International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 5 Issue 3, March 2016

Research Paper on Linear Programming in Optimization of Household Energy

Monika Dalal[1], Sweety Sharma[2]

[1]Student, Department of Electrical Engineering, Indus Institute of Engineering & Technology, Jind, Haryana
[2]Asst. Professor, Department of Electrical Engineering, Indus Institute of Engineering & Technology, Jind, Haryana

ABSTRACT

There is many techniques that work for energy conservation in a building or house, each having a specific function cost. Our main objective is to conclude the budget by saving maximum energy of household using Linear Programming methodology. In this objective problem of power saving and budget estimation, solution is given in the two steps: in first, energy savings are taken as the objective function and in second step, the budget is taken as constraints function. Here we are using different budget as the constraints function for the different value of savings of energy. For calculations to install photovoltaic solar cell and solar panels, Linear programming is used to change normal windows having double glazed window. We are also changing normal incandescent bulbs to fluorescent light bulbs; also changing the quality of appliances i.e. C class appliances is changed with A class. When we are doing this by the appropriate method we can see that replacing with double glazed window and triple glazed window and normal CFL bulbs are the effective choice for low budget. Using this method we can get maximum savings of energy in the household building or we can also use it for commercial purpose. An effective algorithm has been developed that solves the problem. If we are spending certain amount of money in our building then how much energy can be saved by that algorithm this is our basic problem. After obtaining optimized result, the money which we have spent as an initial cost in the objective function, is also recovered. For all different budget then we are calculating the payback period and profitability for different budget.

Keywords: Energy security, Linear Programming, Double gazed window, Triple gazed window, Payback period, Profitability.

I. INTRODUCTION

Energy is important in supporting people's daily lives and the continual quest for human development. In the past decades, the demand for various energy resources, in both sufficient quantities and satisfactory structures, has been increasing worldwide, along with population expansion, economic development and living standard improvement. At the same time, the depletion of conventional fossil fuels, the limitations of new energy resources/technologies, as well as public concerns over energy-induced environmental issues (particularly GHG emission) have greatly weakened society's capabilities for addressing potential risks and impacts associated with our energy supply. Energy resources can no longer be produced and consumed without addressing the issues of sustainability and a variety of associated problems. Thus, planners and decision makers are facing increased pressure to respond more effectively to a number of energy-related issues and conflicts, as well as GHG emission mitigation within multiple scales of energy management systems (EMSs). This quandary requires a focused effort to a resolve a wide range of issues related to EMSs, as well as the associated economic and environmental implications. Consequently, effective planning of EMSs with the consideration of GHG emission mitigation has been a priority for energy-related and environmental professionals, as well as regulatory agencies. Optimization studies have been conducted in building science in recent years after long being computationally intractable. In the field of building science, the systems of interest are extremely complex, with a high number of variables, non-linear equations, and simulation durations often as large as one year, such systems is a difficult task. This also involves the cost on the initial basis and also the implementation cost.

As the current scenario is according to that it is very important that we use energy where we require and optimization is very important. By this we can support to healthy life and strong economy for today and future as well. By the efficient use of energy we can also decrease environmental pollution by doing these methods we can give supportive hand to development of country and for pollution as well. As we know that building have very great effect as the consumption of building is very high and it is approximately 45% in all the form of energy. It is in the commercial form where that amount

of energy is given in the form of processed form. Then this processed fuel is converted to electricity form which is used in the development of a country [1,2]. To complement efficiency standards, this study illustrates how energy efficiency can be improved through such initiatives as efficiency labeling or certification, very best practice buildings with extremely low or no-energy consumption and other policies to raise buildings' energy efficiency beyond minimum requirements.

