energy savings resulting from energy efficiency standards. This is due to the difficulty of defining baseline energy use and isolating the impact of technical improvements in efficiency from other changes in usage patterns (Meier 1997). Meier calculated the observed energy savings from the implementation of appliance efficiency standards. In an ex ante study, Geller (1997) estimated the total energy savings from appliance standards in 2000 as 1.23 quads and later, in another study, he estimated the energy savings as 1.2 quads in 2000 and cumulative net benefits of $196 billion through 2030. Two other studies on the cost effectiveness of utility-based demand side management programs estimated that utility-based demand side management enables megawatt cost savings to be in the range of $0.008–$0.067/kWh saved (Fickett et al. 1990; Nadel 1992).

On the other hand, studies have been found evaluating the energy efficiency policy portfolio of a country/state (Banerjee and Solomon 2003; Geller and Attali 2005; Gillingham et al. 2006; Jaffe et al. 2005; Wiser et al. 2005). Harmelink et. al. (2008) performs an ex-post evaluation of energy efficiency policies implemented in Europe. Such efforts are also available in developing countries like China (Sinton et al. 2005; Wu et al. 1994) and Hong Kong (Lee and Yik 2002).

Efforts have been found of evaluating policies across countries/states (Austin et al. 2009; Harrington and Damnics 2004; Jollands and Ellis 2009; Lin and Fridley 2006). Jollands and Ellis (2009) comment on the methodological challenges with an international meta-analysis of policies across countries and concludes that despite the difficulties, such international meta-analysis is possible. Austin et. al. (2009) discuss how manufacturers, distributors, and other sellers throughout the world are notified of the requirement for appliance testing and certification, proper labeling and marketing of the certified efficiency, and proper withholding of non-complying models from the entity's area of jurisdiction; and they provide a summary of each entity's analysis of the success or failure of manufacturer and/or distributor cooperation. A comprehensive guide to energy labeling and standards implemented on a global scale can be found in the works of Harrington and Damnics (2004). That study also provides a guide to resources where the most up to date information can be found, along with references to more in-depth and detailed material. In an attempt to analyze international efforts to globalize efficiency standards for products such as office equipment, external power supplies, and compact fluorescent lamps, Lin and Fridley examine several recent cases of such efforts on a global scale (Lin and Fridley 2006).

2.5 Conclusion

From the above discussion it is evident that much research has been performed in the first four categories, i.e., evaluation of the effectiveness of different types of energy efficiency policies, calculation of estimated energy savings by energy efficiency policies, evaluation of energy efficiency policy portfolios of countries/states, and evaluation of particular types of energy efficiency policies across countries/states. But only one ongoing research initiative, by the International Council for Research and Innovation in Building and Construction, has been found under the category for evaluation of energy efficiency policy portfolios across countries/states. The lack of existing research in the area of cross-country evaluation of energy efficiency policy portfolio has prompted the author to investigate this area in further detail. This has provided the motivation for the current research in which a framework for evaluating energy efficiency policy portfolio across countries/states is developed.

Chapter 3. Identifying Socio-economic Factors Affecting Household Energy Consumption

In this chapter the socio-economic factors affecting household energy consumption are analyzed from human behavior perspectives. It begins with the identification of the different functional domains that influence human behavior in terms of energy consumption such as *economy, technology,* etc. Past researches have expended effort in studying various individual factors responsible for increases in household energy usage, while other studies have tried to analyze the effect of standard of living and individual income on overall household energy consumption. However, none of the past studies associate individual consumption factors with the functional domains that influence human behavior. In this chapter the identified energy consumption factors are further analyzed and are associated with the various functional domains that influence human behavior.

3.1 Role of Human Behavior in Energy Consumption

Several researches have stressed the importance of the social and psychological aspects of human behavior for achieving energy efficiency (Moezzi et al. 2009; Shove 2003). Energy conservation can be achieved both by technological improvement and by changing human energy consumption patterns. But most of the time it is the technological improvements that are represented explicitly in energy efficiency study. The main reason for this is that technology diffusion is an easy quantitative measure: the risk of assumptions can be reduced greatly, unlike the study of energy usage behavior. According to DeMeo and Taylor (1984), social and psychological aspects of human behavior should be considered to achieve energy efficiency.

Shove considers humans as autonomous shoppers whose choices determine the fate and future of the planet (Shove 2003). In other words, the adverse environmental impact that is perceived now and is anticipated in the future have their causal roots embedded in human behavior (Nickerson 2003). Taking into consideration the future of the planet, one cannot ignore the looming threat of soaring energy usage by humans and the various countermeasures attempted. As a natural corollary, the question arises: ‘Why haven’t we had greater success with our efforts to promote energy conservation?’ Lutzenhiser (2002) addressed this question succinctly by considering a “set of system characteristics, including the social embeddedness of energy use, the constrained nature of household choice, the counter marketing of consumption lifestyles and behaviors, and the lack of impetus for change". Brown and Cameron in their research reiterate the importance of human behavior in energy efficiency study by explaining how people are responsible for energy consumption decisions and are capable of taking knowledgeable and responsible decisions based on their concern about the environment (Brown and Cameron 2000). Review of existing literature shows strong support of the premise that human behavior has significant influence on energy consumption. Being decisive about human behavior as the cause (directly and indirectly) of household energy consumption, this research identifies the categories of grouped influences which, once altered, will cause a change in behavior patterns. These categories are also referred as functional domains.

3.2 The Functional Domains

The social and economic dimension of energy efficiency, which first surfaced in 1987's Brundtland Report (UNWCED 1987), was addressed in a more integrated fashion by Elkington (1994) via an article in the 'California Management Review on 'win-win-win' business strategies'. In the year that followed, Elkington formulated the 'triple bottom line', which refers to people, planet and profit. Being indecisive about taking steps to protect the language by using trademark, he started using the term in public and later in his book (Elkington 1998). These terms, which were primarily coined to resonate in the business brain, have been recognized as the primary agenda for energy efficiency. With time, different organizations have adopted the 'triple bottom line' as their guidelines; USGBC is one such organization. Considering the significance of people, profit and planet in energy efficiency, this study has formulated three domains, namely: the Environmental domain, the People domain and the Economic domain. In the context of this research, the aforementioned domains have been used to categorize the various human factors responsible for residential energy consumption. While the domain names are self explanatory, the environment domain looks into human behavior factors which are caused by environmental issues such as temperature, humidity, climatic conditions, etc. The people domain encompasses human behavior factors, which are a result of psychological influences, social influences, demographics, household structure, etc. The economy domain includes the human behavior factors having monetary implications. In addition, a fourth domain has been included in this study, referred as the technology domain. The significance of technology as a determining factor towards energy efficiency resonated in the work of eminent environmentalists such as Paul Ehrlich and Barry Commoner as early as four decades ago (Hart 1997). The human behavior factors affecting residential energy consumption caused by technological improvement are included in this domain.

3.3 Factors Affecting Energy Consumption

Potential causes of residential energy consumption have been investigated in previous studies, which only represent viewpoints of respective investigators who are concerned with specific problems. A systematic study of the various factors affecting residential energy consumption that are linked to human behavior perspective has never been performed. This research develops an approach to study the energy consumption factors from a human behavior perspective.

This approach adapts the method of the Cause & Effect (C&E) Diagram that was invented by Kaoru Ishikawa in the 1960s. It is a graphical analysis tool that helps to sort and identify possible causes of a factor. The causes are displayed based on their level of importance using a hierarchical, structured approach. The main cause areas are the main branches of the C&E diagram mentioned as the categories in this research. Other possible causes related to those categories or branches are attached to them as sub-branches—major causes. The minor causes and sub factors are further identified and attached as sub branches to the major cause branches. Figure 3-1 shows a typical example of a cause and effect diagram.

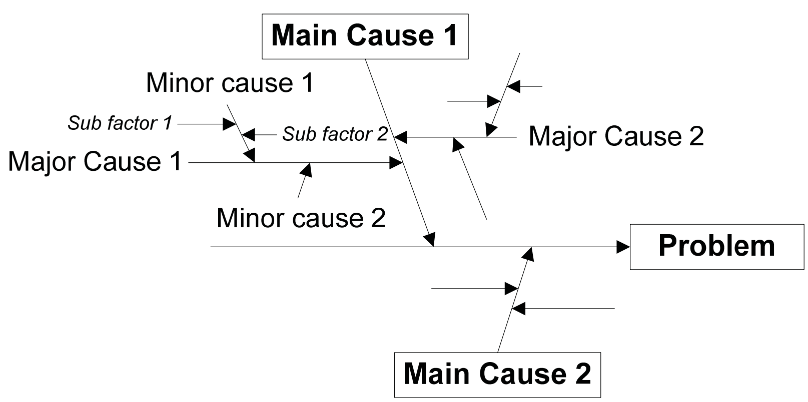

Figure 3-1 Typical example of a C&E diagram

The research investigates the factors and the sub-factors affecting residential energy consumption in five broad categories. Grouping the factors affecting household energy consumption, identified in Chapter 2, has formed these five broad categories: demographics, technology, consumer attitude, economy, and climate. Previous researchers have found that a change in any of the above mentioned categories creates a change in the energy consumption per capita, which are discussed in chapter 2. The five broad categories mentioned above constitute the main categories of the C&E diagram as shown in Figure 3-2. Under each of the categories, the cause factors for residential energy consumption are placed and further explored to identify the sub-factors and the minor factors. The factors that are identified multiple times will be explained only once and briefly introduced in the other cases.

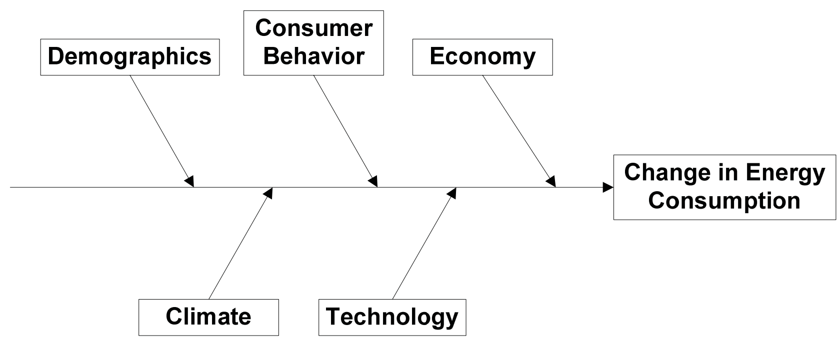

Figure 3-2 The C&E structure of variable energy consumption

Although the five perspectives or categories of the C&E Diagram might not be of equal importance in their influence on residential energy consumption, none of them can be ignored. The following section explains each of the five perspectives, major factors, minor factors and sub factors of the C&E Diagram and their associations.

3.3.1 CATEGORY 1: Demographics

Existing literature reveals the importance of household demographic factors such as household size, dwelling size, time spent at home, level of urbanization, etc., when determining residential energy consumption (Haas 1997; O'Neill and Chen 2002; Tiwari 2000). In the study concerning "300 families' home energy use" conducted by Morrison and Gladhart (1976) the most significant determinants of household energy consumption were: family size, age distribution, the number of wage-earners in the household, and the occupancy time in the house. These factors appear as sub-branches of the core demographics branch as shown in Figure 3-3. Each of the household demographic factors is explained below.

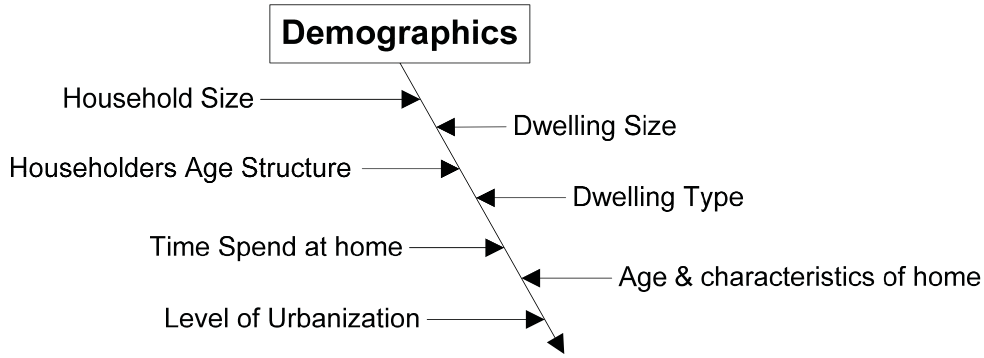

Figure 3-3 The major cause factors in demographics category

3.3.1.1 Household Size

Household size simply refers to the number of people per household. Many researchers argue that occupancy has the strongest influence on variation in energy consumption (Bakhtiari and Shahbudaghlou 2000; Bouchelle et al. 2000; Brown and Rollinson 1985; Haas 1997; Halvorsen and Larsen 2001; Lam 1998; Lenzen et al. 2004; Lenzen et al. 2006; O'Neill and Chen 2002; Pachauri 2004; Schipper et al. 1985; Tiwari 2000; Tso and Yau 2003; Uitdenbogerd et al. 2007; Van Raaij and Verhallen 1983; Wier et al. 2001). To be more specific, Lenzen et. al. (2004) indicated a negative correlation between household size and energy consumption per capita which is due to household members simply sharing consumer items. Differences in household size again can result from a cultural background, economic condition, family life cycle, and income level.

3.3.1.1.1 Culture

Culture for example has here been depicted as a sub-branch of household size as certain cultures still support the concept of big families (also known as joint family), while in other cultures nuclear families are more predominant. Consequently it is often found that family size is influenced by the culture of the members.

3.3.1.1.2 Economic opportunity

Sometimes a single member from the household moves to an **area with greater job availability**, thus causing a change in the household size (Bhattacharjee and Reichard 2009).

3.3.1.1.3 Family life cycle

Household size to a large extent depends on the family life cycle. Family life cycle is defined by Van Raaij and Verhallen as "a construct that combines age and household composition" (Van Raaij and Verhallen 1983). Young families most of the time have fewer household members; but with the birth of a child, family size increases, and then decreases again when the child grows up and leaves home. Thus energy use tends to fluctuate over the family life cycle. Energy consumption not only depends on the family life cycle and the number of children at home, but also on the age at which the children leave home, the divorce rate, and the number of retired parents living with their children (Schipper et al. 1985).

3.3.1.1.4 Economic condition

At the same time, it is frequently observed that people with low income level are often found sharing an apartment or house so as to reduce their monthly living expenditures. This will lead to an increase in the household size of the shared apartment.

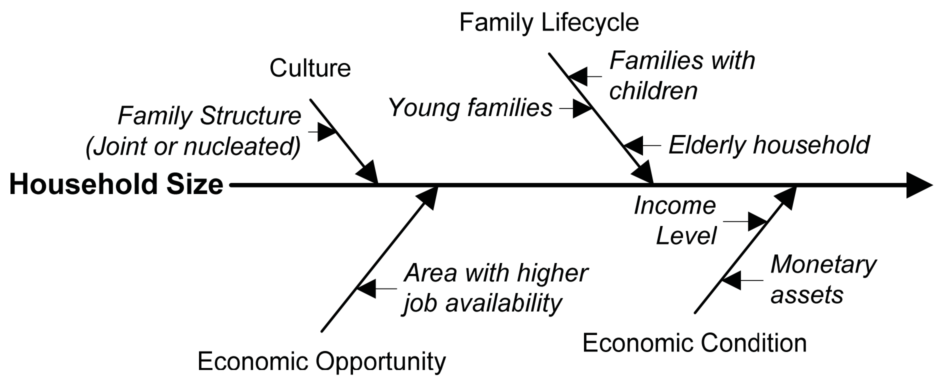

Figure 3-4 The minor causes and sub-factors of household size

3.3.1.2 Householder's Age Structure

Householder's age refers to the average age of the people living in a household. It has a strong influence on the residential energy requirement (Junk et al. 1987; Lenzen et al. 2004; Morrison and Gladhart 1976; O'Neill and Chen 2002; Pachauri 2004; Tonn and Eisenberg 2007; Uitdenbogerd et al. 2007; Van Raaij and Verhallen 1983). The results of a statistical analysis performed by Pachauri (2004) indicate that where the head of the household is in the range of 25-29 years old, the per capita energy requirement is about 7% more than where the household head is less than 25 years old. This percentage further increases by 13% when the household head is above age 50. Much of the energy used by older people is based on their health and comfort (Mileham and Brandt 1990). Some of the reasons put forward as responsible for the increase in per capita energy consumption with age are **lack of information and knowledge** about energy conservation and energy usage patterns, **inertia to change**, and importance of **well being** which is controlled by health and comfort. Each of the above mentioned reasons will be discussed in detail under the relevant sections.

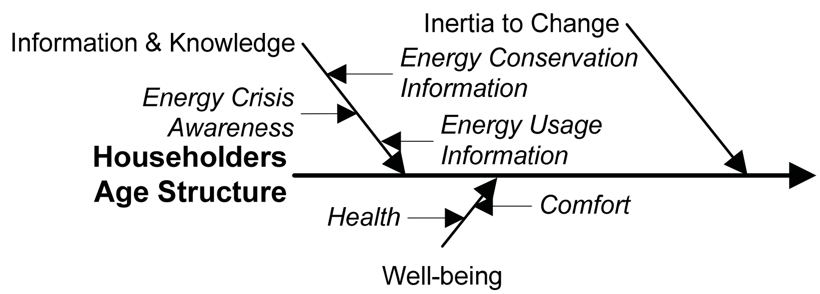

Figure 3-5 The minor cause and sub-factors influencing energy consumption due to household age structure

3.3.1.3 Time Spent at Home

Energy consumption has a direct correlation with the amount of time the dwelling is occupied. The more time a person spends at home, the more energy they use for day to day activities. The factors that affect the time spent at home are:

3.3.1.3.1 Work type of household member

Young households without children and both partners working outside the home tend to have a low level of energy use as compared to the families who either stay at home or work from home (Van Raaij and Verhallen 1983).

3.3.1.3.2 Family life cycle

Family life cycle has a strong correlation with time spent at home. With the birth of a child a family starts spending more time at home thus increasing the energy consumption per capita. After the children grow up and move out, the house energy consumption decreases, but it again increases with the age of the parents (Brown and Rollinson 1985; Van Raaij and Verhallen 1983). This increase of energy use in the later years is because older persons spend more time at home and need higher indoor temperature for their health and comfort (Tonn and Eisenberg 2007).

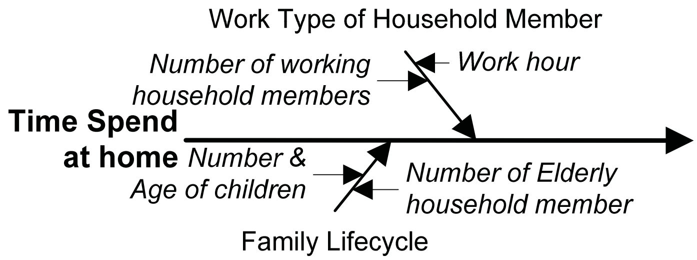

Figure 3-6 The minor causes and sub-factors influencing time spent at home

3.3.1.4 Level of Urbanization

Urbanization is defined by the United Nation as the movement of people from rural to urban areas with a population growth equating to urban migration. Rapid urbanization causes a rise in energy consumption per capita (Bakhtiari and Shahbudaghlou 2000; Dzioubinski and Chipman 1999; Lenzen et al. 2006; Mehrzad et al. 2007; Pachauri 2004; Pachauri and Jiang 2008). With the urbanization of lifestyle the proportion of energy used for cooking decreases, but the proportion of energy used for recreation and comfort increases considerably.

Urbanization occurs when individuals relocate to urban areas to improve their opportunities for income, education, housing, and transportation. One of the major reasons for urbanization is to seek **economic opportunities**. Another reason for the shift from rural to urban can be improved **standard of living (**i.e., with the improvement in health facilities, type of fuel used, types and number of appliances used, and comfort level).

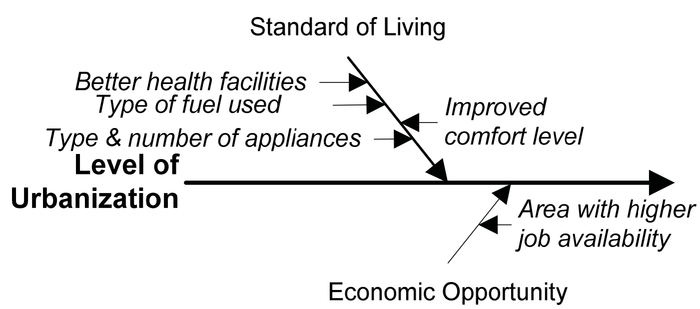

Figure 3-7 The minor causes and sub-factors influencing level of urbanization

3.3.1.5 Dwelling Size

Mileham and Brandt (1990) have found that the size of a dwelling is the best predictor of money spent on energy, since 21% of the variation in energy costs is attributed to the size of the dwelling. According to Morrison and Gladhart (1976) the number of rooms in a dwelling contributes towards the total energy consumption of a house. The increase in the square feet area of houses increases the energy required for space heating, cooling, and lighting. Factors affecting the size of the house are as follows.

3.3.1.5.1 Population density

The higher the population density (population density = number of people per square mile) the lesser will be the space available for individual housing. Despite their economic prosperity the Japanese most of the time live in smaller apartments or houses in comparison to Americans. The explanation for this kind of behavior pattern among the Japanese is their population density, which does not support their having larger and more spacious houses as Americans do.

3.3.1.5.2 Family life cycle

Family life cycle is an important determinant of dwelling size. Families at the beginning of their journey start with smaller houses but increases in household size and better economic condition result in shifts to larger homes.

3.3.1.5.3 Economic Condition

Dwelling size has a positive correlation with the economic condition of the household.

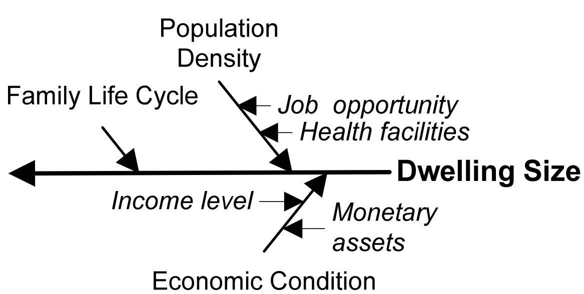

Figure 3-8 The minor causes and sub-factors influencing dwelling size

3.3.1.6 Dwelling Type (Single or Multi family)

Different types of dwellings include single family house, town house, multi-family house, apartment, or even mobile home. Single family detached homes are the most energy intensive dwelling type, consuming more BTU per household than any other type (EIA 1995; O'Neill and Chen 2002; Poortinga et al. 2004). The housing unit type depends to a large extent on economic status, population density and location. **Economic condition**, which depends on both income level and monetary expenditure level, is one of the important guiding factors for dwelling size. Individuals with better economic status will be able to afford bigger houses. The higher the **population density** in an area, the higher is the demand for multifamily housing/condominiums. A typical example for this would be large cities like Chicago and New York. **Location** is another determinant of dwelling type. Housing in and around college towns is predominantly of the multi-family variety.

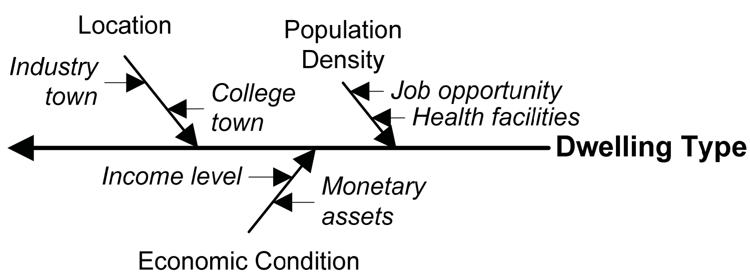

Figure 3-9 The minor causes and sub-factors influencing dwelling type

3.3.1.7 Age and Characteristics of Dwelling

According to some researchers increase in the age of the dwelling increases the amount of energy consumed for space heating or cooling considerably (Junk et al. 1987; Mileham and Brandt 1990; Tiwari 2000). Older houses often lack energy efficiency and hence require capital investment for incorporating conservation measures, especially insulation and storm windows. "Dwelling characteristics" refers to degree of home insulation, wind exposure, glazing, efficiency of HVAC system, etc., which have a direct influence on energy end use (Beccali et al. 2008; Schipper et al. 1985; Van Raaij and Verhallen 1983). Following are the factors which induce people to continue living in old dwellings and refrain from investing in energy efficiency improvements to a dwelling.

3.3.1.7.1 Householder's age

Mileham and Brandt (1990) found older people to be less handy at home improvements and require others' help, which imposes additional cost. As noted by Smiley (1979), older people are less willing to invest in energy conservation measures considering the shorter future life span, thus preferring to dwell in older homes instead.

3.3.1.7.2 Information and knowledge

Consumers often are not aware of their energy consumption pattern. Neither are they aware of how to reduce energy consumption. The monthly utility bill does not include the breakdown of consumption by individual equipment and systems. Thus consumers are left in the dark about the consumption patterns of individual equipment. Kempton and Layne (1994) in their research suggested that the utility companies need to provide more information in utility bills if they expect consumers to use energy rationally.

3.3.1.7.3 Inertia to change

The inherent nature of people to be wary of investing in energy efficiency of their dwelling in spite of the probability of receiving higher returns on investment reflects an inertia to change. They fail to recognize the higher return on investment in energy efficiency initiatives over time and give way to investment with immediate gain (ACG 2004).

3.3.1.7.4 Economic condition

Home weatherization and energy efficiency improvements are costly affairs and are beyond the affordability of people with lower economic conditions. Due to lack of capital and high interest rate for loans, it is often found that some potential borrowers such as low income individuals cannot afford to invest in energy efficiency improvements. Research showed that when a customer borrows money to invest in energy efficient products, its efficiency reduces the risk of the lender, but that on the other hand does not reduce the interest rate (Golove and Eto 1996).

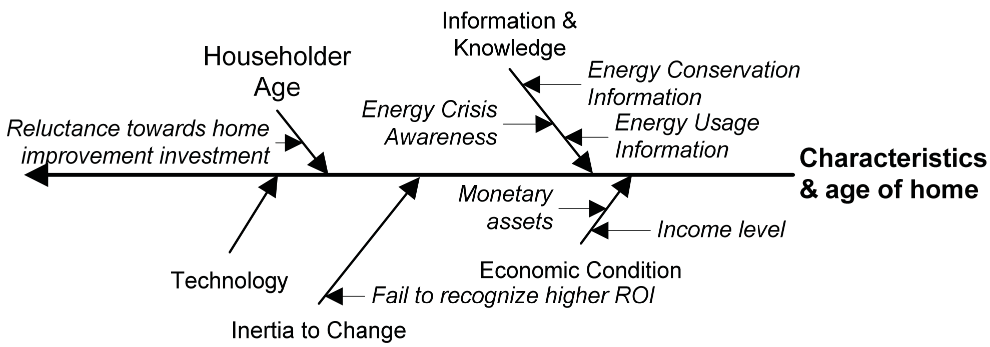

Figure 3-10 The minor causes and sub-factors influencing characteristics and age of home

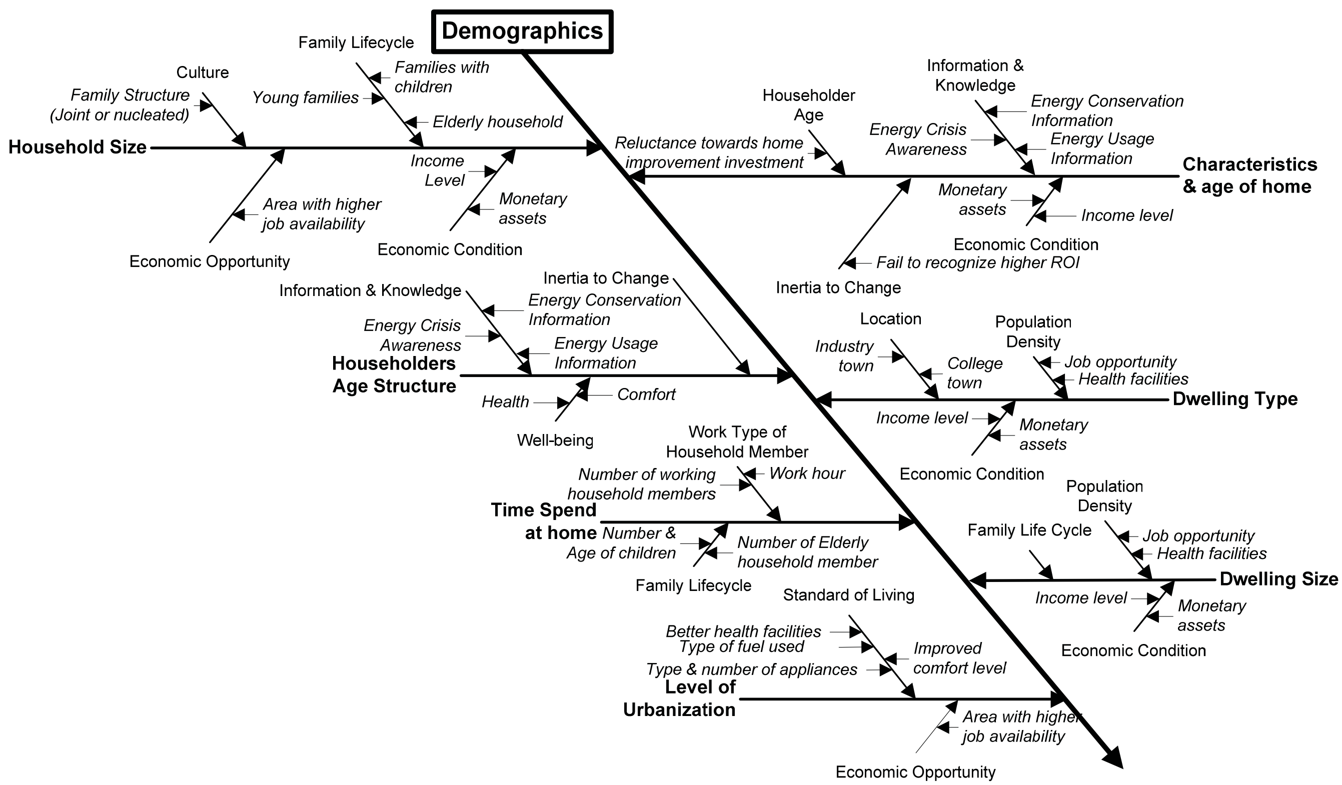

Figure 3-11 The C&E diagram under demographics category

3.3.2 CATEGORY 2: Consumer Attitude

Consumer attitude has a profound influence on energy end use. Just as energy consumption depends on determinants such as income, dwelling size, dwelling type, dwelling characteristics, etc, so attitude, knowledge, positive experience, culture and social status are also important determinants of energy use by an individual or a group (Uitdenbogerd et al. 2007). The factors placed under this category depend on the nature or characteristics of the particular individual or group.

Psychological research has tended to focus narrowly in the area of energy consumption behavior. Such psychological studies have traditionally focused around consumers' decision to alter energy use behavior, to participate in conservation programs or to invest in energy efficient technology. Based on the Theory of Reasoned Action (TRA), a psychological attitudes model of energy consumption was developed by Lutzenhise (1992). According to the model, behavior is governed by two basic determinants, one of which is personal influence (personal attitude towards that behavior) and the other reflecting social influences (subjective norm).

TRA was developed by Martin Fishbein and Icek Ajzen in 1975 and was derived from a previous research known as the 'theory of attitude'. In the words of Hale et al. the theory was "born largely out of frustration with traditional attitude-behavior research, much of which found weak correlations between attitude measures and performance of volitional behaviors" (Hale et al. 2002). Based on the theory of reasoned action, individual behavior is governed by two basic determinants, one of which is personal influence (behavioral belief) and the other reflecting social influences (normative belief).

This is also in accordance with the outcome of the research conducted by Hans-Ulrich Zabel (Zabel 2005). Zabel found that human behavior is the product of "three constituting components: cultural shaping (cultural artifacts, education, socialization, and enculturation), genetic predisposition (pattern recognition based on instincts, needs, drives, etc.), and situational correctives".

Thus the main factors considered to influence consumer attitude and in turn affect energy consumption can be further grouped as **Personal Influence** and **Social Influence**. They are as follows.

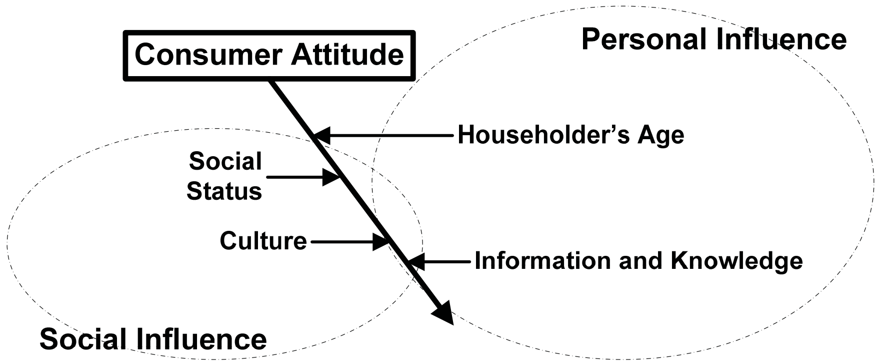

Figure 3-12 The major cause factors of consumer attitude

Personal Influence

According to the TRA, attitudes are a function of personal beliefs. Generally a person who believes that performing a task will lead to a positive outcome will hold favorable attitudes towards that behavior. This belief that underlies a person's attitude towards the behavior is termed as personal influence. For example, a person who believes that keeping the indoor air temperature high in the extreme winter season will keep himself and his family comfortable and healthy, will always keep the indoor air temperature high. Now when the same person believes that due to his extensive use of energy a situation may arise in the future where his grandchildren will suffer, he might not waste as much energy today. Personal belief about energy conservation and motivation to save energy are termed as eco-consciousness.

Increasing knowledge about an energy crisis tends to make people more eco-conscious. Past researchers have found that the total energy requirement between the least motivated and average motivated group of people is about 4% of the total energy requirement (Vringer et al. 2007). Eco-conscious attitudes do not always lead to energy conserving behavior (Van Raaij and Verhallen 1983). Studies about the characteristics of socially concerned individuals have posited the following variables to have the most significant influence towards eco-consciousness.

3.3.2.1 Householder's Age

According to many researchers younger people are more concerned about environmental quality than older people (Balderjahn 1988; Liere and Dunlap 1980; Webster 1975). The contrary position, that age has a positive correlation with eco-consciousness, has also been suggested by

Harry (1971) though most of the other studies did not support this contention. In explaining the reason for the attitude differences by age, Malkis and Grasmick (1977) draw on Manheim's (1972) *Theory of Generation* which suggests that important events occurring at the young adulthood phase of life can permanently affect an individual throughout their life. Based on Manheim's theory, Liere and Dunlap (1980) conclude "continued exposure to alarming information on environmental deterioration (via news media, environmental education courses, etc.) has left a indelible imprint on young people during the past decade, forming an ecology minded generation whose commitment to environmental reform should not disappear as they move to adulthood".

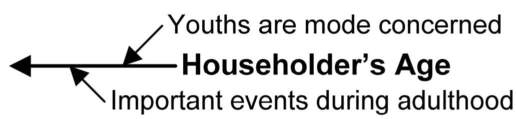

Figure 3-13 The minor causes influencing energy consumption due to householder's age

3.3.2.2 Education and Knowledge

Level of education appears to have an impact on energy conservation beliefs and behaviors (Cunningham and Lopreato 1977). Junk et. al. (1987) in his research found that increasing levels of education resulted in lower consumption levels. Other studies have also reported formal education as a factor towards energy conservation (Yergin 1980). Another study performed in 1984 proved that people with higher levels of education were more likely to take conservation measures (Junk et al. 1984).

Several researchers have found a positive correlation between knowledge and energy conscious behavior (Balderjahn 1988; Berkowitz and Lutterman 1968; Liere and Dunlap 1980; Roberts 1996; Tognacci et al. 1972). This includes knowledge of energy costs, energy usage, energy conservation behavior and energy consequence of these behaviors (Van Raaij and Verhallen 1983).

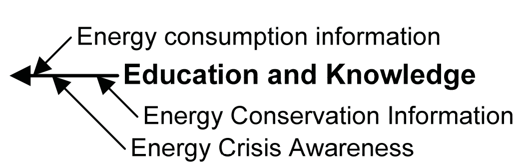

Figure 3-14 The minor causes influencing energy consumption due to education and knowledge

Social Influence

The attitudes of a person are also determined by his/her perception of social pressures put on him/her to perform or not perform a particular behavior. This action has been referred to as subjective norm in the TRA. Major factors that socially influence consumer attitude are **social status** and **culture**. The influence of social status is illustrated in the tendency of a person to buy bigger SUVs to maintain his/her status in society, even though a small sedan car would serve the purpose. Culture in this context refers to societal norms and traditions.

