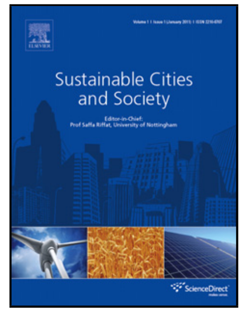
Accepted Manuscript



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Authors: Parmarth Gupta, Sanjeev Anand, Himanshu Gupta

PII: S2210-6707(16)30462-0
DOI: http://dx.doi.org/doi:10.1016/j.scs.2017.02.005
Reference: SCS 584

To appear in:

Received date: 5-10-2016
Revised date: 6-1-2017
Accepted date: 6-2-2017

Please cite this article as: Gupta, Parmarth., Anand, Sanjeev., & Gupta, Himanshu., Developing a roadmap to overcome barriers to energy efficiency in buildings using best-worst multi-criteria decision making methodology.*Sustainable Cities and Society* http://dx.doi.org/10.1016/j.scs.2017.02.005

Developing a roadmap to overcome barriers to energy efficiency in buildings using best-worst multi-criteria decision making methodology

Developing a roadmap to overcome barriers to energy efficiency in buildings using best worst method

Parmarth Gupta[a], Sanjeev Anand[a], Himanshu Gupta[b*]

a- School of Energy Management, Shri Mata Vaishno Devi University, Katra 182320, J&K, India
b- Department of Management Studies, Indian Institute of Technology Roorkee, 247667, India

*-Corresponding Author, himanshuguptadoms@gmail.com

Major Highlights

- This article identifies important barriers of energy efficiency.
- A novel multi criteria technique called best worst methodology has been applied.
- Sensitivity analysis is done to check robustness of results.
- Economic, Technological and government related barriers emerged most important.

Abstract

The rise in consumption of Energy has led to the increased demand for energy. The contributing factors for energy consumption are industrialization and development. Both are important for the human sustenance over long term. The alternate sources of energy particularly renewable sources are being developed and boosted to support the existing production of energy for use. However, the 100% reliability or switching to a total renewable resource may some time required to be supported by strong measures. Looking into the present context the importance of efficient utilization of energy is seen as a strong and possible fit is managing the problem of increase of energy consumption. The challenges arising in the path of energy conservation or energy efficiency are many. A lot of research work is carried on the different individual factors which are hindering the progress of energy efficiency measures. Also a lot of measures have been suggested by different researchers from time to time. All these barriers and measures are either not organized in proper manner or are highly localized. A very meager attempt is made to study these barriers in a holistic manner. Some researchers have highlighted the role of sustainability in the development of energy. The relationship between the increase in demand of energy and economic development of a country is beyond challenge. For a developing country like India, where there is a big mismatch between energy supply and energy demand, and further challenge to keep this gap low due to rapid development, industrialization and urbanization. Energy Efficiency then becomes a very useful tool to overcome the challenges in supplying energy to all. Energy demand can be only be reduced and cannot be eliminated completely. The optimum level to which the energy consumption can be reduced is the indicator of energy efficiency. This term Energy Efficiency is affected in practice by lot of challenges which are making highly dynamic in nature. Therefore, it calls for a detailed and comprehensive approach in identification and listing of different factors governing energy efficiency in buildings in Indian context. Again only identification of barriers is not sufficient. A system needs to be adopted how these challenges or barriers can be addressed, for that some latest tools for ranking of these identified barriers needs to be adopted. Best-Worst multi-criteria decision making is used to rank the barriers. Results show economic, governmental and technological barriers as most prominent barriers among all. The results shall be of great help in decision making for effecting the improvement and development of energy efficiency measures in buildings. With the help of decision makers a roadmap is developed to help overcome these barriers over long, medium and short term respectively.

Key Words: Energy efficiency, barriers, best-worst multi-criteria method, buildings.

1 Introduction

Energy is very important today to carry out different human activities. Energy plays a great role in technology development, industrial development, economic development as well as social development of a nation. How developed a nation is largely determined by how much it is dependent on energy, how much utilization of energy it does. But looking into growing demand of energy in the world and limited resources, future parameters of development shall be dependent on efficient use and sustainable development of Energy. Meeting sustainability while achieving energy saving and environmental protection is a challenge. In order to achieve this, there is a need to change the way energy is supplied and how energy is being used [1]. As energy demand and economic growth of a country like India are closely related the energy consumption needs to be monitored. For that energy conservation policies that facilitate reduction in consumption of energy demand needs to be promoted [2]. As per World commission on Environment and Development, 1987, Sustainability is "meeting the needs of the present without compromising the ability of future generations to meet their own needs", while maintaining Social Development, Economic Development and Environment Protection [3]. All development activities whether its business sector, transport sector, manufacturing sector or infrastructure sector when looked upon from sustainable development perspective leads to focus towards a strategy where environment protection and improvement of quality of human life by means of development is a two prong challenge [3]. The energy utilization when compared with the sustainable development of socio-economic conditions of people in a country like India leads to a diverse viewpoint.

International Energy Agency (IEA) is a renowned agency for publishing statistics related to energy, this data can be used for formulating policies and check the supply concerns [4]. Fig 1.1 and 1.2 shows world Final Energy Consumption and World CO_2 emissions from 1971 to 2012. The trend shows doubling of global energy consumption & CO_2 emissions during the period mentioned,

According to Annual Energy Outlook 2015, the breakup of energy consumption of energy usage of different energy sources is as under-Industrial Sector-31.20%, Transport Sector-24.48%, Commercial Sector-18.10%, Residential Sector-21.10%, and Others-5.2%

According to Energy Statistics 2015, Central Statistics Office, National Statistical Organization, Ministry of Power, Average Sector wise consumption of Electricity during 2005-06 to 2013-14 as under-Industry-44%, Domestic-22%, Agriculture-18%, Commercial-9%, Others-5%, Traction and Railways-2%

As Building sector is a major consumer of energy and hence a major cause of Carbon dioxide emissions, the characteristics of Buildings that contribute to energy consumption must be emphasized [7]. Perez-Lombard et al., [8] in their paper provided an analysis about energy use in commercial and residential buildings relative to period upto 2004 with a special focus on HVAC Systems. Energy Efficiency in Buildings is very important; emphasis is given on achieving sustainable energy efficiency in Buildings. In order to achieve energy efficiency in Buildings, knowledge on practical aspects of Buildings is required. The main areas or focus is identification of Energy Use in Buildings, Barriers to Energy Use in Buildings and Means adopted to achieve Energy Efficiency and Overcoming Barriers for sustainable development of Energy Efficient Buildings [3].

1.1 Research Objectives

Present study addresses the issues and hurdles in the implementation of energy efficiency measures in buildings. The specific aims of current research are as follows:

i. To identify the barriers that hinders the implementation of energy efficiency measures in buildings.
ii. To identify the prominence of each barrier by ranking barriers using best-worst multi-criteria decision making analysis.
iii. To formulate a roadmap to overcome barriers of energy efficiency in buildings.

Extensive literature review and discussion with stakeholders is used to identify the barriers of energy efficiency in buildings. Best-Worst multi criteria decision making analysis is used to rank and find out the prominence of these barriers, after ranking of these barriers a roadmap is developed, through discussion with stakeholders, to overcome these barriers in long term, medium term and short term. In brief the present study aims at first identifying barriers to energy efficiency in building and ranking these barriers using multi criteria analysis, after ranking these barriers a roadmap is developed to overcome these barriers of energy efficiency in buildings.