II. RELATED WORK FOR HOUSEHOLD ENERGY OPTIMIZATION

As we know when the global crisis on energy came in 1973, after that there came some good and effective method of saving of energy and its proper and various methods. That crisis changed the way of energy that started a good effort for saving the energy all around the world in which renewable sources had good role. In that method one was important to design a building in such a way that save the energy and losses can be minimized [3] by that time many countries has changed its law and rules that how can we use energy in efficient way in commercial as well as in household as well because residential consumption is also very large in amount. These restrictions are in the form of timing that how much we are targeting the saving of energy and also the time that in how much time we can achieve that in the commercial and residential place as well.There are many laws which used for optimizing the energy and as well the energy efficiency. Day by day there are many laws came into effect. A law updated recently comprises the basic principal and the method to increase the efficiency of energy in household building as well in commercial building, this also helpful in industries and in transportation. That law will help saving of energy and this will help achieve the desired limit. Each one should do proper action to achieve this goal. The importance of energy efficiency requirements in building codes or standards extends beyond their role in new buildings. Building codes and efficiency standards often serve as the efficiency target for refurbishment or other improvements of existing buildings. Buyers and renters of buildings or units will often compare new and existing buildings. With increased interest for efficiency will high requirements in building codes therefore spur the demand for refurbishment or general improvements of existing buildings[9]. The changes should be such as that they achieve their goal without compromising their living of standard. Energy saving is the most important aim of everyone.

As we know that multi objective method is very effective for this type of problem and issue and there are many principals and strategy which put attention and are more concerned that we should work on that. Wright et al. find application in which multi criterion algorithm is used. That is used for non-dominated range which shows various results on the issue of cost of energy and requirement of user. This can increase the budget and also change the data according to the demand of household so that they must keep their way of living and quality as well [10]. By using this algorithm which is based on multi criterion genetic we can say this algorithm is good in differentiating the cost of energy and the change in the climate and the user requirement. There are many applications like radiator network which is adjusted through thermostatic valve. Use of thermostatic valve is very good choice for problem of energy and efficiency as well. Chen et al. suggested technique which is used for time consumption in the savings of energy. This technique is also used for maximizing the energy and also the efficiency of utilization of energy in the household buildings. This is done by the method analytical network method used which is multi objective decision process[11]. Verbeeck and Hens concluded two feasible and important conclusions for the improvement of efficiency in the buildings. First, they find when they have lack of financial support or help. In that analysis that have showed that in the limited budget or in the small budget there is a very small chances of improvement in the energy savings. There are high environmental losses as well and very less number of users will be benefited by this strategy. By the use of high range of budget we can improve more energy savings. Energy savings is not a single benefit in which we are concerned, but there is a one more issue that on which time or by which time we can recover that money which we are going to invest in the savings of energy and for improving the efficiency of energy. So by the calculations we see that in most of the cases payback time is very less and we can be benefited in the energy savings in less time and after that time energy savings will increase year by year. Diakaki proposed that for the improvement of energy savings we can do many changes and improvements. Like we can change or improve the quality of window, doors and heating systems of the window [13]. Their model method was not only for the savings of energy or for the consumption of energy. It was for the carbon dioxide emission from the building. We know that on the emission of heat or on using of normal bulb electricity loss occur in the form of heat and as well in the form of carbon dioxide. So by the emission of carbon dioxide temperature increases and it will put very adverse effect on the human being and nature. Carbon dioxide gas is the main source of greenhouse effect which is primary cause of global warming. Magnier and Haghighat calculated an optimization methodology which is two theories. One is multi objective evolutionary algorithm and another one is neural. That combination of these two algorithm we can generate a database systems. This algorithm is based on the sampling of artificial neural network and multi objective functions [14]. By calculating and discuss all the case we can produced a methodology which will be more friendly to user on the basis of thermal conditions and also on the basis of energy use and budget.

In the markets many light bulbs are available which can save energy and can provide good light energy. These are given as below:

a) Halogen light bulbs.
b) Light emitting diode as a bulb
c) Compact fluorescent light bulb.

These bulbs are good to use and also easily available in the market. When we compare the power of CFL bulb and incandescent bulb then we came to know that for creating same illumination in CFL and normal bulb, CFL takes only 25% of energy to the comparison of normal bulbs. The life cycle of CFL is more than 6 times with respect to normal bulbs. The one disadvantage of CFL is that it is considerably expensive than normal incandescent bulb ratio is approximately 6:1 in price. A good amount of household electricity consumption is used in household appliances. Mills and Schleich suggested that refrigerator and freezer uses approximately 17%-20% of resident electricity [21]. They claimed that washing machines consumes 6% and dish washer consumes 2%.By the energy efficiency policy it is not easy to maintain the efficiency of all appliances. To encourage manufacturer and the customer to the more energy efficiency for the future, there are many systems introduces.