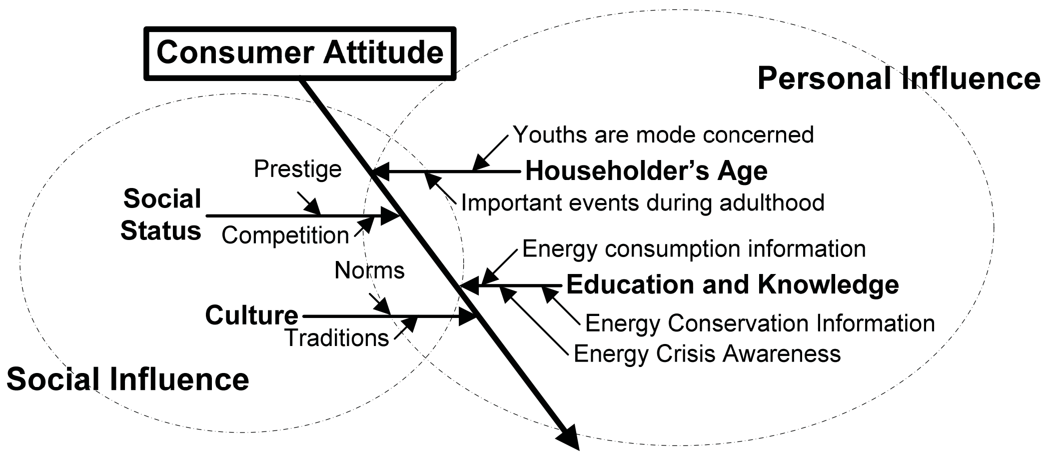

Figure 3-15 The C&E diagram under consumer attitude category

3.3.3 *CATEGORY 3:* Economic Variables

Economic growth has a strong influence on energy consumption of a country (Lam 1998). A healthy economy is essential to fulfill people's needs and also to assure efficient distribution of resources. Due to the increasing involvement of technology in our day to day life, the economic system now decides the consumption of technology and in turn affects the consumption of energy (Zabel 2005). The most important economic variables influencing residential energy consumption are total monetary expenditure of a household, income (Haas 1997; Karlsson et al. 2004; Vringer et al. 2007), energy prices (Haas 1997; Schipper et al. 1985), and energy efficiency equipment prices (Lam 1998).

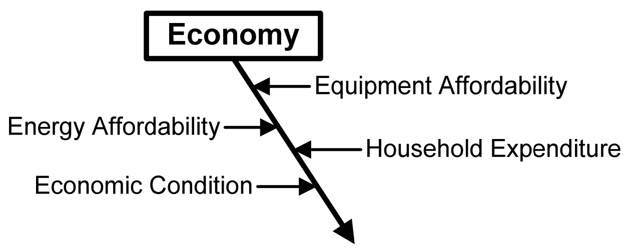

Figure 3-16 The major cause factors under economic category

3.3.3.1 Energy Affordability

Energy affordability refers to the price of energy related to the income level of a society/region. This means that energy affordability will not only depend on energy prices but also on the economic condition.

3.3.3.1.1 Energy price

Energy price is an important determinant of residential energy use in both the short and the long run (Archibald and Gillingham 1980; Halvorsen and Larsen 2001; Lam 1998; Schipper and Ketoff 1983; Schipper et al. 1985; Tiwari 2000). Along with reductions in energy use, increased energy prices also cause a shift in the types of energy used (Schipper and Ketoff 1983; Schipper et al. 1985). Dzioubinski and Chipman (1999) found that it is difficult to estimate the effect of energy prices on residential energy consumption in developing countries. This is because the majority of energy consumed are traditional fuels gathered informally without any monetary expenditure but mostly time (e.g., gather fuel wood). Another study performed by Hass et. al.

(1998) suggest "small differences in energy prices do not always have an impact on residential energy use. Only if the price exceeds a certain threshold is a reduction in energy demand observable".

Energy price does not always depend on the ***price and availability of crude oil*** but also on ***additional taxes, or surcharges*** for infrastructure and technology investments. ***Technological advancements*** make the process of fuel production more efficient, which leads to lower costs and ultimately makes fuel more affordable. On the other hand, fuel prices can be directly controlled through state mandates or taxes.

3.3.3.1.2 Economic condition

With the improvement in economic condition a growing share of household energy is used for lighting and electrical appliances (Dzioubinski and Chipman 1999).

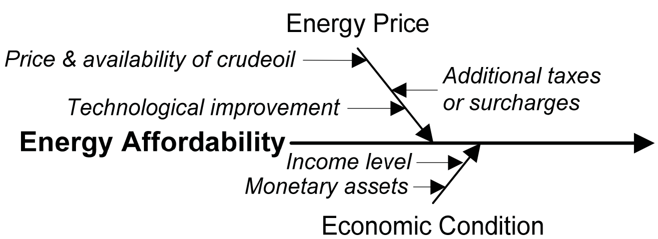

Figure 3-17 The minor causes and sub-factors influencing energy affordability

3.3.3.2 Economic Condition

Environmental consciousness is positively associated with the economic condition of the householder (Liere and Dunlap 1980). One explanation for this hypothesis is that people are concerned about environmental quality only after most basic material needs like adequate food, shelter and economic security are met (Dunlap et al. 1983). This explanation is based on Maslow's (1970) hierarchy of needs theory. Morrison et. al. (1972) further explains the hypothesis through the concept of relation depreciation. According to him poor people have experienced only poor physical conditions and are less aware of environmental pollution, compared to rich people who experience a pleasant environment and are hence concerned about the deterioration of the physical environment. Thus it is the relative depreciation that leads to environmental concerns. The lack of energy conservation knowledge among low income households has been documented by Cunningham and Lopreato (1977) and Brown and Rollinson (1985).

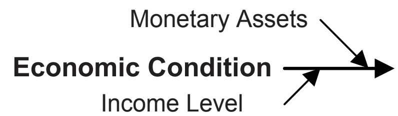

Figure 3-18 The minor causes influencing economic condition

3.3.3.3 Household Expenditure

Household expenditure refers to the spending behavior of the householder. Households with higher monetary expenditure have a higher energy requirement, which is evident from the research performed by Pachauri (2004). She also found that the difference in indirect energy requirements between households in different expenditure classes is much greater than the difference in direct energy requirements. All fuels and electricity consumed are referred to as direct energy use, whereas the indirect energy use comprises the energy embodied in all goods and services consumed. The monetary expenditure level of the household depends on **economic condition**.

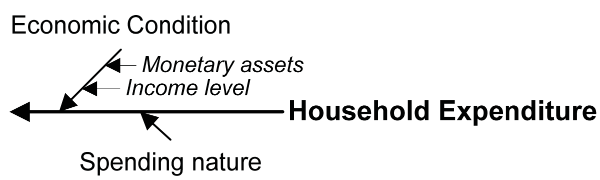

Figure 3-19 The minor causes and sub-factors influencing monetary expenditure of household

3.3.3.4 Energy Efficient Equipment Affordability

Energy consumption in the residential sector can be parsed into five major end uses: space heating, water heating, cooking, lighting and electric appliances. Appliances can be further broken down into refrigerators, clothes washers, dryers, dishwashers and even TV. However, the magnitude of each end use differs from country to country; for instance, in the United States it is important to consider air conditioning as another major end use. Appliance affordability refers to the cost of new and improved appliances in accordance with the wage level of a society. Appliance affordability caused the highest increases in residential energy demand (Haas 1997).

Affordability depends both on price and supply of appliances and **economic condition**. In this research appliance affordability is called equipment -affordability, as it also considers certain mechanical and electrical systems.

3.3.3.4.1 Price and supply of appliances

Technology is a driving factor with respect to price and supply of appliances, as ***technological improvements*** can simplify the production process and thus lower manufacturing costs. On the other hand the ***market*** has its own dynamic. In a global market the same equipment can show a wide range of different prices depending on marketing strategies targeted by manufacturers and businesses.

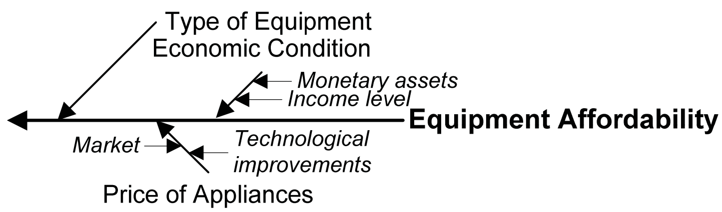

Figure 3-20 The minor causes and sub-factors influencing appliances affordability

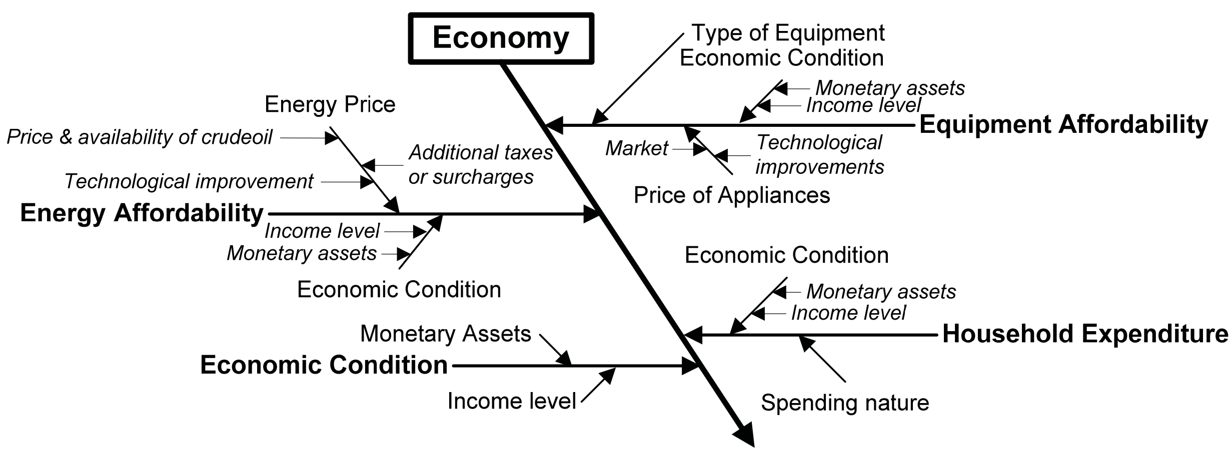

Figure 3-21 The C&E diagram under economy category

3.3.4 CATEGORY 4: Climate

In addition to the socio-demographic and socio-economic factors affecting energy demand, numerous studies have illustrated the influence of weather variables on energy consumption and especially on electricity demand (Beccali et al. 2008). The climatic environment in which a person lives not only affects the need for heating or cooling, but also plays a role in defining an individual's response behavior to different environments. Comfort levels are perceived differently for people living in different climates (e.g., temperature settings). Even if people live in the same climate, their behavioral response is different if they grew up or lived for a long time in a different climate. Day-to-day habits and practices of consumers originate to some extent in the climate where they live. Several national level and regional level studies have been performed in the US to determine how energy use in the residential building stock relates to climate (Amato et al. 2005; Huang 2006; Loveland and Brown 1990; Mansur et al. 2005; Rosenthal and Gruenspecht 1995; Ruth and Lin 2006; Scott et al. 2005). The climatic factors, which influence residential energy consumption, are weather, dwelling microclimate, and indoor air temperature.

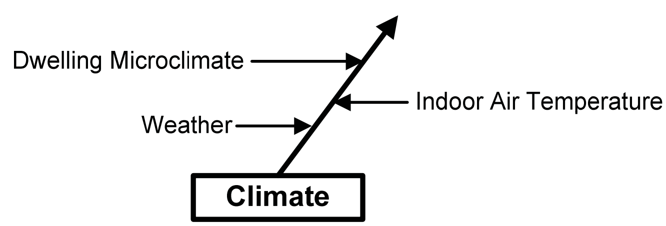

Figure 3-22 The major cause factors under climate category

3.3.4.1 Weather

In addition to the large number of human factors affecting the residential energy consumption, several studies have illustrated the influence of weather variables on energy consumption and especially on electricity demand (Beccali et al. 2008; Bouchelle et al. 2000; Haas et al. 1998; Meyers and Schipper 1984; Schipper et al. 1985). Weather refers to the atmospheric temperature. It influences the heating and cooling degree-days which are quantitative indices used by energy analysts when calculating the impact of outdoor temperature on energy use in buildings (Wilbanks et al. 2008). Every building has a minimum energy use temperature, i.e. when the building is neither heated nor cooled, which is called "balance point" for that building. Each degree deviation from the balance point results in either heating or cooling the building. This deviation from the balance point is mainly due to the atmospheric temperature (Wilbanks et al. 2008). The other factors which influence weather are humidity, wind flow and number of sunny days (Schipper et al. 1985).

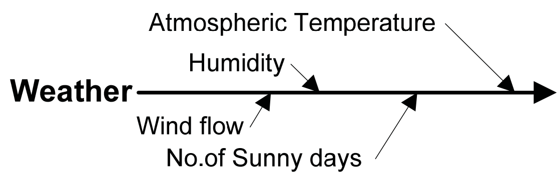

Figure 3-23 The minor cause influencing energy consumption due to weather

3.3.4.2 Dwelling Microclimate

Microclimate refers to the local temperature around a dwelling. An important reason for considering the microclimate in building design is to minimize the the building's energy use (Brown and Gillespie 1995). It can be assumed that people living in the same country share a similar socio-economic and climatic condition, and have access to similar technology. The differences of energy consumption observed across individual dwellings make it obvious that building micro climate has a major influence on the total amount of energy consumed. Small scale climate patterns resulting from the influence of topography, urban forms, water bodies, vegetation, etc. are known as Microclimates. These depend on factors such as weather, building orientation, neighboring objects, and building shape**.**

3.3.4.2.1 Building orientation

The orientation of the building has a strong influence on the energy consumption pattern. Rooms of a house in the northern hemisphere that are on the south side receive more direct sunlight on the walls and windows thus both heating and lighting the room during the day. On the other hand the rooms on the north side lose more heat than any other façade and also get diffused sunlight. The case is reversed in the southern hemisphere. From an ideal energy efficient design standpoint, the south façade of a building in the northern hemisphere, and thenorth façade of a building in the southern hemisphere, should maximize the utilization of solar access as solar energy is most intense from those directions.

3.3.4.2.2 Neighboring objects and weather

Presence of trees, buildings, a body of water, etc., around a building can significantly affect the energy use of the building through modification of theamount of *radiation* (solar and terrestrial radiation), *wind* speed and direction, *temperature*, and *humidity* (Brown and Gillespie 1995). Solar radiation is affected by mostly every object in the landscape. Trees typically allow one quarter of the solar radiation through in summer and three quarters through in winter (Brown and Gillespie 1995). This significantly affects the energy consumed for space cooling and heating respectively. Shading from surrounding buildings is not encouraged as it provides permanent shading all year round. In the winter season solar heat gain through external surfaces reduces the heating load considerably. Wind is another component of the building microclimate affecting the energy consumed by the people and the building. The landscape can be used either to increase or decrease the velocity of wind or to change its direction. Both temperature and humidity strongly affect the thermal comfort of individuals and the energy usage of the building. Though these cannot be significantly modified by the surrounding landscape, there are notable exceptions such as the "vest-pocket" parks in heavily urbanized areas like Manhattan. The presence of a water body surrounding a building often reduces the temperature and increases the humidity level of the air.

3.3.4.2.3 Building shape

Building shape can have a major influence on energy consumption. The detailed parametric analysis performed by AlAnzi et. al. (2009) indicated that "the effect of building shape on total building energy use depends on primarily three factors, the *relative compactness*, the *window-to-wall ratio*, and the *glazing type* defined by its solar heat gain coefficient". Relative compactness as described by Ourghi et al. (2007) in his research is the ratio of the volume to the exterior wall area and has a strong effect on energy consumed for spaced heating and cooling.

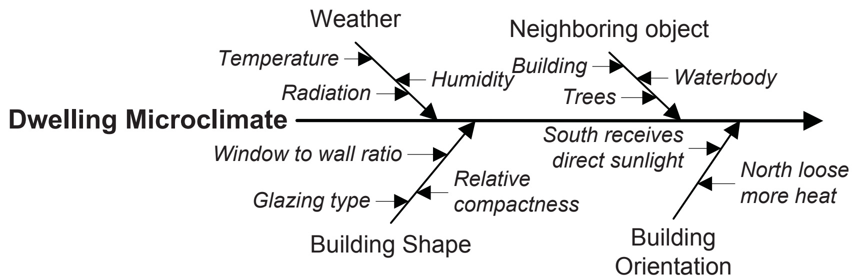

Figure 3-24 The minor causes and sub-factors influencing energy consumption due to micro climate

3.3.4.3 Indoor Air Temperature

The thermostat set point temperature of the HVAC system has a strong influence on the energy consumed for space heating or cooling. Though the designing of the HVAC system is done considering a fixed thermostat set point for heating and cooling season, building users often adjust the setpoint to their convenience. There are certain factors influencing the set point temperatures, such as householders' age, dwelling characteristics, atmospheric temperature, and lifestyle.

3.3.4.3.1 Householder's age

Most often the daytime and nighttime set point temperatures of the homes of older people are significantly higher than the rest of the population. This may be due to their acute health concern that requires warmer homes. Maintenance of a constant indoor temperature is important for the comfort and well being of older people as their bodies' temperature regulating capacity is diminished with age (Brown and Rollinson 1985; Mileham and Brandt 1990). Reduced temperatures in homes of elderly people can result in diseases like hypothermia.

3.3.4.3.2 Dwelling characteristics

Dwelling characteristics influence the rate of heat loss in a building. Heat losses from a building occur due to conducted loads through building envelope elements (walls, windows and roofs), and loads from leakage through doors and windows (infiltration and exfiltration). Heat transfer by conduction depends on the insulation quality (U value) of the envelope, which is measured by resistance to heat transfer. The building envelope should be designed tighter to reduce the energy consumed for space heating and cooling. Air also leaks into the building through cracks in the doors and windows, between foundation wall and sill plates, and at connections between walls made of different materials.

3.3.4.3.3 Weather

Heat transfer due to conduction is proportional to the temperature differences between the interior and exterior of a house. During the winter season if the external temperature falls, the heating system will run longer to reach the same set point temperature, as the heat loss through conduction will increase with the increase or decrease in temperature. The case is similar for the summer season. With the increase in the external temperature the heat gain through conduction will also increase, making the cooling system run longer.

3.3.4.3.4 Lifestyle

Day-to-day habits and practices of consumers might originate to some extent in the climate where they live. However, over years the adaption to a climate becomes part of a people's culture. It can also be observed that set-point temperatures for air conditioning units differ even in countries with comparable climate. Apparently, humans get accustomed to otherwise uncomfortable environments, if they are exposed to them just long enough (e.g., too cold set point temperatures of A.C. systems in hot climates, just because owners can "afford" it). Sooner or later a practice that originated in a status symbol suddenly becomes a life style. A person's life style is directly reflected in his/her consumer behavior and is influenced by the ***culture*** (Bhattacharjee and Reichard 2009).

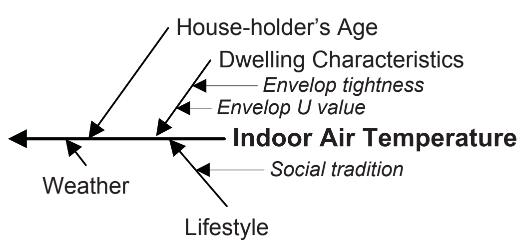

Figure 3-25 The minor causes and sub-factors influencing indoor air temperature

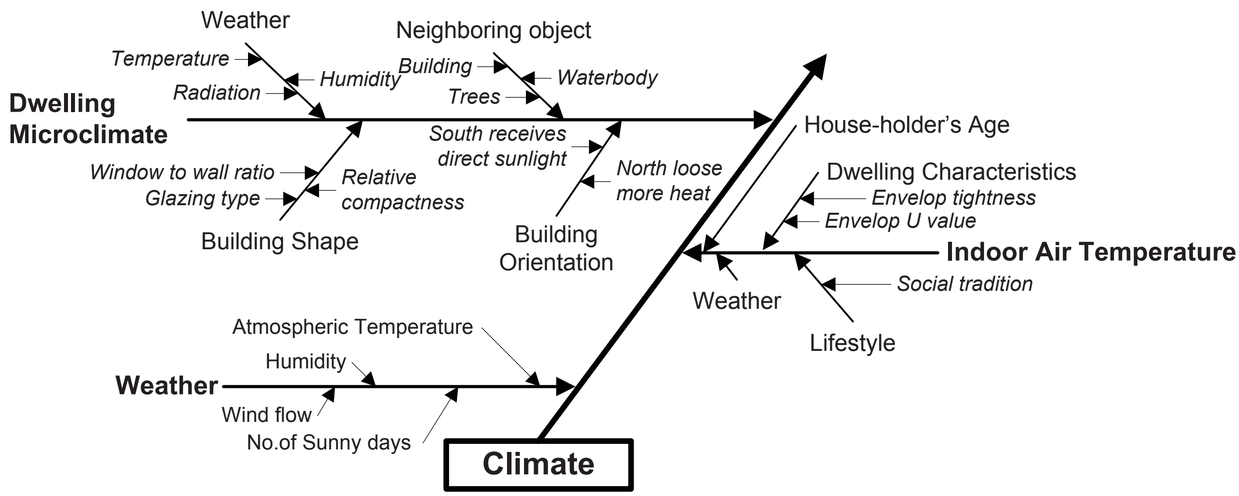

Figure 3-26 The C&E diagram under climate category

3.3.5 CATEGORY 5: Technology

Technological improvements including the development of building stock and improved energy efficient appliances, production of fuel, innovations of alternative fuel use, etc., affect the energy consumption rate of the residential sector (Schipper et al. 1985). Availability of technology to an individual is another important factor guiding the behavior of that person. The ease with which technology is available will determine the amount of technology a particular individual will use. For example, the millennial generation, which is growing up in this age of computers, cannot think of their life without them. On the other hand, earlier generations are still averse to using computers in their daily activities. Needless to say, the energy consumption of these two groups of people will vary significantly. The different ways in which technology influences residential energy consumption rate are described below.

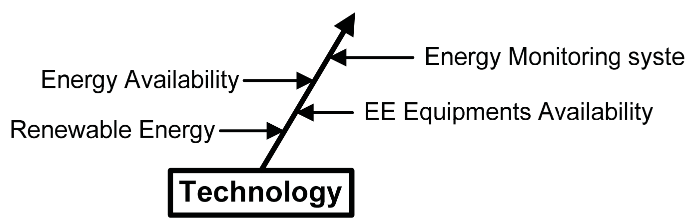

Figure 3-27 The major factors under technology category

3.3.5.1 Energy Availability

Energy Availability refers to the types and the amounts of fuels that are available in certain areas. Besides the obvious geographical/geological availability that can't be influenced, this factor strongly depends on the availability of technology. Technological advancements and infrastructure investments can directly support the availability of fuel in certain places. Furthermore, availability of fuel depends on price and availability of crude fuel.

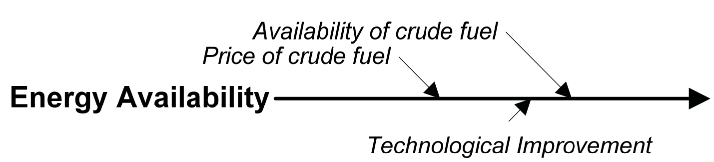

Figure 3-28 The minor causes influencing energy availability

3.3.5.2 Energy Efficient Equipment Availability

Energy efficient equipment is that which provides the same service as any other equipment of its type with considerably less amount of energy input. To make this equipment widely available in the market, research and development in the area of technology plays a major role.

Figure 3-29 The minor cause influencing EE equipment availability

3.3.5.3 Energy Monitoring System

Information provided to household members on domestic energy-consumption has proved effective in inducing household energy saving (Ueno et al. 2006). Numbers of previous research have been conducted to investigate this phenomenon. For example, research conducted by Mansouri and Newsborough (1999) analyzed the effectiveness of an appliance-specific display that showed energy consumption for cooking. Another study further classified the elements necessary for displaying energy information (Wood and Newborough 2003). Prior studies have also looked into the most effective energy saving technique among several feedback methods, such as computers, leaflets, etc. Display formats also play an influential role in providing information, which was investigated by Egan (1999). Egan (1999) explored the relationship between different display formats and the reaction to each from respondents. However, these studies do not take into account the energy awareness of the consumers due to display of detailed information on actual energy consumption. The development of an energy monitoring system mainly depends on technological improvements.

Figure 3-30 The minor cause of energy monitoring system

3.3.5.4 Renewable Energy

The troubles of people living mainly in rural areas with restricted access to modern forms of energy, can be ameliorated by the use of renewable energy (Painuly 2001). Renewable energy technologies are less expensive when compared with conventional energy sources, and include such technologies as solar water heating, off-grid electrification with solar photovoltaics (PV), small-scale biomass power generation, biofuels, grid-connected and off-grid wind power, small hydropower, geothermal power, and methane utilization from urban and industrial waste (Martinot and McDoom 2000). The main guiding factor for renewable energy in this context is technology development.

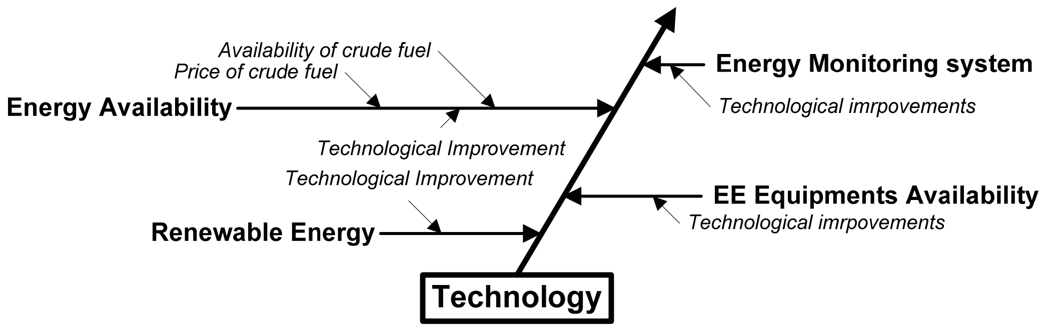

Figure 3-31 The C&E diagram under technology category

3.4 Associating the Energy Consumption Factors with the Functional Domains

In this section the factors affecting residential energy consumption identified above are associated with the functional domain. From the five broad categories of the C&E diagram, the demographic and consumer attitude falls within the People domain. Similarly, climate is a part of the environment domain. As the names suggest, economy and technology are part of the economic and technology domain respectively.

3.5 Identifying Control Elements under the Consumption Factors

Figure 3-32 shows the sequential steps to generate energy consumption control elements from the energy consumption factors under the demographics category. In the first step the elements that affect energy consumption are identified from the factors. The elements are formed from the key words of the major factor or the descriptive names. Identification of the control elements is followed by highlighting them and placing them under the major factors. The aforementioned process is executed with the help of an affinity diagram. Affinity diagrams are used to gather large amounts of data and organize them into groups based on their relationship.

In the process of identifying the control elements from the major factors, if more than one element is identified, then all of them are listed to avoid omission. If the same element is generated from multiple major factors under the same or a different category, it is also recorded in the diagram. This means that one element could lead to an increase in residential energy consumption under different circumstances. Here, only two levels are shown under the main category as any third level elements are merged into the second level.

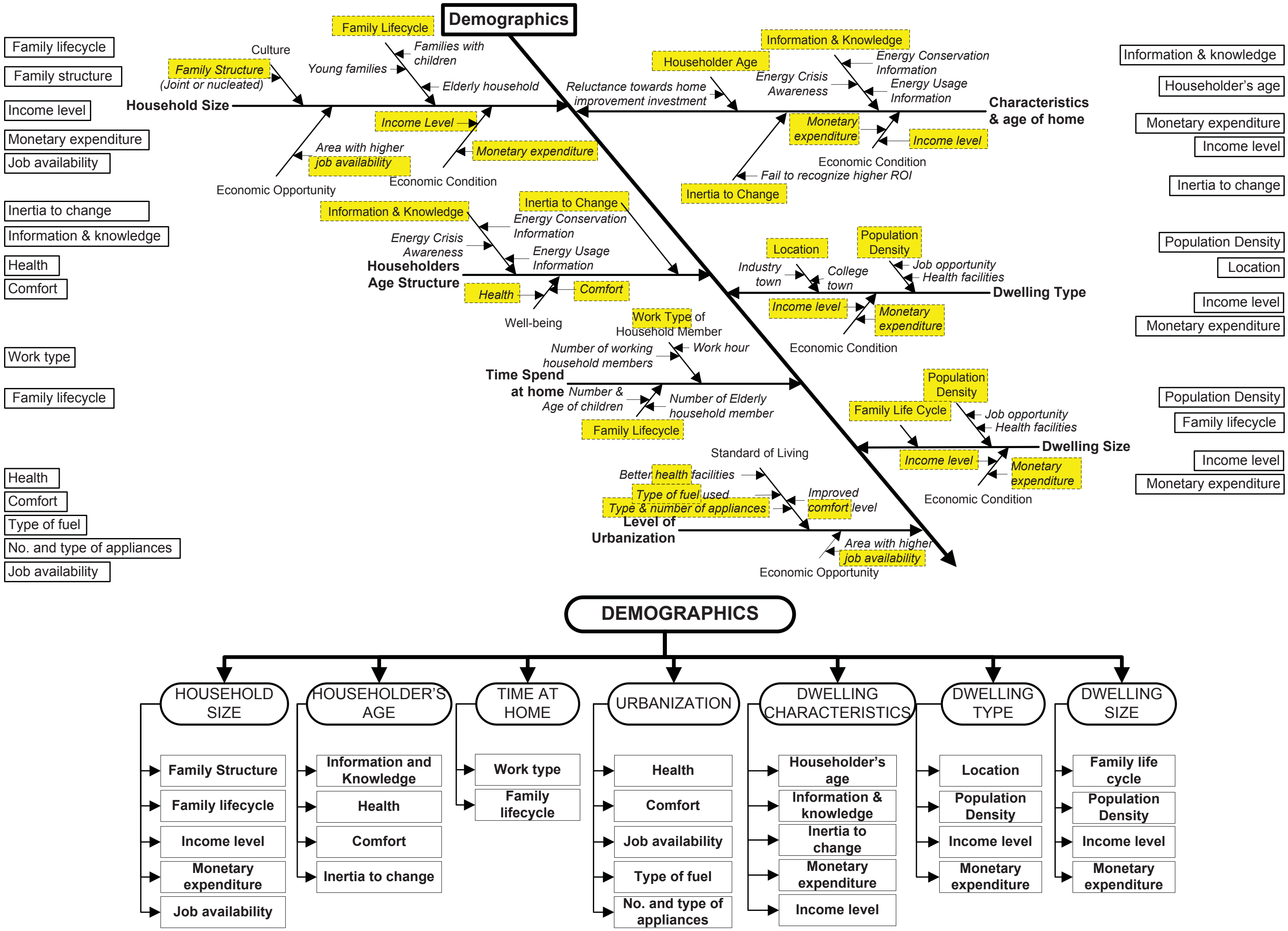

Figure 3-32 The process of identifying control elements under demographics category

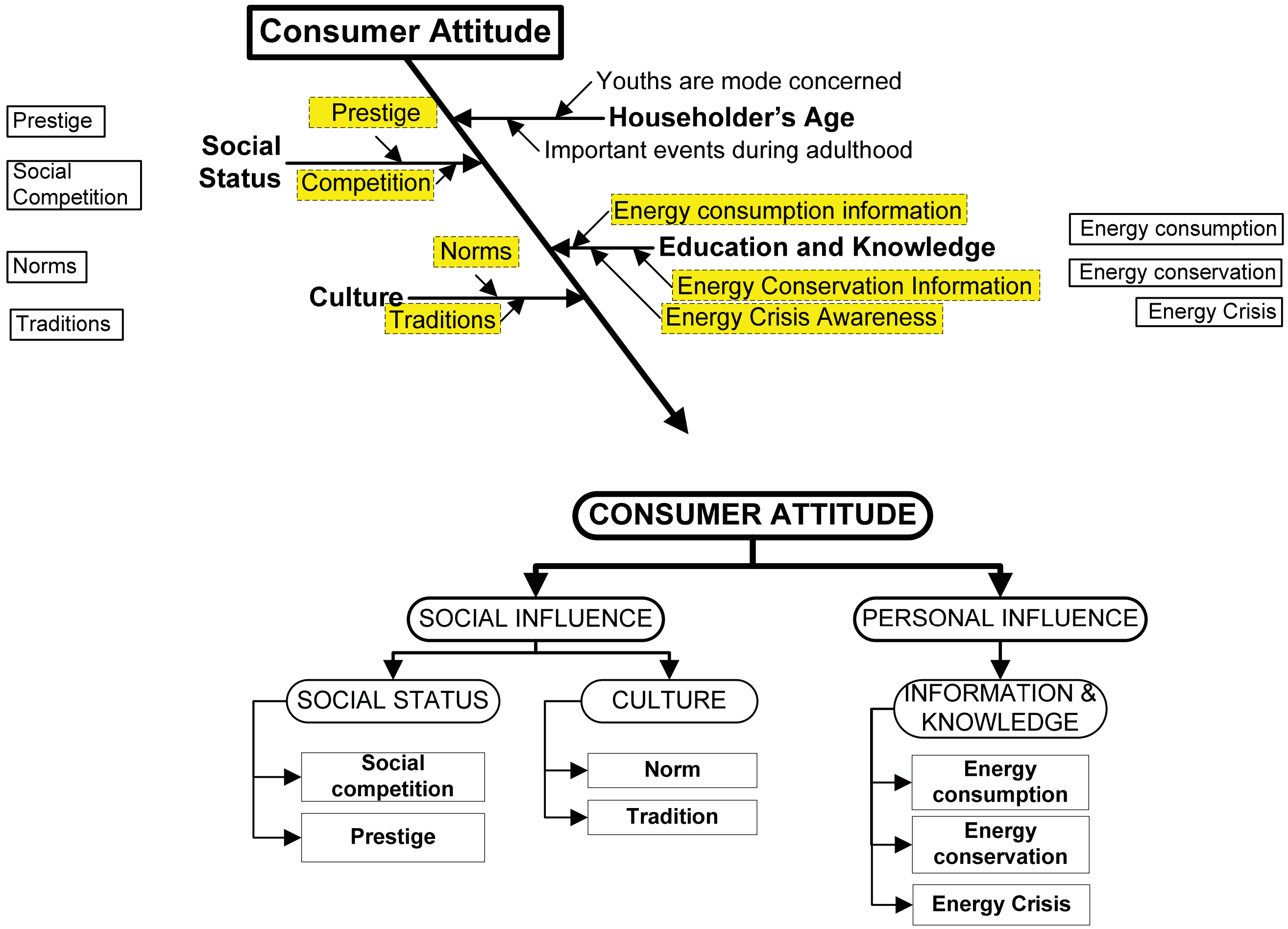

Figure 3-33 The process of identifying control elements under consumer attitude category

