JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Review on Energy Consumption & Energy Optimization Analysis in Heating Ventilation & Air Conditioning (HVAC) System

[1]Amol A.Gawali , [2]Dr. Milind M.Dhobe
[1]Assistant professor, [2] Associate Professor
[1,2] Department of Mechanical Engineering
[1,2] P.E.S.College of Engineering, Aurangabad, India

Abstract: It is necessary to find out solution for lowering the energy consumption in buildings. Heating, ventilation and air-conditioning system is the largest energy user in buildings. Large quantities of energy are spent in office buildings due to poor thermal performance and low efficiencies of HVAC (Heating Ventilation and Air Conditioning System) systems. This paper gives short analysis on worldwide energy consumption in building and various authors research methodology & techniques in form of review. To calculate cooling and heating of any building we need to go for cooling load calculations. Current HVAC system design approaches are often based on specified cooling loads derived via the use of design parameters. These designing parameters are uncertain and vary with cooling load calculation. The cooling load profile may differ from the design. This causes poor thermal efficiency, loss of electricity & higher running cost, wastage of energy, load on cooling devices and imbalance and poor cooling effect over the area. To eliminate or minimize this difficulty of designing a system, some papers are reviewed which suggest the current power consumption by HVAC. It also gives ideas about designing & modelling scenarios of HVAC systems with various optimization techniques & gives guidelines of designing of HVAC systems.

IndexTerms - HVAC, Energy management, review on Energy consumption In HVAC, Energy losses, HVAC system analysis, HVAC system optimization, HVAC energy consumption in commercial Building

I. INTRODUCTION

Heating, Ventilating and Air conditioning (HVAC) is a branch of mechanical engineering that provides human comfort in terms of air temperature, humidity and ventilation. The term human comfort is condition of mind in which humans feel satisfied with thermal conditions. HVAC systems are used to change air from a closed location and add fresh air with filtration. During this process ventilation is added by removing the bacteria, odours and dust particles and moisture to provide suitable comfort. HVAC systems have many industrial applications. Most important and essential is storage & pasteurization of milk and its preservation. Rather than this textile industry, laboratories, pharmaceuticals industry are used to HVAC system. As commercial & industrial use of HVAC is increased huge power consumptions specially in commercial buildings. Transportation, commercial, industrial, and residential are the main four sectors in which energy Consumption is divided. In case of Commercial building energy consumption is higher. Energy Consumption in Commercial & residential Building depending on income levels, standard of living, geographical conditions, natural resources, climate, and available energy infrastructure.