III. HOUSEHOLD ENERGY CONSERVATION METHOD: STRATEGY AND OBJECTIVES

Energy security is very important for many commercial, industry and government sectors. During the last years we have become more aware of the need to save energy by using more energy efficient equipments, but the need for energy will still increase in the nearest future. Today two billion out of about six billion people have no access to electricity in their homes [3,4]. It is urgent to improve this, and it can only be achieved by energy efficient method. A method which reduces risks that comes from energy use. Energy security is basically defined on the term that how we can supply reliable and effective energy so that it can play an important role in the economy of country and national growth at reasonable price [5]. However, few issues are addressed that are needed to be resolved while planning this method. Some of the issues are given below [6]:

a) To reduce the difference between energy requirement and supply,
b) To improve efficiency of energy and securing by low to energy and its intensity,
c) To achieve the optimum energy combination
d) To Diversify sources of energy and also its supply
e) To investigate in energy manufacture and its development
f) To shift and use the alternate and renewable methods of energy.

The objectives of the research are:

1) To study the basic need of energy: To study the optimization techniques for energy saving
2) To understand the energy conservation methods in buildings various methods and algorithm to calculate and maximize the energy savings. To calculate the payback period for small, medium and large scale budget: To analyze and comparison for the different methods by which energy saving is being maximized.

IV. HOUSEHOLD ENERGY CONSERVATION METHOD

To promote energy efficiency for residential buildings, a research has been conducted to investigate the characteristics of energy consumption in the residential buildings and develop a suitable energy labeling system for assessing the building energy performance. The aims of the research are to review worldwide experience, study the feasibility of establishing building energy labels, and evaluate the key factors for design and implementation of the building energy labels. In one of them system is labeling system. Energy efficiency label is very important as that gives information of the product. Product has information like date of manufacture, content, rating, energy consumption, power consumption, current rating, voltage rating, revolution per second, number of turns and many more these all are written on the label. These labeling are very important to the consumer so that he can purchase product according to the requirement. Energy star is also a program used for labeling.

The materials used for the optimization and techniques used to improve the energy efficiency is different for different one and varies in many sense of parameters. Jaber and Ajib represented the main terms to achieve and acquire the conservation of energy in industrial and residential sectors:

i. Design for considering climate effects. To decrease heat, cooling, sparking, appliances and water loads generally it is hot water.
ii. To enhance the quality of equipment of the house. Equipment may be mechanical or electrical or both.

iii. Replacing waste to renewable sources that is used for the primary energy.

Two systems spend a good amount of currency in the household expenditure. The decrease in heating load due to excess electric lighting is smaller than the excess lighting energy load leading to higher cooling loads and thus to higher total energy load. This effect has also been observed by Bourgeois et al. [5]. As we know in the building there are two types of systems: Heat system and cold system. Heat systems are of many types as boilers, heat pipes, heater and cooling machines, air conditioner. As we know that air conditioner is very expensive and its installation cost is very high as well. Energy requirement for the building is done by using much transformation and energy requirement cannot meet by using these type of expensive appliances. So we will use equipment according to energy requirement of the building.

Window glazing techniques used to optimize the energy savings of a building. We assume that the construction of building or house is as per the norms of civil engineering and related authorities. In order to achieve this goal, house owner and flat owner must take suitable actions to reduce their energy consumption without compromising from their standard of living. The energy conservation methods involved in this research were installing the Solar Panel at roof , replacing normal Single glazed windows with Double glazed windows ones , then with Triple glazed windows ones .
HOW DO DOUBLE GLAZED WINDOWS WORKS?