The present research work is organized as follows: section two discusses about energy efficiency in buildings and its importance, section three highlights the barriers of energy efficiency, section four briefly describes steps of best-worst methodology, section five presents results and discusses these results, section six presents a roadmap to overcome barriers of energy efficiency, section seven gives concluding remarks and last section discusses limitations of current work.

2 Energy Efficiency in Buildings

According to Patterson [9], Energy Efficiency is the production of same amount of useful work (output or service) by use of comparatively less energy. The reference here is made to the adoption of measures that tend to reduce the use of energy. Also the ratio of Maximum quantity of energy services obtainable to the quantity of final energy consumed is Energy Efficiency [10]. Different researchers have come up with different interpretation of Energy Efficiency. The Efficiency can be considered as useful work done while the lack of efficiency is wastage in terms of some other forms of energy other than as desired during the intended process [11]. The extent to which energy can be utilized in a useful manner is governed by systems and processes it is exposed to, thus leading to the study of systems and processes for the purpose of energy efficiency [12].

Building sector has a huge burden on environment by means of utilization of natural resources, release of solid wastes, creation of different forms of pollution, reduction of forest cover, etc. Over the entire life cycle of Buildings, energy in consumed in numerous forms like during the production of construction materials Steel, Cement, Brick, etc ,during construction, during operation, during demolition. Also there is a huge impact on environment as a result of release of Carbon Dioxide emissions during preparation of construction materials, during consumption of different fuels in buildings and also during production of electricity which is a major source of energy and operation in modern buildings [3].

Various initiative are adopted for Energy reduction in Buildings like Energy Performance Building Directive (EPBD) 2002/91/EC and its recast 36/EC/2010 launched in 2002 by European Parliament and Council [13]. Buildings contribute to 1/3rd of Green House Gas emissions [14]. The different parameters which predict the energy use in buildings are diverse. However, different models like: Simplified Engineering Methods, Statistical Methods and Artificial Intelligence methods have been developed to predict the use of energy in buildings. It is observed that the prediction of parameters which have been affecting energy use in buildings is not found satisfactory [15]. Energy consumption by Residential Buildings is 54% of total energy consumption by Building Sector in US, contributed mostly by increased use of appliances and electronics [5].It was reported in 2008 that 56% increase in energy consumption of residential buildings is expected by 2020 [16].Residential Building sector is the second largest consumer of Energy accounting to 11% National energy end use [17]. The potential benefits of energy efficiency in buildings are immense but are often marred by barriers that hinder adaptation of energy efficiency measures in buildings. Next section deals with identification of barriers of energy efficiency in buildings through literature review and discussion with decision makers.

3 Identification of barriers of energy efficiency in buildings

Barriers is anything that prevents or obstructs or hinders the progress, movement or development of something. With reference to energy efficiency and extensive literature survey followed by feedback from stakeholders, a number of factors have been identified as barriers. Also these barriers are further categorized into 27 different categories which are again organized up into 6 different groups based on their similar nature. Before listing the categories as per reference discussion on categories and groups of barriers is mentioned as under.

3.4.1 Economic or Financial Barriers

Economic and Financial Barriers is very important group of barriers that hinder the progress and development of Energy Efficiency Measures. In order to explain the effects Economic barriers are further classified into Scarcity of Financial Means, Absence of Lucravity, Poor arbitrage, Inadequate Monetary Assessment and Limits in Financial Provisioning. The different categories are further explained as under:

3.4.1.1 Scarcity of Financial Means

Lack of Financial Means is an important factor impeding Energy Efficiency Programs. Lack of efficient funds, Lack of Capital for Energy Efficiency Projects, Lack of access to capital for carrying out energy efficiency projects, limited availability of resources and inappropriate infrastructural support are some of the factors contributing to Scarcity of Financial Means.

3.4.1.2 Absence of Lucravity

Profitability of Energy Efficiency Program is often a cause of concern. Most of the time the Energy Efficiency Measures are not profitable due to huge investment costs involved. Technologies Supporting the Energy Efficiency Measures are often costly resulting in reduced Profitability. The applicability of Energy Efficiency Programs in existing buildings, structures, processes, formats are often costly resulting in reduced profitability. Lack of proper financial modelling and other studies like Payback Period, Life cycle costing, etc. have often resulted in incorrect projection of profits associated with Energy Efficiency Programs making such programs as non-profitable. Non realization of long term energy savings in Energy Efficiency programs often results in making the Efficiency Programs as lacking profitability.

3.4.1.3 Poor arbitrage

A Poor risk assessment in terms of financial risks involved with adopting and carrying out energy efficiency measures is also a matter of concern. Lack of studies on profitability of energy efficiency, non-availability of results associated with financial benefits of energy efficiency programs, inaccurate assessment by auditors on financial benefits, Lack of confusion and consistency of costs and benefits related to Green Building adoption, inaccurate assessment of financial risks or regulatory risks affecting financial profit making related to Energy Efficiency are some of the factors affecting Energy Efficiency Programs.

3.4.1.4 Inadequate Monetary Assessment

Cost of Energy Efficiency Products, Energy Efficiency Programs or Measures is also a matter of concern. Sometimes there is a lack of consistency in Real and Perceived Cost, Hidden Costs associated with Energy Efficiency Programs are sometimes ignored or not taken into account to promote energy efficiency products or techniques. The production disruptions or hassles are also sometimes not taken into account during planning process, often resulting into increase in costs latter on. Higher cost of documentation associated with adoption or seeking energy certification is often not assessed properly.

3.4.1.5 Limits of Financial Provisioning

Lack of financial planning to effectively carry out, adopt and maintain energy efficiency programs is an important factor. Lack of budget funding or lack of long term Budget horizon, Lack of financial priorities, poor investment decision making are seriously affecting the development of energy efficiency programs.

3.4.2 Governmental Barriers

Governmental Barrier is also a very important group of barriers that too hinder the progress and development of Energy Efficiency Measures. In order to explain the effects of Governmental barriers to Energy Efficiency are further classified as- Lack of Financial Motivation, Bridles in Hierarchical Inspiration and Functional Harmony, difference in plan of action for energy and environment integration, inappropriate antecedences, lack of standards and references, lack of strong authority. The different categories are explained as under:

3.4.2.1 Lack of Financial Motivation

Lack of financial incentives or no incentives or split incentives are a major detrimental in promoting energy efficiency measures. Often the financial incentives are not distributed properly or not targeted to the specific cause of problem affecting energy efficiency.

3.4.2.2 Bridles in Hierarchical Inspiration and Functional Harmony

Lack of proper leadership in government or political parties or political leadership is an important barrier in energy efficiency programs. Also lack of coordination among different departments or agencies, stakeholders, etc. is also a barrier in energy efficiency. Lack of political stability, Lack of weak structure in government, weak linkage among policy makers, policy implementers is an important barrier to energy efficiency in Buildings.

3.4.2.3 Differences in Plan of Action for Energy and Environmental Integration

When mentioning Sustainability with reference to Energy use and Efficiency, environment and related factors like climate change, carbon credit, etc. also comes to focus. Role of government in promoting Environmental Integration with Energy Efficiency is very important. Lack of integration of energy and environmental issues during policy formulation, uncertainty on future energy prices and fiscal policies, inadequate national policies and regulations, lack of environmental enforcement, quantifiable sustainability targets and failure to recognize the need for social regeneration are some of the barriers.

3.4.2.4 Inappropriate Antecedences

Prioritization is a basic task or responsibility of any government especially when it comes to the efficient decision making, utilization of resources and finances. Lack of prioritization in capital investments in relation to energy efficiency programs, lack of interest in prioritization by government of energy efficiency policies supporting efficiency and more use of renewable sources of energy is often reflected as one of the governmental barrier to energy efficiency.

