

Optimization of Household Energy using Linear Programming

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CERTIFICATE

This is to certify that the thesis entitled “**Optimization of household energy using linear programming**” by **SWATI DIXIT (212EE5395)**, in partial fulfilment of the requirements for the award of the degree of Master of Technology in **ELECTRICAL ENGINEERING** with specialization in **INDUSTRIAL ELECTRONICS** during session 2012-2014 in the Department of Electrical Engineering, National Institute of Technology Rourkela is an authentic work carried out by him under our supervision and guidance.

To the best of our knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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ABBREVIATIONS

- Q_h Transfer of heat via window
- ΔT_a Change in the temperature of inner side and outer side
- A_s Area of window for installation
- h_a Coefficient of heat in air
- d_{gl} Width of glass layer
- k_{gl} Glass thermal conductivity
- d_{ai} Width of air
- k_{ai} Thermal conductive coefficient of air
- Q_d Heat flux by double glazed window
- Q_{sa} Energy savings after installing double glazed window
- Q_{rg} Heat flux in regular window
- C_d Purchase and installation cost by double glazed window
- P_{Ra} Power used by refrigerator
- E_{Ra} Energy used by refrigerator in a year
- P_{Wa}^a Power used in washing machine
- E_{Wa} Energy used in washing machine in one revolution
- N_{Wa}^T Washing machine used in a year in numbers
- P_{Da}^a Power used by dishwasher
- E_{Da} Energy used by dishwasher in one revolution
- N_{Da}^T Dishwashers used in a year in numbers
- X_d Area of double glazed window
- y_{ip} Solar plate in numbers
- Z_c Incandescent light bulb
- r, p, t are binary variable
- i can vary between 1, 2,.....m
- Q_x Saving of energy in installing 1 m²
- Q_{Yip} Production of electricity in solar panel

Q_{zc} Difference in energy rate incandescent and CFL bulbs
 Q_r Energy difference between appliances in changing the quality of dishwasher
 Q_p Energy difference between appliances in changing the quality of washing machine
 Q_{tr} Energy difference between appliances in changing the quality of refrigerator
 C_{xw} Cost and installation cost of double glazed window
 C_{yip} Cost and installation cost of solar plate for different type
 C_{zc} Cost of a CFL bulb
 C_{rd} Cost of A Class dishwasher
 C_{pw} Cost of A Class washing machine
 C_{tr} Cost of A Class refrigerator
 a_{ip} Solar plate area for different type

X_d Total available window area
R Total roof area
L Number of CFL bulb used in the house

CHAPTER 1

Introduction to Literature Review

ABSTRACT

Linear programming method used for energy conservation methods. This was used in this operation to install photovoltaic solar cell and solar panels, changing normal windows having double glazed window. It is 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 window. The cost of these methods which involve replacing of low class appliance to high class appliances is taken from manufacturer website. When we are doing this then by the appropriate method which we are using we can see that replacing with double glazed window and triple glazed window and normal CFL bulbs are the effective choice for low budget. If we have good budget then there is a good option that we can install a solar panel it is a good and feasible choice. By the calculations and result showed that changing the quality of household appliances is advantageous and good on a little more budget or in terms we can say that when it is more than €20,000 should be there. Recovering period for this budget and for more than this budget is found as less and it can be a less than half a year. By this strategy we have find that for low budget as for €800 is a optimization result and for high budget which is €24000 is a good choice for optimization of energy and we can save energy on a good extent.

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 method 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]. From many times we are discovering the methods in which should be simple. In that process we are taking a simple and ideal location on the basis of geography and the location of building where we find good climate for building. After the technology improvement, the methods to optimize the energy and saving that energy becoming very complex as time passes. 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 a 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. After that this area is becoming more interesting day by day [4–8]. Law which adopted these rules and regulations they have certain restrictions. 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. These laws also aim to minimize energy intensity of high level so that it can achieve effective as well as productive use in every field of energy. These law also helpful in preventing the expenditure, also protect the environment and for stable economy. 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. So for this home owners must be take care and should design buildings in such a way that can save the energy and optimized the cost as well [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 every one.

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].

In this project we have considered many aspects like climate and thermal condition and location of building. For this we have taken suggestion from many property dealers and also discussed the various features that help in improving the efficiency of energy and cost minimization. This method was also

discussed on the view of visitors in that place where we are going to implement that method. Verbeeck and Hens introduced a method which works on the building where low level of energy is required and for that it is very effective method. In this method we are considering climate of building and atmospheric condition and the environmental effect as well and total use of energy. The cost of energy is also considered, the cost of building and the life cycle of building also put a significant effect on the minimization issue [12]. There is some software which is used for minimization of energy and cost both. In many application some used software named TRNSYS for optimization of energy. The effect of whole optimization is based on the life cycle of the buildings by this we calculate the savings in cost and in energy both and can also do the analysis on the yearly basis.

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 Haghghat 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.

LITERATURE REVIEW:

The planning of an Eco city has multiple functions. It includes consumption of energy by the building, carbon emission by the environment. This also involves the cost on the initial basis and also the implementation cost. Local geography of the place and economic condition or the social condition also matters. There are many theories which are working on that issue that how could we make a eco city. A eco city on the optimum choice, which is quick and easy to use and user friendly as well. In which we can use multi objective choices or that can predict an easy strategy on the low budget on the basis of optimization tool. There are basically three categories in which we are going to work like energy consumption of building, emission of carbon in the form of carbon dioxide and cost for initialization. There are many optimization parameters as well. Which include for building like heat transfer, cost and also the window glazing. As we know that there are two types of buildings one in air conditioned and another is non-airconditioned. For both the case conditions will be different and parameters as well. The carbon emission is decided by the amount of carbon emission and it is also calculated that amount of energy consumption by various type of energy and manner in which energy is consuming. As we are increasing the initial cost so it is depend on the price of the product. As we have taken three objectives so in that case which one is preferred is decided by the amount of use in the optimization process. Priority is also an important concern in this case. The amount of use or weight factor can be decided by analyzing many parameters and studies after many studies we have taken the amount. The results which we got after optimization can be given by policy makers. Multiple parameters effect on the result of optimization of energy. In the optimization problem because we are considering primary stage. As we are going to plan for a new eco city, there are many technologies which can do this. Here we need to keep eye on the carbon emission, greenhouse gas effect and renewable energy sources available in the nature. So we can optimize the energy in effective and in cheap way. Those factors also include initial investment. Amount by which energy can be saved, level of carbon, as well as local geography, geography and social economic climate parameters. After considering that issue we are able to find the relation between the consumption of energy in the building and the factors which are influencing the results. That result is obtained by some mathematical model like regression method. Artificial intelligence method can also obtained that relation or by any other engineering mathematical model. This method can utilize the physical or climate condition in which building is situated and that can simulate the result for energy consumption. This method can be explained in the descriptive model and in simple model as well. Both building which have both demand one is cooling and another is heating demand. These both demands are

taken in the model. By the changing parameters or appliances in the problem statement or in the building like as we are changing wall and type of window used, climate condition , thermal condition in the building weather it may be cooling or heating. As we know that in the problem statement or in the building we are replacing low energy appliance with the good one. So by using and considering all the parameters after optimization we can see a good result of saving of energy and emission of carbon can be optimized so that we can save good amount of energy on account of users choice. This can overcome waste of energy and excess use of energy in the slight change in the cost. After this as a result we can see that for obtaining the optimum solution we can use many parameters as a combined result and combination of variables like window, refrigerator, dishwasher for each type of buildings, to achieve the minimum energy consumption of building, minimum carbon emission and affordable initial cost. For this on the primary level we need to know that demands of building, climatic condition and what amount of load is in the building which we are going to consider or for which we are going to optimize the value of energy after that consider all the data. Because we know that the climatic condition or thermal zone and heat flows matters by estimation of this we can estimate the intensity of energy and as well as duration of heat flow from outside wall to inside. As flow depends on the conduction of heat through walls, radiations and internal convection and external convection, sun radiation duration of sun light in the atmosphere, heat stored due to equipment paced on the building and as well the ventilation facility. In the building manufacturing, design and operation energy plays an important part. While manufacturing there are many factors which affects so all should be consider and take long-term and Careful decisions can manage the energy use and as well as the user requirement that should all be consider in the early stage before manufacture the building by this thermal performance can be improve and that also reduce the energy consumption. In residential sector in order to maintain energy conservation and to reduce CO₂emissions, first and important is to examine the energy consumption and pattern of residential building. According to study, citizens of UK and US consume 81, 45.7 kW h of energy per annum for a single person, with the comparison of an estimate of 36.3 kW h per person per annum in Europe. In the past two decades in many countries the demand of energy has rapidly risen. So for the fulfillment of energy requirement and increasing demand of energy, they are importing energy in many ways. From 2001 to 2008, demand of energy is increases of 7.1%. Energy imports increases by 30% per year and many more.

By increasing the demand of energy, many countries are importing approximately 75% energy requirement total in the year 2008. According to report approximately 81% of the total requirement of energy will be fulfilled. This demand will be fulfilled by importing the energy by 2032. As the energy requirement is increasing day by day the importing data will be regularly or annually updated because day by day we will need more and more energy. As we know that economy of each country depends on the

energy consumption and its importing option so for each country's economy will be considerably high because of the energy income day by day. Due to the increase in the consumption of energy and also in the increase of the income which is related to energy income and some climatic issue like global warming and the increased pollution of increase which also increase the thermal condition of atmosphere. In the future days energy will be on the primary issues and would have primary importance in the transportation, industries, agriculture, residential hubs, medical, science each and every field which are mobile in any country or place. As according to the currently scenario, 31–45% of its total energy consumption is in the country's residential buildings [4].

As the data provided here proves a large amount of energy is used in the residential buildings so to work on that issue there is an alarming position that to reduce the excess cooling and heating loads from the residential building and for our facility use passive systems which can fulfill all need as per user without compromising your needs and for this designing of building can play an important role. Building should be such manufacture or design so that they use less amount of energy. For this there should proper strategy so that architects, engineer builders and owners should be trained for designing and implementing the building for low consumption of energy. They should know the methods that how to reduce the consumption energy in the building and also minimize the CO₂ emission.

Recently there are many studies published in which there are various method and working condition so that we can achieve our needs and can also minimize the energy consumption. In the many studies they are working on the parameters which affects the building for energy purpose these studies are clearly showing that there are many ways to achieve our goal like wall construction, climate, orientation of building, window type, door type, solar control device which we can install in our building that can also provide energy to some extent to fulfill our needs and that method are also cheap and we can afford that and also manage the heating and cooling load. For this there are various methods and software's in which we write a equation in which some parameters are known and some are unknown which have some constraints that is according to the hypothetical building for which we are going for. That problem is based on software in which MATLAB programming is used that is easy and simple and user friendly as well, we can also do manual calculation but that will be quite tough so by the use of programming result can be easily achieved and the most optimized result which is energy saving can be determined. In the case of optimizing the energy there are many simulation methods which are considered [14–18], several studies also were performed, including which are more concern towards analyses of buildings [17,18,19,20]. In these studies one is very important and also have great importance while considering the optimization of energy that is cooling and heating load via the windows which is very energy efficient [22–24]. The production of glasses which have low e-coated and also that are solar control so that they can control the absorbing and reflective properties are in very much use now a day. Because the use of

that type of window save much more energy and transfer very less amount of heat from the outer walls to inner walls. These glass are low-e coated that control the heat of the climate. Low-e basically is Low emissivity implies that surface which emits low level of energy. All objects absorb, reflect and emit radiant energy. But in this case radiant energy wavelength is in priority level so for the material which have temperature in the range of 42 to 63 degree Celsius have low emissivity. Weir and Muneer found that the effects and use of gases which is inert in nature that are four in numbers [15]. In the construction of that type of double glazed window that inert gas like argon is filled. Argon is an inert gas and is also a perfect insulator of heat and double glazed construction is used in the energy saving appliances. By this objective function, Sekhar and Toon calculated the energy consumption of double glazed units in the different type. They are mainly of these 3 type one is heat conservation second is solar control and the third one is heat conservation with solar control which is used in typical models of building [24].