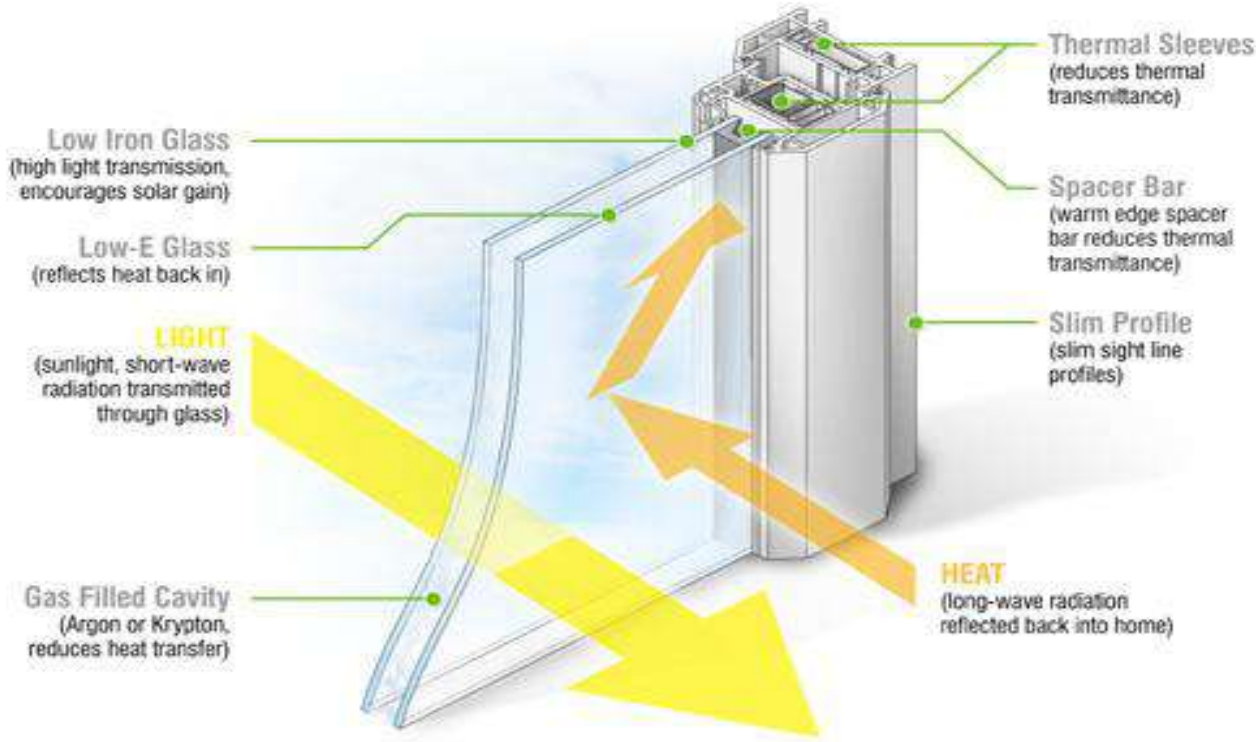

Fig. 1: Double glazed window (working)

MERITS OF DOUBLE GLAZED WINDOW

a) Cost of double glazed window is less than triple glazed window of same dimension.
b) Double glazed window can reduce the heat loss up to 50%
c) It has less weight than triple glazed window
d) The cost of frame is less.
e) It is best suited for normal winter and summer.

DEMERITS OF DOUBLE GLAZED WINDOW

a) Less energy efficient than triple glazed window
b) Less durable than triple glazed window
c) It has higher U value than triple glazed window

TRIPLE GLAZED WINDOW

Triple glazed window in which there are three glasses and having two separations in which inert gas like argon is filled, we used triple glazed window because due to two separations there is very less heat and thermal energy transferred from outer climate to inner or desire done. As we are moving towards next section we can see that many other energy savings factors and theories are which work on the optimization techniques. For that location of resident and climate condition of place also matters a lot.

To overcome these demerits we can use 'Triple Glazed Window'. In the triple glazed window three glass panes are separated by one another. The distance between the glasses is as according to the area or width of window socket. The distance between each glass panes reduces the heat loss so in the triple glazed window the separation is filled by the inert gas or by the argon gas which is good insulator of heat. So in that case more heat loss can be saved and we can minimize more energy and can save more energy. This is a good approach for saving energy and this strategy is called as the envelope of building. Use of double glazed window is good but it is not the effective way because the cost of double or triple glazed window is comparatively high than normal window.