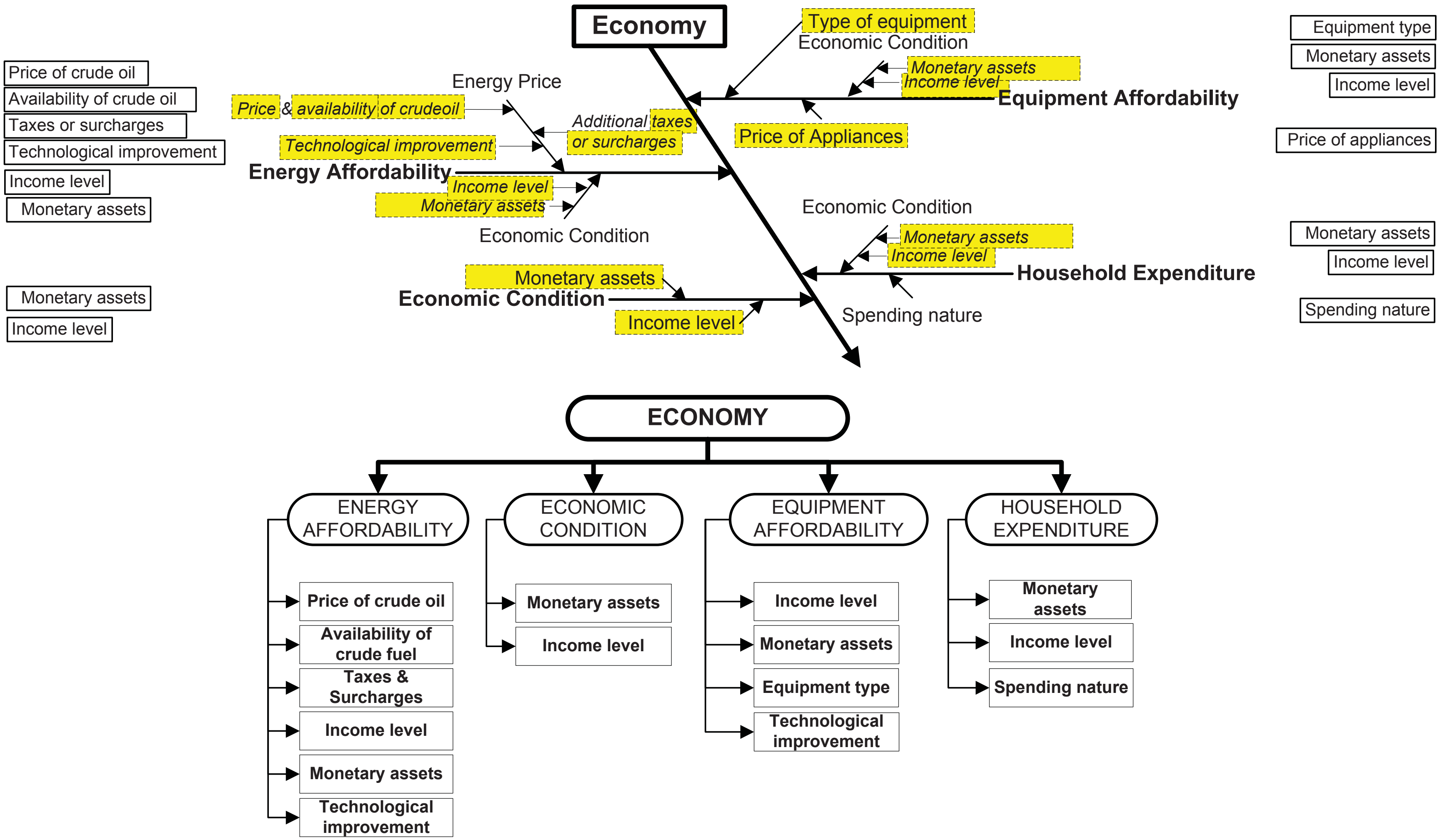

Figure 3-34 The process of identifying control elements under economy category

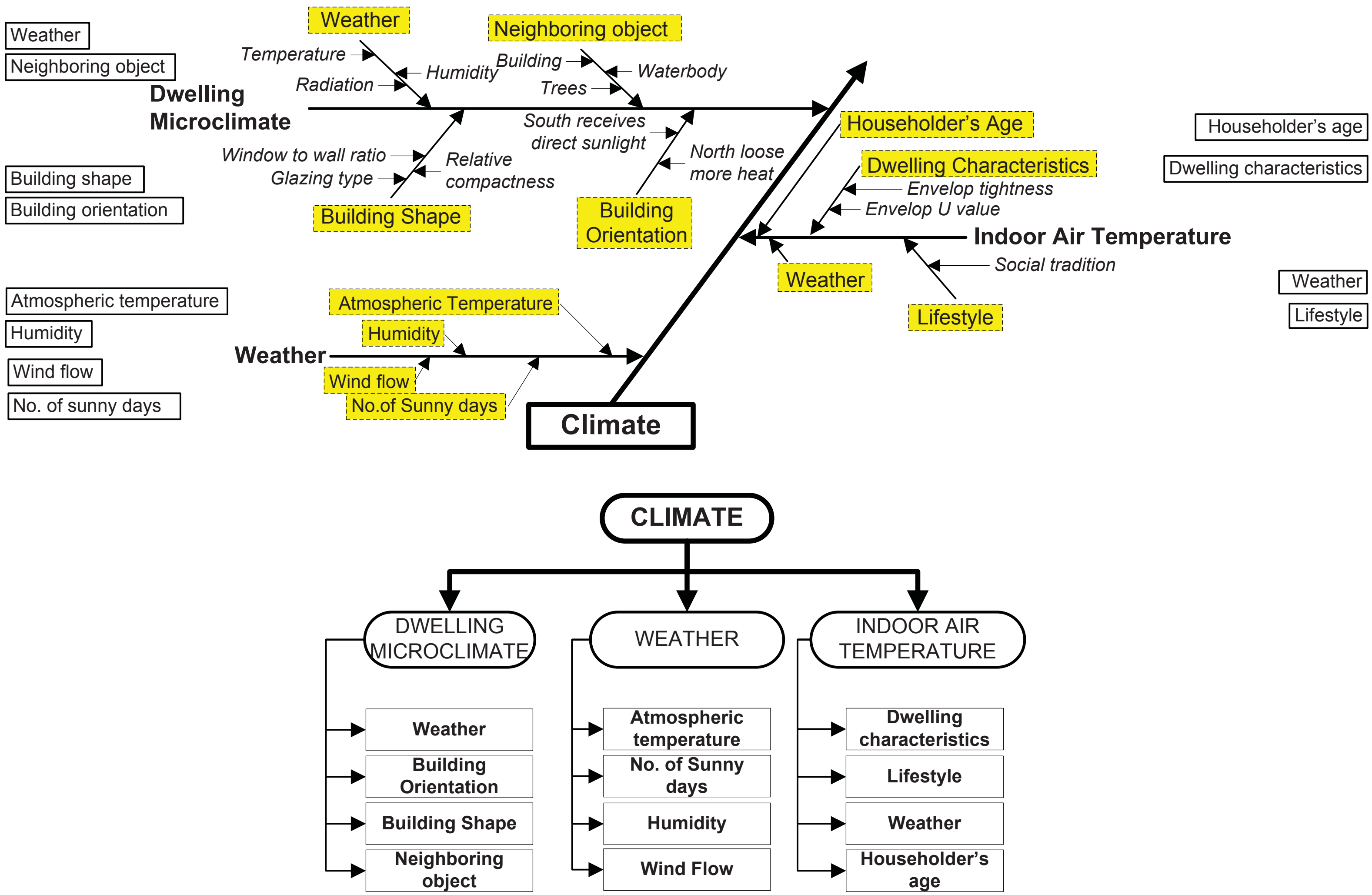

Figure 3-35 The process of identifying control elements under climate category

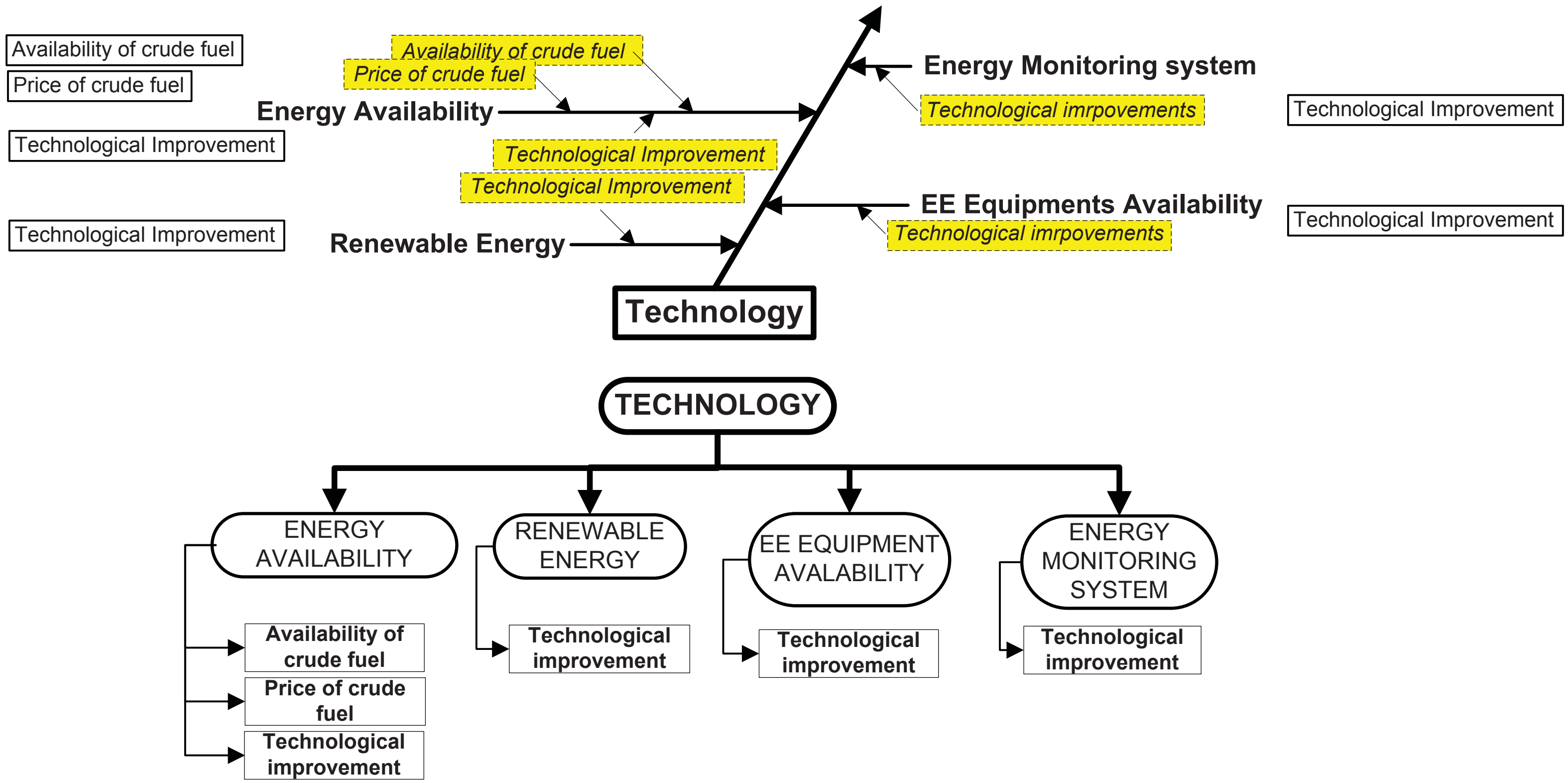

Figure 3-36 The process of identifying control elements under technology category

3.6 Conclusion

The important finding and achievements of this research are listed below:

This chapter adds a holistic view of the influence of human behaviors on energy consumption to the existing body of knowledge. The association of the energy consumption factors with the environmental domain in the chapter will provide policy makers an initial perspective on which particular domain has been identified to have the maximum influence on overall household energy consumption in a given socio-economic context.

The research successfully performs an analysis of the factors contributing towards the increase in residential energy consumption. The control elements identified under the five categories can be controlled with the implementation of proper energy efficiency policies. These control elements are used in the later part of the research to identify the factors targeted by each of the individual policies implemented in different countries/states.

The demographic category seems to have the largest number of control elements associated with it. Financial and knowledge related control elements seem to be most significant, as they appear the greatest number of times. Incentive based energy policies and government subsidies can help towards control of the financial elements. Knowledge based elements can be overcome with implementation of energy awareness programs. Normative policies can control elements resulting from personal attitudes.

Chapter 4. Identifying the Working Strategies of Different Types of Energy Efficiency Policies

In order to create a framework to evaluate or compare energy efficiency policies across countries or states, it is important to study the different policy types and their working principles. A graphical analysis diagram consisting of the functional domains influencing the process of energy efficiency has been developed. Further, with the help of the graphical analysis diagram this research describes how the government influences each of these domains to achieve the eventual goal of a better environment. This study was published in the proceedings of the ASME 2009 3rd International Conference of Energy Sustainability, San Francisco, California (Reichard and Bhattacharjee 2009).

4.1 Direct and Indirect Energy Efficiency Strategies

Direct methods to achieve energy efficiency in the residential sectors as part of an environmental protection program include building codes, mandatory standards for various building types, industrial regulations, and other laws imposed to directly protect the environment. It is inherent in these methods that they push other entities (i.e., economy and people) to involuntary adapt to (newly) set boundary conditions. It is obvious that these measurements are often rejected – first by the industry, and subsequently by the people, who both have to pick up the higher cost. Thus direct energy efficiency strategies are rather unpopular for governments and they are carefully weighed against individual political ambitions.

Indirect methods that can be applied in energy efficiency policies include grants or subsidies, fiscal measures, preferential loans, and general soft instruments (non-regulatory measures). They can address individual entities or all of the functional domains discussed above (i.e., technology, economy or people) and aim to provide specific incentives to overcome investment barriers.

Energy efficiency policies tend to fall under the following general categories, mandatory regulations, financial incentives and subsidies, information and awareness programs, research and development grants, and voluntary agreements. Chapter 2 presented an overview of the different types of energy efficiency policies implemented in the OECD countries after the oil crisis of the 1970s.

4.2 Roles in Energy Efficiency Policies

For this study the main protagonist of energy efficiency policies are the four functional domains indentified in the previous chapter. They are environment, economy, technology, and people. Each of these functional domains has a different agenda, a different perspective of issues, and possesses different methods for participation in energy efficiency policies. Environment and economy are often perceived to be contrary in their goals and have therefore been set as opposites in the model shown in Figure 4-1. On the other hand it often seems that there is a wide gap between technological advances made in the building sector and the actual buildings that people require, build, and finally occupy. In this model the government with its elected representatives, acts as the central entity to bridge the gap between environment and economy and also to create a pivotal momentum when it comes to transferring technology to people. While the goal of the government is to protect the environment, various strategies adopted for the purpose include educating the people, improving the available technology, or using economy as a stimulator for the people and the industry (which in this case is referred to as the technology).

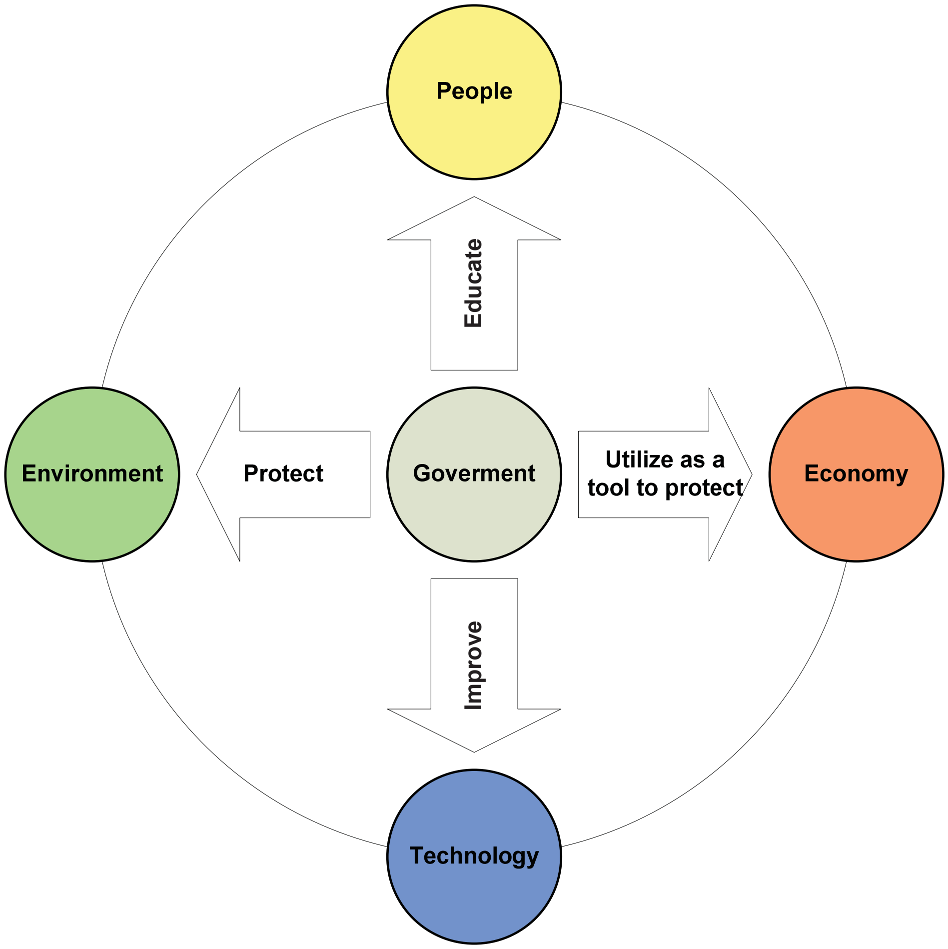

Figure 4-1 Actors of energy efficiency programs

The methods a society (i.e., government) can employ vary from direct measurements of environmental protection to various paths of indirect strategies. Indirect strategies can often achieve the same goal with a better inclusion of all participating entities.

4.3 Analysis

In the analysis it is evaluated how the government as a central body influences the four functional domains to achieve energy efficiency. This analysis is performed through a graphical approach to visualize and compare the different strategies of energy efficiency policies.

4.3.1 Mandatory Regulations

As outlined above, mandatory regulations are the main representatives of direct environmental impact strategies. The government as a central body imposes laws and regulations on either the people or the industry to perform certain measures or to meet certain goals. The process of mandatory regulation is explained using two international examples of regulatory strategies: the EU Directive on the Energy Performance of Buildings and its implementation on the state level, and the United States based energy standards (IECC 2004) and its implementation in California's state regulations.

4.3.1.1 Prescriptive and Trade-off Model Codes

The International Energy Conservation Code (IECC) implemented in the United States is based on mandatory prescriptive values for building components (e.g., U-values). Furthermore, it offers a trade-off model, which compares a building to a reference building, and allows for compensation of elements with lower energy efficiency. Once a new revised version of the IECC has been released, all US states are required to update their residential codes according to this standard, or they must document and report the reason for rejection to the United States Department of Energy. It is up to the states to set and enforce minimum requirements. While many states follow the levels set in the most recent IECC, some states stick with former versions, and other states raise the bar even higher. The state of California, for example, has the most restrictive, but also the most comprehensive energy efficiency standards, with requirements significantly exceeding the requirements stated in the IECC 2004.

Prescriptive regulations are easily understood by all actors as they directly address specific requirements for building components. It is obvious that regulations have an immediate impact on factors like dwelling type, and the mandatory nature of regulation also changes consumer behavior. Though the building codes force people towards environmental protection they do not directly address equipment or material availability. However, they can significantly influence a shift in the market.

An example of this shift could be observed in the European fenestration market. Once lower U-values were required for windows in new construction, high performance windows with argon filled double glazing systems became the standard and triple glazing systems with sophisticated frame constructions became the new high performance windows. According to the author increased demand imposed by stricter regulations became an economic driving factor for the whole fenestration industry, which also invested in research and development to provide competitive products. Interestingly enough, this also positively influenced the affordability of high performance windows. Suddenly there was no demand for former generations of windows and the large numbers of newly produced units quickly lowered the originally higher prices of high performance windows.

Meanwhile, performance based codes replaced the prescriptive codes in the EU, which led to more diversity in construction type.

4.3.1.2 Energy Performance Codes

The EU Directive on the Energy Performance of Buildings (2002/9/EC) requires a transparent methodology to calculate the energy performance of an entire building to be implemented at a national or regional level by all EU member states. Although the directive was issued already in 2002, a majority of member states have not yet fully implemented all elements. However, many countries that had no performance based energy model for building have now made the transition from prescriptive to performance based code requirements. The directive defines the content and to some extent the method for how to evaluate energy performance, but it leaves it up to the states to define the level of efficiency they require for their buildings.

The European Directive on Energy Performance in Buildings also demands energy ratings of all buildings at the time of construction, sale or change of occupancy, and several other inspections. A building energy efficiency certificate is new to most of the member states and has led to a variety of implementations. Some countries (e.g., Denmark and Portugal) require the energy efficiency certificate already to be declared before construction, with an additional evaluation to obtain a building occupancy permit.

The Energy Performance Building Directive influences people and the economy in many ways due to its comprehensive scope and the large scale of its measurements. The industry now has new tools to document (energy) savings. This documentation can in turn foster investments in two directions, product development and marketing. The direct visibility of energy efficiency also influences the availability of different housing types. Large scale regulations such as EPDB create a high demand for education and training, which ultimately leads to a high awareness among all functional domains. Reducing energy consumption also reduces the demand for fuel availability and in the long run diminishes the dependency on fuel affordability.

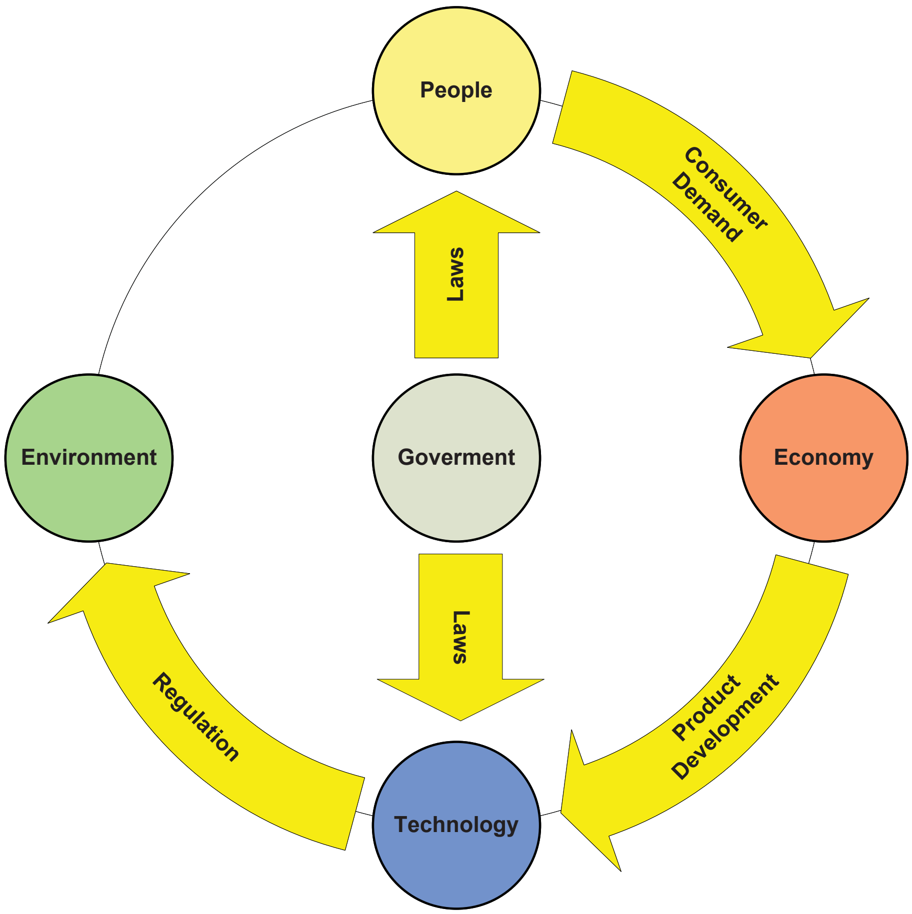

Figure 4-2 Environmental protection path of mandatory regulations

4.3.2 Financial Incentives and Subsidies

Comparative analyses of the conventional command-and-control regulation (including performance codes and prescriptive models) and market-based incentive approaches (including taxes and markets in pollution rights) have proved that conventional regulations fail to achieve environmental objectives in the most cost effective manner. Needless to mention, outdated or less restrictive regulations create no incentive for a functional domain to over perform. One way to reward performance beyond code would be to create standards that can be picked up by other incentives. In contrast, market-based approaches provide incentives for firms to equate abatement costs at the margin, thus achieving a given level of environmental quality at least cost. Simulation output suggests that the proposed emission-rights market for curbing acid rain in the United States could save $1 billion annually in comparison to a command-and-control approach in which scrubbers would be required on selected power plants. Theoretically introduction of an appropriately scaled emission tax can be used to achieve similar results (Hahn and Stavins 1992).

The environmental protection path for both the conventional regulations and the incentive programs is the same. In this case the government uses the economy as a tool to achieve its goal of environment protection. A typical example of how a regulative measure is converted to a financial incentive would be the implementation of the Passive House Standard in Germany and Austria.

Passive houses take low energy buildings one-step further. A passive house, according to the Passive House Standard, is a building in which a comfortable indoor climate can be obtained without a traditional heating or cooling system (Feist and Adamson 1988). It results in low energy buildings that require very little energy for space heating or cooling. The Austrian government subsidizes a loan (currently twenty five thousand Euro), provided a new building complies with the Passive House Standard. This new incentive created a demand for passive houses, which are now generally available on the market. In 2006 passive houses already held a market share of 7% in the state of Upper Austria. The passive house incentive in Austria has created a high demand for emerging technologies supporting the high efficiency of these buildings. The long-term commitment of the government also rectifies investments made by the industry in new research and development. This public incentive also created a heightened interest and awareness among occupants and caused a significant shift in consumer behavior.

Similar policies are also found in the United States where the government gives grants to low income groups to improve their dwelling characteristics (Low-income Home Weatherization Program).

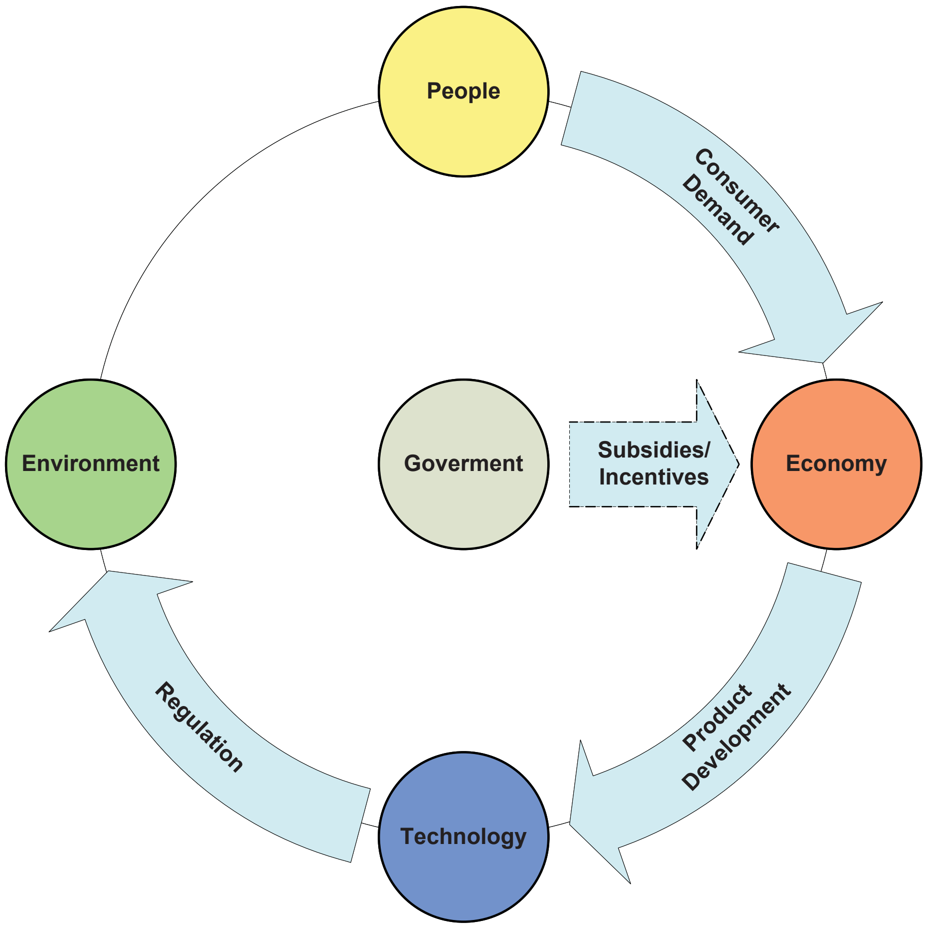

Figure 4-3 Environmental protection path of subsidies/incentives

4.3.3 Information and Awareness Programs

Information and awareness programs try to foster a market by creating awareness among functional domains through education, training, and labeling, which in turn should create a change in user behavior driven by a demand for energy efficient products.

Several information and awareness programs implemented in the OECD countries have helped the government to raise people's awareness and thus create a market for the diffusion and adoption of new technologies or products. Instances of such policies are the Energy Star Labeling implemented in the United States and the Energy Performance Certificate implemented in the EU countries.

4.3.3.1 Positive Labeling – Energy Star

A much simpler awareness/marketing incentive in the United States is the Energy Star Qualified New Homes program. To earn the label, a home must be at least 15% more energy efficient than homes built to the 2004 International Residential Code (IRC), and include additional energy-saving features. The program mainly provides marketing tools to address consumer awareness and thus impact consumer habits. There are no direct incentives to overcome financial barriers other than tools to evaluate possible savings through higher efficiency and a possible higher re-sale value.

In the southern hemisphere in Australia, a similar label is used, but is defined through a slightly different rating system. A maximum number of five stars can be obtained to show the actual efficiency of a particular building. However, as the Australian rating system refers directly to energy consumption, the energy star rating system can be misleading over time. In recent years the state of Victoria has consistently increased the requirements for energy efficiency per code, which meanwhile made buildings that simply comply with code into 5-star buildings.

4.3.3.2 Energy Performance Certificate

As already mentioned earlier in this paper, the EU Energy Performance in Buildings Directive requires a performance certificate for all new buildings to be issued in all member states. Many countries in the European Union define a level beyond the requirements of their building code with specific letters. Typical examples are A or B with C representing current code requirements on a scale from A-G. Others use the letters A+ and A++ to label buildings that outperform the standard.

These labels are highly visible to the consumer as they are part of code and mandatory for each new building. Many countries already use a similar label to rate electrical equipment, for example refrigerators. This rating system has the potential to quickly change consumer habits as it creates a high demand for more efficient building solutions. As the label is required by code, this also creates a more competitive market, which makes new technologies more affordable and forces industries to invest in new material, equipment, and construction technologies.

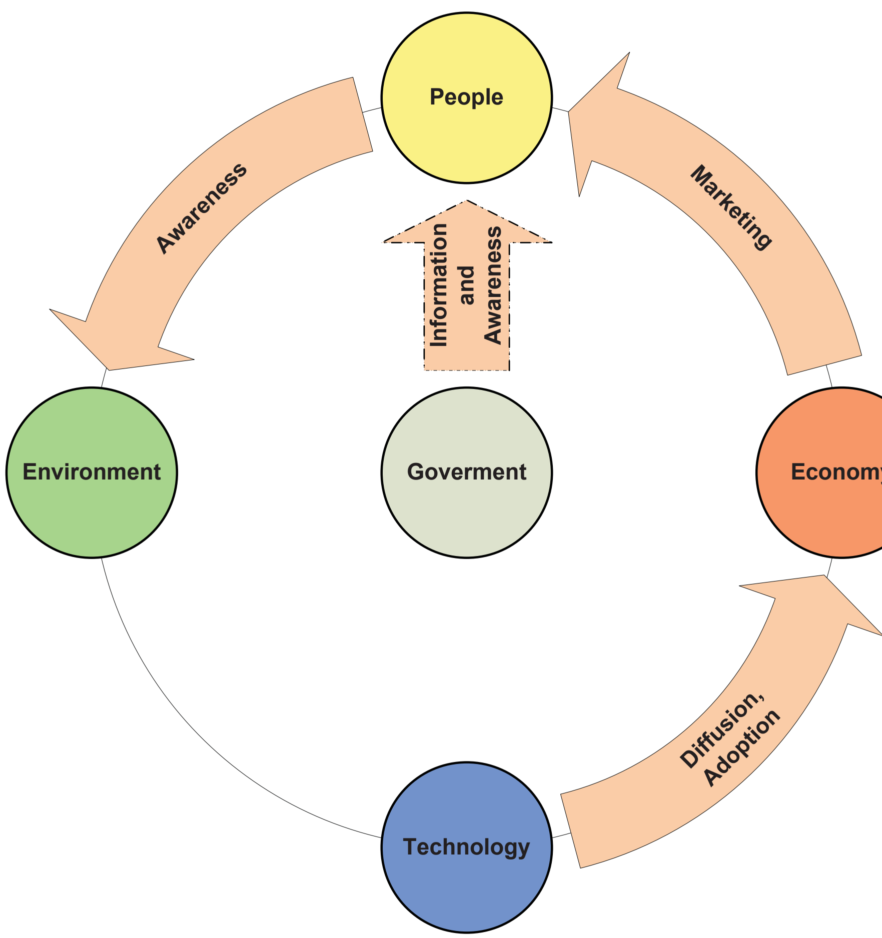

Figure 4-4 Environmental protection path of information & awareness policies.

4.3.4 Research and Development Grants

Grant programs can overcome the financial barrier if there is no economic demand for a market to invest in new development. In general, grants also have the potential to carry additional information to a market. As these grants have a limited lifetime, the success will be directly related to how well the idea behind a program can be sustained by all actors of this market.

4.3.4.1 Building America

The Building America initiative is an industry affiliated research and development program supported and initiated by the United States Department of Energy. It was designed to accelerate the development and adoption of advanced building energy technologies in new and existing homes. Using a systems engineering approach it clearly addresses the factors such as construction type, housing type, and also strives to achieve systems and equipment affordability through a large scale involvement of industry partners. Up to this point this initiative lacks the focus on changing consumer behavior in a broader perspective and does not directly address the initial cost barrier connected to income level factors. The long term outcome of this initiative is in danger of failing, if the development results are not picked up by other initiatives focusing on changing consumer habits and thus creating a demand for new technologies.

4.3.4.2 Building of Tomorrow

Building of Tomorrow, an energy efficiency program, is a subprogram of the Austrian Program on Technologies for Sustainable Development, which was launched in 1999 by the Austrian Federal Ministry of Transport, Innovation, and Technology. This five-year research and technology program initiated trend-setting research and supported the development of demonstration projects, which ultimately should lead to market diffusion of these buildings and their implemented technologies.

This program was clearly focused towards research and development of new technologies and building methods to support the passive house and low energy building concepts mentioned above. However, the success of this program is difficult to evaluate. Although the availability of a passive house market could be attributed to this program, the second focus of this program, which was creating visibility and awareness leading to market diffusion, has been less successful. The program is hardly known outside the research and innovation arena as no direct incentives were made to the broader public.

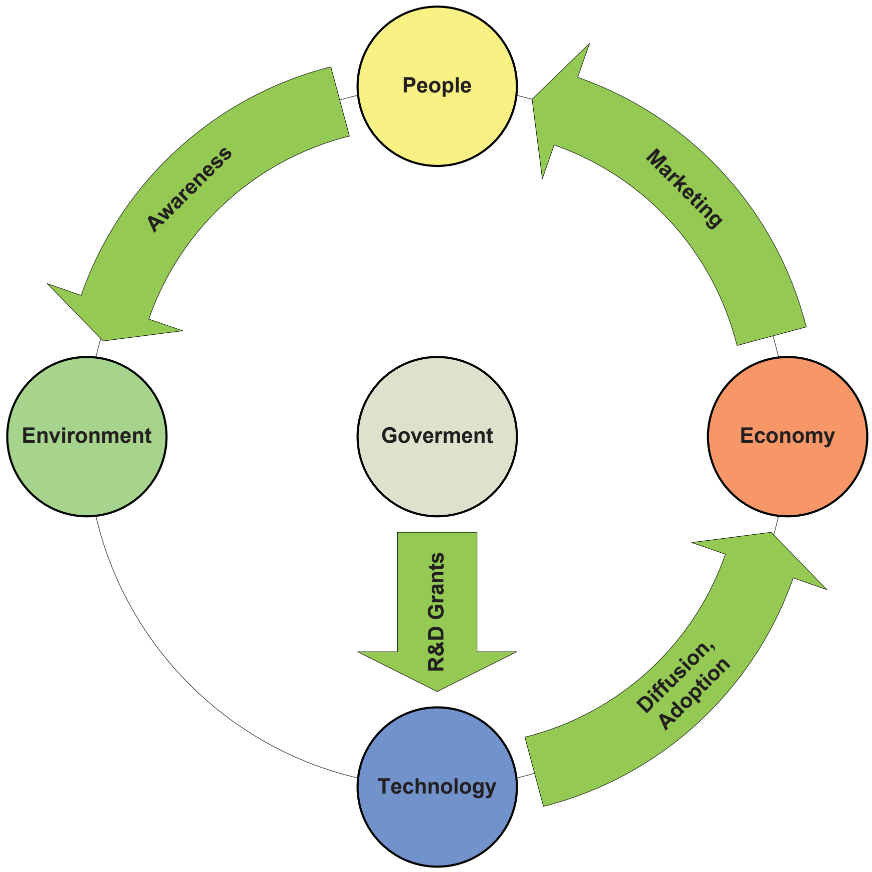

Figure 4-5 Environmental protection path of research and development grants

4.3.5 Voluntary Agreements

An example of a Voluntary agreement would be the Leadership in Energy and Environment Design (LEED) Certification. The LEED standard is defined and maintained by the United States Green Building Council (USGBC). It is a voluntary, consensus-based national rating system for developing high-performance, sustainable buildings. It sets demands for different parts of a building's life circle. A certain number of points must be fulfilled for a building to achieve a particular level of certification. LEED started out with existing commercial buildings and new commercial construction. It has meanwhile been extended to LEED for schools, healthcare, retail, and since 2008 it is also available as LEED for homes. It is a third party certification program that provides owners, operators and developers with a benchmark and marketing tool to promote sustainability in the built environment. The program has been quite successful and is meanwhile widely recognized in the construction industry. Facility managers of public and private enterprises are aware of the various certificate levels.