The given calculation is concluded by the use of simulation of energy software.

Performance of life cycle and cost of window is also used which is based on double glazed window. In opposite to Sekhar, Toon's study, Karlsson et al. proposed a method to calculate the consumptions of energy of differently glazed windows in several climates and various buildings and climatic conditions. By this they concluded an analysis called economic analysis [24]. Bojic et al. used many methods [25] as of Sekhar and Toon. Instead of the glass typically used in normal flats we choose low-emissivity coated glass.

Their model determined not only the CO₂ emission but also the energy consumption of the building. Magnier and Haghghat derived an optimization method which was based on a combination of a neural network and a multi objective function which is a multi-objective algorithm. Latin Hyper cube sampling and automation engine is used to create the database of samples [27]. Their objective function and their result showed the effect of energy of the thermal condition made by the user without compromising their needs.

MOTIVATION:

Energy security is very important for many commercial, industry and government sectors. To increase the security of energy supply it is essential to develop a method. A method which reduces risks that comes from energy use. Rapid growth of population and economy in the country resulted in increase in the requirement of energy year by year. Energy is a very important parameter of economy. It is important for the transport and production of materials and object for many ways. It may be oil, electric power or gaseous material. We know that the economy of world depends on its natural savings and accessibility of goods, natural resources. It also depends that how easily we can access its good and can supply of energy

on the minimum and reasonable prices. The security of energy is very important and top in priority on the international and national issue list and widely spreading on worldwide level.

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].

A full and effective strategy is as written below [6]:

- To reduce the difference between energy requirement and supply,
- To improve efficiency of energy and securing by low to energy and its intensity,
- To achieve the optimum energy combination
- To Diversify sources of energy and also its supply
- To investigate in energy manufacturing and its development
- To shift and use the alternate and renewable methods of energy

Energy security has been divided into two main parts short energy policy and long energy policy [3].

By the energy security policy, it is important that we should choose the option which is for long term energy policy and challenge. That is also related to the long term policy and challenges and requirement of energy and temporary energy supply [5]. Linear programming algorithm and method is used for the optimization of energy savings in the typical household or residential sectors. The energy saving methods and involves the installation of solar panels. Solar photovoltaic cell can fulfill some requirement of electricity in the household building. We are considering many parameters for optimization of energy like replacing the normal window quality to the double or triple glazed window. By replace low energy class appliance to high class appliances in case of refrigerator and dishwasher. By replacing normal incandescent bulb to the CFL bulbs is a good option. Which save more energy in comparison to the normal bulbs. The price which we are taking for all these appliances are taken from the manufacturer's websites. The savings of the energy on the annual basis can be calculated by the given method or by the sources which we are using for these cases. Installing double glazed windows in the place of normal window and fluorescent light bulbs are good for low budgets, this was clearly seen in the result.

Thesis Objective:

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.

3. 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.

Use of the method:

Linear programming method is used for optimization and the allocation of budget. It is used to maximize the energy savings of a household building. Linear programming is mathematical concept for determination of problem and to achieve the best result in a given mathematical algorithm and model. The list of requirements showed as linear relationship [15]. A linear programming algorithm contains an objective problem based on the function. Constraint function has many equations in the form of restriction. Linear programming method is a very functional tool, used to solve the problem. Optimize the data which is based on the various types of problems like industrial and economical both.

In this objective problem, whose details are given in the following Section: taken energy savings as the objective function and the budget is taken as constraints function. Solar panel is installed whose data is roof area that is in the problem statement. There are various techniques that result in energy savings in a building or house, each having a special cost of function and different cost. The main aim of this methodology is to conclude the budget. Actions are taken in the problem statement that is used to save the maximum energy of the household or resident. Here we are using different budget as the constraints function for the different value of savings of energy. In the output we are getting maximum savings of energy in the household building or we can also use it for commercial purpose.

In the development of problem and the method used our main target is to analyze the problem of building energy and efficiency of energy from the requirement end of the owner of household or tenants of building. We are developing an effective algorithm 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 desired result or optimized result now the work is to recover that money which we have spent as an initial cost in the objective function. For all different budget then we are calculating the payback period for different budget. After this we are calculating the profitability in each budget. Profitability is basically the profit on that budget year by year.

CHAPTER 2

Household Energy Conservation Method:

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.

As we know in the building there are two types of systems one is heat and cold. These two systems spend a good amount of currency in the household expenditure. 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 many transformation and energy requirement can not met by using these type of expensive appliances. So we will use equipment according to energy requirement of the building. We use insulating materials which can prevent heat loss or in other terms save energy for good extent and quality. As we know there is gap between the wall of window and frame so windows are supposed to loss more heat in comparison to the floor. To overcome heat loss problem from the window we can use insulating materials in windows.

Double glazed window is having more sufficient insulating material than normal window. Double glazed window is basically a window having two glass slabs. In between these two slabs or glass some inert gas or vacuum can be filled because inert gas like argon is a good insulator of heat. So when the heat ray or sunlight falls on the window then due to that insulating material on the window very less amount of heat transfer from outside wall to the inside wall. In the double glazed window the material used is basically the low emissivity material so thermal condition can be overcome in some aspect. No heat can transfer from inside wall to outside wall. It is the straight forward approach by which we can save more energy and heat loss could be minimized. There is an advanced version of double glazed window as well that is known as 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. Thermal conductivity has also a great impact on this. As we seen by the performance part it is very important that cost and thermal conductivity should be in manageable condition [17]. In that case we can use another option like solar energy. As we know that solar energy is most abundant in the atmosphere.