3.4.2.5 Lack of Standards and References

Even if the other barriers like lack of policies, lack of leadership, lack of financial motivation etc. are removed, there must be a set of standards which the government must adopt for uniform and widespread implementation to induce energy efficiency. However, non-adoption or delay in adoption of standards by government. Often the old standards have become obsolete and are not replaced by latest standards.

3.4.2.6 Lack of Strong Authority

Even if all the policies are put in place and there is a strong leadership or authority, the energy efficiency cannot be achieved, if these policies are not strictly implemented. So, the lack of strong enforcement of government regulations, Lack of evaluation and monitoring criteria, noncompliance of regulations are some of the important barriers. Lack of strong authority by energy managers or authorities are also important barriers.

3.4.3 Information and Training Barriers

Like other barriers, information and training related barriers are also very important in achieving Energy Efficiency. The Information and Training barriers are further classified into-Lack of Education, Inexperience or Untrained persons and Fallacious Information. These are further explained as under:

3.4.3.1 Lack of Education

Energy along with Energy Efficiency is a much sought after topic of research yet the proper system of spreading education on the Energy Efficiency is lacking. Lack of education about energy efficiency, Lack of proper knowledge of energy efficiency, Lack of proper education programs spreading awareness of energy efficiency. Lack of education about energy policies, lack of information about proper evaluation of energy efficiency measures, lack of education on cost and benefits associated with energy efficiency are some of the barriers.

3.4.3.2 Inexperience or Untrained Persons

Training is the teaching of skills. When dealing with the energy efficiency often it is found that new products, methodologies, means, etc. are introduced which are not supported by trained manpower for the implementation, maintenance and support. The contractors, consultants, engineers are not trained properly for dealing with same. The manpower involved or associated with energy efficiency is not trained properly or often face the problem of lack of proper training programs.

3.4.3.3 Fallacious Information

Due to conflict of interest among technology providers supported by weak legislation, it often occurs that users or people dealing with energy efficiency products or issues are fed with false or misleading information sources, false or misleading information, false promises, incomplete misguided information are barriers affecting energy efficiency.

3.4.4 Market related barriers

Market do play a very important roles in the success of a product or service. The relationship between energy efficiency and markets are a topic of research. The market related barriers are further classified into following categories- price contention, perceptual knowledge, aspousal, dubiety of demand. The individual categories are explained as under-

3.4.4.1 Price Contention

When we see market of energy efficient products, buildings etc. we find that the price competition is a major issue. Price competition from inefficient or conventional products, practices and buildings etc. is a barrier. Low prioritization as a result of Price contention is a barrier to energy efficiency.

3.4.4.2 Perceptual Knowledge

Misconceived Knowledge on energy pricing, misconceived knowledge on market demand, misconceived knowledge on market size, negative perceptions of energy efficient products especially green buildings, energy rated buildings , energy rated products are some of the barriers.

3.4.4.3 Aspousal

Slow market adoption of energy efficient products, lack of steering mechanisms, Biased reasoning about energy efficiency, lack of business case understanding are some of the barriers.

3.4.4.4 Dubiety of Demand

Lack of Demand of energy efficient products, lack of customer interest in energy efficient products, uncertainty in demand of energy efficient products are some of the barriers affecting energy efficiency programs.

3.4.5 Organizational and Social Barriers

Like other barriers organizational and social barriers too play an important part in hindering energy efficiency programs. In order to be successful energy efficiency measures have organizational and social support, but this is marred by certain barriers. Organizational and Social Barriers are further classified into- Lack of Cognitive Decision Making Approach, Lack of Authority and Jurisdiction, Ill-defined Vision, Torpidity in Process and Practices. The individual categories are explained as under:

3.4.5.1 Lack of cognitive Decision Making approach

Perceived lack of empowerment or decision making in an organization, Insufficient and Inefficient approach of top management, fear of losing support by leadership or top management, differences in perception of managers, complex decision making chain in organizations, negative attitudes to social mix, risk and fears associated with using new technology or processes that promote energy efficiency are some of the barriers identified.

3.4.5.2 Lack of Authority and Decision Making

For Successful implementation of energy efficient measures in an organization, strong authority or decision making is required. Lack of influence by managers or energy managers, limited authority of managers, limitation in jurisdiction of management powers, different contact form of project delivery are some of the organizational barriers identified for energy efficiency.

3.4.5.3 Ill Defined Vision

For any organization to be successful, a clear and well defined vision is a prerequisite. However low focus on adoption of energy efficiency, lack of management's time and focus on energy efficiency, changing site practices and behaviors, lack of planning policy, Insufficient policy implementation efforts, divergent interest of management, lack of shared vision on sustainable housing, lack of development of facilities supporting energy efficiency are some of the organizational and social barriers identified.

3.4.5.4 Torpidity in Process and Practices

For efficient working of an organization all the processes and practices adopted in an organization needs to be robust and efficient. For better energy efficiency, process like procurement and tendering, timing, cooperation and networking, must be fast. Slow processes, longer design time using integrated design teams, longer approval process for new technologies and recycled materials are some of barriers identified.

3.4.6 Technological Barriers

Technological Barriers is the sixth category of barriers affecting energy efficiency. Technology is considered as one of the most important group of barriers. Technological Barriers are further classified as – Incompatible Technology, Process related Risks, Unavailability of Energy Efficient Materials, Lack of feasibility study, slow embodiment of new technologies. The individual categories are further discussed below:

3.4.6.1 Incompatible Technology

Non availability of Technology, Inadequate technologies, Poor quality of designs, Poor Codes and Standards associated with technology, Poor performance of Green Buildings, Lack of proven alternate energy efficient technologies, lack of labelling and measurement standards are some of the barriers identified which are associated with Incompatible Technology.

3.4.6.2 Process related risks

Technical Risks such as risk of production disruptions, Lack of Technological fitment in actual process, Failure of Technology's applicability to a process. Failure of energy efficiency measures to perform upto mark are some of the barriers identified as Technological Barriers.

3.4.6.3 Unavailability of Energy Efficient Materials

For the development of Energy efficiency, New and innovative materials needs to be developed which may replace new and conventional materials. Lack of success of new and greener materials, non-availability of green and energy efficient materials are some of the barriers which are important part of Technological barriers.

3.4.6.4 Lack of feasibility Study

New Technical Process, Material, Projects must be adopted after carrying out proper Feasibility studies, Life cycle analysis, Life cost analysis, Technological forecasting, etc. However, lack of proper feasibility studies with new technologies associated with energy efficiency are the barriers identified as Technological Barriers.

3.4.6.5 Slow embodiment of New Technology

Delay in inadequate replacement of existing technologies, inefficient integration of energy or emissions into operating maintenance or purchasing procedures are some of the barriers which are identified as Technological Barriers.

The barriers to energy efficiency are summarized in table 3.1 below:

4 Methodology

4.1 Best Worst Multi Criteria Decision Making Method

Best worst MCDM technique is a novel technique developed by Rezaei in year 2015, it is an innovative methodology where in the number of pairwise comparison are lesser as compared to other MCDM techniques like AHP [73]. This methodology has been successfully applied in few past studies [75, 76].

Also this methodology has the advantage of saving a lot of time of decision makers as well as the researchers due to fewer comparisons of the alternatives, as it requires comparisons between best and all other criterion and between others and worst criterion. Few other studies have used multi-criteria methods for energy analysis like AHP [76; 77], ISM [78; 79; 80] but most of these methods suffer from inconsistency during pairwise comparison of alternatives.

The steps involved in this technique are described below [73; 81]:

Step 1: Determination of selection or decision criterion.