There are examples of other voluntary agreement policies implemented in the OECD countries, between the industry and the government. Examples of such policies would be, Voluntary Agreement on the Phase out of incandescent light bulbs implemented in United Kingdom. As a part of the agreement, retailers have agreed to phase out the sale of incandescent light bulbs before the final ban agreed at EU level, in 2011. The Secretary of State for Environment, Food and Rural Affairs, Hilary Benn has confirmed this agreement on September 27th, 2007 (Smith 2009). An example of a voluntary agreement between the United States Federal government and the industry would be GreenChill Advanced Refrigeration Partnership. The GreenChill Advanced Refrigeration Partnership is an Environmental Protection Agency (EPA) cooperative alliance with the supermarket industry and other stakeholders to promote the adoption of technologies, strategies, and practices that reduce emissions of ozone-depleting substances (ODS) and greenhouse gases (GHGs) and increase energy efficiency of refrigeration system (IEA 2009).

In all of the above mentioned cases, the government enters into a voluntary agreement with the industry to produce more energy efficient products and technologies and promote the adoption of these technologies. The environmental protection path of the voluntary agreements is shown in Figure 4-6.

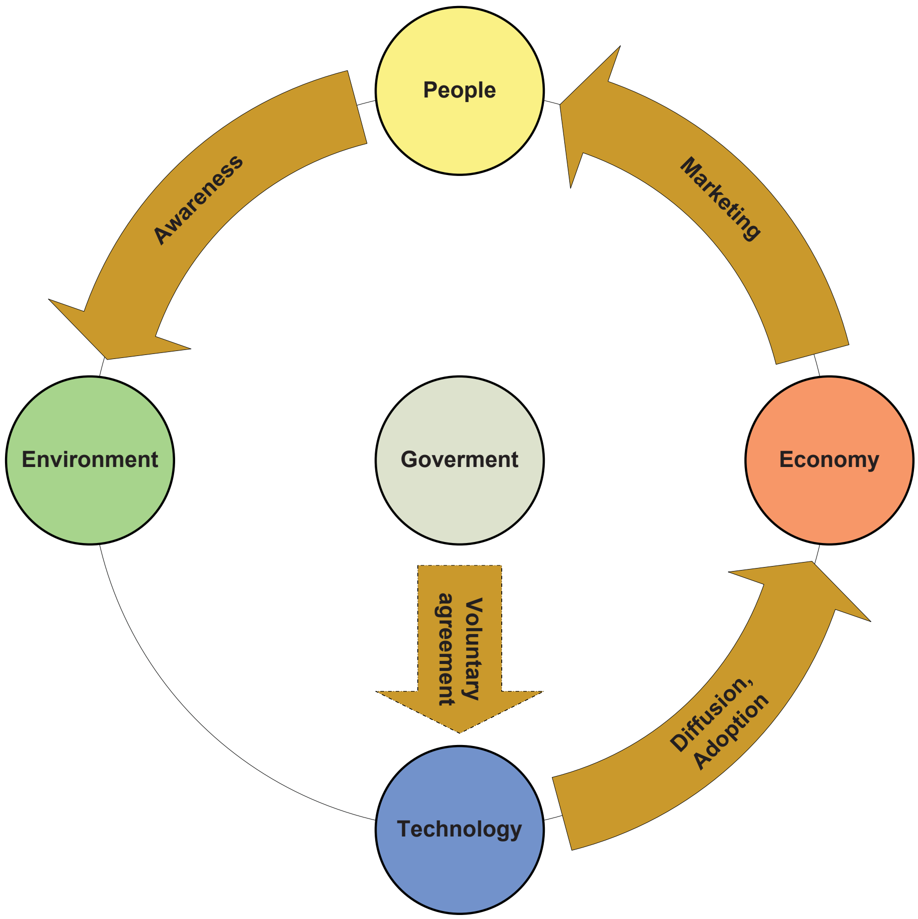

Figure 4-6 Environment protection path of voluntary agreements

4.4 Conclusion

This chapter presented a graphical approach to visualize, analyze and compare working strategies for the different types of energy efficiency policies implemented in the OECD countries. Patterns of working strategy for five different types of energy policies that have been implemented in the OECD countries have been depicted in this chapter. The government with all its elected representatives acts as a central body to bridge the gap between the four functional domains and also creates a pivotal moment when it comes to transferring technology to people. From the patterns it is evident that mandatory regulation and financial incentive and subsidies create a demand for energy efficient products. On the other hand research and development grants, voluntary agreements and information and awareness programs push the energy efficient products to the common people through proper marketing.

These working strategies of the energy efficiency policies are used later in this research to develop a prototype method for implementing energy efficiency policies on an evaluation framework.

Chapter 5. Understanding the Success of Energy Efficiency Policies in Addressing the Factors Known to Influence Residential Energy Consumption

This chapter develops a prototype method to understand the success of energy efficiency policies in addressing the factors known to influence residential energy consumption. Various socio-economic factors known to affect residential energy consumption have been identified from a human behavior perspective in Chapter 3. This chapter describes the step by step process of analyzing the effectiveness of the energy efficiency policies in targeting the residential energy consumption factors identified previously. The tool used for this research is content analysis.

5.1 Content Analysis

Content analysis has been defined in many studies as an orderly, replicable method to pack together a set of data into fewer selected categories based on a clear set of rules (Berelson 1971; Stemler 2001; Weber 1985). It is a useful technique to sift through large volumes of data and categorize them in a more methodological and systematic manner. "Content analysis came to prominence in the social sciences at the start of the twentieth century, in a series of quantitative analyses of newspapers, primarily in the United States" (Robson 2002).

In his book, Krippendorf (2004) has traced the growth of content analysis. It was visibly used in the analysis of religious scriptures during the Renaissance. With the advent of the 20th century, its focus shifted to the content of newspapers, concerns and propaganda related to World War II, and eventually in the postwar years to media and advertising.

According to Stemler (2001) and Krippendorff (2004) the six questions that need to be addressed to successfully perform a content analysis are:

- Which data are analyzed?
- How are they defined?
- What is the population from which they are drawn?
- What is the context relative to which the data are analyzed?

- What are the boundaries of the analysis?
- What is the target of the inferences?

The steps given by Robson (2002) that is needed to be performed to complete the analysis are:

- Start with research questions
- Decide on a sampling strategy
- Define the recording unit
- Construct categories for analysis
- Test the code on samples of text to assess reliability
- Carry out the analysis

5.2 Identification of Energy Consumption Factors Targeted by a Policy

The following steps were performed in applying the Content Analysis method to analyze the effectiveness of energy efficiency policy portfolios in targeting the factors affecting residential energy consumption. These steps pursue the methods shown by Krippendorff (2004), Weber (1985) and Robson (2002). Each of the steps performed is described in the section below.

5.2.1 Identify Research Question

The question identified for this analysis is, "How effectively does the energy policy portfolio of a country/state target the factors known to influence energy consumption?"

A number of initiatives have been taken at the international level to analyze the effectiveness of the energy efficiency policies of a country/state. This research evaluates the effectiveness of these policies to target the factors affecting residential energy consumption. The affecting factors have already been identified and discussed in Chapter 3.

5.2.2 Select Sampling Strategy

For this research no particular sampling is performed. Since the effectiveness of a policy portfolio is being assessed here in this research, all the policies are studied. The phrase 'all the policies' here refers to all the policies targeting the residential sector. This categorization of the policies based on which sector they target has already been performed and segregated in the energy efficiency policy online databases like MURE 2, IEA, DSIRE and ACEEE. Each of these databases is discussed below.

MURE refers to Measures d'Utilisation Rationnelle de l'Energie. The main objective of MURE was to establish a database of Rational Use of Energy (RUE) measures and policies in the EU member states, to serve as a permanent, dedicated information basis and monitoring tool. MURE over the years has grown into a policy support system, allowing to build and run RUE scenarios in countries throughout the world. Now it is recognized as a tool providing full coverage of European and other national policies, and allowing for cross-country comparisons and analyses of policies (MURE 2009).

The Energy Efficiency Policies and Measures database by the International Energy Agency (IEA) provides information on policies and measures taken or planned to improve energy efficiency. Other than the IEA member countries the database also covers the energy efficiency policies implemented in Brazil, China, India, Mexico, Russia and South Africa. In future this online database aims to complement the policy analysis carried out by the IEA on energy efficiency improvements and climate change mitigation (IEA 2009).

The Database of State Incentives for Renewables & Efficiency (DSIRE) is a comprehensive source of information on state, local, utility and federal incentives and policies that promote renewable energy and energy efficiency. It was established in 1995 and is funded by the United States Department of Energy. DSIRE is an ongoing project of the North Carolina Solar Center and the Interstate Renewable Energy Council (DSIRE 2009).

The American Council for an Energy Efficient Economy (ACEEE) has played an active role in identifying opportunities for state action. Their database of statewide energy efficiency policies serves as a comprehensive gateway to detailed information on a variety of energy policies implemented at the State and Federal levels, and is searchable by state or by policy area. ACEEE also produces broad-scale comparisons of state policies and un-tapped opportunities, including the recent 2009 State Energy Efficiency Scorecard (ACEEE 2009).

5.2.3 Select Category for Analysis

The selection of the categories for analysis depends on the research question. Robson (2002) discusses the wide range of possible types of categories depending on the various types of research question for which content analysis is used. According to Holsti (1969) there are several types of categories, e.g., subject matter, direction, values, goals, methods, traits, actors, authority, location, conflict, ending, etc. It is highly desired that the categories are exhaustive and mutually exclusive. For this research the category for analysis is the objective of energy efficiency policies.

The primary objective of energy efficiency policies is to generate required conditions that can expedite both advancement and deployment of market efficient equipment through the means of: 1) knowledge for and interaction with the end users; 2) potential threat shared with both distributor and producer; 3) R & D and diffusion of the skill inherent in the energy efficiency sector; 4) operation of particular mechanisms pertaining to finance; 5) parameters for consumers and/or of equipment used (World Energy Council 2008).

5.2.4 Select Recording Unit

Apart from determining the categories, another important task is to select the recording unit. Individual word is the most commonly used unit. In its simplest form, each time the word occurs, it would be treated as equal and the counts of these occurrences would be made as well as compared. However, if the approach is a little more sophisticated, then it can distinguish between the words with multiple senses and meanings and the code phrases that constitute a semantic unit.

For this research the recording units are the control elements identified under each energy consumption factor in Chapter 3. Energy consumption can be managed through properly targeting these control elements.

5.2.5 <u>Carry Out Analysis</u>

1. Each policy description is read once to look for the control elements. Exact words or phrases are not found most of the time. It is the meaning that is understood and looked for. Brief notes are made in the margin whenever something containing relevant information comes up.

2. Margin notes are reread and a list is made of different types of control elements that have been found.

3. The list of control elements is then categorized and associated with the respective energy consumption factors.

Figure 5-1 to Figure 5-3 below show an example of the identification of energy consumption factors targeted by a policy implemented in United States at the Federal level, Building America. This initiative is an industry affiliated research and redevelopment program supported and initiated by the United States Department of Energy. It is designed to accelerate the development and adoption of advanced building energy technologies in new and existing homes. Using the approach mentioned above it is identified that this program addressed the factors dwelling characteristics and economic condition.

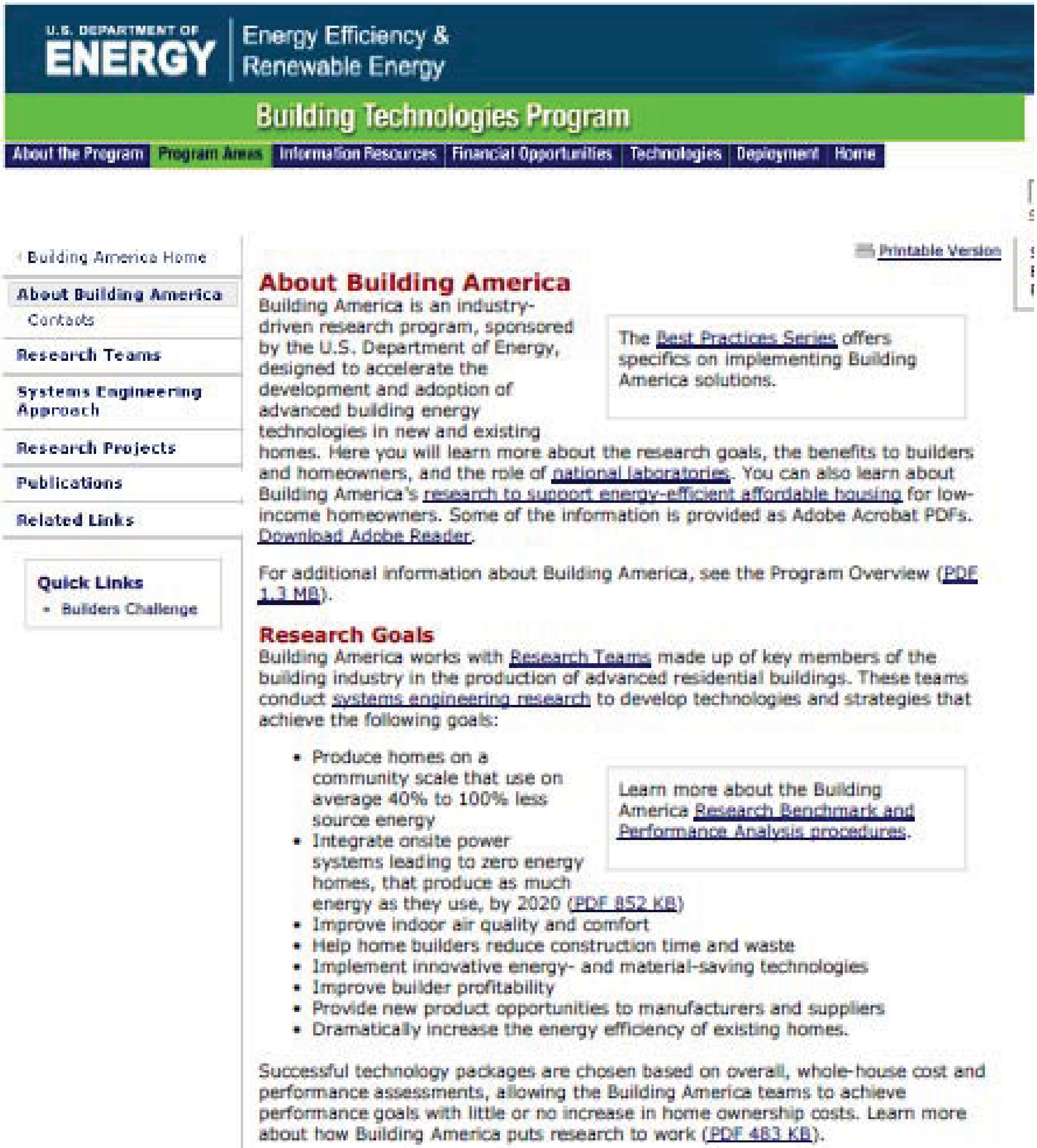

Figure 5-1 The description of Building America Program

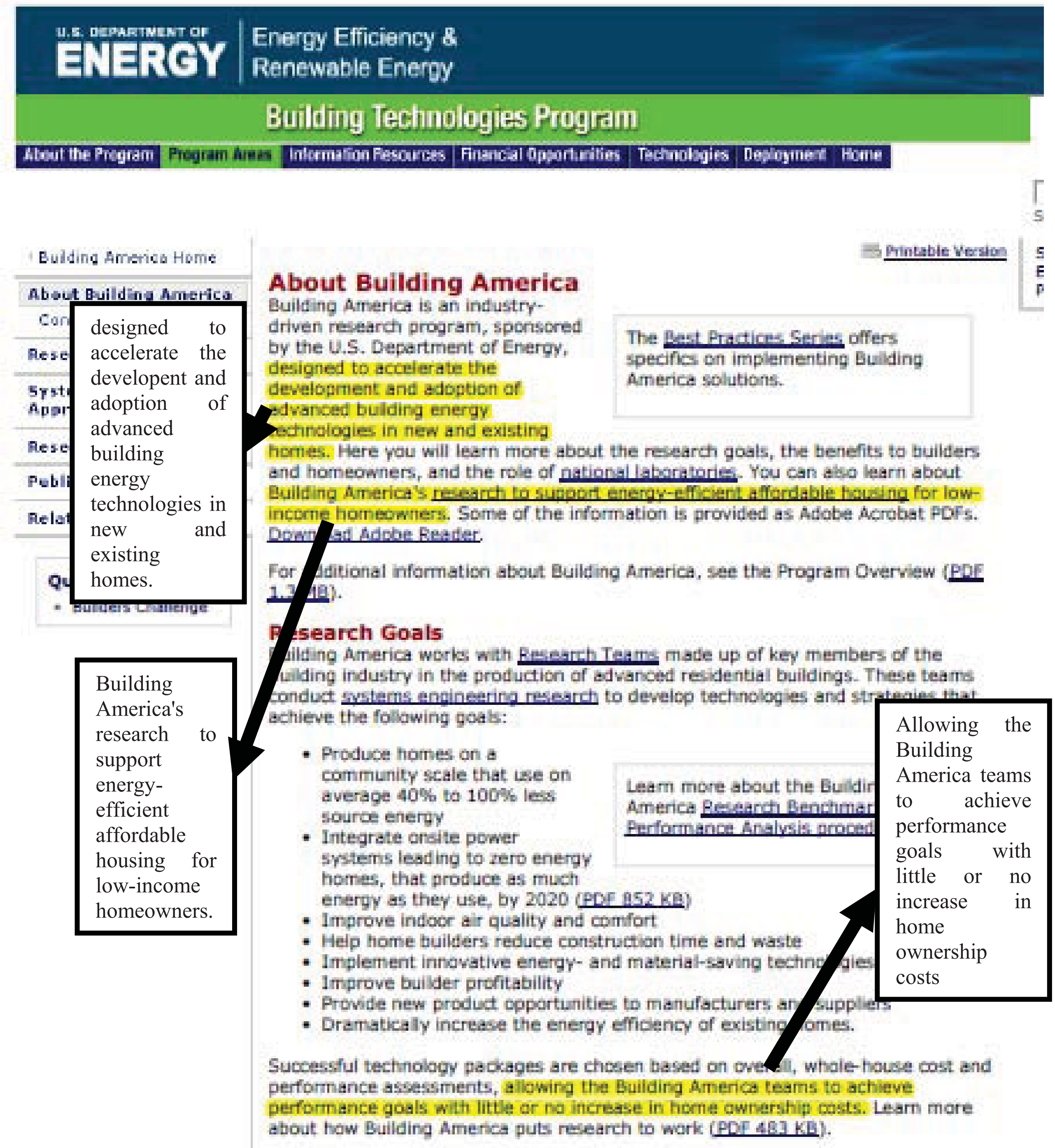

Figure 5-2 Creation of brief notes from the description

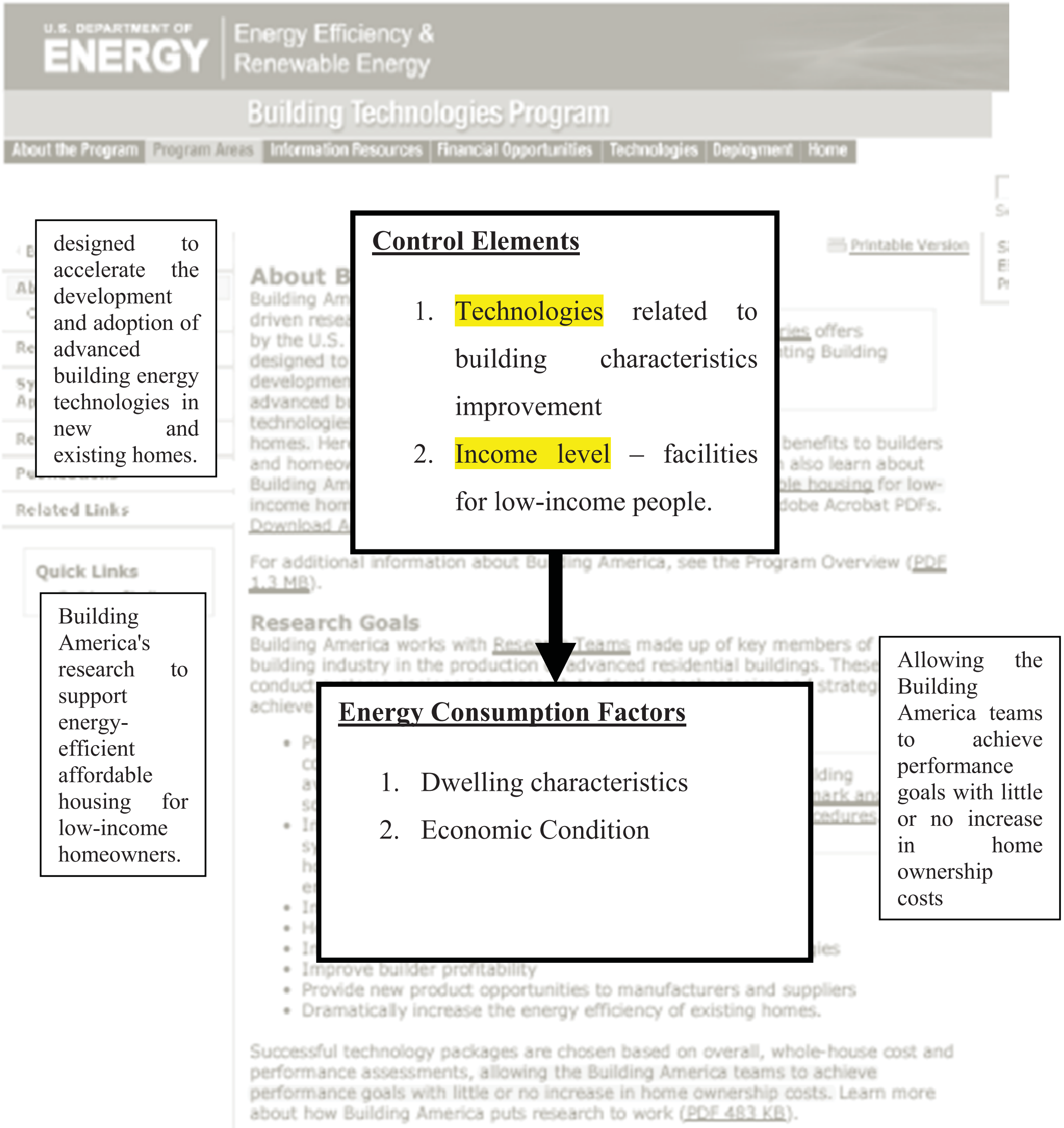

Figure 5-3 Identification of control elements and then associating them with factor affecting energy consumption.

The final list of factors targeted by individual policies is identified and listed in a matrix form. Figure 5-4below shows an example of the list of energy efficiency policies implemented in Austria listed in the form of a matrix.

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENC	FACTORS TARGETED
1	New Housing Subsidisation Scheme	2009	Planned	Subsidies Mandatory Regulation	Buildings	People	Economic Condition Dwelling Characteristics
2	Energy Certificates for Buildings	2008	Ongoing	Mandatory Regulation	Buildings	People	EE Equipment Dwelling Characteristics
3	Climate and Energy Fund	2007	Ongoing	Research and Development	Buildings	Industry	EE Equipment Availability EE Equipment
4	Consumer Guide to Energy Efficient Products	2006	Ongoing	Information and Awareness Programs	Appliances	People	Information & Knowledge
5	Federal Promotion of Extraordinary Efficiency in Buildings	2006	Ongoing	Subsidies	Buildings	People	Dwelling Characteristics Household Expenditure
6	Quick-Check Online Household Energy Efficiency Calculator	2006	Ongoing	Information and Awareness Programs	Appliances Buildings	People	Information & Knowledge
7	klima:aktiv programme "holzwärme" - increasing the share of biomass heating	2005	Ongoing	Information and Awareness Programs	Appliances	People	Information & Knowledge Renewable energy
8	klima:aktiv haus - new standards for efficient new houses	2005	Ongoing	Information and Awareness Mandatory Regulation	Buildings	People	Dwelling Characteristics

Figure 5-4 Factors targeted by the energy efficiency policies implemented in Austria listed in a form of a matrix.

5.3 Test Code for Reliability

The process of identifying the factors targeted by individual policies, described above, is tested for reproducibility and lack of ambiguity in the definition. This is called reliability testing and it is likely that this process will lead to revision of the scheme. The key to a reliable content analysis process is that the coding instruction should be reproducible. As mentioned by Neuendorf (2002) "given that a goal of content analysis is to identify and record relatively objective (or at least intersubjective) characteristics of messages, reliability is paramount. Without the establishment of reliability, content analysis measures are useless". The coding instruction should be understandable to the reader and describe the procedures for the codes to relate their observations to the intended analysis. It should also enable future researchers to run the code and add to the existing lists.

Inter-rater reliability is performed to test the reproducibility of the coding instruction and check against any bias of the researcher. A test is considered reliable if the same or similar results are generated with multiple testing. It evaluates the degree of agreement among more than one rater and gives a measure of homogeneity and consensus of the conclusion drawn by each individual rater. In the words of Hayes and Krippendorff (2007) inter rater reliability evaluates "whether a coding instrument, serving as common instructions to different observers of the same set of phenomena, yields the same data within a tolerable margin of error". Most of the time it is useful for refining and removing bias in a tool or process provided to human beings, for example in this case it will help in refining the process of identifying the factors targeted by individual policies. Krippendorff's alpha (Krippendorff 1970) is used to test the reliability of the code. This method generalizes across scales of measurement, can be used with any number of observers and satisfies the important criteria for a good measure of reliability. The section below discusses the other methods available to perform inter-rater reliability and justifies the reason for using Krippendorff's alpha.

The most widely used inter-rater reliability measures or indices are percent agreement, Holsti's method, Scott's pi, Cohen's kappa, and Krippendorff's alpha (Lombard et al. 2010). Hayes and Krippendorff (2007) describe certain criteria which should be met by the measures or indices of reliability. They further explain the limitations of the other types of measures available. The major limitation of percent agreement is that it can only measure between two observers and the greater the number of categories the more difficult it becomes to achieve agreement among observers. Scott's pi (Scott 1955) was the first coefficient to represent reliability interpretations in the form of a numerical scale between two points. Though Cohen (1960) was intended to improve on Scott's pi, it has its own limitations. It does not allow observers to be freely permutable or interchangeable. Krippendorff's alpha satisfies all of the required criteria for reliability measures discussed by Hayes and Krippendorff (2007) and is thus proposed as the standard reliability statistic for content analysis. It dispels the major limitation that reliability is difficult with a greater number of observers, and defines two reliability scale points: 1.0 for perfect reliability and 0.0 for the absence of reliability.

5.3.1 Krippendorff’s Alpha Reliability

Krippendorff's alpha is a reliability coefficient to statistically measure the agreement achieved between observers or coders. It is used in content analysis where textual information is studied to categorize and draw conclusions. In its general form

$$\alpha = 1 - \frac{D_o}{D_e}$$

where D_o is observed disagreement and D_e is the measure of disagreement when the coding is attributable to chance. In the absence of disagreement D_o= O and $\alpha = 1$, which indicates perfect reliability. In case of disagreement $\alpha = 0$ (Krippendorff 2004).

5.3.2 Analysis

Three observers each identified the factors targeted by three policies implemented in three different countries of the EU. The observers comprised faculty members and a graduate student from the Department of Building Construction, Virginia Tech. They were provided with the coding instruction and information about each of the three policies obtained from the IEA online database, attached as Appendix 1. The three policies were the New Housing Subsidisation Scheme implemented in Austria, the Sustainable Economy Law implemented in Spain and the Community Energy Savings Programme implemented in the United Kingdom. Each of the observers completed the reliability form for each of the three different policies. The reliability form completed by each of the three observers to check inter-rater reliability among them is attached as Appendix 2. Their response was interpreted in the form of a matrix as shown in

Table **5-1**,

Table **5-2** and

Table **5-3**. A check in the checkbox “N” is represented in the data matrix as 1, “S” as 2 and “Y” as 3. The energy consumption factors are represented as F1 to F21.

Reliability testing was conducted for the three different policies using Krippendorff’s alpha. A minimum level of 80% ($\alpha \geq 0.8$) is the standard for content analysis study to be considered as reliable (Riffe et al. 2005).

Table 5-1 New Housing Subsidization Scheme

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21
Obs1	1	1	1	2	3	2	2	1	1	2	2	3	1	1	1	1	1	1	1	2	1
Obs2	1	1	1	1	3	2	2	1	1	2	1	3	1	1	1	1	1	1	1	2	1
Obs3	1	1	1	1	3	2	2	1	1	2	1	3	1	1	1	1	1	1	1	3	1

Table 5-2 Sustainable Economy Law

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21
Obs1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1
Obs2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	1	1
Obs3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	1	1

Table 5-3 Community Energy Savings Programme

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21
Obs1	1	1	1	1	3	3	1	1	1	2	2	3	1	1	1	1	1	1	1	2	2
Obs2	1	1	1	1	2	2	1	1	1	3	2	3	1	1	1	1	1	1	1	2	1
Obs3	1	1	1	1	2	2	1	1	1	3	1	3	1	1	1	1	1	1	1	2	1

Krippendorff's alpha was calculated using SPSS 16.0. SPSS macro for computing the α was obtained from Hayes and Krippendorff(2007). The minimum 80% was exceeded in all the three policies. For the New Housing Subsidation Scheme α=0.88, for the Sustainable Economy Law α=0.81, and for the Community Energy Savings Programme α=0.86. The SPSS outputs for all the three policies are attached as Appendix3. Since $\alpha > 0.8$ for all the three policies, the reliability of the coding instruction is verified.

5.4 Conclusion

A process has been developed in this chapter to identify the energy consumption factors addressed by each individual energy efficiency policy. The content analysis method was adopted to perform the process. In simple terms, the energy efficiency policies were studied with the intention to locate the control elements in each of the policy descriptions. Following this, the list in which the control elements were generated (in Chapter 3) was consulted to find out the factors being influenced by these control elements. This enabled the author to identify the factorsthat are targeted by the energy efficiency policies. To test the reliability of this process, three other persons have repeated the same procedure and their inter-rater agreement was determined using Krippendorff's alpha. The test proved the coding instruction to be reliable. This process if followed will help policy makers to identify the gaps in their policy portfolio and help them generate a mix of strategies that target most of the energy consumption factors.

Chapter 6. Analytical Framework for Cross Country Comparison of Energy Efficiency Policy Portfolios

Energy conservation and the implementation of effective energy efficiency policies and programs have become imperative to curbing the escalating consumption of energy. This chapter presents a first component of a framework to analyze the effectiveness of energy policies that seek to foster enhanced energy savings. Various socio-economic factors known to affect residential energy consumptions have been identified from a human behavior perspective in Chapter 3. The framework uses four functional domains that influence human behavior, identified in Chapter 3; and these represent the directions (axes) of the graphical analysis diagram. Various factors known to affect energy consumption in the residential sector have then been positioned in the diagram using concept mapping. This mapping suggests that energy consumption is significantly influenced by the *economy* domain.

6.1 Concept Mapping

A concept map is a diagrammatic representation of the relationships among different concepts. It is a graphical tool for organizing and representing knowledge (Novak and Cañas 2006).

In order to represent the emerging science knowledge of students, Novak and his research team at Cornell University developed this tool in 1972 (Novak and Musonda 1991). Subsequently, the concept map has been used as a tool to represent expert knowledge of individuals and teams in education, government and business. The tool is based on the learning psychology theory of David Ausubel (Ausubel 1963; Ausubel. 1968). According to Ausubel, a learner learns by assimilating new concepts and propositions onto the existing cognitive. This knowledge structure of a learner is termed as the individual's cognitive structure and the foundation knowledge is called scaffolding upon which new knowledge is built.

Later Novak discovered that concepts maps have wider application than representing the knowledge of children. They can be used by researchers to express their understanding about a domain. Another powerful aspect of concept maps is that they are a vehicle to create new knowledge. Novak argues that knowledge creation comes about by a " …relatively high level of meaningful learning accomplished by individuals who have a well organized knowledge structure in a particular area of knowledge, and also strong emotional commitment to persist in finding new meanings."

A number of attempts have been made to conceptualize the process of creating concept maps. Mapping in essence is a process of off-loading knowledge. McAleese (1998) posited that the process of making knowledge explicit by using concept maps enables the individual to be aware of his/her cognitive base. This presents an opportunity to the individual to modify and improve his/her knowledge about a subject matter. This concept of a knowledge arena is suggestive of a virtual space where learners may explore the known and the unknown.

The advancement of knowledge is based on the foundation; the better the groundwork the easier it is to develop on it. In contrast, an erroneous groundwork of concepts can lead to false development, and any further development on this will be erroneous as well. Thus it is imperative to correct the underlying concepts so that knowledge can advance.

6.2 Creating Concept Maps

A concept map is a mode of graphical representation, where the concepts are housed in circles or nodes of some kind, and the relationship between the concepts are expressed by using links (or arrows) having the relation written explicitly. For this research the different socio-economic factors affecting household energy consumption and the relationships between them have already been identified in Chapter 3. This chapter uses the identified factors and their individual relationships and draws a concept map using the data.

It starts with the major cause, i.e., changing household energy consumption, which is affected by socio-economic factors falling under five main categories as shown in Figure 6-1. The main categories are demographic, consumer attitude, economy, climate, and technology.

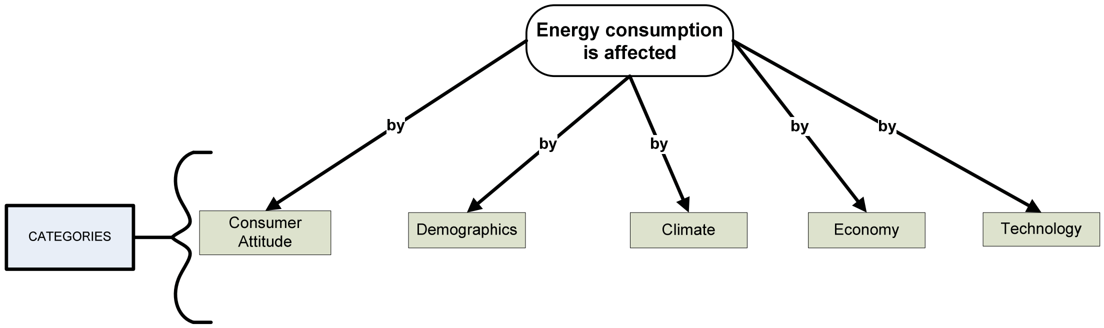

Figure 6-1 Concept map – step 1

In the next step the different socio-economic factors under each of the categories are listed as shown in Figure 6-2.

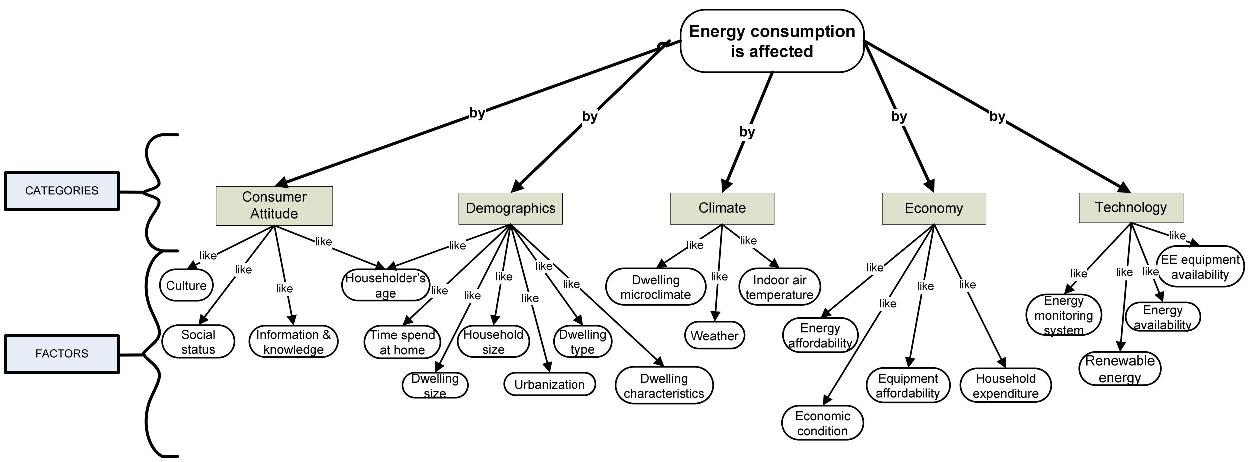

Figure 6-2 Concept map – step 2

The relationships between the different factors are then drawn in the concept map. The relationship between factors is concluded from the affinity diagram created in Chapter 3 to identify the control elements. The process of identification of relations between factors is shown below.

From the affinity diagram, it is evident that the factor household size is governed by control elements, namely family structure, family life cycle, income level, monetary assets, and job availability. However, under the Economy category the factor economic condition is governed by two control elements, which are income level and monetary assets. As this same set of control elements also governs the factor household size, it can be concluded that "Household Size" depends on "Economic Condition". Similar scenarios are also observed under the factors dwelling size, dwelling type, and dwelling characteristics under the Demographics category as shown in Figure 6-3.