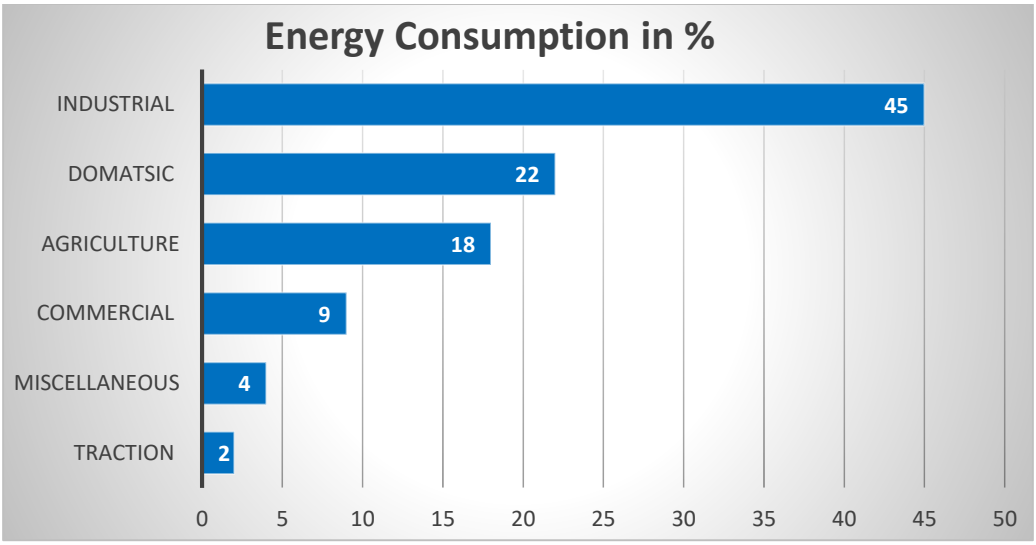

Fig No. 1 Total energy consumption in various Sectors

World market energy consumption is continuously increasing and it will be increased by 50% from 2009 to 2035 as shown in Fig. 1. Energy Consumption Growth occurs in an organization named as Organization Economic Cooperation and Development (OECD). As per report China utilizes 48% Energy while USA is using 29% of Word total energy consumption in 2018 as shown in Fig.2 [14]

To calculate the expected future energy consumption National Energy Modeling System (NEMS) used by U.S. Energy information administration. The International Energy module predicts the consumption of petroleum products, oil & coal and their production year by year to find out supply and demand balance for future. This shows the how we can pay more and more for Energy consumption in building. The module used to find out residential sector is known as Residential and Commercial Demand Module. It used building types , number of equipment, number of offices.[5]

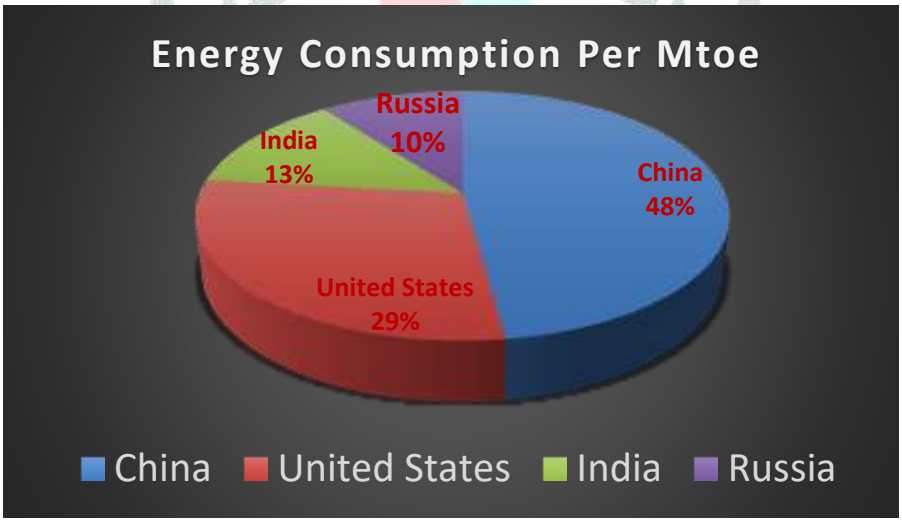

Fig No. 2 Energy consumption of the world

Designing HVAC systems is quite critical because it involves so many parameters. If it is installed properly then only it runs efficiently. So we can get affordable running costs with lower initial costs. During designing the HVAC system various parts of HVAC & various parameters are considered. Parameters include the selection Indoor air temperature, need of humidity, what is outer temperature and whether it is the peak temperatures of that region. Then calculation of cooling load, Then selection of machine parameters like proper tonnage of air handling unit and duct size, reducer and grill, diffuser size. Selection of all above parts properly is required to maintain the comfort otherwise it cannot be achieved. At the same time improper selection of and designing design efforts are wasted and result in poor thermal efficiency and higher consumption of electricity

II. Optimization of Heating, Ventilating and Air-Conditioning

Once a Luxury Now a day considered as the essential. The great example is the HVAC system, nowadays it is used in hospitals, data centres, laboratories, cooling our homes, businesses and fulfilling our industrial demands of maintaining the indoor air quality. In fact, HVAC is so important that 45% of all energy consumption of buildings is used for cooling and heating. This leads to emission of CO2, greenhouse effect, higher energy consumption in building, and poor performance of the system.[8] As the industry grows, and so does the amount of energy consume. As a result, in the building industry, energy conservation and the use of energy from renewable sources are crucial steps to take in order to reduce greenhouse gas emissions.