Literature review and discussions with experts is used to identify certain set of n criteria $\{c_1, c_2, \ldots, c_n\}$.

Step 2: Next step is determine the best and worst criterion among all the criterion using experts' opinion.

Step 3: Using a scale of 1-9, determine the preference rating of best selected criteria over all other criterion and represent it in terms of a vector as shown below,

$A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})$,

Where a_{Bj} indicates the preference of the best criterion B over criteria j. Also here $a_{BB} = 1$. Consensus of experts is used for arriving at final ratings.

Step 4: Similar to above, using a scale of 1-9, determine the preference rating of all the criterion over the worst criteria. The vector representation of this comparison can be:

$A_W = (a_{1W}, a_{2W}, \ldots, a_{nW})^T$,

Where a_{jW} indicates the preference of the criteria j over the worst criterion W. Also here $a_{WW} = 1$. Consensus of experts is used for arriving at final ratings.

Step 5: After getting the preferential ratings for all the criterion, next step is to find the optimized weights $(w_1^*, w_2^*, \ldots, w_n^*)$, such that the maximum absolute differences for all j is minimized of the following set $\{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$.

The above can be represented as following model:

min max $\{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$

s.t. $\sum_j w_j = 1$

$w_j \geq 0$, for all j (1)

Model (1) can be solved by converting it into the following linear programming problem model:

$\min \xi^L$

s.t.

$|w_b - a_{Bj}w_j| \leq \xi^L$, for all j

$|w_j - a_{jW}w_W| \leq \xi^L$, for all j

$$\sum_j w_j = 1$$

$w_j \geq 0$, for all j (2)

Solving the linear model (2) we will get optimal weights (w_1^*, w_2^*, …….,w_n^*) and optimal value ξ^L.

Step 6: After obtaining the weights for each criteria using model (2) the next step is to check the consistency level of the comparisons. Consistency of the comparison depends on the value of ξ^L, a value closer to 0 indicates higher consistency. All the values below 1 for ξ^L indicates consistent comparison (Rezaei, 2015b).

5 Results and Discussions

5.1 Results

As discussed above multi criteria analysis has various applications among which is prioritizing of the alternatives. In this study multi criteria analysis has been employed to prioritize the barriers of energy efficiency in buildings. Through extant review of literature six main criteria of barriers have been identified and a total of twenty seven sub criteria of barriers have been identified. Experts were chosen among various stakeholders of energy efficiency use that includes technical officers from various government agencies, building architects and persons having vast experience regarding energy efficiency.

Based on the steps discussed above and scale mentioned in Table 5.1, experts were asked to give pairwise comparison ratings for each criteria and sub criteria using panel census approach wherein all the experts were asked to arrive at a common rating based on discussion among them.

The interpretation of scale is mentioned in Table 5.1. Where pairwise comparison is done among various criteria, suppose 'a' is a criteria then a_{ij} = 1 shows equal importance of criteria i over j, and if aij >1 it shows high importance of i over j.

The results of pairwise comparison for main criteria of barriers of energy efficiency is presented in table 5.2.

The results for pairwise comparison of all the sub criterion is shown in tables 5.3 –5.8.

The pairwise comparison for Economic barrier main criteria is represented in Table 5.3 below, The pairwise comparison for Government barrier main criteria is represented in Table 5.4 below,

The pairwise comparison for Knowledge and Learning barriers main criteria is represented in Table 5.5 below,

The pairwise comparison for Market Related barriers main criteria is represented in Table 5.6 below,

The pairwise comparison for Organizational and Social barriers main criteria is represented in Table 5.7 below,

The pairwise comparison for Technological barriers main criteria is represented in Table 5.8 below,

Step 5 is used next to obtain optimal weights for each criteria and sub criterion by solving model 2. The optimal weights for main criterion and consistency value is represented in Table 5.9, The value of 0.011 indicates a high consistency.

The optimal weights for sub criterion are also calculated using step 5 and these weights alsog with global weights of each sub criterion is represented in Table 5.10,

5.2 Sensitivity Analysis

Sensitivity analysis has been done to check the biasness in results and to filter out any effect of enabler with highest weights on other enablers in study. [82; 83] suggested use of sensitivity analysis by varying weights of all the factors in study in proportion to variation in weight of top ranked enabler. Table 5.12 indicates the weights of all the enablers when weight of Economic barrier is varied from 0.1 to 0.9, the weights of all the barriers are varied accordingly. Table 5.13 indicates the ranking of these barriers based on weights obtained in table 5.12. It can be seen from the table and figure that E1 barrier is occupying first rank during sensitivity analysis most of the time when weight of economic barrier is varied from 0.1 to 0.9 in different runs also last rank is consistently occupied by M1 barrier during sensitivity analysis. The result of sensitivity analysis indicates that the results obtained through best worst method are free from any bias and results are consistent even if there is variation in weights of one enabler.

5.3 Discussion

Based on extant literature review the barriers effecting energy efficiency were identified. The analytical prioritization was then carried out using multi criteria analysis. However it is not possible to address all the barriers simultaneously at a time. So a system needs to be adopted so that maximum effects of barriers are minimized to the largest extent and energy efficiency can be improved. In that context using the Pareto principle top 20% barriers are taken up for discussion and review. Therefore out of 27 identified categories top 20% (i.e. top 6) categories as per the ranking obtained through analysis are discussed herewith. The top six categories of Barriers are Scarcity of Financial Means, Limits in Financial Provisioning, Differences in the Plan of action for Energy and Environment Integration, Lack of Education, Incompatible Technology and Absence of Lucravity. The first two factors are largely dependent on the third factor. If the Profitability is ensured, the Financial Resources can be made available through investors and availability of funds during Budget or Financial Planning will be automatically done. So there is a need to access the profitability aspect of any energy efficiency measure as well as new technology. Also an educated client, engineer, contractor, planner, etc. Stakeholders knowledge of energy efficiency is must as this will support in accessing profitability as well as proper decision making. Also the addressing of sustainability in developing energy efficiency problems is a great point in addressing energy efficiency. New technology replacing the old ones, products or services, will require the consideration of compatibility issues to be addressed. So Lack of compatibility is sure to affect the energy efficiency. This can be overcome by suitable Research and Development of Technology. Six barriers discussed above needs to be addressed holistically by adopting energy efficiency measures which are in line with addressing these barriers.

However the measures cannot be developed as in instant solution or a fit and forget type of solution. The measures for addressing the above barriers must be designed for different stages of an energy efficiency program like policy stage, designing and development stage, implementation and support stage

In order to clearly explain the methods of overcoming the identified barriers in energy efficiency using the identified energy efficiency measures a new theoretical framework, after seeking feedback from stakeholders, is proposed as under in table 6.1. The measures were categorized according to the different stages of an energy efficiency program. The roadmap or possible outcome is given based on division of time line into short term, medium term and long term for each measure and stage of development. Without the identification and prioritization of barriers it will not be possible to identify the different stages of an energy efficiency program as well as suggest the roadmap or possible outcomes. The importance of multi-criteria analysis thus comes to force as it was due to use of this technique we are able to identify the most critical barriers.

6 Solution or Roadmap for energy efficiency

After ranking of barriers, through discussion with stakeholders/decision makers is done to establish a framework to overcome these barriers. The framework is presented in Table 6.1.