This energy is clean and quality energy as we see in the renewable energy. Solar energy stored in the solar panels or solar cells and then we can use it in in the form of heat like boiling water and for cooking food and in the household use. So for that we need to install the solar panels of good quality which can store good amount of thermal energy. Solar panel works on the principal as when the sun rays falls on the solar panel then the heat energy converted in the electrical energy then it is converted into ac supply. After that we utilize that energy in various forms. Solar panels installed on the roof of the building because there good amount of heat can be fall on the solar plate and for very long time [21].

Working of photovoltaic cell:

When sun light falls on the solar plate then light energy falls on the plate as a photon. We know that there are plenty of electrons and protons available in the solar panel plate, so then due to recombination of electron and hole they neutralize each other. Due to recombination of electron and hole a current generate in the solar plate and by the converter it can be convert in to usable form and used by the user in various form. Photovoltaic cell are manufactured in such a way that each and every photon which is taking part in that operation delivers an electric energy to the circuit connected to that solar cell and load as well [19].

We can connect number of solar cells in the series form to create a model so that it can provide a large amount of electricity to the building. Connected solar plate can be installed on the roof of the building or on the location where good amount of heat is available for conversion from heat energy to the electric energy. Thermal solar collector has advantage that it does not require continuous heat from the atmosphere or from sunlight. It converts available light energy to the electric energy. So they can be used in the rough or general way. As they provide significant amount of energy for the household or any building so can save money from purchasing electricity. Solar cells can also be used in the various fields like in the field of communication, satellites and in the space craft. In the application of space craft solar

energy play a significant role in the space vehicle. In our country there are many places where electricity is supplied by the solar plants whole day. Solar plants are also working on the project where large power is required [20]. There is the main disadvantage of solar cell is that solar cell is very expensive. The high cost of solar cell can be minimized or can be less when we will use that in household building or in any commercial building. One more disadvantage of solar is that the deficiency of sun light. Suppose there is less light available due to fog or weather condition so generation of photon will be less, then less heat will be generated by the photon. So we can use solar in a large way where more sun light is available.

In the starting of nineteenth century invention of electricity was a great invention, it changes the economy of world and created a huge market for its application. So when the light bulb was invented by the great scientist Thomas Alva Edison. By that time use of electricity started in the houses and buildings as lighting. From the starting normal or incandescent bulbs are popular for lighting in the building due to its low cost and availability. As we know that incandescent bulbs emits light as a heat loss. In other word we can say that normal bulb or incandescent bulbs emits heat in a large amount. Approximately 92% light is emitted as heat or 92% of power emits as heat from the normal bulb. That power is wasted in term of heat rather that useful or visible light. That was the issue of concern so from some time or in recent years efficiency of appliances taken a great concern so in the case of incandescent bulb. Many studies and worlds surveys are putting interest to increase the efficiency of any appliance in the reasonable price. E.U. commission continuously making rules and regulations for the efficiency of product. So they have replaced incandescent bulb to the compact fluorescent bulbs. In many countries mainly in Europe incandescent bulb is prohibited to use.

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

- Halogen light bulbs.
- Light emitting diode as a bulb
- 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 dishwasher 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.

In one of them system is labeling system. Energy efficiency label is very important as that give 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. This scheme was first introduced in the United States of America. Today many countries has adopted that scheme in that main countries are Australia, Canada, Japan, New Zealand and many more. The product having good star saves good amount of energy. So the consumer should buy good star quality product so that energy savings can be maximized and heat loss can be minimized. The consumer wants information on appliance. So energy efficiency is required to maintain the product on the reasonable price [26]. After using the double glazed window, we can also use triple glazed window.

COST OF APPLIANCE AND ENERGY SAVING:

The given method is to improve the energy efficiency in a building:

TABLE 2.1:

HOUSE SPECIFICATION	QUANTITY
Total base area, m ²	100 (10m×10m)
Total floor area for solar installation, m ²	70
Window area in the building, m ²	32
Room in the building	7
Lights required	10×100 W incandescent bulbs

Capacity, area and cost of photovoltaic solar panel:

TABLE 2.2:

CAPACITIES (W)	AREAS (m²)	COST (€)	EFFICIENCY (W/€)
51	0.435	182.2	0.276
66	0.63	224.4	0.289
122	0.99	328.2	0.366
142	1.43	414.2	0.344
184	1.35	452.4	0.405
204	1.49	545.2	0.366

These prices are given for the mono crystalline solar plates.

Here are some points we should work on that or install according to that.

- To install the photovoltaic cell, where the area is variable.
- To install the double glaze window, where area is variable.
- To change incandescent bulb to compact fluorescent bulb, where bulbs are variable.
- To change C Class appliance by A Class appliance.

The price, area and power output (capacity) of solar panels is taken from different distributors' website [26–29]. The cost value of different product with same capacity units is in Watt and their average is taken to find the last price. The values are given in the below table. Price of double glaze window unit is taken from manufacturers' website [30,31]. In double glaze window technique, the width of glass and air gap or layer of inert gas can vary. In this project we taken air thickness as 12 mm and glass width on any side as 3 mm. The average purchase and installation for that cost 1 m² of double glaze window is

taken to be € 23. The energy savings calculation is done by taking both conducting and convecting heat theory as ignoring all possible radiation contributed by them.

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 desired one.

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.

CHAPTER 3

Household Energy Conservation Model: Objective Function

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 m² 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 area is 32 m².

From the data and literature known to us total area of roof is 140 m² and the basal area is 100 m² [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 area 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.