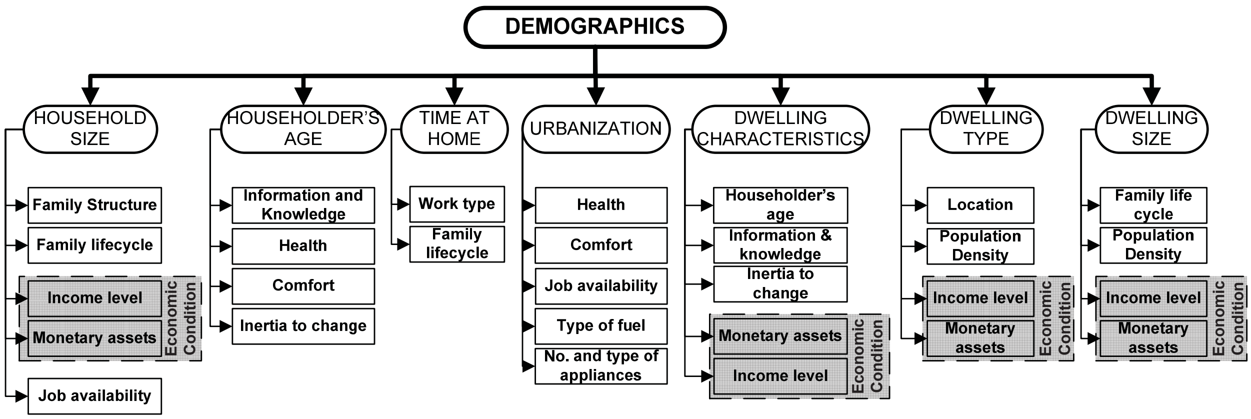

Figure 6-3 Relationship between factors under demographics category

Similarly, relationships between the different factors are drawn under both the Economy and Climate categories as shown in Figure 6-4 and Figure 6-5.

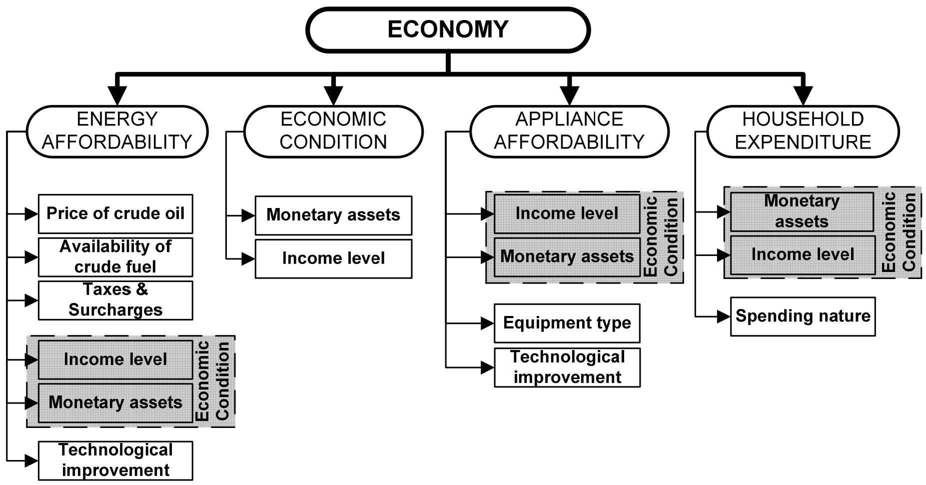

Figure 6-4 Relationships between factors under economy category

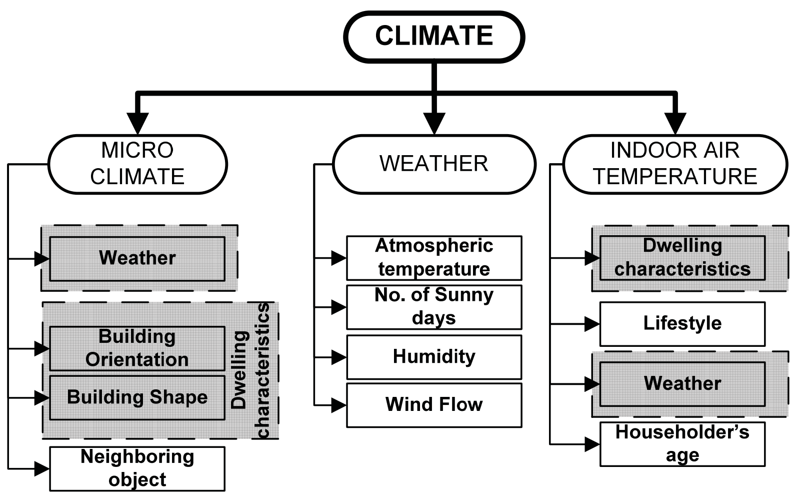

Figure 6-5 Relationships between factors under climate category

The above displayed relationships between different factors are mapped in the concept map as shown in Figure 6-6.

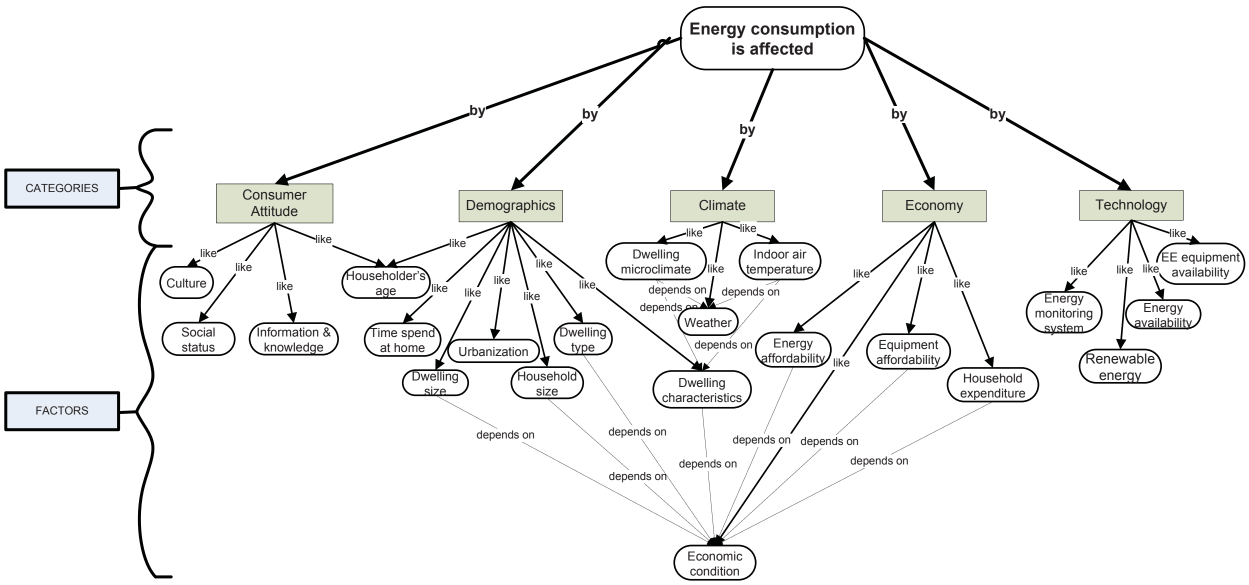

Figure 6-6 Concept map – step 3

Next the individual factors are associated with the four functional domains people, economy, environment, and technology, as mentioned in Chapter 3. Table 6-1 explains the reason for the association of each of the individual socio-economic factors with the functional domains.

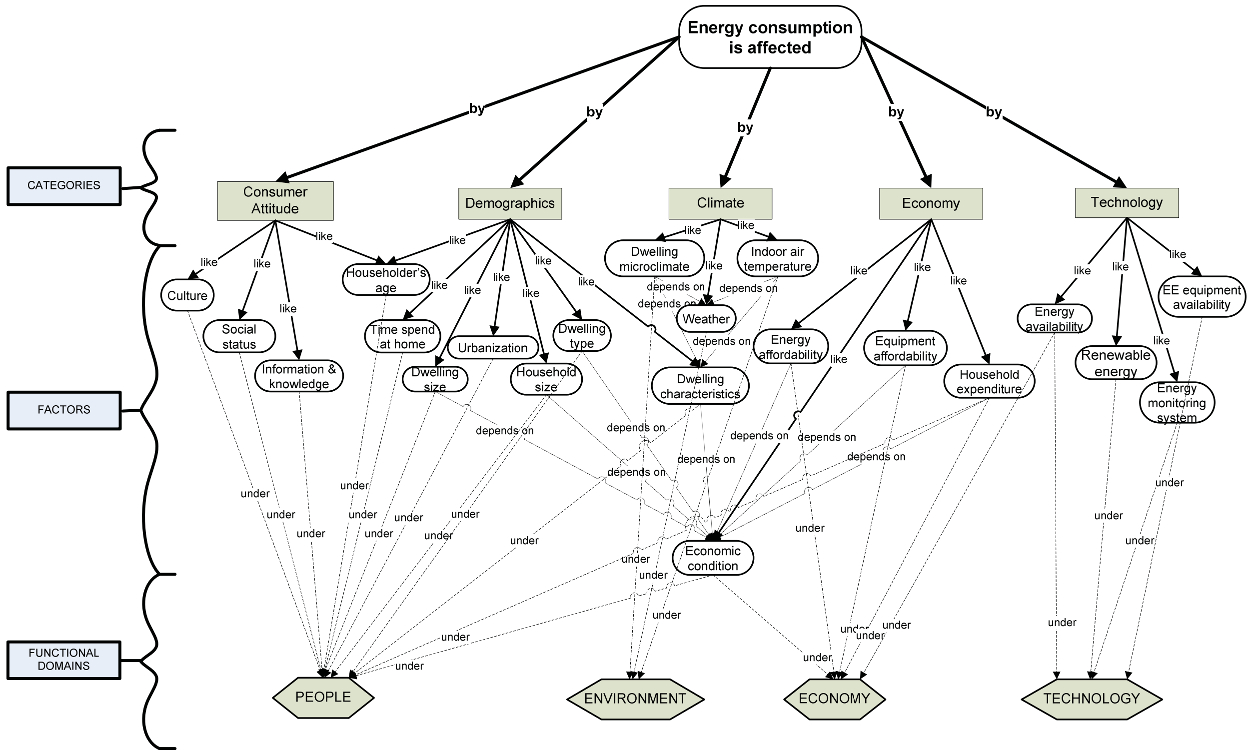

Figure 6-7 Concept map – step 4

Table 6-1 Relationships between factors and functional domains

CATEGORY	FACTOR	FUNCTIONAL DOMAIN	REASON
Demographics	Household size	People Economy	Depends on both culture and economic condition
Demographics	Householder's age	People	Personal characteristics
Demographics	Time at home	People	Personal characteristics
Demographics	Urbanization	People Economy Technology	Personal choice and is guided by available technology and economy of the region
Demographics	Dwelling characteristics	People Economy Technology	Personal choice and depends on economic condition and available technology
Demographics	Dwelling type	People Economy	Personal choice and depends on economic condition as well
Demographics	Dwelling size	People Economy	Personal choice and depends on economic condition as well
Consumer Attitude	Social status	People	Society driven
Consumer Attitude	Culture	People	Society driven

CATEGORY	FACTOR	FUNCTIONAL DOMAIN	REASON
Consumer Attitude	Information & knowledge	People	Personal characteristics
Economy	Energy affordability	People Economy	Depends on both economic condition of householder and price of energy
Economy	Economic condition	People Economy	Economic factor and personal condition
Economy	Equipment affordability	People Economy	Depends on both economic condition of householder and price of equipment
Economy	Household expenditure	People Economy	Depends on both economic condition and individual spending behavior
Climate	Dwelling microclimate	People Environment	Depends on dwelling characteristics which is personal choice and local climate
Climate	Weather	Environment	Depends on environment
Climate	Indoor air temperature	People Environment	Depends on dwelling characteristics which is personal choice, individual lifestyle and local climate
Technology	Energy availability	Economy Technology	Depends on technological improvement and price of oil
Technology	Renewable energy	Technology	Depends on technological improvement
Technology	EE equipment availability	Technology	Depends on technological improvement
Technology	Energy monitoring system	Technology	Depends on technological improvement

6.3 Creation of Framework

For the creation of the evaluation framework the following four core directions that influence human behavior in terms of energy consumption—People, Economy, Technology and Environment—have been identified above and named as the four functional domains. It is often argued that the economy and the environment are often perceived as antagonists in society and thus these two functional domains are placed on opposite sides along the horizontal axis. However, the environment can have a direct influence on people or the cultural background. Furthermore technological advancement can be beneficial or harmful to the environment. There is also a strong connection between technology and economy. On the other hand, it is also argued that technological advances are often rejected by a culture or its people. Therefore the two functional domains, people and technology are placed on opposite sides along the vertical axis. Figure 6-8 below shows a representation of the four functional domains. This diagram makes it also visible that technology can affect a culture in two ways, through economic change and also unfortunately through environmental changes caused by technologies.

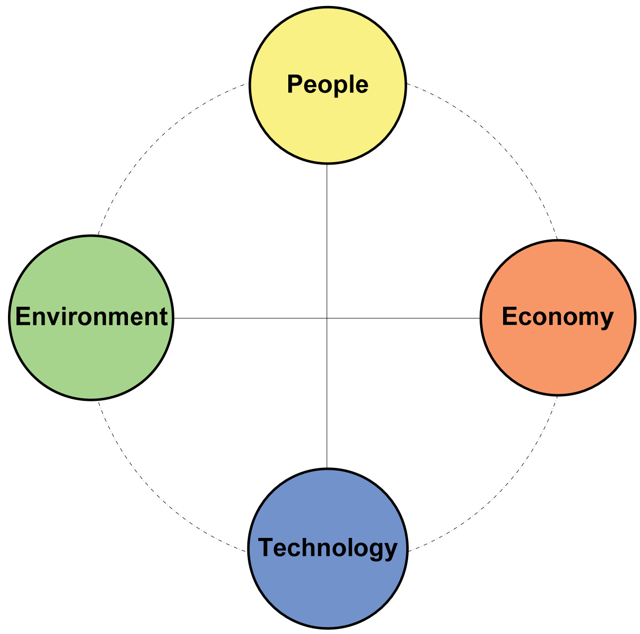

Figure 6-8 Diagrammatic representation of the functional domains to form the evaluation framework.

The various factors affecting energy consumption identified under the five categories are placed in the evaluation framework based on their association with the functional domains as shown in Table 6-1. The factors that are associated with one domain are placed on either the vertical axis or horizontal axis along with the domain. Factors associated with two domains are placed on the diagonal axis between two domains, and the factors associated with more than two domains are placed on the diagonal axis between all the associated domains. Figure 6-9 below shows the placing of various socio-economic factors on the evaluation framework.

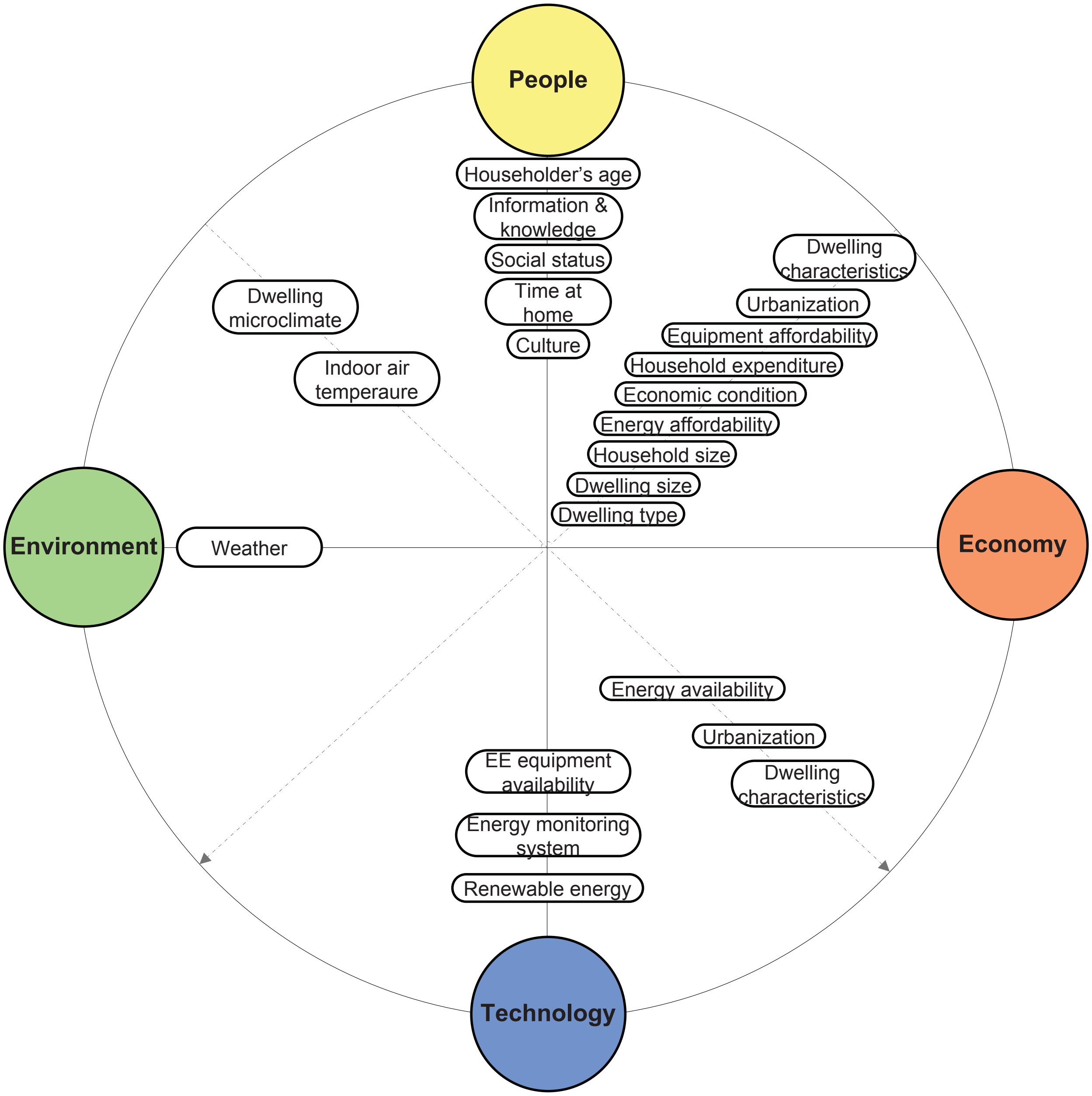

Figure 6-9 Placing of the socio-economic factors on the evaluation framework based on their association with the functional domains

Subsequently a prototype mechanism is developed to place the energy efficiency policies on the evaluation framework. Each policy is placed on the evaluation diagram based on its type and working principles, for example mandatory regulations, information and awareness programs, research and development grants, voluntary agreements, financial incentives and subsidies.

Chapter 4 explains the working principles of all the different types of policies implemented in the OECD countries to date.

As shown in Figure 6-10, the policies are placed based on the strategies followed by each policy type. The government as a central body imposes certain mandatory laws and regulations on the industry to improve the environment. Thus mandatory regulations for the industry are placed at the bottom left quarter of the evaluation framework. Similarly, mandatory regulation policies for the people are placed at the top left quarter of the evaluation framework.

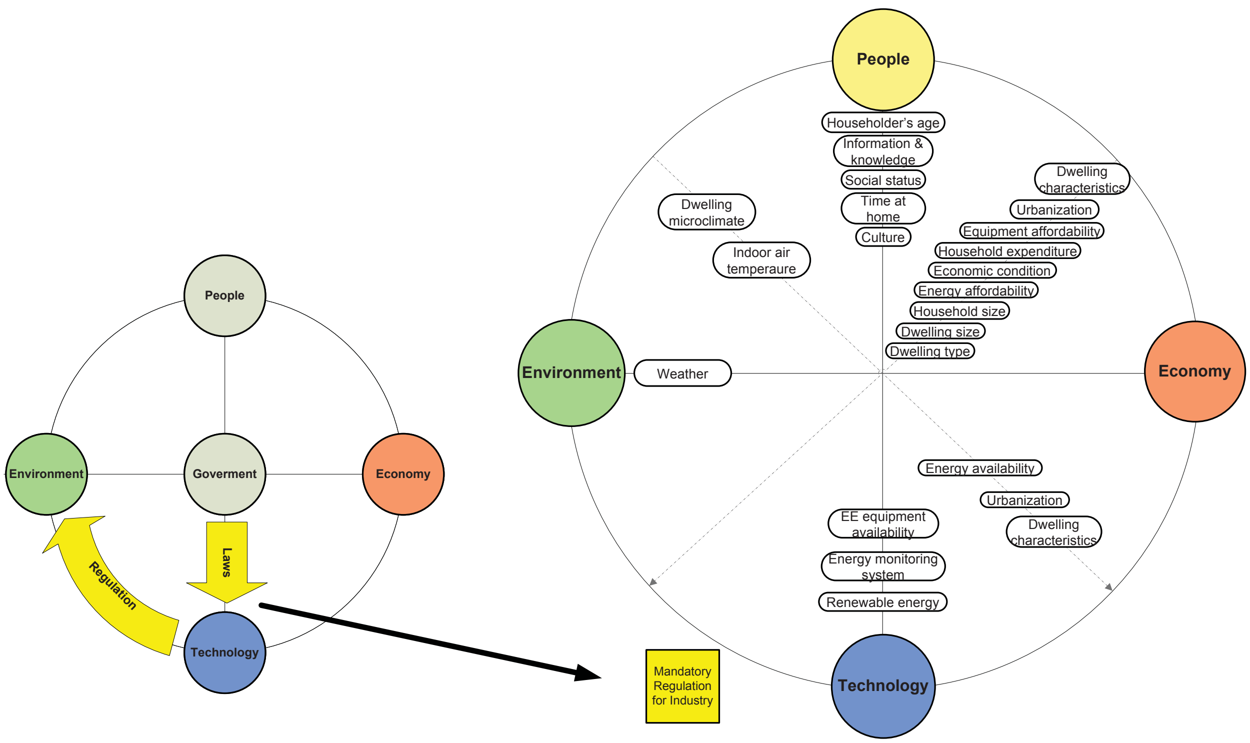

Figure 6-10 Placing of mandatory regulation policies for industry in the evaluation framework

Financial incentives and subsidies for people or industry are placed on the top right and bottom right quarter respectively as shown in Figure 6-11.

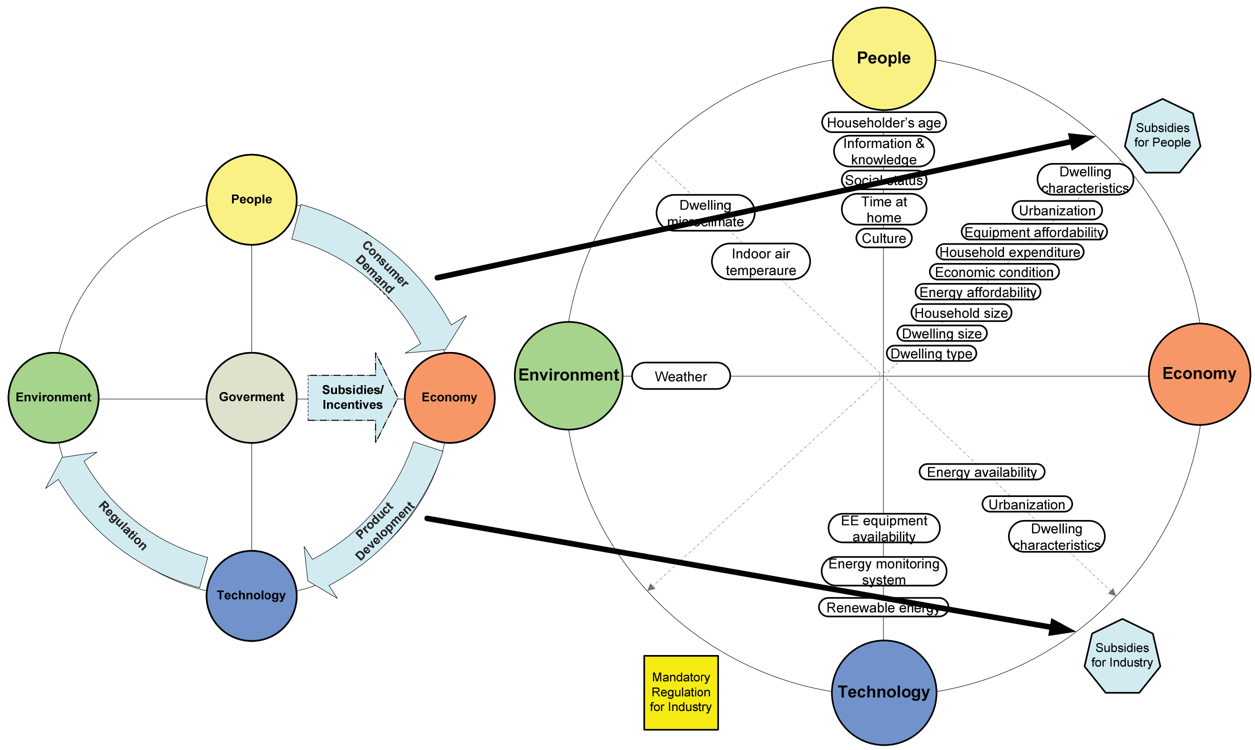

Figure 6-11 Placing of financial subsidies for industry or people in the evaluation framework

Following this method all the other types of policies implemented in the OECD countries are placed on the evaluation framework as shown in Figure 6-12.

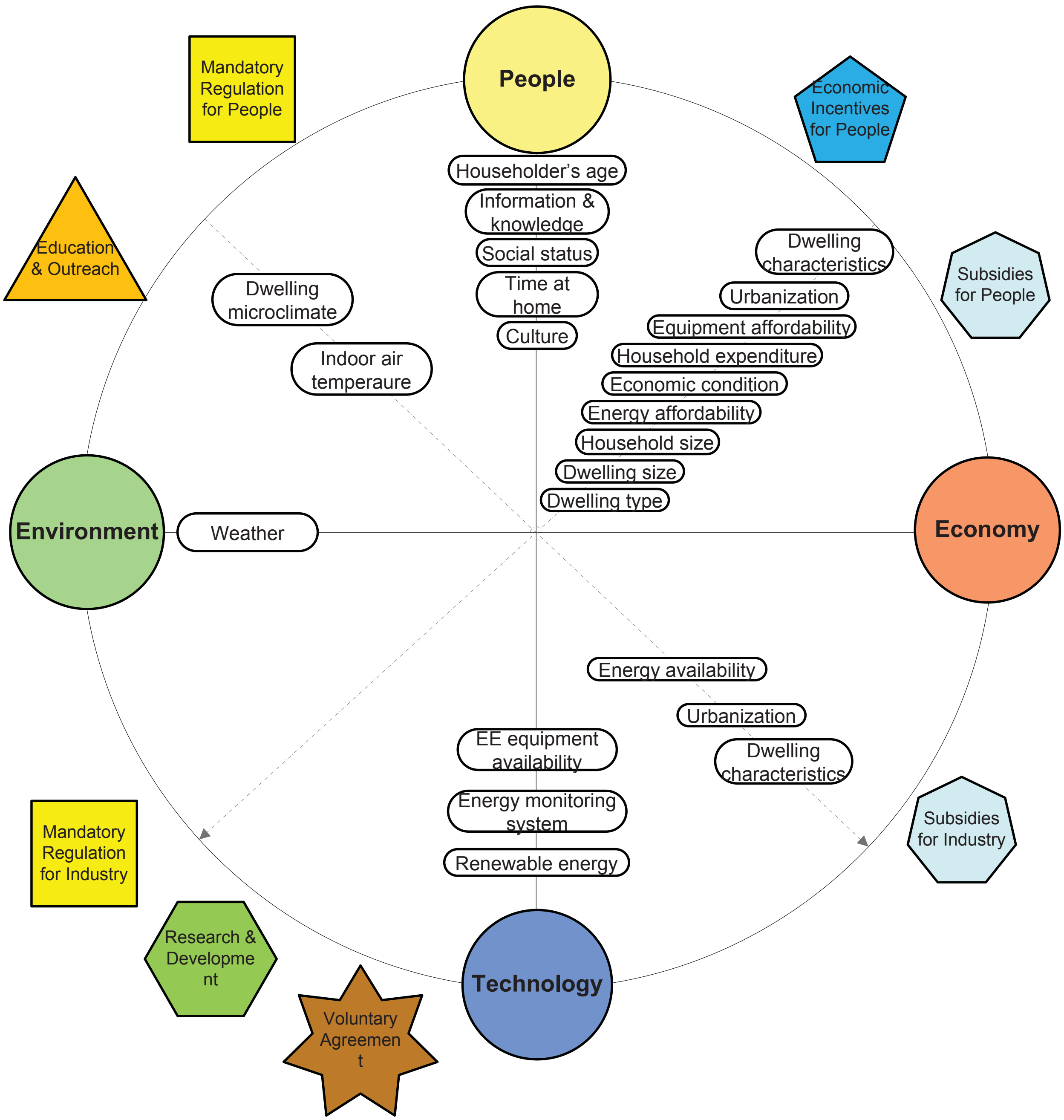

Figure 6-12 Placing of all the different types of policies in the evaluation framework

6.4 Conclusion

The framework developed will help to map the energy efficiency policies implemented in a country with respect to the energy consumption factors and the functional domains that influence human behavior. At this state this mapping is purely looking at numbers of policies implemented without including any weighting factors. The more balanced distribution could suggest a concerted approach for preparing and introducing policies on a national level. This analytical framework will enable policy makers and other decision makers to identify the factors affecting energy consumption, evaluate their existing policies in reference to the identified factors, compare their energy policy portfolio with that of other countries within a similar context, locate gaps and deficiencies in the respective portfolio, and gain from lessons learnt by other countries before and after implementing energy efficiency policies.

Chapter 7. Establishing Trustworthiness of the Framework

This chapter presents the processes that are adopted to check the validity and the generalizability of the framework designed in Chapter 6. The process of validating the developed evaluation framework is a critical step in this study. Although some of the methodologies used in the research are already validated and published, the overall framework—including the adopted design methods and the assumptions made—are validated for their appropriateness and comprehensiveness.

7.1 Validation of the Framework

Validity from a realistic perspective refers to the accuracy of results. Validity in context of qualitative research deals with it being accurate, or correct, or true. Some of the features of good flexible research as mentioned by Robson (2002) are to focus on developing an in-depth analysis of a single case or multiple cases, use of multiple sources for data collection, and data analyses based on description and themes.

The validity or trustworthiness of findings from flexible, qualitative research is the subject of much debate. There is absence of standard means of assuring reliability and validity, such as checking inter-observer agreement, use of quantitative measurement, explicit controls for threat to validity, and direct replication in flexible research designs. While some researchers posit that social life contains some elements that are generalizable across settings and others that are particular to given settings (Bloor 1997), there are strategies to reduce the threat to validity in qualitative research. One such strategy to reduce threat from reactivity, researcher bias, and respondent bias is reliability check.

7.1.1 <u>Reliability</u>

The concern of reliability is whether the tool or instrument produces consistent results. Thinking in such terms is problematic for most qualitative researchers (Mason 1996). The causes of unreliability are researcher error and bias. In a more general sense, researchers using flexible designs need to concern themselves with the reliability of their methods (Robson 2002). For the purpose of this research, the reliability of the data analysis process is assessed using inter-rater reliability.

The research used more than one analyzer to identify the factors targeted by individual policies using the code developed by the author in Chapter 5. The good inter-rater agreement demonstrated through this process defends against the biass of the author in the process of development of the code, confirming the validity of the methodology.

7.1.2 Construct Validity

The question that follows the reliability check is whether the research measures exactly what the researcher intend to measure. In the words on Robson (2002), "Does the research have construct validity?" According to Robson there is not a single way of determining construct validity.

For this research a draft framework was created at a preliminary stage and presented at the International Energy Program Evaluation Conference, Portland 2009. The research was non-blinded peer-reviewed by experts in the area of energy policy analysis. In this context it is worth mentioning that existing literature does not find any difference in the review quality between blind and non-blind peer reviews (Justice et al. 1998; Van Rooyen et al. 1999). The reviewers were selected by the conference committee member based on their area of interest and expertise. The comments of the two reviewers construct the validity of the framework. Below are descriptions of the reviewers and their comments on the draft evaluation framework.

Cynthia Austin, a senior project manager, evaluation analysis at Heschong Mahone Group, led a variety of projects providing research and policy analysis for building energy efficiency. She has been involved in energy efficiency program evaluations through management, data collection, analysis, and reporting, for the last ten years. She has used both qualitative and quantitative methods as tools for assessment. Through her experience in program evaluation, Ms. Austin has expanded her expertise into energy efficiency program and portfolio design, assisting both municipal and investor-owned utilities. She currently manages process and market assessment studies for the following Southern California Edison programs: Savings By Design, Sustainable Communities, and Codes and Standards Advocacy. Ms. Austin received a BA in Environmental Studies from the University of Chicago and a Certificate in the Advanced Study of Evaluation from Claremont Graduate University. She is a member of the American Evaluation Association and Association of Energy Services Professionals. Her comments on the framework were as follows.

> *"Overall I found the mapping methodology interesting and would prefer the technique be the emphasis of the paper. As an evaluator, I'd enjoy more explanation of how the mapping methodology was developed, how it has been used, and what types of evaluations it could applied to (or not applied to). I'd also like to know more about how to deal with interactive effects and how one would weight factors based on their level of significance."*

Rafael Friedmann has over 35 years of international experience in renewable energy and energy efficiency. His career has included work on solar thermal and biogas technologies and, since 1990, the development, implementation, and evaluation of energy efficiency policies and interventions. He has worked as an academic researcher, consultant and, since 2000, at PG&E, where he is part of the energy efficiency policy and strategic research and evaluation group. He has a Bachelor's degree in Energy Engineering from UAM, Mexico; a Masters degree in Mechanical Engineering from Technion, Israel; and a Ph.D. in Energy & Resources from U.C. Berkeley, US. He has published widely and given many presentations on energy efficiency policy and evaluation. His comments are as follows:

> *"The value I see in the paper is that it proposes a way in which policy makers and/or portfolio designers can analyze what they are doing in a more holistic and organized fashion, to see if the mix of policies and programs is aligned with the context they seek to influence. Paper needs to highlight this more, and take a less "certain" attitude about the results and the conclusions.*
>
> *I see potential in what you are presenting. It brings a non-traditional perspective; a new framework if you wish, on how to examine whether the policies and procedures being implemented are likely to work to affect customer behavior towards more energy conservation and efficiency adoption. The framework you show could be useful in this regard. What is also missing is the importance of specific interventions – i.e., where do you get more bang for the buck—and this is very contextual. As the EE marketplace evolves the interventions you should use change, as do the actors that should implement them. Early on you need*

more government-led RD&D as well as education and some financial incentives. As your trade ally networks develop, they're able to carry more of the marketing burden. You mention this in your last sentence—it should be highlighted more."

7.2 Generalizability of Framework

Generalizability refers to the extent to which the findings of the enquiry are more generally applicable. Application can be extended to different contexts, situations, times or persons other than those directly involved (Robson 2002). In simple terms, generalizability refers to the applicability of the conclusions within the setting studied as well as beyond that setting. Campbell and Stanley (1963) used an alternative term for generalizability: 'external validity'. It is imperative to verify the generalizability of conclusions within the setting studied for flexible designs (Robson 2002). However, purposeful sampling to exclude people or settings, which may be threatening or disturbing, is likely to bias the study. In response to such concerns, it is important that the investigator understands the relative strengths and weaknesses of different sampling strategies. At the same time, findings based on large samples are also stripped of their context when generalizations are made across time and space (Patton 1990). In the context of generalizability, one major disparity between scientists and qualitative evaluators is that the latter tend to focus on providing information that is fairly specific to one or a few programs, in comparison to generalization across time and space (Patton 1990).

Generalizability of this research refers to the applicability and functionality of the developed framework when used in the context of any country or state. To ensure the generalizability of the framework, it has been used to map and compare the energy efficiency policies of countries and states other than those used for the development of the framework. The framework will be developed with data from three selected EU countries and three selected US states. The framework is considered to be generalizable if it can be successfully demonstrated in the following cases.

7.2.1 EU Countries and US States Selection Justification

To compare the energy efficiency policy portfolio the framework will be created for three EU countries and three US states. The EU countries and US states are selected based on the following criteria:

- A mix of countries and states are selected whose household energy consumption per capita has increased, decreased or remained the same.
- The countries and states selected are from different climate zones.
- The socio-economic conditions of the countries and the states are different.