7 Concluding Remarks

In the current research, different barriers affecting energy efficiency have been identified and studied. Also different measures affecting energy efficiency have been identified and possible solutions to energy efficiency problems have been given. The methodology involved first literature review followed by discussion with stakeholders, then the possible barriers to energy efficiency and measures taken for energy efficiency improvement were identified. The analysis was carried out on the barriers through a latest tool of multi criteria decision making i.e. Best Worst Method. Based on the prioritization, top 20% of barriers were addressed using a theoretical framework or roadmap. The roadmap suggested not only suggests any short term action but long term vision. The measures are first classified into stages of an energy efficiency program like policy, planning, design and development, then solutions were recommended under three time scales, short term or immediate action, medium term and long term. Although it was not possible to predict the future or indicate any results of action taken to improve energy efficiency with outmost accuracy. But by means of this approach, it is proposed to design or plan the actions into three stages for their effective implementation and success. The above work must not be seen as a case of isolation or a simple study carried out to analyze the energy efficiency. A good feedback on the positive as well as negative aspect is highly anticipated. Also it is anticipated that work must be of great help and significance in removing barriers to energy efficiency and achieve energy efficiency.

8 Limitations and Scope of future work

1. Energy efficiency is on the top of World energy policy agenda and efforts are placed to tackle the barriers to energy efficiency. The study highlights the importance of energy efficiency and barriers to energy efficiency. Also various barriers hindering the energy efficiency use have been categorized and presented in the study. However, there is always the other side of the coin. Identification of motivators to energy efficiency was totally ignored in the study. Further study on the motivators to energy efficiency can be conducted in future.
2. The study involved the discussion and expert opinion of stakeholders. However there is a scope of carrying out the study based on statistical survey tools like SEM in order to further strengthen the findings of the literature survey.
3. Future work can also include identifying the most critical barriers among all identified barriers to energy efficiency from different sectorial perspective so as to frame policies and strategies to tackle these barriers to mitigate the risks of lack of energy efficiency in the specific sectors like housing or building sector, Industries, agriculture and other sectors.

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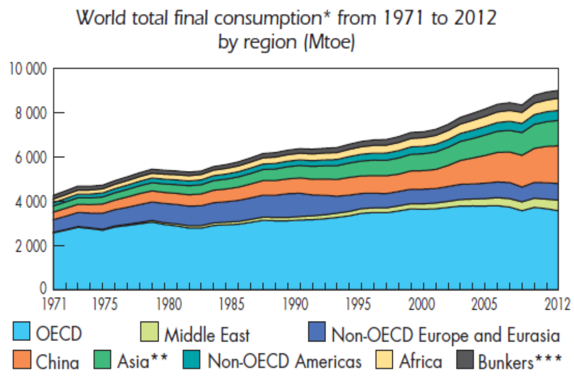

Fig 1.1, Source: International Energy agency (IEA) [4]

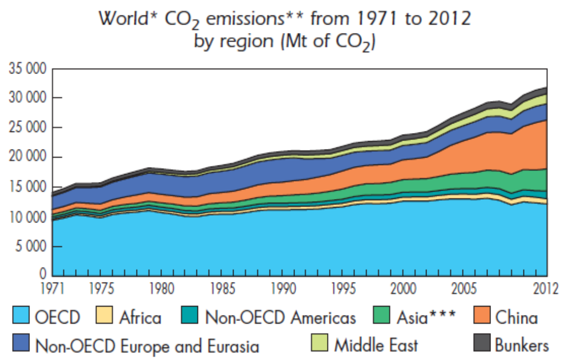

Fig 1.2, Source:International Energy agency (IEA) [4]

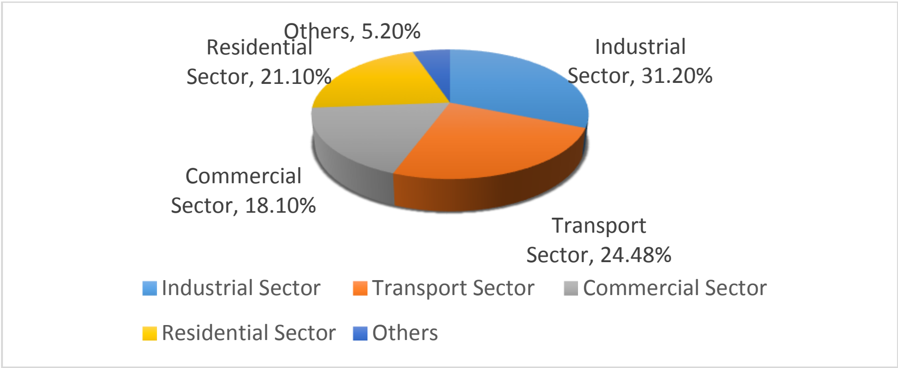

Fig 1.3, Source: World Data as per Annual Energy Outlook 2015, US Energy Information Administration [5]

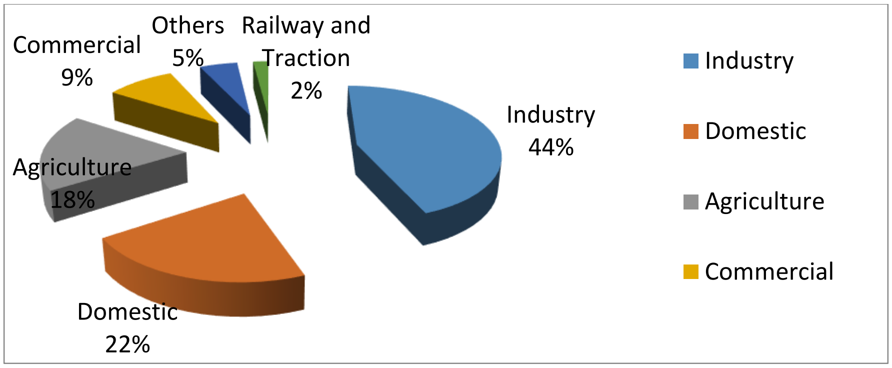

Fig 1.4, Energy Statistics 2015, National Statistics Organization, Ministry of Power [6]