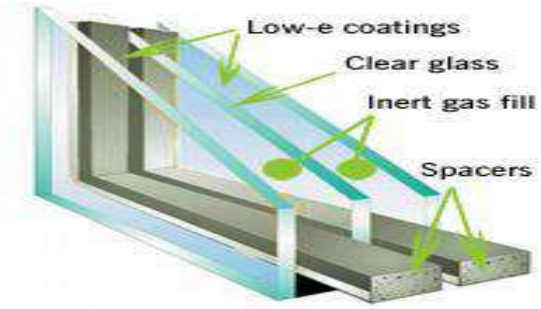

Fig. 2: Triple glazed window (structure)

These windows offer 28% - 30% (approx.) more insulation than double-glazed window. It also decreases thermal transfer by 75% - 80% making it the most energy-efficient option around. It also mitigates noise. Therefore triple-glazed windows perform all the functions of double-glazed windows, but with more effectiveness. They are just marginally more expensive.

BENEFITS

a) They are well suited to climates where there is extreme heat, humidity and cold.
b) They are more suited for congested area since it is highly effective for sound proofing.
c) It provides more security against intruder.
d) Improves lifestyle and many more.

V. HOUSEHOLD ENERGY CONSERVATION MODEL

In this project we are using linear programming. This programming is used for the optimization of budget. For this we are using a building which is situated in the hot climate region. This method is designed as in the minimum budget we can get maximum savings of energy and quality of energy as well. In this problem the data we have taken is from local data and is in Euro. In this problem we are using two store building, which is having seven rooms. This design is taken because it is simple and we see many of buildings of this type. By taking this type of building we can do our calculation very easily. Suppose we took multistory building then heat loss calculation and other calculations could be tough and complicated. We can calculate heat loss in multistory building but calculation would be tough. Dimension of the building is well known to us. We have taken 140 m^2 roof area of the building. In the total of roof area we are installing solar panel in the half of the area. Area taken for double glazed window is known to us. Total window are is 32m^2

From the data and literature known to us total area of roof is 150m^2 and the basal area is 120m^2 [25]. As we know that solar plates have weight so installing that on the roof strength of floor matters and also the durability of roof. So for this reason we cannot install or cover whole roof are with solar plates. In the building 7 living rooms are available. In that 10 incandescent bulb is used which is sufficient for the lighting of the building. Table given below shows the characteristics of the building.

PAYBACK PERIOD

The payback or recovery period for a budget is achieved by converting unit. Power is converted to kilo watt hour. We have supposed that we are gaining energy through the year. Cost of electricity in taken as neglecting the difference between the day light and nightlight.

PROFITABILITY

Now our aim was to calculate the profitability which shows the profit in each and every year. Profitability is calculated by the saving of energy in each year. In that case we are ignoring the maintenance cost. So in each year in the same level of budget how much we are saving in the terms of money this is calculated in the profitability section. This is called profitability.

VI. APPROACH

In problem we used MATLAB 2013a software for energy savings: The linear approach we designed by using the cost and saving of data. After taking the data and consider the physical constraints that was given in the earlier section is given below. x_d, y_{ip}, z_c, a, b, c are the decision variable of the problem:

$$\text{MAX } Zz = (Qxd * xd) + (\sum_{i=1}^{n} QYip * yip) + (Qzc * Zc) + (Qrd * a) + (Qpw * b) + (Qtr * c) \quad \text{……Eq. 1.1}$$

$$(Cxw * xd) + (\sum_{i=1}^{n} CYip * yip) + (Czc * Zc) + (Crd * a) + (Cpw * b) + (Qtr * c) \leq Ww \quad \text{……..…Eq. 2}$$

$$\sum_{i=1}^{n} (yip * aip) \leq R \quad \text{…….....…… Eq. 3}$$

Where,

x_d, y_{ip}, z_c, a, b, c are non-negative and y_i is integer

a, b, c are binary variable
i= 1, 2, 3, …….,n

$$a = \begin{cases} 1 \text{ if } C \text{ class dishwasher is changed by } A \text{ class} \\ 0 \text{ otherwise} \end{cases}$$

$$b = \begin{cases} 1 \text{ if } C \text{ class washing machine is changed by } A \text{ class} \\ 0 \text{ otherwise} \end{cases}$$

$$c = \begin{cases} 1 \text{ if } C \text{ class refrigerator is changed with } A \text{ class} \\ 0 \text{ otherwise} \end{cases}$$

STEPS IN MATLAB

a) Maximize the energy savings
b) Work on various budget strategies
c) Find what is the payback period for each and every budget
d) Relation between the budget and payback period

By the allocation of data there are three regions defined:

a) Low Budget, which is from ` 40000 to`400000.
b) Medium Budget, which is from ` 600000 to` 1600000.
c) Large Budget, which is in between ` 2000000 and` 4000000.