7.2.2 Comparison between Energy Efficiency Policies of EU Countries

The three EU countries selected for the study are the United Kingdom, Austria and Spain. Austria, although much smaller than the United Kingdom and Spain, has not only a well developed energy efficiency policy portfolio but a wider range of climate extremes (from alpine climates to Mediterranean influenced climates) and is thus comparable to the State of California with respect to its innovative energy efficiency improvement policies. The United Kingdom is also one of the leading countries of the EU in implementing more and more energy efficiency policies. Spain is one of those countries that, in spite of being under the EU directive, still is less advanced in terms of energy efficiency policies as compared to other developed EU countries. Figure 7-1 shows their energy consumption per capita from 1980 to 2006.

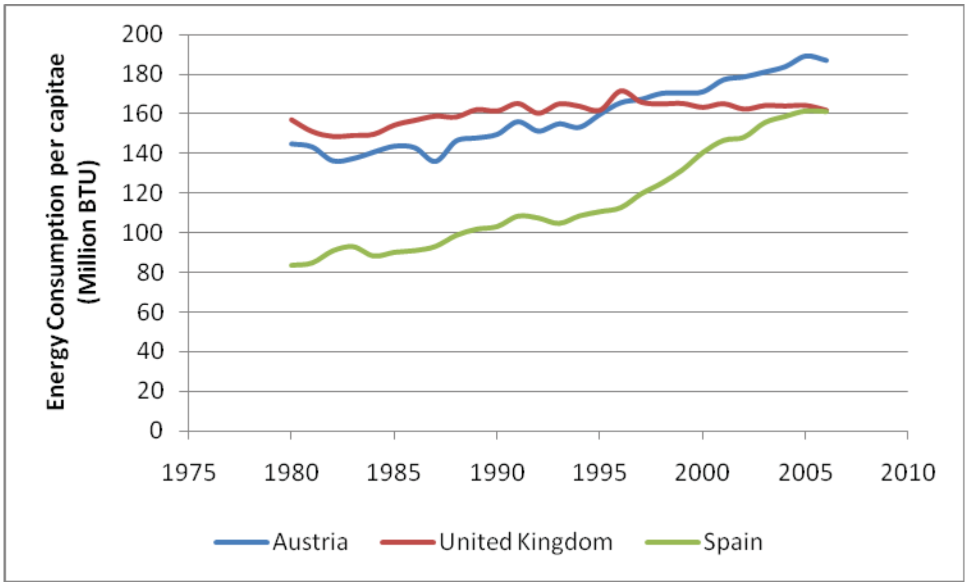

Figure 7-1 Energy consumption per capitae of Austria, Spain and United Kingdom from 1980 to 2006

The following sections discuss the energy efficiency policies implemented in the above mentioned EU countries.

7.2.2.1 Energy Efficiency Policies of Austria

Austria has implemented many energy efficiency policies over the years which aim to improve energy efficiency by granting subsidies for suitable measures. The Austrian Low Energy Building program has proven to be most successful in Austria, which heavily built on overcoming the misplaced incentives barrier. Similar to housing subsidies, building regulations lie within the Austrian provincial authority. The energy related regulations for the existing buildings are with respect to renewing of construction, extension, and replacement of equipment such as heating systems. Several renovation programs and initiatives in Austria have been implemented at the provincial level. Some of the prominent energy efficiency policies implemented in Austria targeting the residential building sector are Housing support scheme—refurbishment of buildings, Grants for renewable energy, and Domestic appliances labeling. During the period between 1990 and 2006 the overall household energy efficiency of Austria improved by approximately 23% (ODYSSEE 2008a). Table 7-1 shows the list of the energy efficiency policies targeting the residential building sector implemented in Austria to date, and the factor(s) targeted by each of these policies.

Table 7-1 Energy Efficiency Policies implemented in Austria targeting the residential building sector

No	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS TARGETED
1	New Housing Subsidisation Scheme	2009	Planned	Subsidies Mandatory Regulation	Buildings	People	Economic Condition Dwelling Characteristics
2	Energy Certificates for Buildings	2008	Ongoing	Mandatory Regulation	Buildings	People	EE Equipment Affordability Dwelling Characteristics
3	Climate and Energy Fund	2007	Ongoing	Research and Development	Buildings	Industry	EE Equipment Availability EE Equipment Affordability
4	Consumer Guide to Energy Efficient Products	2006	Ongoing	Information & Awareness Program	Appliances	People	Information & Knowledge
5	Federal Promotion of Extraordinary Efficiency in Buildings	2006	Ongoing	Subsidies	Buildings	People	Dwelling Characteristics Household Expenditure
6	Quick-Check Online Household Energy Efficiency Calculator	2006	Ongoing	Information & Awareness Program	Appliances Buildings	People	Information & Knowledge
7	klima:aktiv programme "holzwärme" - increasing the share of biomass heating	2005	Ongoing	Information & Awareness Program	Appliances	People	Information & Knowledge Renewable energy
8	klima:aktiv haus - new standards for efficient new houses	2005	Ongoing	Information & Awareness Program Mandatory Regulation	Buildings	People	Dwelling Characteristics
9	Top products - Platform for energy efficient appliances	2005	Ongoing	Information & Awareness Program	Appliances	People	EE Equipment Affordability
10	Energy Consulting for Households: klima:aktiv leben to Employ Chimney-Sweepers as Climate Ambassadors	2005	Ongoing	Information & Awareness Program	Buildings	People	Information & Knowledge
11	Heat pumps programme	2005	Ongoing	Information & Awareness Program	Appliances	People	Information & Knowledge
12	"solarwärme" - solar energy for water and space heating	2004	Ongoing	Information & Awareness Program	Appliances	People	Renewable energy
13	klima:aktiv Programme	2004	Ongoing	Subsidies Information & Awareness Program	Buildings	People	Dwelling Characteristics Economic Condition Information & Knowledge
14	Third Party Financing for Efficiency Investment	2003	Ongoing	Subsidies	Buildings	People	Dwelling Characteristics Economic Condition
15	Federal Environment Fund	2001	Ongoing	Information & Awareness Program	Multi-sectoral Policy	People	Information & Knowledge

No	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS TARGETED
				Subsidies			Dwelling Characteristics
				Research and Development		Industry	Renewable energy
16	Financial Incentives for Investment in Residential Renewable Generation and Residential Efficiency	2001	Supersede d	Financial Incentives	Buildings	People	Economic Condition
				Subsidies			Household Expenditure
17	Combined Heat and Power (CHP)	2000	Supersede d	Subsidies	Buildings	Industry	Energy Affordability
				Mandatory Regulation			
18	Promotion of Energy Efficient Electronic Products, The Group for Energy Efficient Appliances (GEEA)	2000	Ongoing	Information & Awareness Program	Appliances	People	Information & Knowledge
19	Building of Tomorrow	1999	Ongoing	Research and Development	Buildings	Industry	Dwelling Characteristics
							Information & Knowledge
20	Energy Taxes	1996	Ongoing	Mandatory Regulation	Energy price	Industry	Energy Affordability
21	Building shell insulation	1995	Ongoing	Mandatory Regulation	Buildings	People	Dwelling Characteristics
22	Agreement on Energy Saving	1995	Ongoing	Mandatory Regulation	Multi-sectoral Policy	Industry	Dwelling Characteristics
							EE Equipment Availability
23	Domestic appliances labelling	1994	Ongoing	Information & Awareness Program	Appliances	People	Information & Knowledge
24	Grants for renewable energy (thermal solar, heat pumps, biomass heating, ...)	1992	Ongoing	Financial Incentives	Appliances	People	Renewable energy
25	Heating Costs Accounting	1992	Ongoing	Mandatory Regulation	Buildings	People	Energy Affordability
26	Energy Research Society of the Austrian Utilities (Energieforschungsge meinschaft, EFG)	1991	Ongoing	Research and Development	Appliances	Industry	EE Equipment Availability
					Energy		Renewable Energy
27	Housing support scheme - new buildings	1989	Ongoing	Financial Incentives	Buildings	People	Dwelling Characteristics
							Economic Condition
28	Housing support scheme – refurbishment of buildings	1989	Ongoing	Financial Incentives	Buildings	People	Dwelling Characteristics
							Economic Condition
29	Personal Income Tax– Deduction for Energy Saving Investments	1989	Ongoing	Subsidies	Buildings	People	Economic Condition
							Dwelling Characteristics
							EE Equipment Affordability
30	Heating system design standards, maximum exhaust gas losses	1989	Ongoing	Subsidies	Appliances	People	EE Equipment Affordability

7.2.2.2 Energy Efficiency Policies of Spain

Energy consumption in Spain has been remarkably lower than that of other EU countries. Lower equipment ownership of Spanish households and the minimal influence of energy prices on the households' expenses are some of the major reasons for this improvement. However, both these factors have started to deteriorate in the last year. This recent change is evident in the ODEX index, which shows a progress of 3% in the energy efficiency of this sector against 6% at European level (ODYSSEE 2008b).

Recently a series of improvements can be noticed in the energy efficiency legislation of the building sector, among which Technical Building Code (TBC), Regulation on Indoor Heating and Air-conditioning Systems (RITE), and the approval of a Building Energy Certification procedure for new buildings are noteworthy. A procedure for energy certification for existing buildings is also underway. Similarly, Bylaws on Solar Thermal Uses has been outstanding in the buildings sector since 2001. Establishment of the Energy Saving and Efficiency Action Plan through an agreement by the Council of Ministers in 2007, ensures that both the SGA and its dependent bodies should play an exemplary role in incorporating energy saving measures in their buildings (ODYSSEE 2008b). Table 7-2 shows the list of the energy efficiency policies targeting the residential building sector implemented in Spain to date, and the factor(s) targeted by each of these policies.

Table 7-2 Energy Efficiency Policies implemented in Spain targeting the residential building sector

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS TARGETED
1	Sustainable Economy Law	2010	Planned	Financial Incentives	Multi-sectoral Policy	Industry	Renewable Energy
2	Energy Saving and Efficiency Plan 2008-11	2008	Ongoing	Subsidies	Appliances	People	Economic Condition Household Expenditure EE Equipment Affordability
3	Grants for Energy Efficiency in Buildings	2008	Ongoing	Subsidies	Buildings	People	Dwelling Characteristics Economic Condition
4	National Plan for Scientific Research, Development and Technological Innovation 2008-2011	2008	Ongoing	Research and Development	Appliances	Industry	EE Equipment Availability
5	Plan for the Progressive Replacement of Electricity Meters (Smart meters)	2008	Ongoing	Mandatory Regulation	Buildings	Industry	Energy monitoring system

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS TARGETED
6	Regulation on Indoor Heating and Air-conditioning Systems (RITE)	2008	Ongoing	Mandatory Regulation	Appliances Buildings	Industry	EE Equipment Availability Energy Monitoring System
7	Ecodesign requirements for energy-using products (EuPs)	2007	Ongoing	Mandatory Regulation	Appliances	Industry	EE Equipment Availability
8	Building Energy Certification	2007	Ongoing	Information & Awareness Program Mandatory Regulation	Buildings	People Industry	Information & Knowledge
9	Technical Building Code	2007	Ongoing	Mandatory Regulation	Buildings	People	Dwelling Characteristics EE Equipment Affordability
10	Renove Plan for Electric Appliances	2006	Ongoing	Subsidies	Appliances	People	EE Equipment Affordability Household Expenditure Economic Condition
11	Action Plan 2005-2007: Incorporation of efficient equipment in new homes	2005	Ongoing	Subsidies Voluntary Agreement	Buildings	Industry	EE Equipment Availability
12	Action Plan 2005-2007: Awareness raising and training of consumers and salespeople	2005	Ongoing	Information & Awareness Program	Appliances	People	Information & Knowledge
13	Financing for Renewables and Energy Efficiency	2002	Ongoing	Subsidies	Multi-sectoral Policy	Industry	Renewable Energy
14	Plan for the Promotion of Renewable Energies in Spain 2000-2010	2000	Completed	Subsidies	Energy	People	Renewable Energy
15	Energy Efficiency in Buildings	2000	Ongoing	Information & Awareness Program Mandatory Regulation	Buildings	People Industry	Information & Knowledge
16	Housing Labels	1999	Superseded	Information & Awareness Program Mandatory Regulation	Buildings	People Industry	Information & Knowledge
17	Labelling and information on energy consumption of Domestic Use Equipment.	1994	Completed	Information & Awareness Program Mandatory Regulation	Appliances	People Industry	Information & Knowledge
18	Heating, Air Conditioning and Sanitary Water Equipment Regulations	1981	Completed	Mandatory Regulation	Appliances	People	EE Equipment Affordability
19	Basic Building Standards for Thermal Insulation	1979	Completed	Mandatory Regulation	Buildings	People	Dwelling Characteristics

7.2.2.3 Energy Efficiency Policies of the United Kingdom

In the United Kingdom, Energy Trust Savings promotes energy efficiency in the household sector. Energy Efficiency Commitment (EEC) is another key policy, which places an obligation on the energy suppliers in the United Kingdom to instigate energy savings among their customers. EEC has been put in effect in two phases: the first phase stretched from 2002-2005 and the second phase continued till 2008. In April 2008, the Carbon Emission Reduction Target (CERT) replaced the EEC. Under CERT, the scope was extended to include microgeneration and behavioral measures. Centrally funded government schemes in England (known as Warmfront) and Wales, Scotland and Northern Ireland specifically are aimed at alleviating fuel poverty via improvements in energy efficiency. This intention is carried forward by the 'Building a Greener Future: a Policy Statement' announced by the UK government in July 2007, with a vision to achieve zero carbon standard for all new homes by 2016.

In the period 1990-2005, overall household energy efficiency in the United Kingdom has improved by 14%. After a phase of noticeable improvement in the early part of the 1990s, the progress faded away due to rising fuel consumption in dwellings (increased by approximately 10% over the period). It is expected that this rise in energy consumption will reach a plateau due to saturation of ownership for some appliances, coupled with continued efficiency improvements. Things have already started to move in a positive direction, as improvement in energy consumption was recorded in 2005 in comparison to the previous year (ODYSSEE 2008c).

Table 7-3 shows the list of the energy efficiency policies targeting the residential building sector implemented in United Kingdom to date, and the factor(s) targeted by each of these policies.

Table 7-3 Energy Efficiency Policies implemented in United Kingdom targeting the residential building sector

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS TARGETED
1	Community Energy Savings Programme (CESP)	2008	Ongoing	Subsidies	Buildings	People	Economic Condition
							Household Expenditure
				Information & Awareness Program			Information & Knowledge

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS TARGETED
2	Energy Saving Scotland advice centres	2008	Ongoing	Information & Awareness Program	Framework Policy	People	Information & Knowledge
3	Energy Saving Scotland Home Help	2008	Ongoing	Information & Awareness Program	Buildings	People	Information & Knowledge
4	Planning and Energy Act 2008	2008	Ongoing	Mandatory Regulation	Buildings	Industry	Renewable Energy
5	Act on CO2 advice line	2007	Ongoing	Information & Awareness Program	Buildings	People	Information & Knowledge
				Subsidies			Economic Condition
6	Code for sustainable homes	2007	Ongoing	Mandatory Regulation	Buildings	People	Dwelling Characteristics
7	Energy Technologies Institute	2007	Ongoing	Research and Development	Multi-sectoral Policy	Industry	EE Equipment Availability
				Voluntary Agreement			Renewable Energy
8	International Task Force for Sustainable Products (ITFSP)	2007	Ongoing	Voluntary Agreement	Appliances	Industry	EE Equipment Availability
9	Metering and Biling	2007	Ongoing	Voluntary Agreement	Buildings	Industry	Energy Monitoring Systen
10	Stamp Duty Relief for Zero Carbon Homes	2007	Ongoing	Financial Incentives	Buildings	People	Household Expenditure
11	Technology Strategy Board	2007	Ongoing	Research and Development	Buildings	Industry	EE Equipment Availability
12	Voluntary Agreement on the Phase Out of Incandescent Light Bulbs	2007	Ongoing	Voluntary Agreement	Appliances	Industry	EE Equipment Availability
13	Building Regulations Part L	2006	Ongoing	Mandatory Regulation	Buildings	People	Dwelling Characteristics
14	Low Carbon Buildings Programme	2006	Ongoing	Subsidies	Buildings	People	Dwelling Characteristics
							EE Equipment Affordabilty
				Research and Development	Industry	Industry	EE Equipment Availability
15	Market Transformation Programme - Partnership with China	2006	Ongoing	Research and Development	Appliances	Industry	EE Equipment Availability
16	Market Transformation Programme - Publication of Appliance Efficiency Cost/Benefit Analyses	2006	Ongoing	Mandatory Regulation	Appliances	Industry	EE Equipment Availability
17	Market Transformation Programme - Standards for Energy Efficiency of Electric Motor Systems (SEEEM) Membership	2006	Ongoing	Voluntary Agreement	Appliances	Industry	EE Equipment Availability
				Information & Awareness Program		People	Information & Knowledge
18	Microgeneration Strategy	2006	Ongoing	Subsidies	Buildings	Industry	Renewable Energy
19	Northern Ireland - Efficiency Upgrade for Building Regulations	2006	Ongoing	Mandatory Regulation	Buildings	People	Dwelling Characteristics

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS TARGETED
20	Anglo-Swedish Initiative for Greener Buildings	2005	Ongoing	Information & Awareness Program	Buildings	People	Information & Knowledge
21	Climate Change Communication Initiative	2005	Completed	Information & Awareness Program	Multi-sectoral Policy	People	Information & Knowledge
22	Energy Efficiency Commitment (2005 - 2008)	2005	Superseded	Information & Awareness Program	Multi-sectoral Policy	People	Information & Knowledge
				Subsidies			Economic Condition
23	Landlords' Energy Saving Allowance (LESA)	2004	Ongoing	Financial Incentives	Buildings	People	Household Expenditure
							Dwelling Characteristics
24	Research Councils Energy Programme (RCEP)	2004	Ongoing	Research and Development	Industry	Industry	Energy Availability
25	Large-scale PV Demonstration Project	2002	Completed	Subsidies	Buildings	People	Renewable Energy
				Research and Development		Industry	
26	Scotland - Household microgeneration grants	2002	Ongoing	Subsidies	Buildings	People	Economic Condition
27	Community Energy Programme	2001	Completed	Information & Awareness Program	Buildings	People	Information & Knowledge
28	Decent Homes	2001	Ongoing	Mandatory Regulation	Buildings	People	Dwelling Characteristics
29	Northern Ireland Warm Homes Scheme	2001	Ongoing	Subsidies	Buildings	People	Economic Condition
30	Scottish Government Central Heating Programme	2001	Ongoing	Subsidies	Buildings	People	Economic Condition
31	Energy Labelling for New Buildings	2000	Superseded	Mandatory Regulation	Buildings	Industry	Information & Knowledge
				Information & Awareness Program		People	
32	Energy Labelling Report	2000	Completed	Information & Awareness Program	Multi-sectoral Policy	People	Information & Knowledge
33	Wales Home Energy Efficiency Scheme (HEES)	2000	Ongoing	Subsidies	Buildings	People	Dwelling Characteristics
34	Warm Front Scheme	2000	Ongoing	Subsidies	Buildings	People	Economic Condition
35	Scottish Government Warm Deal Programme	1999	Ongoing	Subsidies	Buildings	People	Economic Condition
36	Reduced VAT for energy saving materials	1998	Ongoing	Financial Incentives	Appliances	People	Household Expenditure
					Buildings		
37	Market Transformation Programme, including Energy Labelling for Appliances	1997	Ongoing	Information & Awareness Program	Appliances	People	Information & Knowledge
38	Northern Ireland - Energy Efficiency Levy	1997	Ongoing	Mandatory Regulation	Buildings	Industry	Energy Affordability
				Subsidies	Appliances		

7.2.2.1 Analysis

Analyses of the factors targeted by each of the policies implemented in the three EU countries present the opportunity to compare between the number of policies (expressed as percentage) targeting the respective factors. Figure 7-2 shows a graphical representation of the comparison.

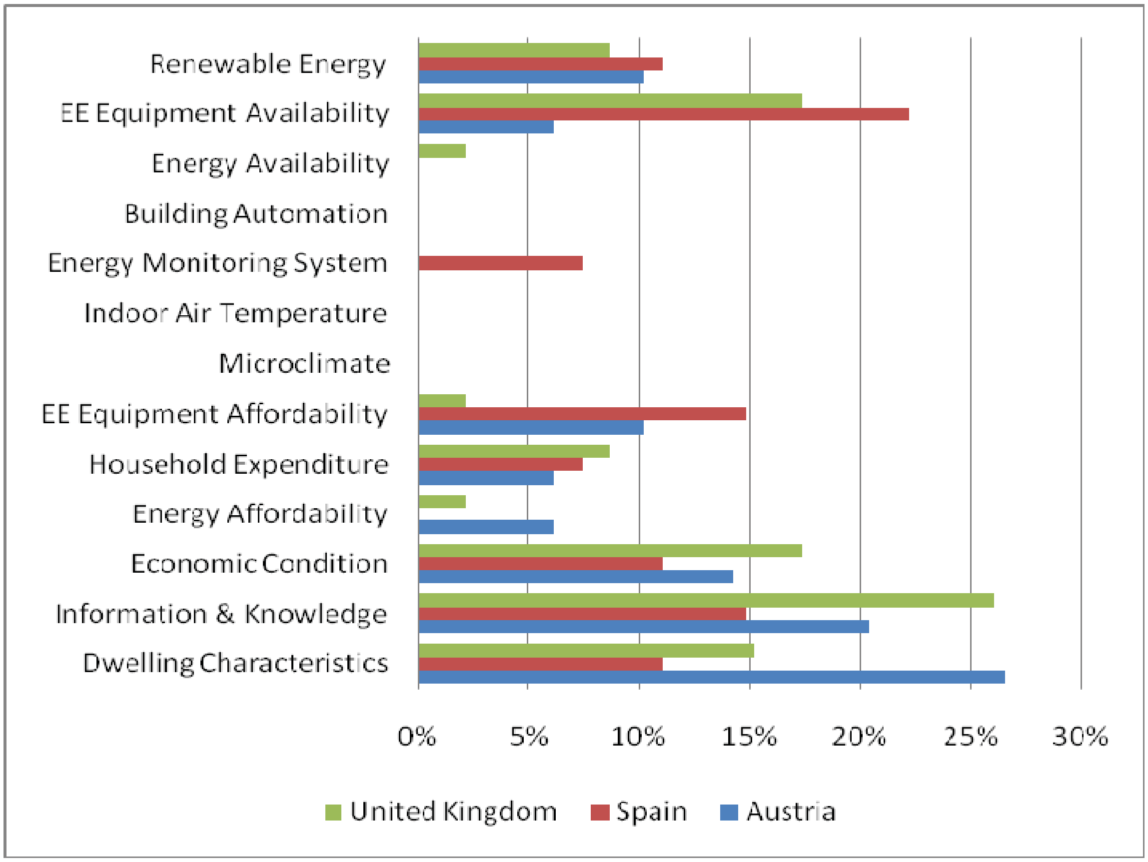

Figure 7-2 Comparison of factors targeted by energy efficiency policies implemented in Austria, Spain and United Kingdom

From the analysis it is evident that energy efficiency policies implemented in the United Kingdom focus more towards the factors information & knowledge and economic condition as compared to Austria and Spain. Energy policies implemented in Austria are more focused towards improving the dwelling characteristics, be it through mandatory regulation or financial incentives and subsidies. Spain on the other hand focuses more towards the availability and affordability of energy efficient equipment and renewable energy.

In the figures that follow (Figure 7-3, Figure 7-4, and Figure 7-5) energy efficiency policies of three EU countries have been mapped on the evaluation framework developed in this research. The number inside each policy type shown in the framework refers to the policy corresponding to that number, in the list of policies for the respective country.

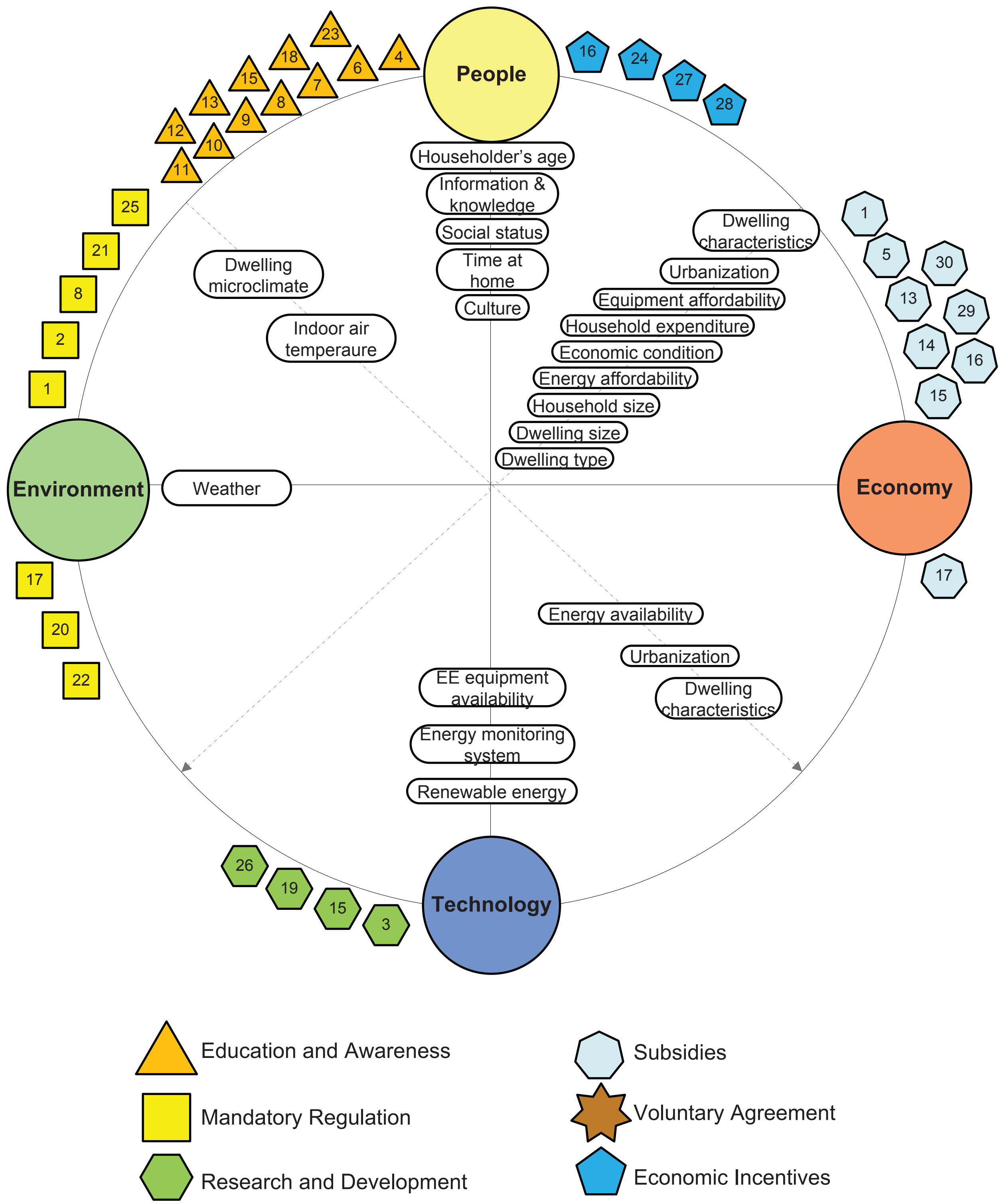

Figure 7-3 Evaluation framework of the energy efficiency policies implemented in Austria targeting the residential building sector

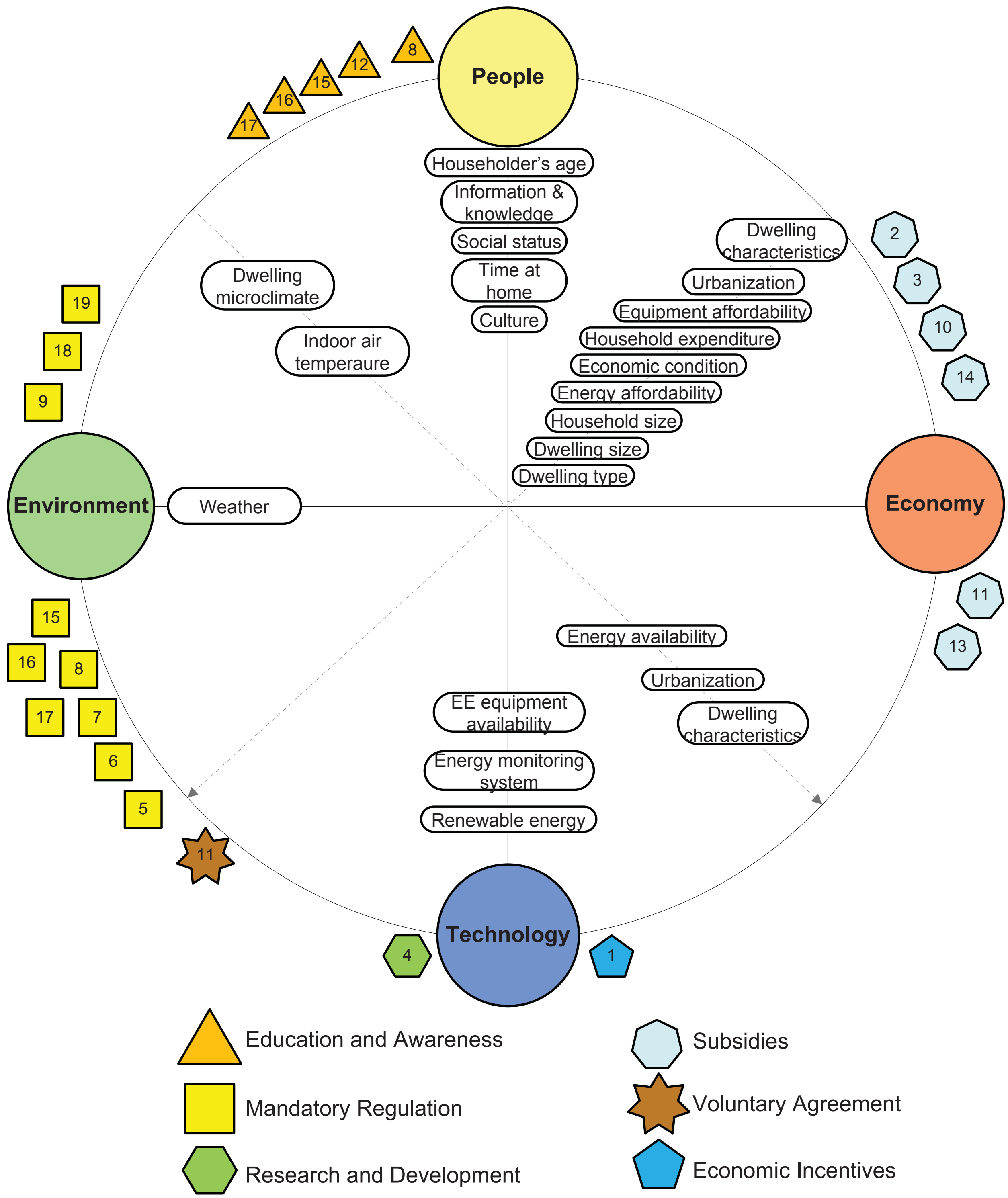

Figure 7-4 Evaluation framework of the energy efficiency policies implemented in Spain targeting the residential building sector

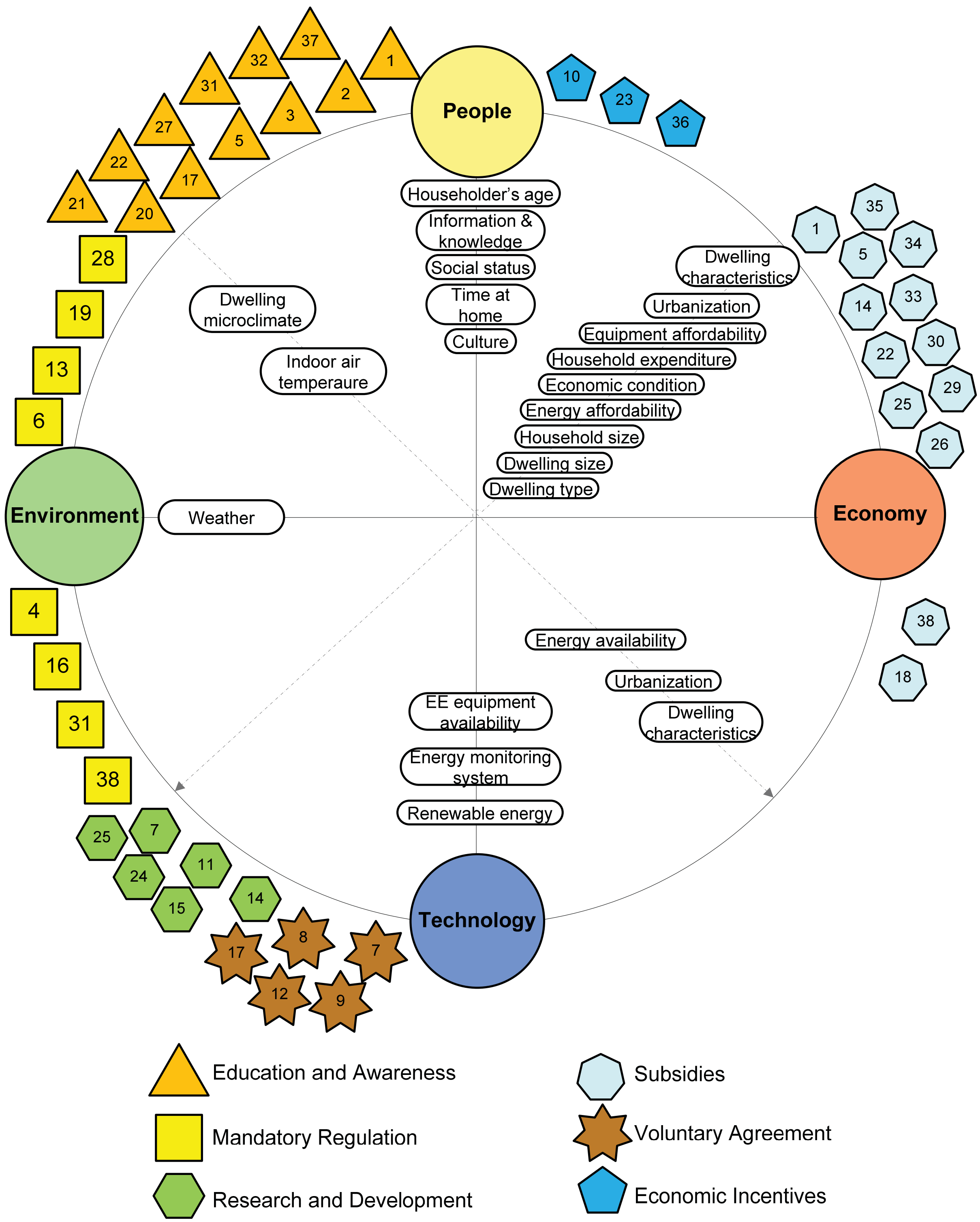

Figure 7-5 Evaluation framework of the energy efficiency policies implemented in United Kingdom targeting the residential building sector

Comparing the evaluation frameworks of the three EU countries, it is evident that the total number of policies implemented in the United Kingdom is the greatest among the three countries, followed by Austria. The United Kingdom has several voluntary agreements with the industry to improve energy efficiency as compared to Austria. Other than this there is not much difference between the types of policies implemented in Austria and the United Kingdom. Spain has fewer energy efficiency policies implemented to date compared to the United Kingdom and Austria, and the majority of their policies are either mandatory regulation or subsidies for the industry or people.

7.2.3 Comparison between Energy Efficiency Policies of US States

The three US states selected for the study are California, Massachusetts and Florida. According to the 2009 Energy Efficiency Scorecard (Eldridge et al. 2009) California and Massachusetts are considered among the top 10 US states doing the most to implement energy efficiency improvements. Florida on the other hand is one of the most natural gas dependent states in the US with more than one third of their electricity generated from natural gas (Elliott et al. 2007). Figure 7-6 below shows the energy consumption per capita of the above mentioned US states from 1980 to 2006.