C-CLASS APPLIANCE AND A-CLASS APPLIANCE:

The formula for the calculation of heat flux via the window is given:

$$Q_h = \frac{\Delta T a}{1/A_s \left(\frac{1}{h_a} + 2 \frac{d_{gl}}{k_{gl}} + \frac{d_{ar}}{k_{ar}} + \frac{1}{h_a} \right)} \quad \text{-----Eq 3.1}$$

Where

Q_h , heat transfer by window, W

$\Delta T a$, temperature difference of inner and outer side during winter, °C

A_s , double glaze window area of surface, m^2
 h_a , heat factor of air, $W/(m^2 \text{ } ^\circ C)$
 d_{gl} , width of glass layer, m
 k_{gl} , temperature conductivity of glass, $W/(m \text{ } ^\circ C)$
 k_{ar} , temperature conductivity of air, $W/(m \text{ } ^\circ C)$
 d_{ar} , layer thickness of air, m

Formula given above shows, that Q is the heat transfer by the double glaze window. As we know in our project we are comparing our data with the regular window and calculating that how much energy we are saving after installing the double glazed window. So we are calculating this data in the presence of air in between the glass slabs and in the absence of air. That difference in the data shows the heat flux. Average temperature for this calculation we have taken is 7 degree Celsius. Suppose the temperature inside the room is 22 degree Celsius, then the difference between these two values is 15 degree Celsius. We can vary the window area in our project. Thickness of the glass is 4 mm. The width of air layer is 12 mm. in the table given below shows that the data provided for heat transfer by the double glaze window, saving of the energy using double glaze window. Price and installation cost of double glaze window. The cost of CFL bulb is taken by manufacturer's website. The product which we are using is of branded companies like Philips, OSRAM, Green go etc. in the project we want to replace CFL in the place of incandescent bulb so that we can achieve good light intensity in the reasonable price having good quality of light.

There is great power rating difference in the incandescent bulb and in the CFL bulbs. The power consumption of CFL bulbs is 19.5 W but in the incandescent bulb it is 100 W. So the difference in the power consumption of incandescent and in CFL bulbs is 80.5 W. The price and power consumption of appliance is taken and calculated by taking average from five websites [23–26]. The appliances are based on according to size, technology and materials as given below:

- Refrigerator is selected as Non Frost in which storage space is 600 l ($\pm 5\%$). The appliance is A class.
- Washing machine has capacity of 8 kg. Appliance is A class.
- Dishwasher is 5 programed. Appliance is A class.

Electricity unit cost is in kWh. How much time the appliance is working it is to be known to us. We should also know that how to switch from watts to kWh. In the project we have calculated energy savings in watts unit. Gain of energy is due to installation of solar panel. There may be loss of energy as well due to the continuous use of energy. We cannot apply the same rule or method to all the appliances. As we know that refrigerator works almost whole the year or little less. Dishwasher and washing machine used single time in a week. It depends on the family member of building. Refrigerator takes more energy than washing machine and dishwasher on the yearly basis. As we know refrigerator takes less power than another two, but it operates whole the year so on combined basis it takes or consumes more energy [24]. Because refrigerator works whole of the year so when we see the ratings of refrigerator then it is mention as kWh in a year. Rating of washing machine written as kWh per revolution and for dishwasher same rating is applicable. Power requirement for each appliance is a good and reliable choice for problem statement.

So we have taken a general approach for the residential appliances. So instead of taking the power requirement of all the appliances, we have taken for refrigerator only. For washing machines and dishwashers we have taken power as adjusted power. Adjusted power is a quality of power. It is calculated by taking the sum of all power of appliance working on the whole year. As we know that for refrigerator because it is for whole of the year.

The calculation of adjusted power of washing machine and dishwasher are given below:

$$P_{Ra} = \frac{1000 \times E_{Ra}}{365 \times 24} \text{-----Eq 3.2}$$

$$P_{Wa}^a = \frac{1000 \times E_{Wa} \times N_{Wa}^T}{365 \times 24} \text{-----Eq 3.3}$$

$$P_{Da}^a = \frac{1000 \times E_{Da} \times N_{Da}^T}{365 \times 24} \text{-----Eq 3.4}$$

Where

P_R , actual power desired for refrigerators, W

E_R , actual energy taken by refrigerator annually, kWh

P_W^a , adjusted power for washing machines, W

E_W , actual energy taken by washing machines per revolution, kWh

N_W^T , washing machines is works in number in a year

P_D^a , adjusted power for dishwasher, W

E_D , actual energy taken by dishwasher per revolution, kWh

N_D^T , dishwasher run in the year

E_R , E_W and E_D value are taken by website.

Energy saving parameter for double glaze window:

TABLE 3.1:

ΔT_a ($^{\circ}\text{C}$)	h_a W(m^2 $^{\circ}\text{C}$)	d_{gl} (m)	k_{gl} (m°C)	d_{ar} (m)	k_{ar} (W/m $^{\circ}\text{C}$)	Q_{rg} (W/ m^2)	Q_d W/ m^2	Q_{sa} (W/ m^2)	C_d ($\text{€}/\text{m}^2$)
15	50	0.004	0.96	0.012	0.026	310.3	29.4	280.9	60

Where Q_{rg} , heat dissipation by regular window

Q_d , heat dissipation by double glaze window

Q_{sa} Energy savings after installation of double glaze window

C_d Price of double glaze windows and installation cost per meter²

$$Q_{sa} = Q_{rg} - Q_d$$

Energy saving parameter for triple glaze window:

TABLE 3.2:

ΔTa ($^{\circ}C$)	$h_a W$ (m^2 $^{\circ}C$)	$d_{gl}(m)$	k_{gl} ($m^{\circ}C$)	d_{ar} (m)	k_{ar} ($W/m^{\circ}C$)	Q_{rg} (W/m^2)	Q_d W/m^2	Q_{sa} (W/m^2)	C_d ($\text{€}/m^2$)
15	300	0.004	0.96	0.012	0.026	29.4	13.56	15.56	179

Power requirement, energy saving and price of A class home appliance

TABLE 3.3:

	POWER REQUIREMENTS (W)	ENERGY SAVING(W)	COST (€)
REFRIGERATOR	57.601	40.04	785
WASHING MACHINE	17.098	11.099	501.02
DISHWASHER	17.303	5.719	521.22

The average of the energy which is applicable and required for C class and A class appliances is taken then we approximated this. As we know that we have taken adjusted power for all appliances except refrigerator. That adjusted power requirement find as 98 W, 30.97 W and 25.12 W.