On the low budget the best solution for optimization of energy is replacing incandescent bulb to CFL bulb and installing double glaze window. In this process when we replace all the bulbs of building with the CFL bulbs and all windows are replaced by double glazed window then we need to do some extra and effective method. So after that our next step is to

install solar panel. For this we have taken six types of solar panel with different efficiency. Each solar panel has its own capacity and power consumption. Among 6 types of solar panel E solar panel is very good for this type of problem. Performance of E solar panel is very good in the unit of capacity, price and power. In this case we have seen that replacing the appliance is not the good option for energy savings. But installation of solar panel comes as a feasible and good option in spite of more cost of solar panel. When the solar panel installed in the multiple units it gives a tremendous result. By this changing the appliance does not seem to be an economical choice. After installing double glazed window we can install solar plate. Solar panel shows highest energy savings. But this is applicable in the case only when we have high budgets. In that case replacement of appliances shows a good option for the energy savings. As we have seen in the result that we are getting highest energy saving in the budget of ` 280000. In that case maximum amount of energy saving is 19477.7 watts. This amount of energy savings is taken by appropriate readings of all the data like number of bulbs and installation of solar panel. Under the budget range of ` 2800000 to ` 3200000 maximum amount of energy savings obtained. The parameters that gives the maximum energy saving is given below:

32.1 m^2 area of double glaze window installed

- To purchase 10 CFL light bulb
- To install 1 "solar panel type B", 1 "solar panel type E" and 46 "solar panel type F" solar plate
- To replace refrigerators, washing machines and the dishwashers

This total installation costs a total of ` 2880600 for double glazed window and ` 2349500 for triple glazed window; by spending this much of amount in household building energy efficiency can be improved.

TABLE I
OPTIMIZATION OF BUDGET AND ENERGY SAVING, FOR LOWBUDGET

BUDGET(`)	DOUBLE GLAZE WINDOW(m^2)	SOLAR TYPE' A'	SOLAR TYPE'B'	SOLAR TYPE'C'	SOLAR TYPE'D'	SOLAR TYPE'E'	SOLAR TYPE'F'	ENERGY SAVING (W)
40000	15	0	0	0	0	0	0	5255.3
80000	32.1	0	0	0	0	0	0	9796.7
160000	32.1	0	0	0	1	1	0	10095.7
240000	32.1	0	1	0	0	4	0	10389.7
280000	32.1	0	0	0	0	4	0	10594.4
360000	32.1	0	0	0	0	6	1	10803.7
400000	32.1	0	0	0	0	8	1	11063.7

TABLE II
OPTIMIZATION OF BUDGET AND ENERGY SAVING, FOR HIGHBUDGET

BUDGET	DOUBLE GLAZE WINDOW	SOLAR PANELINSTALLATION						TOTAL ENERGY SAVINGS(W)
		TYPE' A'	TYPE'B'	TYPE'C'	TYPE'D'	TYPE'E'	TYPE'F'	
2000000	32.1	0	0	1	2	43	0	17435.7
2800000	32.1	0	1	1	0	1	46	19477.7
3600000	32.1	0	2	1	0	1	46	19499.9

VII CONCLUSION

We have used linear programming in this dissertation work to maximize the energy savings according to the budget and household. The residential building which we have taken is two floored building. This method involved to reduce the energy consumption of building. For this purpose we install photo voltaic solar plates, used double glaze window and changes low class appliances to the high class. In these appliances we have taken refrigerator, dishwasher and washing machine. Some parameters which we have taken in the objective function are given as:

a) Windows area $32m^2$
b) Roof area where solar panel is installed is $70m^2$
c) Light bulb used is 10