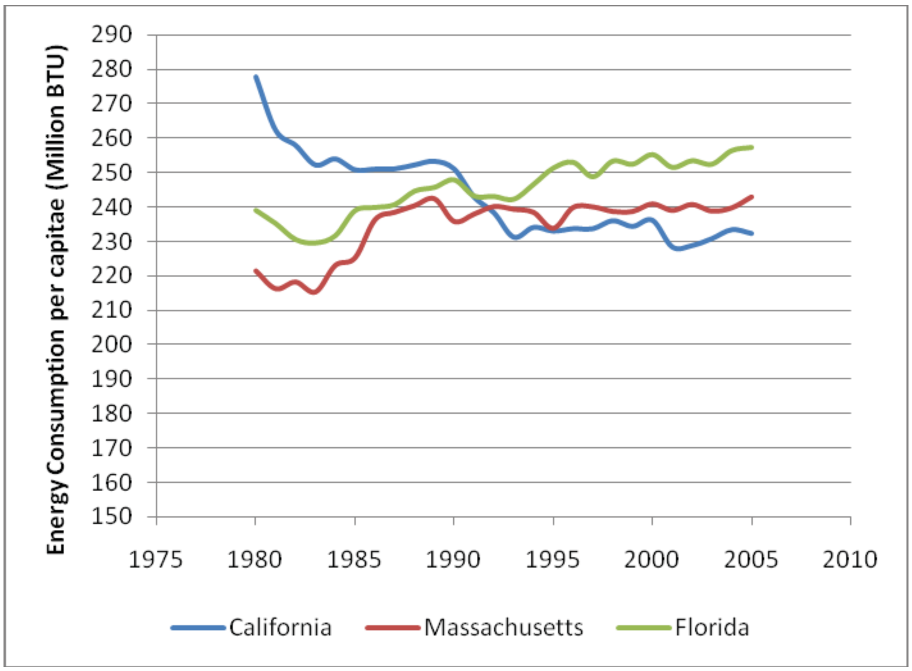

Figure 7-6 Energy consumption per capitae of California, Florida and Massachusetts from 1980 to 2006

The following sections discuss the energy efficiency policies implemented in the three US states.

7.2.3.1 Energy Efficiency Policies of California

California is one of the US statesthat has implemented energy codes as early as 1974, with the Warren-Alquist Act. The state's energy code has earned the reputation of being the most aggressive and best enforced in the United States. California's energy code has proven to be a powerful vehicle for advancing energy-efficiency standards for building equipment. Many specifications mentioned in the California energy code are performance based which offers flexibility to the designers. In addition, the code includes field verification requirements for certain measures and reports high compliance rates overall.

The building code of California is revised every three years (the 2008 revisions were approved by the Building Standards Commission on September 11, 2008). In 2004, California governor Shwarzeneggar announced the “Green Building Initiative” (Executive Order S-20-04), which created an additional target of 20% savings in new commercial buildings by 2015 (ACEEE 2010d). This indicates a more aggressive approach in the upcoming adoption cycles. A new bill is currently being debated in California’s Committee on Appropriations. The bill under consideration (California Assembly introduced AB 212 on Februrary 2, 2009) directs the California Energy Commission (CEC) to adopt standards to achieve “zero net energy” that will require new residential construction to be "zero net energy" starting in 2020.

It was also the first state in the United States to adopt appliance and equipment efficiency standards. This started in 1974, and since then California has adopted standards on more than 50 products, which later on went to become federal standards. The state’s aggressive campaign for energy efficiency is manifested by the fact that it has standards on more than a dozen products that are not covered by federal standards. California’s 2006 Appliance Efficiency Regulations was made effective in the state from December 30, 2005 superseding all previous versions of regulations. These regulations create standards for 21 categories of appliances, which is inclusive of both federally-regulated as well as non-federally-regulated appliances (ACEEE 2010a).

Table 7-4 Energy Efficiency Policies implemented in California targeting the residential building sector

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS
1	Warren-Alquist Act	1974	Superseded	Mandatory Regulation	Appliances	Industry	EE Equipment Availability
					Buildings	People	Dwelling Characteristics
						Industry	
2	California's net-metering law	1996	Ongoing	Mandatory Regulation	Energy	Industry	Renewable Energy
				Financial Incentives		People	
3	Emerging Renewables Program	1998	Ongoing	Subsidies	Energy	Industry	Renewable Energy
4	Property Tax Exclusion for Solar Energy Systems	1999	Ongoing	Financial Incentives	Energy	People	Renewable Energy
5	Public Benefits Funds for Renewables & Efficiency	2002	Ongoing	Subsidies	Energy	Industry	Renewable Energy
				Research and Development			Energy Availability

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS
				Subsidies	Buildings	People	Dwelling Characteristics
6	Appliance Efficiency Regulations 2006	2005	Superseded	Mandatory Regulation	Appliances	Industry	EE Equipment Availability
7	Solar Contractor Licensing	2006	Ongoing	Mandatory Regulation	Energy	Industry	Information & knowledge
8	California Solar Initiative	2006	Ongoing	Subsidies	Energy	People	Renewable Energy
9	CEC-New Solar Homes Partnership	2007	Ongoing	Subsidies	Energy	Industry	Renewable Energy
10	California Solar Initiative - Multi-Family Affordable Solar Housing (MASH) Program	2008	Ongoing	Subsidies	Energy	People	Renewable Energy
11	Appliance Efficiency Regulations 2009	2008	Ongoing	Mandatory Regulation	Appliances	Industry	EE Equipment Availability
12	California State Energy Code	2008	Ongoing	Mandatory Regulation	Buildings	People	Dwelling Characteristics
13	PACE Financing	2008	Ongoing	Subsidies	Appliances	People	EE Equipment Affordability
					Buildings		Dwelling Characteristics
							Economic Condition
14	California Solar Initiative - Single-Family Affordable Solar Housing (SASH) Program	2009	Ongoing	Subsidies	Energy	People	Renewable Energy
15	California Feed-In Tariff	2009	Ongoing	Financial Incentives	Energy	People	Renewable Energy
16	Self-Generation Incentive Program	2010	Ongoing	Financial Incentives	Energy	People	Renewable Energy

7.2.3.2 Energy Efficiency Policies of Massachusetts

Following the path shown by California, in 1986 Massachusetts adopted appliance standards and became one of the frontrunners in doing so. Almost 20 years later, in 2005 Massachusetts expanded its appliance standard legislation to cover as many as seven products. However, the federal Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007 introduced standards that superseded the state standards on two of those products. New products that are considered for state standards are adopted through the Division of Energy Resources (ACEEE 2010c).

In Massachusetts, it is mandatory to follow the State Building Code in compliance with the IECC 2006 and 2007 supplement for one and two family dwellings. Alternatively the dwellings have to achieve a Home Energy Rating System score of 100 or fewer points. As in the case of residential buildings, commercial buildings in Massachusetts have to abide by the statewide mandate in compliance with either the IECC 2006 and 2007 supplement or ASHRAE 90.1-2007. As per the Green Communities Act of 2009, Massachusetts has to adopt each new IECC edition within one year of its publication. As a natural corollary, the 2009 version of IECC will be included in the 8th edition of the Massachusetts Building Code (ACEEE 2010c).

Table 7-5 Energy Efficiency Policies implemented in Massachusetts targeting the residential building sector

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS
1	Renewable Energy Equipment Sales Tax Exemption	1977	Ongoing	Financial Incentives	Energy	People	Renewable Energy
2	Residential Renewable Energy Income Tax Credit	1979	Ongoing	Financial Incentives	Energy	People	Renewable Energy
3	Renewable Energy Property Tax Exemption	1984	Ongoing	Financial Incentives	Energy	People	Renewable Energy
4	Appliance Efficiency Standards	1986	Ongoing	Mandatory Regulation	Appliances	Industry	EE Equipment Availability
5	Massachusetts Renewable Energy Trust Fund	1991	Ongoing	Subsidies Financial Incentives	Energy	People	Renewable Energy
6	Massachusetts Pubic Benefit Energy Efficiency Fund	1998	Ongoing	Research and Development Subsidies	Appliances Building	Industry People	Energy Availability EE Equipment Affordability Dwelling Characteristics Economic Condition
7	MassCEC- Commonwealth Wind Incentive Program – Micro Wind Initiative	2005	Ongoing	Financial Incentives Subsidies	Energy	People	Renewable Energy
8	Massachusetts State Building Code	2008	Ongoing	Mandatory Regulation	Building	People	Dwelling Characteristics
9	Massachusetts - Net Metering	2008	Ongoing	Mandatory Regulation Financial Incentives	Energy	Industry People	Renewable Energy
10	MassCEC - Commonwealth Solar II Rebates	2010	Ongoing	Financial Incentives Subsidies	Energy	People	Renewable Energy
11	Massachusetts - Residential Energy-Efficient Appliance Rebates	2010	Ongoing	Financial Incentives	Appliances	People	EE Equipment Affordability Monetary Expenditure
12	Massachusetts Major Renovations Program	-	Ongoing	Subsidies	Appliances Building	People	EE Equipment Affordability Monetary Expenditure Dwelling Characteristics Economic Condition
13	Massachusetts New Homes with ENERGY STAR Program	-	Ongoing	Financial Incentives	Building	Industry	Dwelling Characteristics

7.2.3.3 Energy Efficiency Policies of Florida

Chapter 13 of the Florida Building Code is being used by the state as a mandate for residential construction to meet/exceed the IECC 2006 and for commercial construction to meet/exceed ASHRAE 90.1-2004. In 2008 Florida governor Charlie Crist signed HB 697, which binds the Florida Building Commission to use the most current version of the IECC as a foundation code and at the same time modify it to maintain the thermal efficiencies of the Florida Energy Efficiency Code for Building Construction adopted and amended pursuant to § 553.901 (ACEEE 2010b).

Table 7-6 Energy Efficiency Policies implemented in Florida targeting the residential building sector

No.	POLICY	YEAR	STATUS	TYPE	TARGET	AUDIENCE	FACTORS
1	Solar Equipment Certification	1976	Ongoing	Mandatory Regulation	Energy	Industry	Renewable Energy
2	PACE Financing	1989	Ongoing	Subsidies	Appliances Buildings	People	EE Equipment Affordability Dwelling Chatacteristics Economic Condition
3	Solar Contractor Licensing	1994	Ongoing	Mandatory Regulation	Energy	Industry	Information & Knowledge
4	Solar Energy Systems Equipment Sales Tax Exemption	1997	Ongoing	Financial Incentives	Energy	People	Renewable Energy
5	Solar Energy System Incentives Program	2006	Ongoing	Subsidies	Energy	People	Renewable Energy
6	Florida - Net Metering	2008	Ongoing	Mandatory Regulation Financial Incentives	Energy	Industry People	Renewable Energy
7	Florida State Building Energy Code	2008	Ongoing	Mandatory Regulation	Buildings	People	Dwelling Chatacteristics
8	Florida - Residential Energy-Efficient Appliance Rebate Program	2010	Ongoing	Subsidies	Appliances	People	EE Equipment Affordability Economic Condition

7.2.3.4 Analysis

Analyses of the factors targeted by each of the policies implemented in the three US states present the opportunity to compare between the numbers of policies (expressed as percentage) targeting the respective factors. Figure 7-7 shows a graphical representation of the comparison.

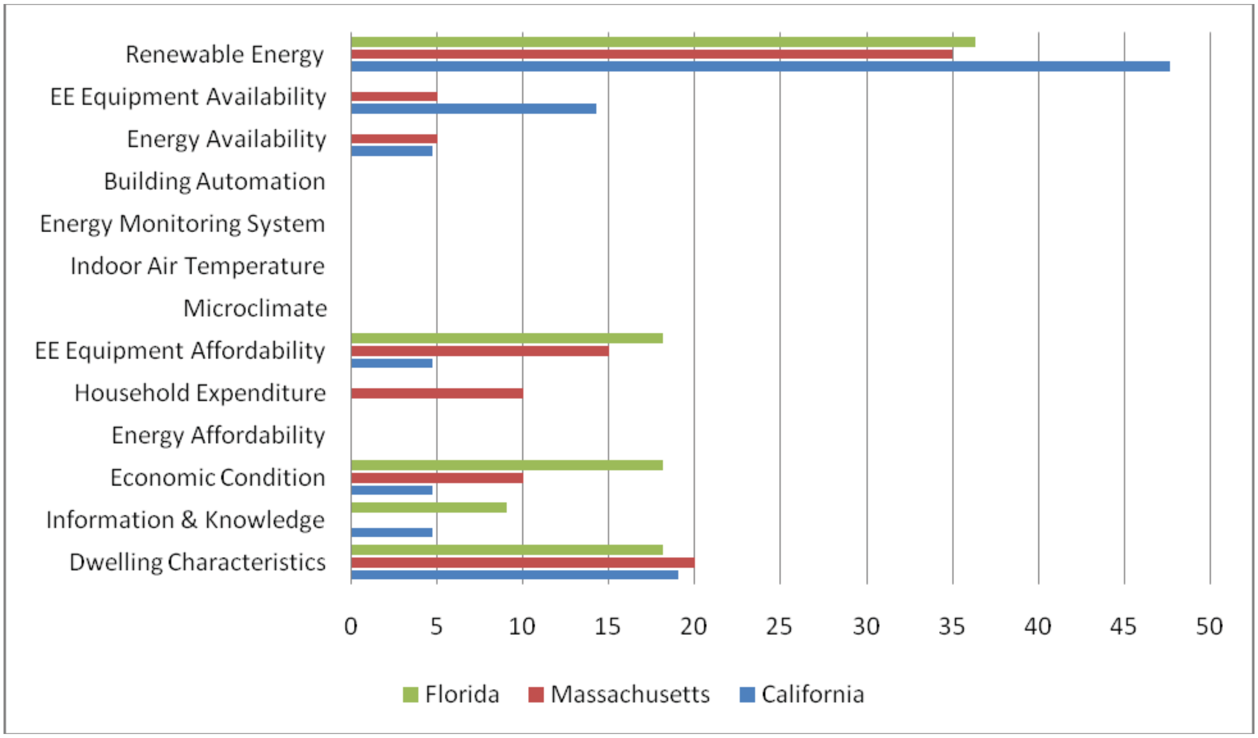

Figure 7-7 Comparison of factors targeted by energy efficiency policies implemented in California, Florida and Massachusetts

California is way ahead compared to Massachusetts and Florida in targeting the renewable energy and energy efficient equipment availability factors. Florida on the other hand focuses more on the economy related factors such as energy efficient equipment affordability, and economic condition. This does not mean that Florida has a greater number of such policies compared to the other two states. This is because the graph represents the percentage of energy policies of the total portfolio that targets a particular factor. From the evaluation framework below it is evident that the total number of such policies implemented in Florida is much smaller.

In the figures that follow (Figure 7-8, Figure 7-9, and Figure 7-10), the energy efficiency policies of three states of the United States have been mapped on the evaluation framework developed in this research. The number inside each policy type shown in the framework refers to the policy corresponding to that number, in the list of policies for the respective state.

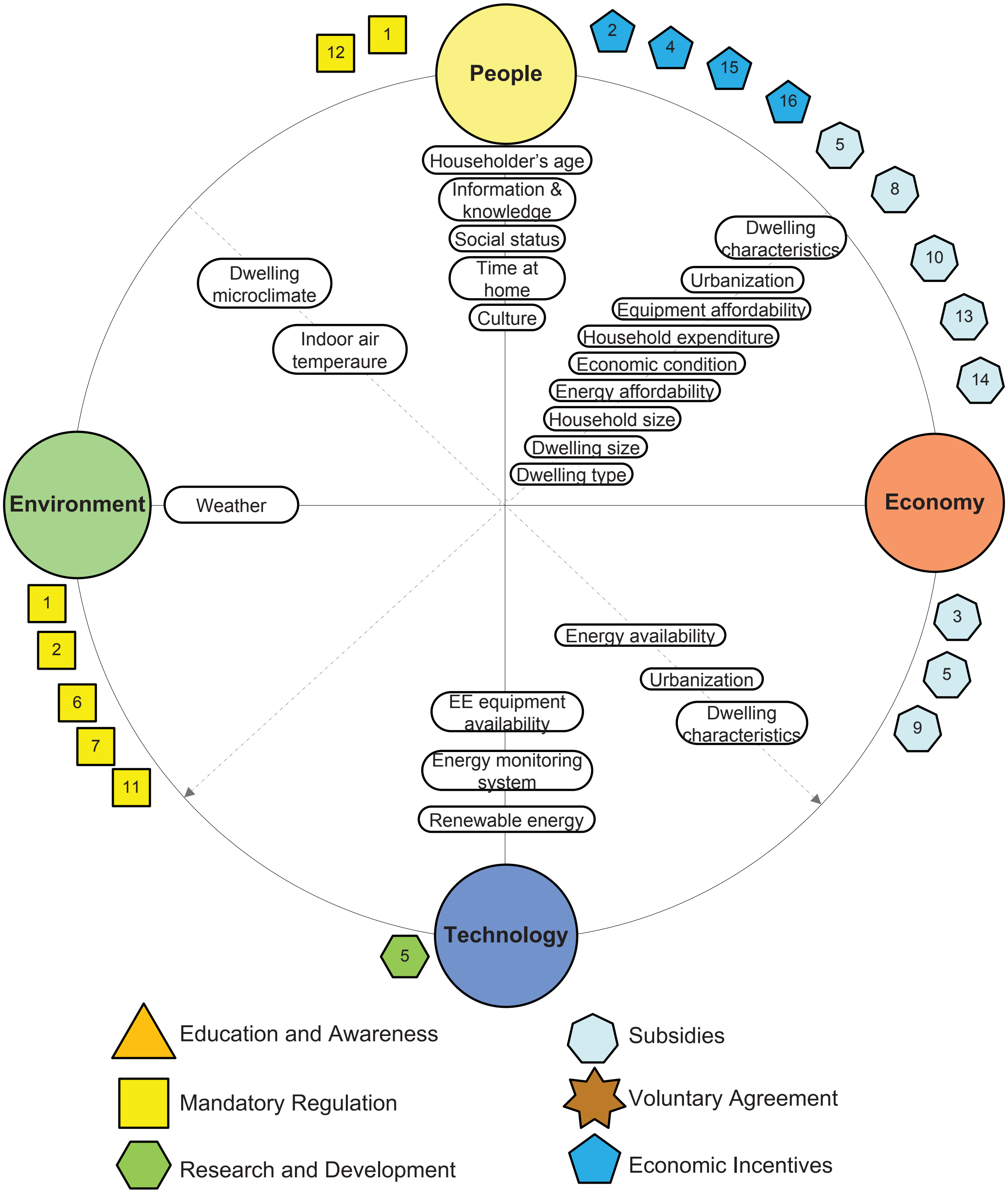

Figure 7-8 Evaluation framework of the energy efficiency policies implemented in California targeting the residential building sector

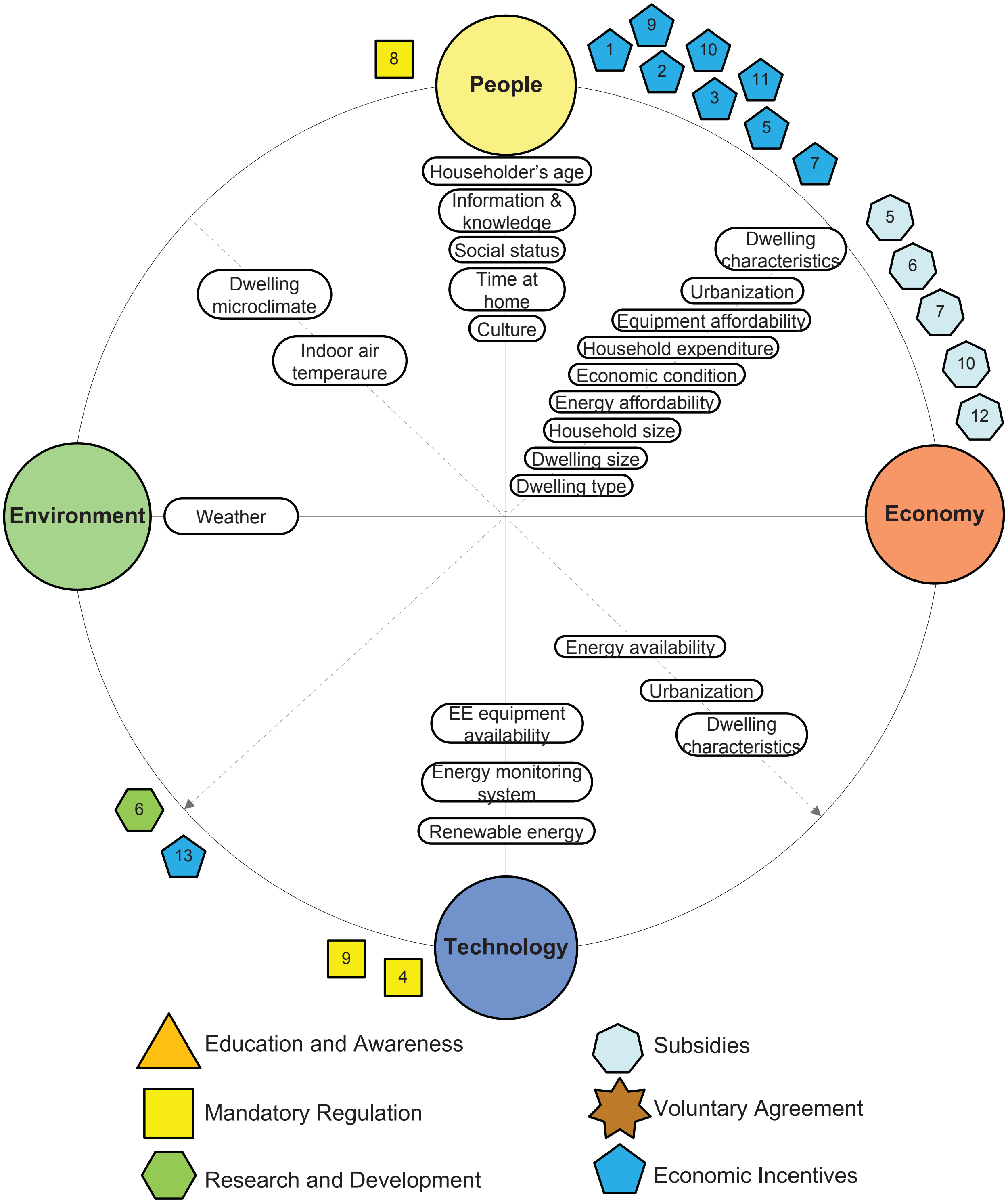

Figure 7-9 Evaluation framework of the energy efficiency policies implemented in Massachusetts targeting the residential building sector

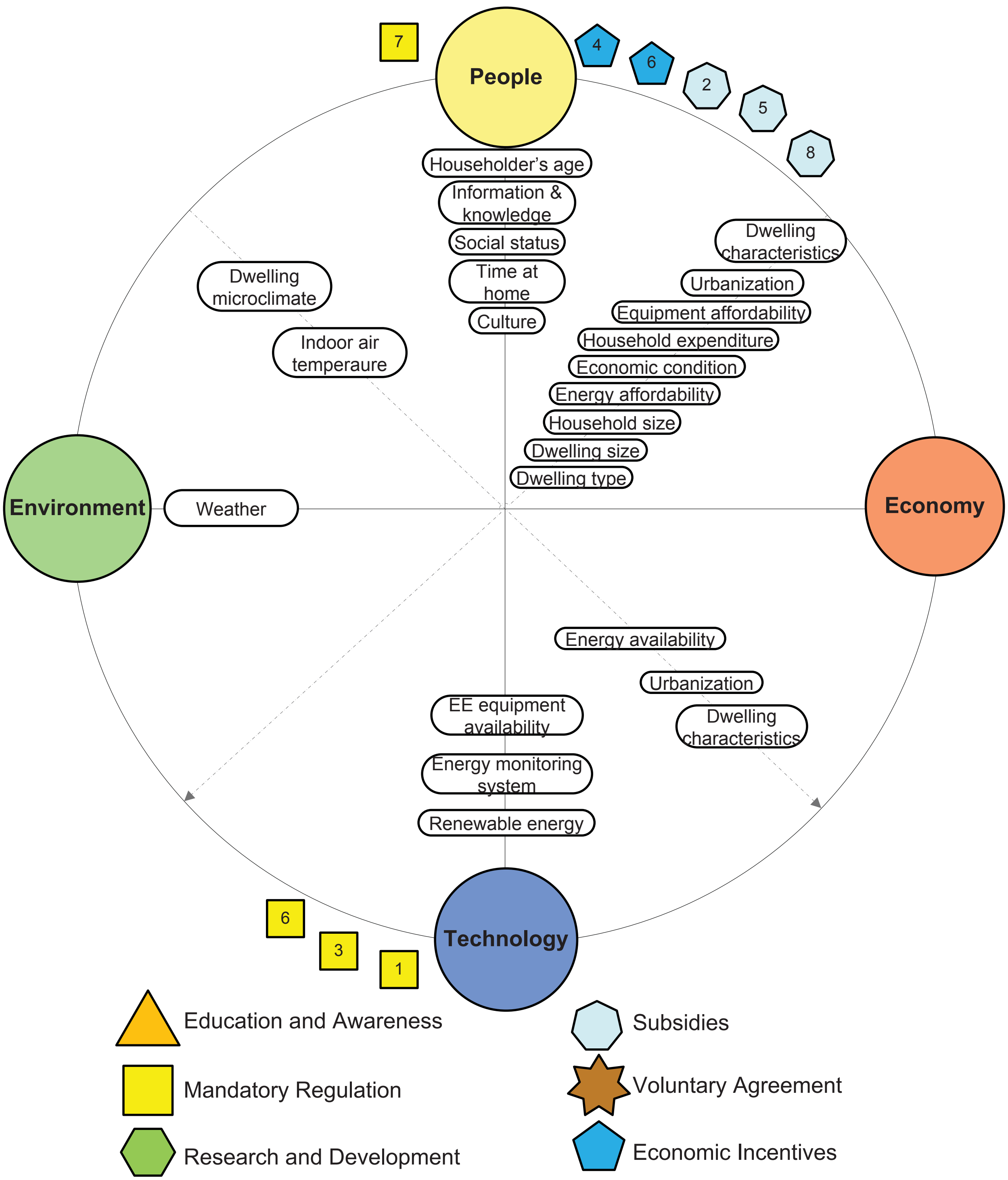

Figure 7-10 Evaluation framework of the energy efficiency policies implemented in Florida targeting the residential building sector

The number of energy efficiency policies implemented in California is the greatest among all the three states. California also has the largest number of mandatory regulations both for the people and for the industry compared to Florida and Massachusetts. There are very few energy efficiency policies implemented in Florida when compared with California and Massachusetts.

7.3 Conclusion

The evaluation framework developed in Chapter 6 was checked for its validity and generalizability. At an early development phase of the evaluation framework the research was submitted for a conference and peer reviewed by experts in the area of energy efficiency policies. Based on the reviewers' comments, the framework has the potential to help policy makers in analyzing the energy efficiency policy portfolio of a country/state in a more holistic and organized fashion, and check if the mix of policies is aligned with the context they seek to influence. According to one reviewer the framework seems to provide a non-traditional perspective towards examining whether the energy efficiency policies and procedures being implemented are likely to work to affect customer behavior towards more energy conservation and efficiency adoption. This proves the validity of the framework which means that the developed framework is capable of functioning in the way the author claims it does.

The second part of this chapter undertakes an exploratory analysis of energy efficiency policies targeting the residential building sector that are currently implemented in three EU countries and three US states. These policies are mapped according to their impact on the four functional domains that have been identified previously. After mapping the policies implemented in the three EU countries and the three US states comparative analyses of the policies were performed. The analyses demonstrated the generalizability of the proposed evaluation framework. The demonstrated method can be used as a core component in our envisioned energy program evaluation framework and will give countries/states a tool to identify gaps in their energy efficiency policy portfolio.

Chapter 8. Conclusion and Recommendations

This chapter summarizes the research findings which include a) identification of factors affecting energy consumption, b) categorization of the policies, c) study of the effectiveness of policy portfolios of countries in addressing factors known to influence energy consumption, and d) development of a framework to compare energy efficiency policy portfolios across countries/states. The chapter concludes with guidelines and possible tasks for future research.

Some of the further developed OECD countries have long been more proactive than many other countries in implementing energy efficiency policies, especially within the building sector. However, the approach followed by each country originates with its own socio-economic need for efficiency. The policies of one country cannot be directly mapped into another due to their different economic background and social perspectives. This research developed a framework for comparing energy efficiency policy portfolios across countries/states. Although the framework can be adapted for any type of energy policy, the current focus is on policies targeting the residential building sector. The research provides methods and a defined terminology on how to evaluate the effectiveness of policies. This evaluation method allows for a uniform assessment process of how energy efficiency policies target specific socio-economic factors that are known to affect energy consumption. The following sections conclude the main research findings.

8.1 Research Summary and Findings

The research findings fall under four topics. First, there is the introduction of socio economic factors affecting household energy consumption and the relationships among them; second, there is the introduction of working strategies of different types of energy efficiency policies; and third, there is the development of a prototype method to identify the factors targeted by individual energy efficiency policies. Finally, there is, derived from the results of the previous topics, the research and development of a framework to compare energy efficiency policy portfolios across countries/states. The research findings under each topic are further explained as follows.

8.1.1 Socio Economic Factors Affecting Energy Consumption

This research conducted an intense literature search to identify the factors affecting energy consumption. It then further analyzed these factors with the help of cause and effect diagrams to identify sub factors or minor causes of energy consumption. It began with the identification of the functional domains that influence human behavior, i.e., people, economy, technology and environment. With the help of the affinity diagram method the control elements under each of the energy consumption factors were identified and associated with the respective functional domains. This process added a holistic view of the influence of human behavior on energy consumption to the existing body of knowledge.

The research shows that energy efficiency can be successfully improved beyond the minimum requirements required by codes. Evaluation of the factors influencing household energy consumption makes it evident that it is essential to generate a mix of strategies that target most of these factors. The association of the major factors affecting residential energy consumption with functional domains, based on their minor causes or sub-factors as shown in Table 6-1, will help policy makers understand the importance of each of the parameters. This association between factors and parameters will further assist in studying the effectiveness of energy policies. The results show a strong association between the energy consumption factors and the economy domain. This indicates that energy policies with economic incentives or subsidies might be more effective in having an impact on human behavior and consequently energy consumption.

The control elements identified under the energy consumption factors can be controlled with the implementation of proper energy efficiency policies. For example, incentive based energy policies and government subsidies can help towards financial control elements such as economic condition, household monetary expenditure, etc. Knowledge based elements can be overcome with the implementation of proper energy awareness programs. Normative policies can control elements connected to personal attitudes. These control elements were further used in the later part of the research to identify the factors targeted by individual energy efficiency policies of a country or state. Based on the outcome of this study, it can be assumed that policies that for instance raise the cost of energy, or other economic incentives, can be more successful in reducing residential energy consumption. Other beneficial options could be the introduction of subsidies for the development and introduction of new technologies, institutional reforms, such as changes in building codes, and utility regulations. The application of technology mandates such as fuel economy standards for equipment or the use of renewable energy sources can be also considered as viable strategies to significantly increase energy efficiency.

8.1.2 Working Strategies of Energy Efficiency Policies

This research presented a graphical approach to visualize, analyze and compare working strategies of the different types of energy efficiency policies implemented in OECD countries. It showed and analyzed in the form of diagrams how the government with all its elected representatives acts as a central entity influencing the four functional domains to achieve the goal of a better environment. It becomes transparent that the government can create a pivotal momentum when it comes to transferring energy efficient technologies to people. This can be facilitated either through economic incentives, or through mandatory regulations, thus forcing a society to shift towards a better environment. The identified working strategies of energy efficiency policies were used later in this research to develop a prototype method for placing energy efficiency policies in an evaluation framework.

8.1.3 Energy Consumption Factors Targeted by Energy Efficiency Policies

The research developed a prototype method to identify factors that are targeted by individual energy efficiency policies. It used the method of content analysis to read through detailed descriptions of policies and then further identified the control elements from the description. Once the control elements were identified under each policy, the factors were recognized based on the association of the control elements with the factors. This enabled the author to identify the factors targeted by the energy efficiency policies. To test the reliability of this process, the same procedure was repeated by other persons and their output was compared with that of the author's. Comparing the list of factors identified by the author and that of other persons, it was found that the identified factors targeted by each policy were similar. This process will help policy makers to identify the gaps in their policy portfolios and help generate a mix of strategies that will target most of the energy consumption factors.

8.1.4 Framework to Compare Energy Efficiency Policies across Countries/States

The socio-economic factors affecting residential energy consumption identified previously were positioned in a graphical analysis diagram based on their association with their functional domains. In a second step, various energy efficiency policies were positioned in the same diagram to demonstrate how well the policies address the factors identified previously. This mapping method is the core component of the framework. At this stage the mapping is purely looking at numbers of policies implemented to target a factor without including any weighting mechanism. With this limitation, a possible interpretation would be for now that a well balanced distribution suggests a concerted approach for preparing and introducing policies on a national level.

A comparison between energy efficiency policy portfolios of three EU countries portrays the difference in the strategies adopted by each country. Though the policies implemented in Austria, the United Kingdom, and Spain are housed under the umbrella of EU directives, each country can implement directives in a different way. Policies implemented in the United Kingdom focus more towards information & knowledge factors as well as economic factors influencing energy consumption. On the other hand, policies implemented in Austria are focused more towards improving the dwelling characteristics. A typical example of such a policy is the New Housing Subsidization Scheme. Based on the European Energy Performance of Buildings Directive of 2009 the European Parliament has agreed that all EU member states must ensure that all new buildings will have high energy performance. This will further improve the dwelling characteristics of newly constructed buildings. The benefits of energy efficiency will reach beyond the actual owners of the buildings and will eventually influence the society as a whole. Thus the users should take responsible steps to create boundaries that will directly influence energy efficient design and construction of buildings. The total number of policies implemented to date is much smaller in Spain compared to Austria and/or the United Kingdom. The majority of the policies implemented in Spain are either of the mandatory regulation type or the economic incentives/subsidies type. Voluntary agreements with the industry to improve energy efficiency are relatively popular in the United Kingdom compared to both Austria and Spain.

Instead of waiting for federal actions, US states are actively moving forward with the implementation of new and more effective energy efficiency policies. The Annual Council for an Energy Efficient Economy (ACEEE) has developed a state energy efficiency scorecard based on the policies implemented in different areas in a particular state. California and Massachusetts both rank respectively as number one and two in this list. A comparison among the energy efficiency policy portfolios of California, Florida and Massachusetts shows how differently each state handles their energy crisis though governed by a central federal authority. California is way ahead in the game compared to Florida and Massachusetts in targeting the renewable energy and the energy efficient equipment availability factors. California's advancement in this regard is supported by its long term energy efficiency strategic plan. This plan was adopted by the California Public Utilities Commission, with support from the Governor's Office, the California Energy Commission, the California Air Resource Board, the state's utilities, local government, and others in September 2008. According to this plan, all new residential construction in California will be zero net energy buildings and all low income customers will have the opportunity to participate in low income energy efficiency programs by 2020.

8.2 Implications

Use of energy in various forms makes an undeniable contribution towards the prosperity of mankind. Having exploited the non-renewable resources of energy for years, all of mankind is now faced with the grave challenge of exploring novel resources for renewable energy and efficiently utilizing traditional energy resources. Considering the significance of energy to mankind, energy efficiency has now become the 'bigger than life' question to almost every human being, especially to the league of scholars interested in green environment. Being born in the latter half of the twentieth century and having spent the adolescence through a time when the whole world is astounded by the energy crisis, the author was motivated to look deeper into energy efficiency. The term energy efficiency is gaining importance each day throughout the world, be it in the developed countries or the developing countries. One major aspect that differentiates between the developed and the developing countries in respect of energy efficiency is the formulation and implementation of energy efficiency policies. A detailed literature review revealed that the approach followed by each country is largely based on its socio-economic need for efficiency. Moreover, the author noticed over the course of this research that there is a deficiency of tools/systems that could support policy makers of any country to gain knowledge from lessons learnt by another country, while implementing energy efficiency policies in their own countries. The author strived to bridge this gap by virtue of this dissertation, and by developing a framework for comparing energy efficiency policy portfolios across countries, states, or regional energy alliances.

The journey through the process of writing the dissertation has dawned upon the realization that the political environment around the globe is at its best for the enhancement of energy efficiency. Bureaucrats as well as common people have realized at last that the current energy system is unsustainable, and that energy efficiency is the most effective solution to our economic security and climatic changes. Business and policy leaders from all political camps have shaken hands to expand implementation of energy efficiency, especially in the form of energy efficiency policies. A developed country like the United States, whose building sector accounts for more than fifty percent of energy consumption, is experiencing a change in the political willingness to invest public dollars in energy efficiency via implementation of policies, subsidies, and also incentives. This change in the awareness and willingness among bureaucrats, business people, and consumers means that forces are combining as never before to change the energy efficiency landscape. Seizing this opportunity will demand greater awareness of various existing and proposed federal, state, and local policies that can impact businesses and organizations. Moreover, the framework developed in this dissertation can also prove to be an essential tool for comparing energy efficiency portfolios across countries, states, or the emerging regional energy alliances. The author strongly believes that the framework has wider application than globally comparing energy efficiency policies across countries/states. Local municipalities can also add their energy efficiency policies to the framework and use it as a tool to compare their portfolio to that of other municipal or regional level policy portfolios. To increase the efficacy of the framework, the author plans to make it operational through a user-friendly web based interface and cross-linked database of policies and lessons learnt in future.