Table given show the average price and power requirement of A Class appliance and also the saving when compare to C class appliances.

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 is taken as neglecting the difference between the day light and night light.

The formula for calculating the payback or recovery time is given in Eq.3.5

Where payback is in year, for converting kW to W we have multiplied by 1000. B_b is budget in €, 365 and 24 indicates the number of day in a year and hour in a day. ES_e represents energy saving in W, and 0.13 is price of current in €/kWh.

$$\mathbf{Payback\ Period} = \frac{\mathbf{1000 \times B_b}}{\mathbf{365 \times 24 \times ES_e \times 0.13}} \text{-----Eq 3.5}$$

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.

The formula for calculation of profitability is given in the equation;

$$\mathbf{PR} = \frac{\mathbf{N(ES_e \times 365 \times 24 \times 0.13)}}{\mathbf{1000 - B_b}} \text{-----Eq 3.6}$$

Where, PR is the profitability in terms €. N is the number of years. ES is the energy savings in watts. 365 and 24 denote the numbers of days in a year and hours in a day.

0.13 is the cost of electricity in Euro per kilo watt hour. 1000 is the conversion factor from kilo watt to watt. B is the budget in Euro.

CHAPTER 4

A Linear Programmed Approach:

In problem we used Lingo 12.0 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 :

$$MAX Z_z = (Q_{xd} \times x_d) + (\sum_{i=1}^n Q_{yip} \times y_{ip}) + (Q_{zc} \times z_c) + (Q_{rd} \times a) + (Q_{pw} \times b) + (Q_{tr} \times c) \text{Eq4.1}$$

$$(C_{xw} \times x_d) + (\sum_{i=1}^n C_{yip} \times y_{ip}) + (C_{zc} \times z_c) + (C_{rd} \times a) + (C_{pw} \times b) + (C_{tr} \times c) \leq W_w \text{-----Eq 4.2}$$

$$\sum_{i=1}^n (y_{ip} \times a_{ip}) \leq R \text{-----Eq 4.3}$$

Where

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

a, b, c are binary variable

$i= 1, 2, 3, \dots, n$

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

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

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

Strategy of problem:

There are many techniques and solution strategy by which we can optimize the energy savings.

Here we are using software's one is LINDO 6.1 and another one is LINGO 12.0 and this software is based on MATLAB programming in this we are working on many prospects like:

- Maximize the energy savings
- Work on various budget strategies
- Find what is the payback period for each and every budget
- Relation between the budget and payback period

CHAPTER 5

RESULTS AND DISCUSSIONS

By the allocation of data there are three regions defined:

- Low Budget, which is from €400 to €4000.
- Medium Budget, which is from €6000 to €16000.
- Large Budget, which is in between €20000 and €40000.

When the data in Table 5.1 is considered, we see that 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 €28001. 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 €28001 to €32001 maximum amount of energy savings obtained.

The parameters that gives the maximum energy saving is given below:

32.1 m² 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

32.1 m² area of triple glaze window installed

- To purchase 10 CFL light bulb
- To install “1 solar panel type B”, “1 solar panel type C”, “42 solar panel type E”, “4 solar panel type F” solar plate
- To replace refrigerators, washing machines and the dishwashers

This total installation costs a total of € 28,806.9 for double glazed window and €23495.3 for triple glazed window; by spending this much of amount in household building energy efficiency can be improved.

TABLE 5.1:

OPTIMIZATION OF BUDGET AND ENERGY SAVING, FOR LOW BUDGET:

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)
401	15	0	0	0	0	0	0	5255.3
801	32.1	0	0	0	0	0	0	9796.7
1201	32.1	0	0	1	0	0	0	9919.8
1601	32.1	0	0	0	1	1	0	10095.7
2001	32.1	0	0	2	1	1	0	10239.8
2401	32.1	0	1	0	0	4	0	10389.7
2801	32.1	0	0	0	0	4	0	10594.4
3201	32.1	0	0	0	1	3	1	10743.7

3601	32.1	0	0	0	0	6	1	10803.7
4001	32.1	0	0	0	0	8	1	11063.7

OPTIMIZATION OF BUDGET AND ENERGY SAVING, FOR MEDIUM BUDGET:

TABLE 5.2:

BUDGET(€)	SOLAR PANEL INSTALLATION						ENERGY SAVING(W)
	TYPE'A'	TYPE'B'	TYPE'C'	TYPE'D'	TYPE'E'	TYPE'F'	
6001	0	1	0	0	12	0	11836.7
8001	0	0	0	0	18	0	12653.7
10001	0	0	0	0	22	0	13453.7
12001	0	0	1	0	22	1	14293.7
14001	0	0	0	0	26	1	15063.7
16001	0	0	1	0	35	0	15883.7

In the medium range budget area of double glazed windows is 32 m².

In the all the case small, medium and large budget CFL bulbs used are 10 CFL's.

OPTIMIZATION OF BUDGET AND ENERGY SAVING, FOR HIGH BUDGET:

TABLE 5.3:

BUDGET (€)	DOUBLE GLAZE WINDOW(m ²)	SOLAR PANEL INSTALLATION						TOTAL ENERGY SAVINGS(W)
		TYPE'A'	TYPE'B'	TYPE'C'	TYPE'D'	TYPE'E'	TYPE'F'	
20001	32.1	0	0	1	2	43	0	17435.7
24001	32.1	0	2	0	0	55	0	19036.7
28001	32.1	0	1	1	0	1	46	19477.7
32001	32.1	0	1	0	0	5	46	19456.9
36001	32.1	0	2	1	0	1	46	19499.9
40001	32.1	0	2	0	0	6	48	19499.9

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.