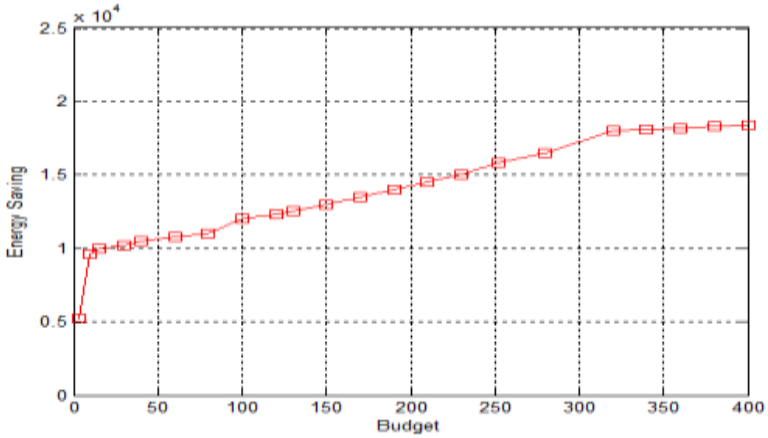

Fig 3: GRAPH BETWEEN BUDGET AND ENERGY SAVINGS (1 UNIT= 10000)

After the calculation for preserving of energy then we will calculate payback time and period. Payback period shows that in how much time we will recover the budget. Payback time is different for different budget.

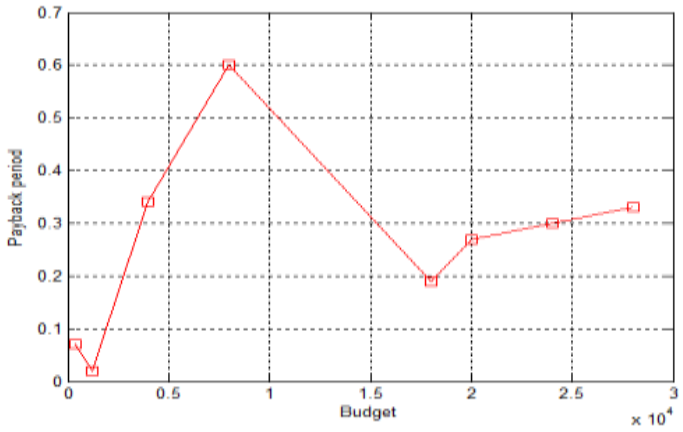

Fig 4: GRAPH BETWEEN BUDGET AND PAYBACK PERIOD

Costs of installation and price of product is taken from Manufacturer Company and from website. There are many methods to optimize the energy. We have taken low, medium and large budget. Range of budget is from `40000 to `40000000. Budget was taken as the input of the objective function some constraints are also taken. When we are changing or replacing the appliances then it does not come as good option. When we install solar panel energy savings goes on high value. So installing solar panel is good option. We have profit of each year which works on the long term goal. By the calculation we calculated payback period. So in this project we have worked on many cases according to the requirement of user or customer.By the approach we have taken is a consumer based methodology. This is used for the maximization of energy savings with respect to the budget. Here our main aim is to recover that amount which we have invested as the initial cost. So the payback period and profitability is an important factor affects for calculation. So the payback period is calculated by some conversion factors. Such as power values are converting in kilo watt hour supposing that gain in the energy is throughout the year. The formula for payback period is given above. Table for payback period is table 5.4. In the result part of payback period we see that we can recover our budget or investment in very less time.

Fig. 4 implies that at the high investment recover point reach before 18 months. So by that approach it is easy to recognize that installing solar plates, replacing appliances is a good approach because we are gaining so much from that and also payback period is very less. Energy savings are good with high energy efficiency. So solar panel installation is a sounding choice.

This project can be modified in the case if we take another building or for other climate condition. In that case final result will be different due to different constraints. We have taken data from local as well as other sources. By this method we can optimize the data globally or according to user's demand and requirement.