As of now, the framework can enable policy makers and other decision makers (1) to gain an understanding of the main factors influencing energy consumption and energy efficiency, (2) to evaluate their current programs towards these factors, (3) to compare their portfolios to those from other countries with similar socio-economic context, (4) to identify gaps and links in their portfolios, and (5) to benefit from lessons learned by other countries and states. Each country/state can then scale the effectiveness of a planned (and already studied) measurement through an assessment of the impact of the related efficiency parameters in their own socio-economic context.

8.3 Future Research

The model approach introduced within this paper represents a first step of an evaluation framework that is envisioned by the author. To build on the findings of this research future investigations can be conducted in the following areas.

Development of a framework to analyze the effectiveness of energy efficiency policies targeting the barriers to the process of diffusion of energy efficient technologies

Researchers in every field are working closely with the industry to develop new energy efficient technologies. There have been a considerable number of energy efficient technological improvements throughout the world since the late 1970s. In contrast to these improvements the consumption of energy has not been reduced at anywhere near the same level. This indicates that the diffusion rate of these technologies is too slow. A typical example would be the US lighting industry which has improved its energy efficiency more than 300% since 1978 (EnvironmentalLeaders 2008), but the energy consumption due to lighting has not reduced in such magnitude. It can therefore be concluded that certain factors hinder the process of diffusion of new technologies. Thus it is necessary to investigate the factors that influence the diffusion of new energy efficient technologies. Proper application of strategic energy policies targeting the factors that affect the diffusion of new technologies will help to improve the present situation.

This research will aim to investigate some of the market barriers that impede the diffusion of energy efficient technologies. It will focus on understanding to what extent some of the identified barriers could be overcome through implementation of energy policies. The results are expected to show gaps that may exist between market barriers affecting the diffusion of energy efficient technologies and the policies targeting these barriers.

<u>Research possible measurables for the effectiveness of energy efficiency policies and programs</u>

Future research will investigate measurables to develop weighting mechanisms for different types of policies, which will better address the quantitative effectiveness of energy efficiency policies rather than the schematic assessment demonstrated within this research. The research will investigate weighting models that allow for rating the importance/impact of different measurables on the evaluation process, and/or weighting models that can change the importance/impact of a particular parameter or barrier for a policy maker during policy evaluation.

<u>Development of a tool for generating options of possible alternative energy efficiency program solutions for particular stakeholders or policy makers</u>

The research will develop a relational database system reflecting the framework created in this research and the proposed frameworks. The tool will have a user interface that will allow for collecting energy efficiency policy case study data. This information will include policy type, diffusion patterns, selected available measurables and other parameters provided through the framework. In addition the tool will allow for evaluation of program effectiveness in a scalable social context. This evaluation will be facilitated directly against selected peer portfolios or can be derived from a subset of existing information in the database. For example, a specific factor of energy consumption or a specific market barrier can be selected to filter for relevant policies addressing those in general, and subsequently the resulting programs can be compared in their effectiveness for a given set of socio-economic boundary conditions (e.g., climate, household size, income level, etc.).

Development of a similar framework to analyze and compare energy efficiency policies targeting other sectors

The theoretical approach of graphically grouping and mapping energy efficiency policies targeting the residential building sector can also be used to analyze policies targeting other sectors such as the commercial building sector, or the industry and transportation sectors. However, the future focus of my research will mainly investigate building related policies. It is believed that this model can also be used by developing countries to compare their whole energy efficiency portfolio with those of a further developed country.

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APPENDIX A - Document provided to the inter-rater reliability observers

Following documents are included in this appendix:

- Empty reliability form
- Short description of the factors and core influences
- Coding instruction

Detail description of each of the three energy efficiency policies is available from the following online database:

1. New Housing Subsidization Scheme:

   http://www.iea.org/textbase/pm/Default.aspx?mode=pm&id=4314&action=detail

2. Sustainable Economy Law

   http://www.iea.org/textbase/pm/Default.aspx?mode=pm&id=4479&action=detail

3. Community Energy Savings Programme

   http://www.iea.org/textbase/pm/Default.aspx?mode=pm&id=4236&action=detail

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

Energy efficiency policy name: ______________________________

CATEGORIES	FACTORS						
Demographics	**Household Size** ☐Y ☐S ☐N	**Householder's Age** ☐Y ☐S ☐N	**Time spent at Home** ☐Y ☐S ☐N	**Urbanization** ☐Y ☐S ☐N	**Dwelling Characteristics** ☐Y ☐S ☐N	**Dwelling Type** ☐Y ☐S ☐N	**Dwelling Size** ☐Y ☐S ☐N
Consumer Attitude	**Social Status** ☐Y ☐S ☐N	**Culture** ☐Y ☐S ☐N	**Information & Knowledge** ☐Y ☐S ☐N				
Economy	**Energy Affordability** ☐Y ☐S ☐N	**Economic Condition** ☐Y ☐S ☐N	**EE Equipment Affordability** ☐Y ☐S ☐N	**Household Expenditure** ☐Y ☐S ☐N			
Climate	**Dwelling Micro-climate** ☐Y ☐S ☐N	**Weather** ☐Y ☐S ☐N	**Indoor Air Temperature** ☐Y ☐S ☐N				
Technology	**Energy Availability** ☐Y ☐S ☐N	**Renewable Energy** ☐Y ☐S ☐N	**EE Equipment Availability** ☐Y ☐S ☐N	**Energy Monitoring Syst.** ☐Y ☐S ☐N			

Legend: **Y-** Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

FACTORS SHORT DESCRIPTIONS and CORE INFLUENCES

CATEGORIES	FACTORS						
Demographics	**Household Size**	**Householder's Age**	**Time spent at Home**	**Urbanization**	**Dwelling Characteristics**	**Dwelling Type**	**Dwelling Size**
Description:	Number of people living in a household	Average age of the people living in a household.	Amount of time the dwelling is occupied	Proportion of energy used for recreation and comfort	Envelope performance, efficiency of systems, exposure, orientation	Single family house, town house, multi-family house, apartment, mobile home	Square feet area of dwelling
Influenced by: (Control Elements)	culture, economic environment, family life cycle	Lack of information, inertia to change, health, comfort	Work type of occupants (office/from home), family lifecycle,	Standard of living, economy	Owners economic condition, information, householder's age, inertia to change	Householder's economic cond., population density, location	Population density, family lifecycle, economic condition
Consumer Attitude	**Social Status**	**Culture**	**Education & Knowledge**				
Description:	Social pressures towards behavior	Societal norms and traditions	Level of education amount of available information, inform. awareness				
Influenced by: (Control Elements)	prestige, competition	Social norms, traditions	Consumption and conservation knowledge, energy crisis awareness				
Economy	**Energy Affordability**	**Economic Condition**	**EE Equipment Affordability**	**Household Expenditure**			
Description:	Price of energy related to the income level of a	Economic condition of the householders	Ease for an individual to buy energy efficient equipment	Spending behavior of household			

	society/region			members			
Influenced by: (Control Elements)	Energy price, economic condition	Monetary expenditure, income level	Economic cond., price and supply of equipment	Economic condition			
Climate	**Dwelling Micro-climate**	**Weather**	**Indoor Air Temperature**				
Description:	Local temperature around a building	Atmospheric weather data	Set point temperature of the thermostat				
Influenced by: (Control Elements)	orientation, neighboring objects, shape	temperature, humidity, wind flow/direction, # of sunny days	Householder's age, envelope, exterior temperature, lifestyle				
Technology	**Energy Availability**	**Renewable Energy**	**EE Equipment Availability**	**Energy Monitoring Syst.**			
Description:	Types and amounts of energy resources that are available in certain areas	Availability and affordability of renewable energy generation systems	Availability of equipment providing same service as standard equipment using less energy	Equipment providing information to the users about energy consumption			
Influenced by: (Control Elements)	Availability of crude oil, price of crude oil, technology	Economic condition, technology	Technological improvement	Technological improvement			

Process to identify the energy consumption factors targeted by each energy efficiency policy

The socio economic factors affecting household energy consumption has been identified from previous literatures and grouped in five categories which are demographics, consumer attitude, economy, climate, and technology. The energy consumption factors are further analyzed with the help of cause and effect diagram and the control elements are generated under each factor. Energy efficiency policies can overcome the energy consumption factors by effectively managing the control elements. The figures in the attached document show the control elements under each energy consumption factors under the five categories.

This research develops a prototype method to understand the accomplishment of energy efficiency policies in addressing the energy consumption factors identified before. The tool used for this research is content analysis. The following steps were performed in applying Content Analysis method to analyze the effectiveness of energy efficiency policy portfolio in targeting the factors affecting residential energy consumption.

Identify research question - How effectively does the energy policy portfolio of a country/state target the factors known to influence energy consumption?

Select sampling strategy – No sampling is performed. All the policies targeting the residential sector are selected for the study. The policy information are assessed from the following four website, MURE 2, IEA, DSIRE and ACEEE.

Select category for analysis – The objectives of the energy efficiency policies

Select recording unit – The recording units control elements.

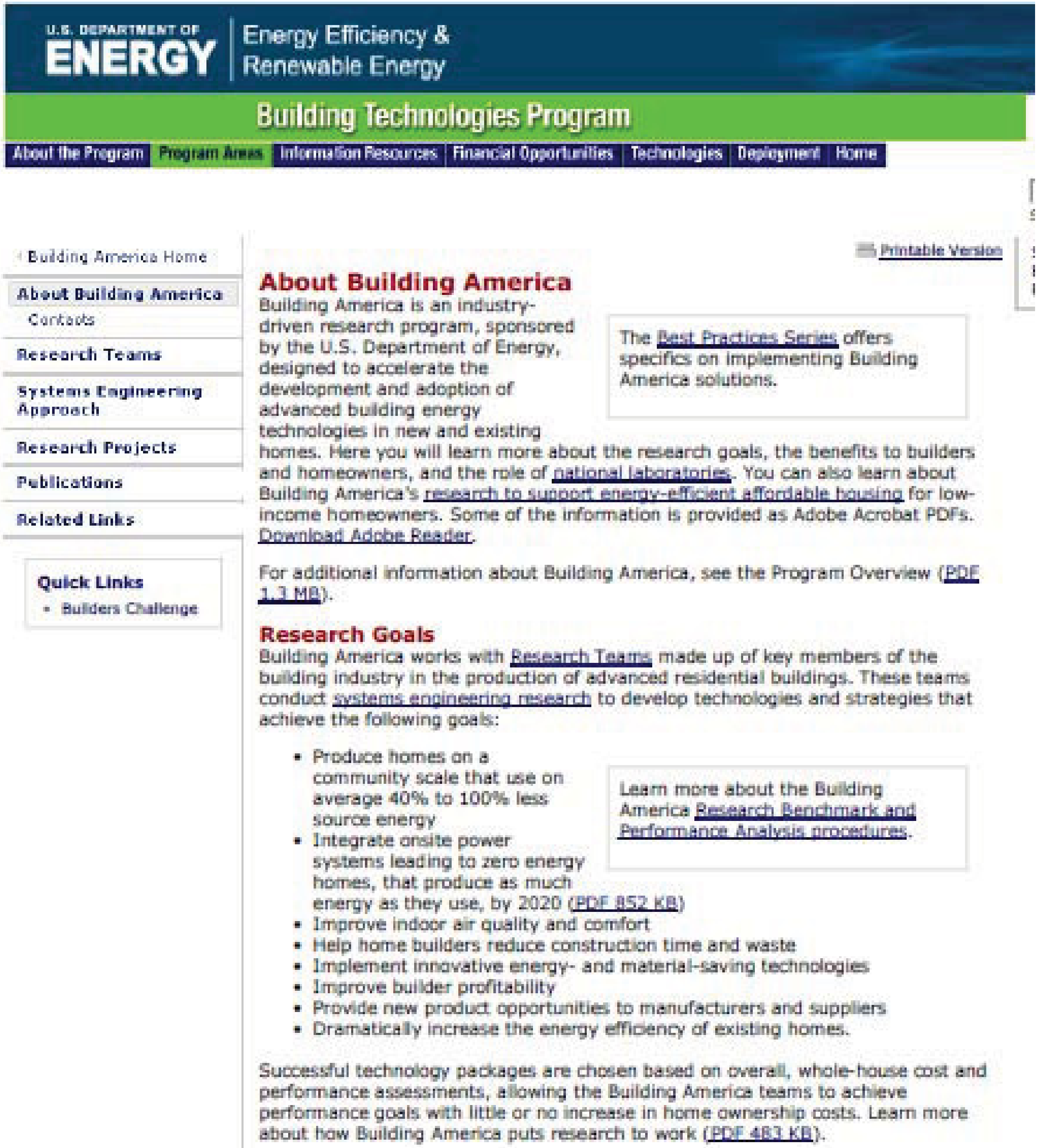
Carry out analysis – The analysis is carried out in the following way.

1. Each policy description is read once to look for the control elements. Exact words or phrase are not found most of the time. It is the meaning which is understood and looked for. Brief notes are made in the margin whenever something containing relevant information comes up.

2. Margin notes are reread and a list of different types of control elements that have been found is made.

3. The list of control elements is then categorized and associated with the respective energy consumption factors.

Below is an example of the identification of energy consumption factors targeted by a policy implemented in United States at the Federal level, Building America.


U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building Technologies Program

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About Building America

Building America is an industry-driven research program, sponsored by the U.S. Department of Energy, designed to accelerate the development and adoption of advanced building energy technologies in new and existing homes. Here you will learn more about the research goals, the benefits to builders and homeowners, and the role of national laboratories. You can also learn about Building America's research to support energy-efficient affordable housing for low-income homeowners. Some of the information is provided as Adobe Acrobat PDFs. Download Adobe Reader.

The Best Practices Series offers specifics on implementing Building America solutions.

For additional information about Building America, see the Program Overview (PDF 1.3 MB).

Research Goals

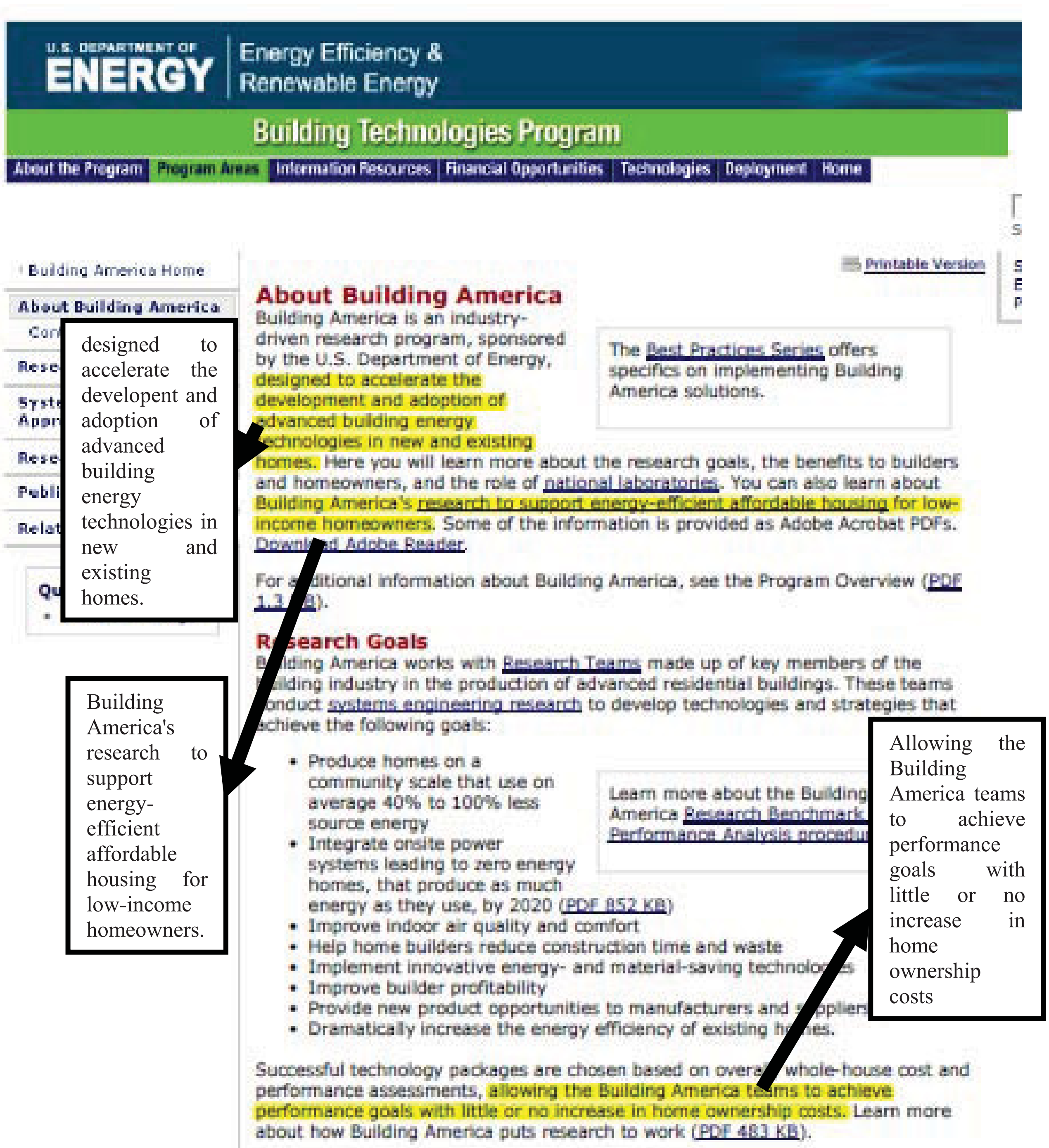
Building America works with Research Teams made up of key members of the building industry in the production of advanced residential buildings. These teams conduct systems engineering research to develop technologies and strategies that achieve the following goals:

- Produce homes on a community scale that use on average 40% to 100% less source energy
- Integrate onsite power systems leading to zero energy homes, that produce as much energy as they use, by 2020 (PDF 852 KB)
- Improve indoor air quality and comfort
- Help home builders reduce construction time and waste
- Implement innovative energy- and material-saving technologies
- Improve builder profitability
- Provide new product opportunities to manufacturers and suppliers
- Dramatically increase the energy efficiency of existing homes.

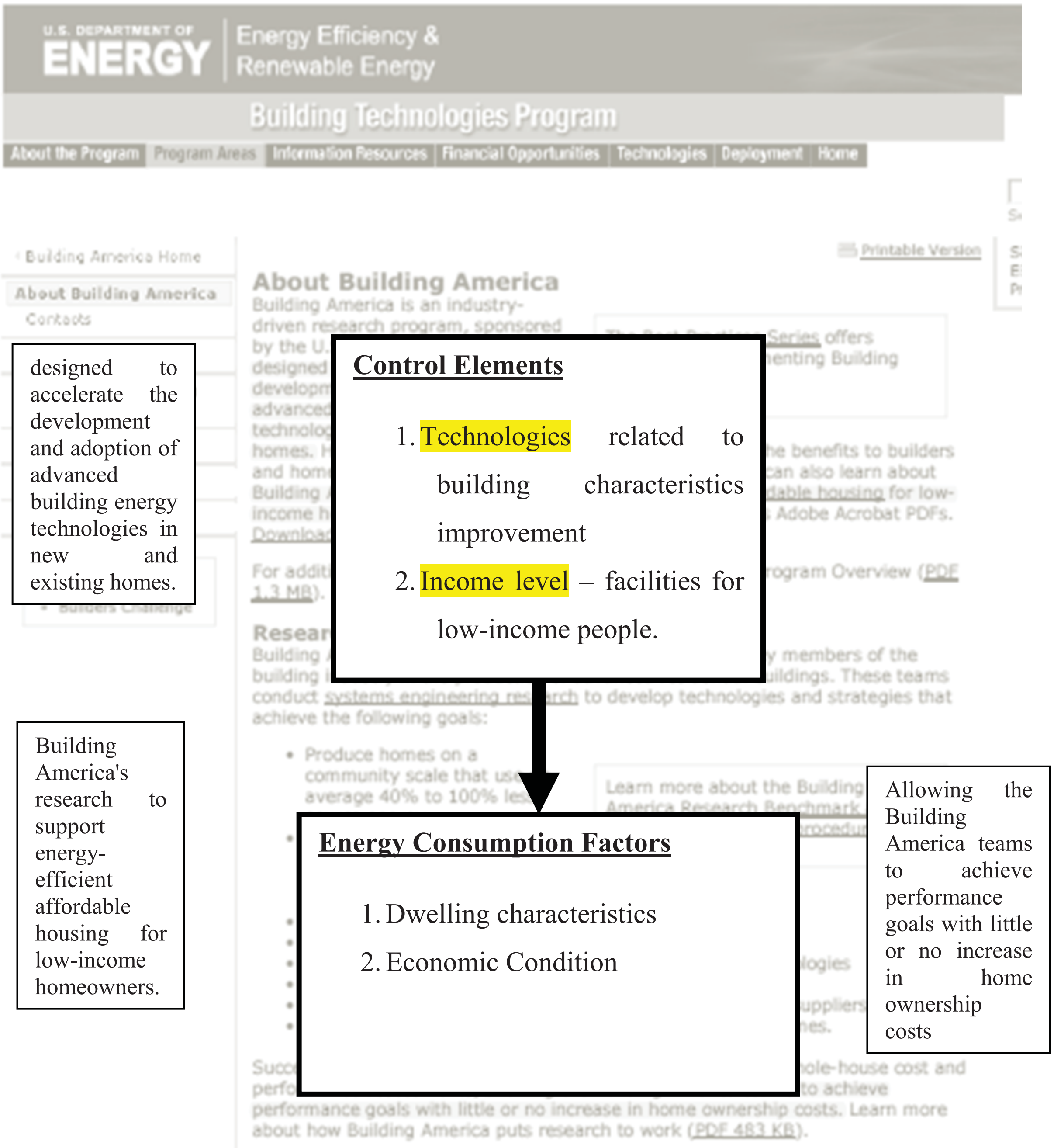
Learn more about the Building America Research Benchmark and Performance Analysis procedures.

Successful technology packages are chosen based on overall, whole-house cost and performance assessments, allowing the Building America teams to achieve performance goals with little or no increase in home ownership costs. Learn more about how Building America puts research to work (PDF 483 KB).

The description of Building America Program



Creation of brief notes from the description



Identification of control elements and then associating them with factor affecting energy consumption.

APPENDIX B – Completed reliability form

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

Observer 1

Energy efficiency policy name: New Housing Subsidation Scheme

CATEGORIES	FACTORS						
Demographics	Household Size ○ Y ○ S ● N	Householder's Age ○ Y ○ S ● N	Time spent at Home ○ Y ○ S ● N	Urbanization ○ Y ● S ○ N	Dwelling Characteristics ● Y ○ S ○ N	Dwelling Type ○ Y ● S ○ N	Dwelling Size ○ Y ● S ○ N
Consumer Attitude	Social Status ○ Y ○ S ● N	Culture ○ Y ○ S ● N	Information & Knowledge ○ Y ● S ○ N				
Economy	Energy Affordability ○ Y ● S ○ N	Economic Condition ● Y ○ S ○ N	EE Equipment Affordability ○ Y ○ S ● N	Household Expenditure ○ Y ○ S ● N			
Climate	Dwelling Micro-climate ○ Y ○ S ● N	Weather ○ Y ○ S ● N	Indoor Air Temperature ○ Y ○ S ● N				
Technology	Energy Availability ○ Y ○ S ● N	Renewable Energy ○ Y ○ S ● N	EE Equipment Availability ○ Y ● S ○ N	Energy Monitoring Syst. ○ Y ○ S ● N			

Legend: **Y**- Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

Observer 1

Energy efficiency policy name: Sustainable Economy Law

CATEGORIES	FACTORS						
Demographics	Household Size ○ Y ○ S ● N	Householder's Age ○ Y ○ S ● N	Time spent at Home ○ Y ○ S ● N	Urbanization ○ Y ○ S ● N	Dwelling Characteristics ○ Y ○ S ● N	Dwelling Type ○ Y ○ S ● N	Dwelling Size ○ Y ○ S ● N
Consumer Attitude	Social Status ○ Y ○ S ● N	Culture ○ Y ○ S ● N	Information & Knowledge ○ Y ○ S ● N				
Economy	Energy Affordability ○ Y ○ S ● N	Economic Condition ○ Y ○ S ● N	EE Equipment Affordability ○ Y ○ S ● N	Household Expenditure ○ Y ○ S ● N			
Climate	Dwelling Micro-climate ○ Y ○ S ● N	Weather ○ Y ○ S ● N	Indoor Air Temperature ○ Y ○ S ● N				
Technology	Energy Availability ○ Y ○ S ● N	Renewable Energy ● Y ○ S ○ N	EE Equipment Availability ○ Y ○ S ● N	Energy Monitoring Syst. ○ Y ○ S ● N			

Legend: **Y**- Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

Observer 1

Energy efficiency policy name: Community Energy Savings Programme (CESP)

CATEGORIES	FACTORS						
Demographics	Household Size ○ Y ○ S ◉ N	Householder's Age ○ Y ○ S ◉ N	Time spent at Home ○ Y ○ S ◉ N	Urbanization ○ Y ○ S ◉ N	Dwelling Characteristics ◉ Y ○ S ○ N	Dwelling Type ◉ Y ○ S ○ N	Dwelling Size ○ Y ○ S ◉ N
Consumer Attitude	Social Status ○ Y ○ S ◉ N	Culture ○ Y ○ S ◉ N	Information & Knowledge ○ Y ◉ S ○ N				
Economy	Energy Affordability ○ Y ◉ S ○ N	Economic Condition ◉ Y ○ S ○ N	EE Equipment Affordability ○ Y ○ S ◉ N	Household Expenditure ○ Y ○ S ◉ N			
Climate	Dwelling Micro-climate ○ Y ○ S ◉ N	Weather ○ Y ○ S ◉ N	Indoor Air Temperature ○ Y ○ S ◉ N				
Technology	Energy Availability ○ Y ○ S ◉ N	Renewable Energy ○ Y ○ S ◉ N	EE Equipment Availability ○ Y ◉ S ○ N	Energy Monitoring Syst. ○ Y ◉ S ○ N			

Legend: **Y**- Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

Observer 2

Energy efficiency policy name: New Housing Subsidation Scheme

CATEGORIES	FACTORS						
Demographics	Household Size ( ) Y ( ) S (•) N	Householder's Age ( ) Y ( ) S (•) N	Time spent at Home ( ) Y ( ) S (•) N	Urbanization ( ) Y ( ) S (•) N	Dwelling Characteristics (•) Y ( ) S ( ) N	Dwelling Type ( ) Y (•) S ( ) N	Dwelling Size ( ) Y (•) S ( ) N
Consumer Attitude	Social Status ( ) Y ( ) S (•) N	Culture ( ) Y ( ) S (•) N	Information & Knowledge ( ) Y (•) S ( ) N				
Economy	Energy Affordability ( ) Y ( ) S (•) N	Economic Condition (•) Y ( ) S ( ) N	EE Equipment Affordability ( ) Y ( ) S (•) N	Household Expenditure ( ) Y ( ) S (•) N			
Climate	Dwelling Micro-climate ( ) Y ( ) S (•) N	Weather ( ) Y ( ) S (•) N	Indoor Air Temperature ( ) Y ( ) S (•) N				
Technology	Energy Availability ( ) Y ( ) S (•) N	Renewable Energy ( ) Y ( ) S (•) N	EE Equipment Availability ( ) Y (•) S ( ) N	Energy Monitoring Syst. ( ) Y ( ) S (•) N			

Legend: **Y**- Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

Observer 2

Energy efficiency policy name: Sustainable Economy Law

CATEGORIES	FACTORS						
Demographics	Household Size ○ Y ○ S ● N	Householder's Age ○ Y ○ S ● N	Time spent at Home ○ Y ○ S ● N	Urbanization ○ Y ○ S ● N	Dwelling Characteristics ○ Y ○ S ● N	Dwelling Type ○ Y ○ S ● N	Dwelling Size ○ Y ○ S ● N
Consumer Attitude	Social Status ○ Y ○ S ● N	Culture ○ Y ○ S ● N	Information & Knowledge ○ Y ○ S ● N				
Economy	Energy Affordability ○ Y ○ S ● N	Economic Condition ○ Y ○ S ● N	EE Equipment Affordability ○ Y ○ S ● N	Household Expenditure ○ Y ○ S ● N			
Climate	Dwelling Micro-climate ○ Y ○ S ● N	Weather ○ Y ○ S ● N	Indoor Air Temperature ○ Y ○ S ● N				
Technology	Energy Availability ○ Y ● S ○ N	Renewable Energy ● Y ○ S ○ N	EE Equipment Availability ○ Y ○ S ● N	Energy Monitoring Syst. ○ Y ○ S ● N			

Legend: **Y**- Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

Observer 2

Energy efficiency policy name: Community Energy Savings Programme (CESP)

CATEGORIES	FACTORS						
Demographics	Household Size ○ Y ○ S ◉ N	Householder's Age ○ Y ○ S ◉ N	Time spent at Home ○ Y ○ S ◉ N	Urbanization ○ Y ○ S ◉ N	Dwelling Characteristics ○ Y ◉ S ○ N	Dwelling Type ○ Y ◉ S ○ N	Dwelling Size ○ Y ○ S ◉ N
Consumer Attitude	Social Status ○ Y ○ S ◉ N	Culture ○ Y ○ S ◉ N	Information & Knowledge ◉ Y ○ S ○ N				
Economy	Energy Affordability ○ Y ◉ S ○ N	Economic Condition ◉ Y ○ S ○ N	EE Equipment Affordability ○ Y ○ S ◉ N	Household Expenditure ○ Y ○ S ◉ N			
Climate	Dwelling Micro-climate ○ Y ○ S ◉ N	Weather ○ Y ○ S ◉ N	Indoor Air Temperature ○ Y ○ S ◉ N				
Technology	Energy Availability ○ Y ○ S ◉ N	Renewable Energy ○ Y ○ S ◉ N	EE Equipment Availability ○ Y ◉ S ○ N	Energy Monitoring Syst. ○ Y ○ S ◉ N			

Legend:
Y- Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

Observer 3

Energy efficiency policy name: New Housing Subsidation Scheme

CATEGORIES	FACTORS						
Demographics	Household Size ○ Y ○ S ● N	Householder's Age ○ Y ○ S ● N	Time spent at Home ○ Y ○ S ● N	Urbanization ○ Y ○ S ● N	Dwelling Characteristics ● Y ○ S ○ N	Dwelling Type ○ Y ● S ○ N	Dwelling Size ○ Y ● S ○ N
Consumer Attitude	Social Status ○ Y ○ S ● N	Culture ○ Y ○ S ● N	Information & Knowledge ○ Y ● S ○ N				
Economy	Energy Affordability ○ Y ○ S ● N	Economic Condition ● Y ○ S ○ N	EE Equipment Affordability ○ Y ○ S ● N	Household Expenditure ○ Y ○ S ● N			
Climate	Dwelling Micro-climate ○ Y ○ S ● N	Weather ○ Y ○ S ● N	Indoor Air Temperature ○ Y ○ S ● N				
Technology	Energy Availability ○ Y ○ S ● N	Renewable Energy ○ Y ○ S ● N	EE Equipment Availability ● Y ○ S ○ N	Energy Monitoring Syst. ○ Y ○ S ● N			

Legend: **Y**- Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

Observer 3

Energy efficiency policy name: Sustainable Economy Law

CATEGORIES	FACTORS						
Demographics	Household Size ○ Y ○ S ● N	Householder's Age ○ Y ○ S ● N	Time spent at Home ○ Y ○ S ● N	Urbanization ○ Y ○ S ● N	Dwelling Characteristics ○ Y ○ S ● N	Dwelling Type ○ Y ○ S ● N	Dwelling Size ○ Y ○ S ● N
Consumer Attitude	Social Status ○ Y ○ S ● N	Culture ○ Y ○ S ● N	Information & Knowledge ○ Y ○ S ● N				
Economy	Energy Affordability ○ Y ○ S ● N	Economic Condition ○ Y ○ S ● N	EE Equipment Affordability ○ Y ○ S ● N	Household Expenditure ○ Y ○ S ● N			
Climate	Dwelling Micro-climate ○ Y ○ S ● N	Weather ○ Y ○ S ● N	Indoor Air Temperature ○ Y ○ S ● N				
Technology	Energy Availability ○ Y ● S ○ N	Renewable Energy ● Y ○ S ○ N	EE Equipment Availability ○ Y ○ S ● N	Energy Monitoring Syst. ○ Y ○ S ● N			

Legend: **Y**- Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

FACTORS TARGETED BY INDIVIDUAL ENERGY EFFICIENCY POLICIES

<u>Observer 3</u>

Energy efficiency policy name: <u>Community Energy Savings Programme (CESP)</u>

CATEGORIES	FACTORS						
Demographics	**Household Size** ○ Y ○ S ◉ N	**Householder's Age** ○ Y ○ S ◉ N	**Time spent at Home** ○ Y ○ S ◉ N	**Urbanization** ○ Y ○ S ◉ N	**Dwelling Characteristics** ○ Y ◉ S ○ N	**Dwelling Type** ○ Y ◉ S ○ N	**Dwelling Size** ○ Y ○ S ◉ N
Consumer Attitude	**Social Status** ○ Y ○ S ◉ N	**Culture** ○ Y ○ S ◉ N	**Information & Knowledge** ◉ Y ○ S ○ N				
Economy	**Energy Affordability** ○ Y ○ S ◉ N	**Economic Condition** ◉ Y ○ S ○ N	**EE Equipment Affordability** ○ Y ○ S ◉ N	**Household Expenditure** ○ Y ○ S ◉ N			
Climate	**Dwelling Micro-climate** ○ Y ○ S ◉ N	**Weather** ○ Y ○ S ◉ N	**Indoor Air Temperature** ○ Y ○ S ◉ N				
Technology	**Energy Availability** ○ Y ○ S ◉ N	**Renewable Energy** ○ Y ○ S ◉ N	**EE Equipment Availability** ○ Y ◉ S ○ N	**Energy Monitoring Syst.** ○ Y ○ S ◉ N			

Legend: **Y**- Yes this factors is targeted by the policy
N- No this factor is not targeted by the policy
S- This factors is somewhat targeted by the policy

APPENDIX C – SPSS output of Krippendorf's alpha

New housing subsidization dataset.sav

```
[DataSet2] C:\Documents and Settings\S U C H I\Desktop\New housing subsidization
dataset.sav

Run MATRIX procedure:

Number of bootstraps must be at least 1000.

Krippendorff's Alpha Reliability Estimate


             Alpha      Units    Obsrvrs      Pairs
Ordinal      .8827    21.0000     3.0000    63.0000

Judges used in these computations:
 obs1     obs2     obs3

====================================================

Observed Coincidence Matrix
     41.00      2.00       .00
      2.00     10.00      1.00
       .00      1.00      6.00

Expected Coincidence Matrix
     29.13      9.02      4.85
      9.02      2.52      1.47
      4.85      1.47       .68

Delta Matrix
       .00    784.00   1444.00
    784.00       .00    100.00
   1444.00    100.00       .00

Rows and columns correspond to following unit values
      1.00      2.00      3.00

Examine output for SPSS errors and do not interpret if any are found

------ END MATRIX -----
```

Sustainable economy law

```
[DataSet1] C:\Documents and Settings\S U C H I\Desktop\Sustainable economy law
dataset.sav

Run MATRIX procedure:

Number of bootstraps must be at least 1000.

Krippendorff's Alpha Reliability Estimate


             Alpha      Units    Obsrvrs      Pairs
Ordinal      .8064    21.0000     3.0000    63.0000

Judges used in these computations:
 obs1     obs2     obs3

====================================================

Observed Coincidence Matrix
```

```
     57.00      1.00       .00
      1.00      1.00       .00
       .00       .00      3.00

Expected Coincidence Matrix
     53.32      1.87      2.81
      1.87       .03       .10
      2.81       .10       .10

Delta Matrix
       .00    900.00   1056.25
    900.00       .00      6.25
   1056.25      6.25       .00

Rows and columns correspond to following unit values
      1.00      2.00      3.00

Examine output for SPSS errors and do not interpret if any are found

------ END MATRIX -----
```

Community Eneryg Savings Programme

```
[DataSet3] C:\Documents and Settings\S U C H I\Desktop\Community Eneryg Savings
Programme.sav

Run MATRIX procedure:

Number of bootstraps must be at least 1000.

Krippendorff's Alpha Reliability Estimate


             Alpha      Units    Obsrvrs      Pairs
Ordinal      .8640    21.0000     3.0000    63.0000

Judges used in these computations:
 obs1     obs2     obs3

====================================================

Observed Coincidence Matrix
     43.00      2.00       .00
      2.00      6.00      3.00
       .00      3.00      4.00

Expected Coincidence Matrix
     31.94      7.98      5.08
      7.98      1.77      1.24
      5.08      1.24       .68

Delta Matrix
       .00    784.00   1369.00
    784.00       .00     81.00
   1369.00     81.00       .00

Rows and columns correspond to following unit values
      1.00      2.00      3.00

Examine output for SPSS errors and do not interpret if any are found

------ END MATRIX -----
```