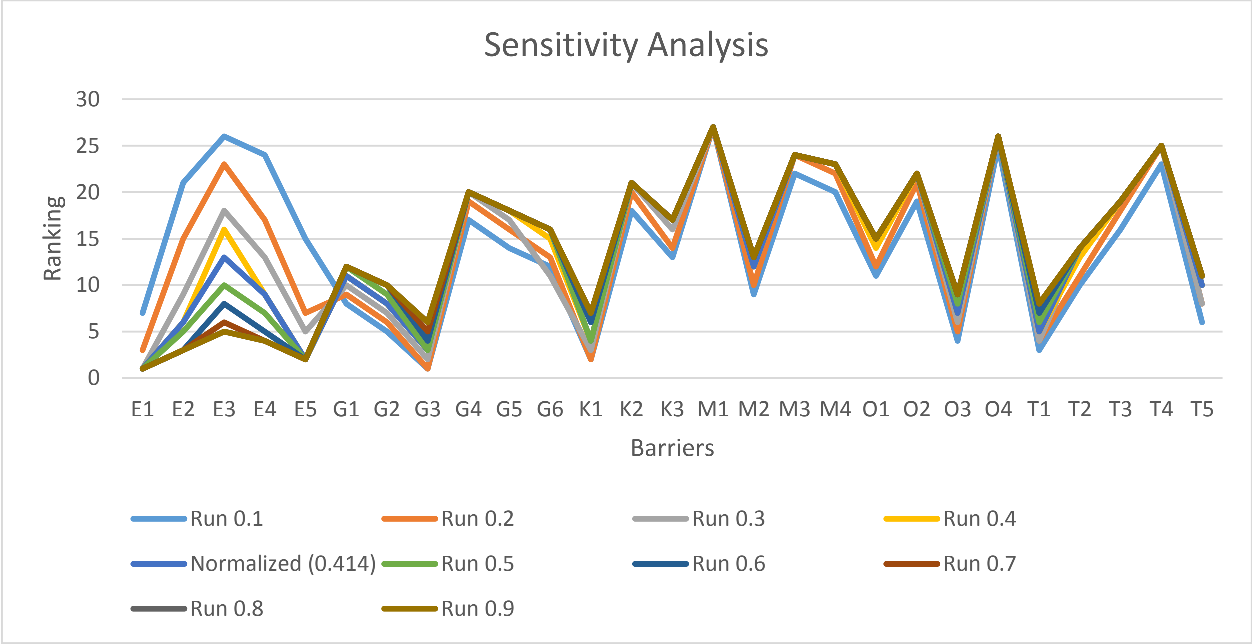

Fig 5.1 Sub Criteria Ranking by varying main criteria weights

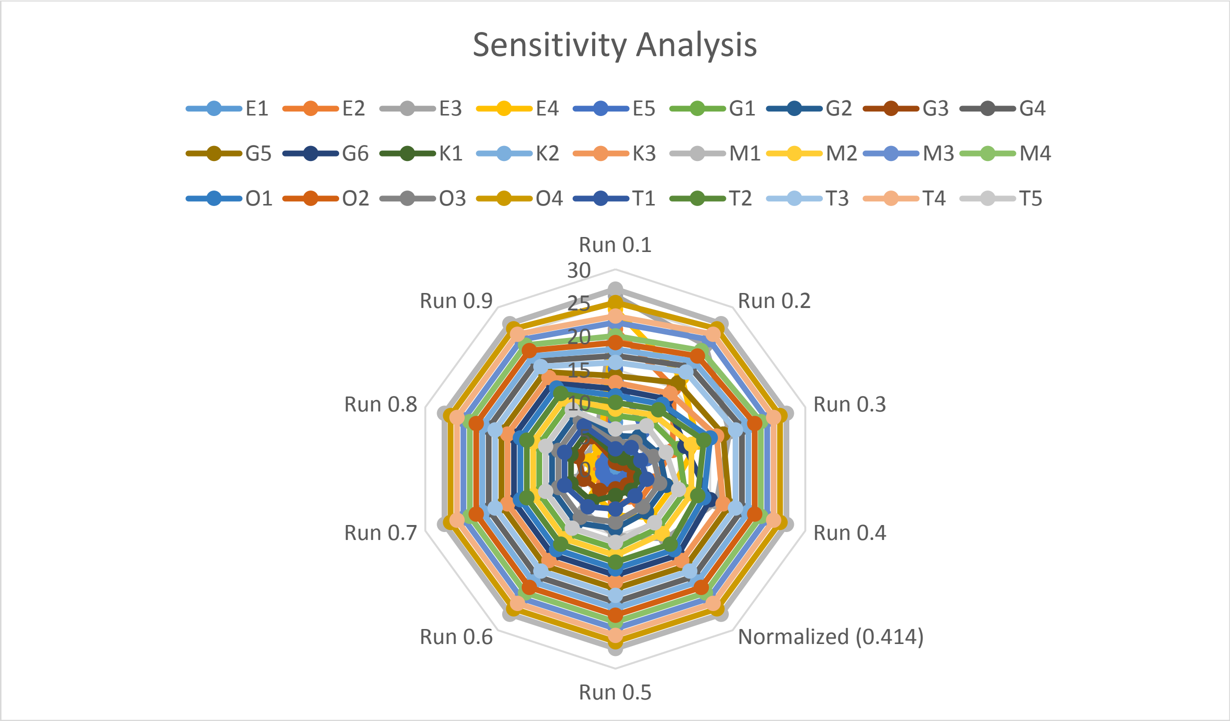

Fig 5.2 Sub Criteria values during sensitivity analysis

Table 3.1 List of Barriers to Energy Efficiency

S No	Category	Sub Category	Reference(s)
A	Economic Barriers (C1)	Scarcity of Financial Means (E1)	[18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38]
		Absence of Lucravity (E2)	[21], [39], [36], [40], [41]
		Poor arbitrage (E3)	[18], [22], [23], [42], [43], [44], [40]
		Inadequate Monetary assessment (E4)	[18], [22], [21], [23], [45], [25], [46], [47], [34], [48], [35], [49], [50]
		Limits in Financial Provisioning (E5)	[51], [52], [35]
B	Government Barriers (C2)	Lack of Financial Motivation (G1)	[46], [38], [47], [53], [33], [56], [50]
		Bridles in Hierarchical inspiration and functional Harmony (G2)	[19], [57], [22], [27], [54], [38], [58], [34], [44], [56], [59], [60]
		Differences in Plan of action for Energy and Environment Integration (G3)	[21], [31], [33], [39], [48], [61], [60]
		Inappropriate antecedencey (G4)	[18], [21], [22], [26], [23], [62], [24], [27], [63], [47], [64], [49], [66]
		Lack of standards and References (G5)	[67], [61], [60]
		Lack of Strong authority (G6)	[18], [23], [63], [38], [31], [32], [68]
C	Knowledge and Learning Barriers (C3)	Lack of cognizance (K1)	[18], [21], [22], [23], [46], [42], [31], [32], [52], [48], [44], [69], [37], [41], [70], [59]
		Inexperient or untrained persons (K2)	[18], [23], [43]
		Lack of Information (K3)	[18], [21], [22], [23], [45], [25], [71], [28], [55], [53], [50]
D	Market related barriers (C4)	Contention (M1)	[19], [52], [59]
		Perceptual Knowledge (M2)	[71], [31], [32]
		Aspousal (M3)	[42]
		Dubiety in Demand (M4)	[32], [69], [36], [41]
E	Organizational & Social Barriers (C5)	Cognitive Decision Making Approach (O1)	[18], [21], [72], [31], [44], [39], [59]
		Lack of authority and Jurisdiction (O2)	[22], [59]
		Ill Defined Vision (O3)	[18], [21], [22], [23], [24], [45], [30], [31], [55], [64], [49], [36], [38]
		Torporpidity in Process and Practices (O4)	[42], [39], [36]
F	Technological barriers (C6)	Incompatible Technology (T1)	[18], [23], [43], [31], [32], [38], [60]
		Process related risks (T2)	[21], [22], [51], [63], [65]
		Lack of energy efficient materials (T3)	[43], [36]
		No Feasibility Study (T4)	[22]
		Slow embodiment of New technology (T5)	[22]

Table 5.1 Scale for pairwise comparison

Intensity of importance	1	2	3	4	5	6	7	8	9
Definition	Equal importance	Weak	Moderate importance	Moderate plus	Strong importance	Strong plus	Very Strong importance	Very, very strong importance	Extreme importance

Table 5.2 Best-to-others (BO) and others-to-worst (OW) pairwise comparison for main criteria

BO	Economic Barriers (C_1)	Government Barriers (C_2)	Knowledge and Learning Barriers (C_3)	Market Related Barriers (C_4)	Organizational and Social Barriers (C_5)	Technological Barriers (C_6)
Best criterion: Economic Barriers (C_1)	1	2	4	9	5	3

OW	Worst criterion: Market Related Barriers (C_4)
Economic Barriers (C_1)	9
Government Barriers (C_2)	5
Knowledge and Learning Barriers (C_3)	2
Market Related Barriers (C_4)	1
Organizational and Social Barriers (C_5)	2
Technological Barriers (C_6)	3

Table 5.3 Best-to-others (BO) and others-to-worst (OW) pairwise comparison for Economic Barrier (C_1) main criteria