REFERENCES

[1] J. Laustsen, Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings, IEA Information Paper, International Energy Agency, Paris,2008.
[2] L. Perez-Lombard, J. Ortiz, C. Pout, A review on buildings energy consumption information, Energy and Buildings 40 (2008)394–398.
[3] B. Hunn, Fundamental of building energy dynamics, in: Massachusetts, Institute of Technology, London, England, 1996.
[4] R.K. Dixon, E. McGowan, G. Onysko, R.M. Scheer, U.S. energy conservation and efficiency policies: challenges and opportunities, Energy Policy 38 (2010)6398–6408.
[5] N. Hamza, D. Greenwood, Energy conservation regulations: impacts on design and procurement of low energy buildings, Building and Environment 44(2009)929–936.
[6] W.L. Lee, F.W.H. Yik, Regulatory and voluntary approaches for enhancing building energy efficiency, Progress in Energy and Combustion Science 30(2004)477–499.
[7] P. Ekins, E. Lees, The impact of EU policies on energy use in and the evolution of the UK built environment, Energy Policy 36(2008)4580–4583.
[8] S. Wiel, C. Egan, M.D. Cava, Energy efficiency standards and labels provide a solid foundation for economic growth, climate change mitigation, and regional trade, Energy Sustainable and Development 10 (2006)54–63.
[9] M. Balat, Security of energy supply in Turkey: challenges and solutions, Energy Conversion Management 51 (2010)1998–2011.
[10] J.A. Wright, H.A. Loosemore, R. Farmani, Optimization of building thermal design and control by multi-criterion genetic algorithm, Energy and Buildings 34 (2002)959–972.
[11] Jacobsson S, Johnson A. The diffusion of renewable energy technology an analytical framework and key issues for research.Energy Policy2000;28:625e40.
[12] YalcınYasar, SibelMackaKalfa, The effects of window alternatives on energy efficiency and building economy in high-rise residential buildings in moderate to humid climates, Energy Conversion and Management 64 (2012)170–181.
[13] Xu Han, Jingjing Pei, Junjie Liu, LuyiXu, Multi-objective building energy consumption prediction and optimization for eco-community planning, Energy and Buildings 66 (2013)22–32.
[14] L. Magnier, F. Haghighat, Multiobjective optimization of building design using TRNSYS simulations, genetic algorithms, and artificial neural network, Building and Environment 45 (2010) 739–746.
[15] A. Ravindran, D.T. Phillips, J.J. Solberg, Operations Research-Principles and Practice, John Wiley & Sons Inc., Canada,1987.
[16] S. Jaber, S. Ajib, Optimum, technical and energy efficiency design of residential building in Mediterranean region, Energy and Buildings 43 (2011)1829–1834.
[17] M. Frondel, S. Lohmann, The European Commission's light bulb decree: anothercostly regulation?Energy Policy 39 (2011)3177–3181.
[18] A.G. Murray, B.F. Mills, Read the label! Energy Star appliance label awareness auptake among U.S. consumers, Energy Economics 12 (2011) 12doi:10.1016/j.eneco.2014.04.013.
[19] R.G. Newell, A.B. Jaffe, R.N. Stavins, The induced innovation hypothesis and energy-saving technological change, Quarterly Journal of Economics 114 (1999)941–975.
[20] M.L. Persson, A. Roos, M. Wall, Influence of window size on the energy balance of low energy houses, Energy and Buildings 38 (2006)181–188.
[21] How to measure and estimate your roof, Retrieved on May 16, 2013 from http://www.newenglandmetalroof.com/roofing-estimator-guide.html.
[22] Solar cell moduleprices,Retrieved on a May 16, 2015from http://www.limitsizenerji.com/haberler/makaleler/141-fotovoltaik panelfiyatlari.
[23] Double-glazed window installation costs Retrieved on May 22, 2015
From: http://www.birimfiyat.com/BF001.php?Ak=G1&D1=BAYINDIRLIK&Anh=6&kayno=28.131/A.
[24] Double-glazed window installation costs Retrieved on May22,2015
from : http://www.firatpen.com.tr/en/profiller.asp?kid=2&id=2&mid=2.
[25] Average winter temperatures of Instanbulregion, Retrieved on May2, 2015 from http://www.dmi.gov.tr/veridegerlendirme/il-ve-lceleristatistik.aspx? m=ISTANBUL.
[26] CFL bulb prices, Retrieved on June 23, 2013 from http://www.ampulcu.com/Enerji-Tasarruflu-Ampuller,LA111-2.html.
[27] Home Appliance Prices and Power Consumption Values, Retrieved on May 28, 2013 from http://www.profilo.com.tr/beyaz-esya.html.
[28] European Union Energy Label, Retrieved on May28,2013 from http://www.energy.eu/focus/energy-label.php.
[29] A.N. Celik, Review of Turkey's current energy status: a case study for wind energy potential of anakkale province, Renewable & Sustainable Energy Reviews 15 (2011)2743–2749.