OPTIMIZATION OF BUDGET AND ENERGY SAVING FOR TRIPLE GLAZED WINDOW:

TABLE 5.4:

BUDGET(€)	TRIPLE 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)
1201	32.1	0	0	0	1	0	0	10008.5
8001	32.1	0	0	1	0	1	0	15315.2
16001	32.1	0	0	1	0	2	1	19678.5
24001	32.1	0	1	1	0	42	4	21065.4
40001	32.1	0	0	1	2	1	47	23495.3

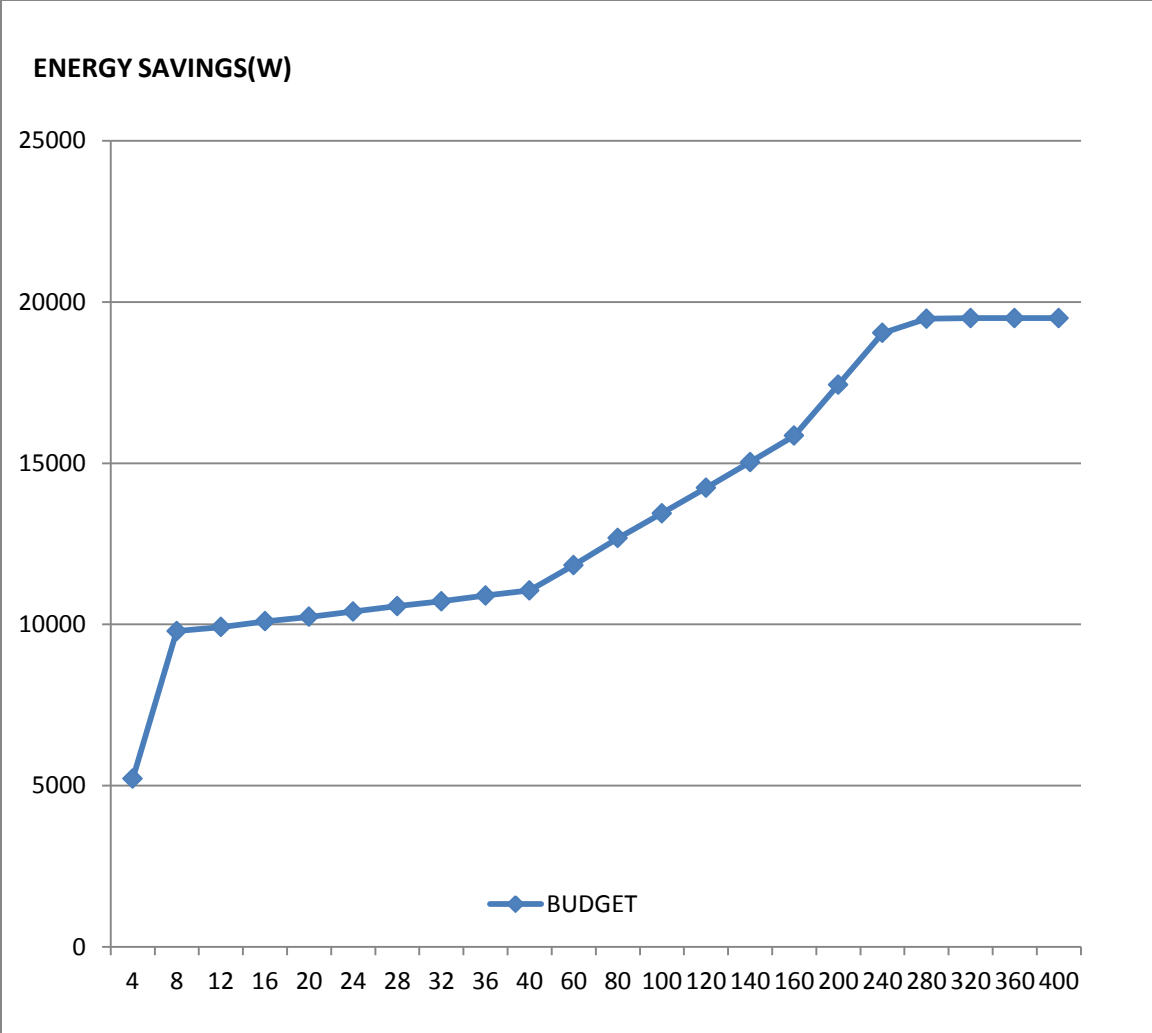


FIG 5.1 GRAPH BETWEEN BUDGET AND ENERGYSAVINGS

PAYBACK PERIOD TABLE FOR DOUBLE GLAZED WINDOW:

TABLE 5.5:

BUDGET(€)	ENERGY SAVINGS(W)	PAYBACK PERIOD(YEARS)
401	5255.3	0.07
1201	9919.8	0.022
4001	11063.7	0.344
8001	12653.7	0.600
12001	14593.3	0.181
20001	17435.5	0.265
24001	19036.7	0.30
28001	19477.7	0.35

PAYBACK PERIOD TABLE FOR TRIPLE GLAZED WINDOW:

TABLE 5.6:

BUDGET(€)	ENERGY SAVING(W)	PAYBACK PERIOD(YEARS)
1201	10008.5	0.105
8001	15315.2	0.458
16001	19678.5	0.714
24001	21065.4	0.0010
40001	23495.3	0.0014

PROFITABILITY TABLE FOR DOUBLE GLAZED WINDOW:

TABLE 5.7

BUDGET	1 ST YEAR PROFITS	2 ND YEAR PROFITS	3 RD YEAR PROFITS	4 TH YEAR PROFITS	5 TH YEAR PROFITS
401	5055.32	11564.6	16146.97	22529.2	26511.6
801	9095.1	18990.2	30185.41	44380.5	50575.6
1201	9231.6	19532.7	31164.16	42385.5	51916.9
1601	9015.6	19560.8	30351.5	45641.9	51562.5
2001	8897.7	19565.5	30723.5	44531.9	55588.8
2401	8931.1	19262.2	30463.3	43924.4	52855.5
2801	8915.3	19990.5	34315.1	41561.2	55626.4
3201	8962.2	19624.4	35986.5	42895.9	56911.1
3601	7961.4	19692.9	34654.6	43678.6	53987.9
4001	7699.6	19589.3	39658.8	43699.3	54568.5
8001	6564.8	19589.6	31684.6	45640.3	56654.2
10001	5532.1	18656.1	32967.7	46538.2	59612.9

12001	4692.0	16264.0	39296.0	47539.8	69360.1
14001	1805.4	17024.9	32967.4	49343.6	62262.3
16001	655.41	17566.8	33290.6	50361.2	65617.1
20001	-1673.69	17350.8	36596.5	53455.2	67367.0
24001	-3996.5	16722.6	38378.5	56393.9	71561.5
28001	-7692.6	12484.1	33481.1	53968.2	74975.9
28806.9	-8349.6	12685.4	32660.6	53179.7	73680.1

PROFITABILITY TABLE FOR TRIPLE GLAZED WINDOW:

TABLE 5.8

BUDGET	1 ST YEAR PROFITS	2 ND YEAR PROFITS	3 RD YEAR PROFITS	4 TH YEAR PROFITS	5 TH YEAR PROFITS
1201	6799.6	13599.2	24398.2	39158.2	48526.0
8001	6591.2	13182.4	27845.6	53152.5	52163.4
16001	7316.2	14632.4	28356.2	65231.6	74832.1
24001	10894.3	21788.6	32456.8	86589.2	95984.2
40001	6860.04	13720.08	45673.20	91263.4	99046.5

GRAPH BETWEEN BUDGET AND PAYBACK PERIOD:

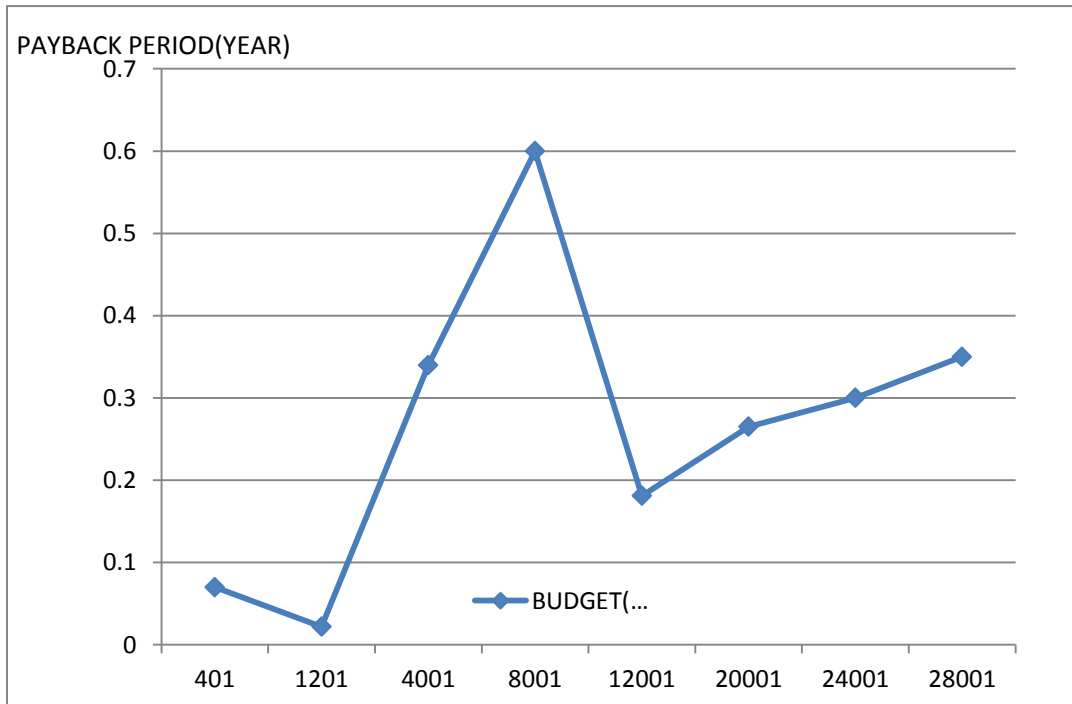


FIG 5.2

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. 5.2 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. The profitability analysis is given below.

Table 5.5 shows the profitability analysis. After seeing table we can analyses that for each and every budget there is a maximum profit. In the case of low budget and short term €800 is the good choice for optimization of the problem and can save maximum saving of energy and reduce heat loss. In the budget of €800 energy savings is 9796.7 watts. This energy saving is for first year but we have calculated for 5 year so in the five year energy savings is €50575.6. For long term budget €24001 is the good choice for optimization and energy savings so in this case profit is 19477.7watts. In this case after 3rd year profit is €38378.5 for 4th year profit is €56393.9 and for 5th year profit is €71561.5. All outputs in the term of energy saving is calculated as electricity and in terms of currency as well.

CONCLUSION:

We have used linear programming in project. Maximizes 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-

- Windows area 32 m²
- Roof area where solar panel is installed is 70 m²
- Light bulb used is 10

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 used Lingo 12.0, Lindo 6.1 software to solve the linear programming. We have taken low, medium and large budget. Range of budget is from €401 to €40001. 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.

Purchasing of double glaze window, triple glaze window and replacing normal bulb to CFL is optimum choice. As they have low cost related to other techniques. So from the given problem statement the maximum energy savings is 19477.7 watts and 23495.3 watts. 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. That was easy for me. So I have taken this model. By this method we can optimize the data globally or according to user's demand and requirement.

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