BO	E_1	E_2	E_3	E_4	E_5
Best criterion: E_1	1	4	8	5	2

OW	Worst criterion: E_3
E_1	8
E_2	2
E_3	1
E_4	2
E_5	4

Table 5.4 Best-to-others (BO) and others-to-worst (OW) pairwise comparison for Government Barrier (C_2) main criteria

BO	G_1	G_2	G_3	G_4	G_5	G_6
Best criterion: G_3	3	2	1	8	5	4

OW	Worst criterion: G_4
G_1	3
G_2	4
G_3	8
G_4	1
G_5	2
G_6	2

Table 5.5 Best-to-others (BO) and others-to-worst (OW) pairwise comparison for Knowledge and Learning barriers (C_3) main criteria

BO	K_1	K_2	K_3
Best criterion: K_1	1	7	4

OW	Worst criterion: K_2
K_1	7
K_2	1
K_3	2

Table 5.6 Best-to-others (BO) and others-to-worst (OW) pairwise comparison for Market Related Barrier (C_4) main criteria

BO	M_1	M_2	M_3	M_4
Best criterion: M_2	8	1	4	3

OW	Worst criterion: M_1
M_1	1
M_2	8
M_3	2
M_4	3

Table 5.7 Best-to-others (BO) and others-to-worst (OW) pairwise comparison for Organizational and Social barriers (C_5) main criteria

BO	O_1	O_2	O_3	O_4
Best criterion: O_3	2	5	1	9

OW	Worst criterion: O_4
O_1	4
O_2	2
O_3	9
O_4	1

Table 5.8 Best-to-others (BO) and others-to-worst (OW) pairwise comparison for Technological barriers (C_6) main criteria

BO	T_1	T_2	T_3	T_4	T_5
Best criterion: T_1	1	3	5	9	2

OW	Worst criterion: T_4
T_1	9
T_2	3
T_3	2
T_4	1
T_5	4

Table 5.9 Optimal weights for main criteria

Criteria	**Weights**	**ξ^L**
Economic Barriers (C_1)	0.414	0.011
Government Barriers (C_2)	0.213	
Knowledge and Learning Barriers (C_3)	0.101	
Market Related Barriers (C_4)	0.045	
Organizational and Social Barriers (C_5)	0.085	
Technological Barriers (C_6)	0.142	

Table 5.10. Weights of Main and sub criteria's

Main criteria	Main criteria weights	Sub-criteria	Sub-criteria weights	Global weights	Ranking
Economic Barriers (C_1)	0.414	E1	0.475	0.197052	1
		E2	0.123	0.050962	6
		E3	0.057	0.023782	13
		E4	0.098	0.040769	9
		E5	0.246	0.101923	2
Government Barriers (C_2)	0.213	G1	0.141	0.029978	11
		G2	0.211	0.044967	8
		G3	0.408	0.086937	3
		G4	0.049	0.010492	20
		G5	0.085	0.017987	18
		G6	0.106	0.022484	16
Knowledge and Learning Barriers (C_3)	0.101	K1	0.717	0.072255	4
		K2	0.100	0.010082	21
		K3	0.183	0.018484	17
Market Related Barriers (C_4)	0.045	M1	0.060	0.002707	27
		M2	0.564	0.025262	12
		M3	0.161	0.007218	24
		M4	0.215	0.009624	23
Organizational and Social Barriers (C_5)	0.085	O1	0.265	0.022537	15
		O2	0.118	0.010016	22
		O3	0.559	0.047577	7
		O4	0.059	0.005008	26
Technological Barriers (C_6)	0.142	T1	0.467	0.066296	5
		T2	0.164	0.023262	14
		T3	0.098	0.013957	19
		T4	0.049	0.006979	25
		T5	0.221	0.031403	10

Table 5.12 Weights of Main Criteria during sensitivity analysis

Barrier	Normalized Weight	Modified weights of all barriers when modifying economic barrier from 0.1 to 0.9								
Economic	0.414	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Government	0.213	0.327	0.291	0.254	0.218	0.182	0.145	0.109	0.073	0.036
Technological	0.142	0.218	0.194	0.170	0.145	0.121	0.097	0.073	0.048	0.024
Knowledge	0.101	0.155	0.138	0.121	0.103	0.086	0.069	0.052	0.034	0.017
Organizational	0.085	0.131	0.116	0.102	0.087	0.073	0.058	0.044	0.029	0.015
Market	0.045	0.069	0.061	0.054	0.046	0.038	0.031	0.023	0.015	0.008

Table 5.13 Ranking of various barriers through sensitivity analysis

	Run 0.1	Run 0.2	Run 0.3	Run 0.4	Normalized (0.414)	Run 0.5	Run 0.6	Run 0.7	Run 0.8	Run 0.9
E1	7	3	1	1	1	1	1	1	1	1
E2	21	15	9	6	6	5	3	3	3	3
E3	26	23	18	16	13	10	8	6	5	5
E4	24	17	13	9	9	7	5	4	4	4
E5	15	7	5	2	2	2	2	2	2	2
G1	8	9	10	11	11	12	12	12	12	12
G2	5	6	7	8	8	9	10	10	10	10
G3	1	1	2	3	3	3	4	5	6	6
G4	17	19	20	20	20	20	20	20	20	20
G5	14	16	17	18	18	18	18	18	18	18
G6	12	13	11	15	16	16	16	16	16	16
K1	2	2	3	4	4	4	6	7	7	7
K2	18	20	21	21	21	21	21	21	21	21
K3	13	14	16	17	17	17	17	17	17	17
M1	27	27	27	27	27	27	27	27	27	27
M2	9	10	12	12	12	13	13	13	13	13
M3	22	24	24	24	24	24	24	24	24	24
M4	20	22	23	23	23	23	23	23	23	23
O1	11	12	15	14	15	15	15	15	15	15
O2	19	21	22	22	22	22	22	22	22	22
O3	4	5	6	7	7	8	9	9	9	9
O4	25	26	26	26	26	26	26	26	26	26
T1	3	4	4	5	5	6	7	8	8	8
T2	10	11	14	13	14	14	14	14	14	14
T3	16	18	19	19	19	19	19	19	19	19
T4	23	25	25	25	25	25	25	25	25	25
T5	6	8	8	10	10	11	11	11	11	11

Table 6.1 Roadmap for energy efficiency

Stage	Measures	Road Map or Possible Outcome		
		Short Term	**Medium Term**	**Long Term**
Policy and Planning	**Rigorous Policy Framework and Target Setting for Energy Security**	Rigorous policy framework for existing buildings, achieving maximum energy efficiency among the available sources as well as means of utilizing energy	Rigorous policy framework for new buildings, realistic and quantifiable energy targets for renewable energy must be set	Strategy for achieving 100% self-sufficiency in energy, becoming most energy efficient country as well as a major supplier of green and efficient energy to the world must be adopted
	Environment Protection and Sustainability	Reducing greenhouse gas emission in existing buildings	Policy formulation for planning buildings with zero or no greenhouse gas emission. Either modifying or replacing existing buildings with sustainable buildings	Permitting construction of 100% sustainable buildings with zero impact on environment i.e. any new building must have 100% waste disposal system, 100% water conservation system etc.
	Subsidies and Incentives	Providing subsidies in green construction material and housing projects for technically approved, more efficiently designed modification or retrofitting activities in the existing buildings as well as adoption of more energy efficient and robust designs in new buildings.	Replacement of subsidies with tax incentives for use of green construction material and adopting green housing projects for technically approved, more efficiently designed modification or retrofitting activities in the existing buildings as well as adoption of more energy efficient and robust designs in new buildings.	Imposing environmental tax for noncompliance of using green materials as well as not building energy efficient green buildings
	User Comfort and Health and Safety issues	Making policies for adopting energy efficient measures that promotes health and safety, productivity and thermal comfort of occupants. Identifying different factors and means of monitoring those factors for holistic thinking in policy development.	Making policies for developing standards and designs of building materials as well as buildings, that are applicable for specific climatic zones, promoting safety, productivity and thermal comfort of occupants. Use of monitoring tools as a mandatory requirement in policy.	Making policies for strict compliance and adoption of standards and designs of building materials as well as buildings, that are applicable for specific climatic zones, promoting safety, productivity and thermal comfort of occupants. Periodic review of data bases of the identified factors for ensuring compliances as well as further modification in policy approach.
	Zero Energy Building Policy	Any modification in the existing building must be focused on improving the energy efficiency with aim to move towards zero energy green building.	A time frame must be set for modifying and certifying the existing buildings to make them more energy efficient and more close to energy efficient green buildings. Also developing policies such that all the new buildings must be designed as zero energy green buildings.	Developing policies to ensure that no building other than green buildings or zero energy buildings must be allowed to be build.
	Early Decision Making	Making the best of opportunities at hand: The decision making should involve any strategic step to improve energy efficiency at any level in minimum cost.	Adopting the policy of prevention rather than cure: The policies must ensure that design decisions must be taken such that all the new developments should be 100% energy efficient.	Developing a policy framework that must be supported by proper documentation, case studies, assessment methodologies like life cycle assessment, life cycle costing, risk analysis and future proofing to design and develop 100% energy efficient materials and buildings.

Design and Development	**Designing and Selection and Innovation**	Design criteria must support efficiency improvement. The primary and immediate focus should be efficiency improvement through better designing. Passive design techniques like green walls, roofs, solar shading, optimal insulation, natural ventilation etc. must be promoted for the existing and new buildings.	Design criteria must support efficiency improvement, innovation and creativity. Over a medium term the designing should also involve the use of new tools and methodologies, research and development in promoting energy efficiencies.	Design criteria must support efficiency improvement, innovation and creativity and sustainability. Over a long term sustainability should be considered as a primary factor governing any design criteria duly supported by innovative and creative research methodologies.
	Development of Case Studies and Documentation	Need for focus on documentation and case study development in any energy efficiency improvement program.	Need for promoting the role of documentation and case studies in policy development. Mandatory referral of existing case studies or documentation of the new ones before carrying out any energy efficiency measures.	Need for imposing mandatory documentation and case study methodologies. No policy should be formulated where the possible outcomes or benefits have been highlighted through case study and documentation.
	Development of Zero Energy or Zero Carbon Buidings	Any modification or improvement in existing building as per the zero energy building policy mentioned above.	Implementing energy efficiency programs and design criteria as per the zero energy building policy mentioned above.	Development programs aimed at strict compliance of zero energy building policy mentioned above.
	Retrofitting	Designing better retrofits for existing build stock.	Designing assembly based components in new buildings to facilitate any change, modification, replacement of retrofits.	Integrating the use of self-healing energy efficient materials in the design and application of retrofits.
	Development of New Energy Efficient Materials	New energy efficient material should be developed and used for modification and retrofitting aimed at achieving energy efficiency in buildings.	All the future designs of the buildings must involve the use of new energy efficient materials which are eco sustainable, recyclable and are readily available. New techniques and methodologies for the development of energy efficient materials must be promoted.	Any new material designed and developed considering the aspect of 100% energy efficiency must be documented and standardized internationally so that its long term effects on energy security and sustainability must be evaluated on a global scale and it must be adopted after thorough assessment, auditing, analysis and support.
Assessment	**Development and Application of Life Cycle assessment Methodology**	Need for adopting widespread utilization of life cycle assessment methodology in new buildings. Life cycle assessment methodology is laid down by ISO 14040/44 series. Life cycle assessment methodology can also be adopted for any new material or retrofits utilized in improving the efficiency of existing buildings.	Life cycle assessment must be supported with establishment and maintenance of large set of data of building related information, best calculation tools, comparative studies, highly trained and experienced expertise, promotion or regulatory support for life cycle assessment, for systematic monitoring and post occupancy evaluation during operational stage.	Design and development must be carried out for finding any drawbacks and further improvising the life cycle assessment methodology duly supported by documentation and case studies so that the life cycle assessment methodology can continue to support the cause of energy efficiency over a long term.
	Risk analysis and Future proofing, Financial analysis	Proper risk analysis before adopting any energy efficiency measure like use of new material, retrofits, and passive technologies must be done. Risk analysis may involve use of stochastic models, study of payback period, return on investment, depreciation etc.	In addition to the existing ones, the risk analysis must be made mandatory while designing of the any new building. Global standards for tried, tested and proven techniques of risk assessment must be developed.	It must be ensured that no building should be constructed without carrying out proper risk assessment and analysis. Global standards for tried, tested and proven techniques of risk assessment must be enforced.

Implementation and Control	**Strong Authority for ensuring Strict compliance supported by robust Legal System**	The officers or managers involved in monitoring the quality of energy efficiency measures adopted must have sufficient authority and power for taking strong legal action ensuring proper documentation and transparency.	Proper distribution of authority among the officers or managers involved so that the policies are properly and timely implemented and there is proper utilization of funds at all the stages viz. designing, development, implementation and monitoring.	The authorities and powers granted to the officers or managers must be reviewed periodically and updated with latest technology tools so that the power does not becomes a source of redtapism or corruption. The lessons or best examples from the policy enforcements due to strong authority must be brought to public domain.
	Leadership and Motivation for Successful Implementation	Leadership and motivation is always required for successful implementation of any policy or measure.	A person leading an organization or government must be able to set and envision short term realistic goals that can improve energy efficiency. A good leader must be a strong motivator to enhance the productivity and efficiency of any organization or system.	Like short, term a good leader in over a long term must develop winning strategies, execute them brilliantly, must be able to measure their impact and adjust them systematically to achieve productivity and efficiency.
	Energy Supply Chain and Energy Delivery	The drawbacks in the existing energy supply chain must be evaluated, discussed and documented at the appropriate level to design and develop the possible improvements in energy supply arising out of losses due to delivery of the energy.	Development and adoption of measures for improving energy supply chains by the use of latest materials, proven technologies like the use of high voltage transmission lines over long distances, latest information and automation tools like smart grids on priority. Developing guidelines for reverse logistics (buyback of energy from renewable energy clusters having surplus energy).	Building an environment of strong focus on research and development in energy security through development of best supply chain technologies. Total adoption of reverse logistics at all the level of transmission.
	Energy Audit	Energy audit should be made compulsory for every existing building and guidelines or systems must be developed for maintaining the complete database of the auditing aspects.	Lessons from the energy audit of the existing buildings duly supported by facts and figures must be applied to the designing of the new buildings. The existing standards of energy audit must be widely publicized for further review and development of the existing standards.	Energy auditing standards must be strongly complemented with sustainability.
Support and Training	**Service and Maintenance Support**	Development of strong team of experts for technical support of the products and services involving energy efficiency improvement or use of renewable energy.	Making mandatory the servicing and maintenance contracts for all the new products and services involving energy efficiency improvement or renewable energy use.	Developing and integrating product or service specific maintenance standards which are applicable globally so that uniform support and service is available across all the regions.

	Training	Developing short and long term base training and skill development programs aimed at spreading awareness and technical know-how of energy efficiency products and services.	Development of institutional and training programs related to energy efficiency.	Integrating energy programs related to product, tools, standards of energy efficiency improvements and developments with social schemes like MNREGA, so that the gap in adoption of renewable technologies due to lack of user confidence on its reliability be minimized.