It is necessary to find an energy efficient solution for HVAC. There are various methods to design HVAC systems but all those systems are related to the variables during calculations. Designing of HVAC systems is quite critical and conceptual in order to arrange all parameters inline. HVAC systems consist of active components like Air Handling Unit, Chillers, heat exchangers and cooling Towers. At the stage of designing according to the cooling load calculations equipment selection is done. Oversizing or under sizing selection of equipment plays an important role for the performance of the entire HVAC system. To design energy efficient HVAC system for industrial or commercial purpose one should used proper selection of equipment and designing configuration of building. Installing energy-efficient HVAC equipment during building construction is often less expensive than retrofitting an older structure with an efficient system. HVAC system design is a decision-making process. It usually consists of four successive phases. Data collection, main design, thorough computation, and component selection are all part of this process. Load computation, ducting and piping layout, detailed component size, and control system design are all part of detailed design. Fully detailed layout drawings are finalized with coordination of architectural and allied services layouts during the engineering design stage. Few methods of designing and optimizing HVAC systems are discussed in this paper to find out the best suitable optimization technique. [14]

III. REVIEW ON RESEARCH DONE FOR HVAC ENERGY CONSUMPTION & SYSTEM OPTIMIZATION.

Mohamed Elhelw suggests a modified bin method Through "Analysis of energy management for heating, ventilating and air-conditioning systems "this paper gives details on how to optimize the energy efficiency ratio (EER). Energy is an integral part of the long-term success of all economies. To find out energy consumption at various stages HVAC designers used Building Energy Analysis (BEA) as a tool. This tool helps to find out minimum to maximum energy utilization and its location in the building. This procedure helps to achieve optimal coefficient of performance of equipment. The calculations are performed monthly or annually, and for occupied and unoccupied building hours. To find out the performance of HVAC systems this paper suggests a new design methodology. This procedure is based on a comprehensive thermal evaluation of the overall infrastructure. It also contains required cooling demand. With these two factors, reduction of energy is also considered. For the experimentation purpose, public buildings from Egypt are considered as benchmarks. Experimentation building is selected on the basis that ASHRE regularly goes through Energy Audits. So, it gives better saving opportunities. A design optimization is a technique which includes a lot of uncertainties when it comes to calculating the cooling load and its variables. In this method some factors are considered like outdoor weather conditions and internal heat sources. These parameters are the uncertain parameters for load calculation. Then cooling load distribution is analysed. There are many methods of calculating the cooling load of Building. Main methods contain cooling load temperature difference (CLTD), solar cooling load factor (SCL) & cooling load factor (CLF). In this paper a new method for cooling load calculation is given. Comparison between the bin methodology and CLTD/SCL/CLF methodology is conducted. This comparison is based on energy consumption and distribution of air in a conditioned area. This comparative Study between economic benefits methods and energy efficiency ratio methods. By using bin methods, we are able to increase the overall energy efficiency ratio up to 44%. [13]

Rutvik Lathia, Jaymin Mistry "Process of designing efficient, emission free HVAC systems with its components for 1000 seats auditorium" This paper gives the complete idea about the designing of the HVAC system. Most of the HVAC companies have a lack of data for the designing purpose which leads to uncomforting. Less standardization in designing criteria of HVAC Systems (Except ASHRAE which provides data for refrigeration systems). There are no sources available that can exactly say how to design an energy efficient HVAC Systems. This paper provides the mathematical aspects for designing the HVAC Systems. This paper includes the process of designing HVAC with components by using mathematical framework confirmed by software. This paper that demonstrate designing parameters with calculation of 1000 seats auditorium situated at Vadodara, Gujarat [16]

Karam M. Al-Obaidin, Mazran Ismail, Abdul Malek Abdul Rahman Suggest "Passive cooling techniques through reflective and radiative roofs in tropical houses in Southeast Asia: A literature review" In tropical areas like south and east Asia high heat gain through the roofs & wall which increase internal heating of Houses. Increasing internal Heat Leads to High Cooling demands & increasing Energy Consumption. This literature gives a new approach to effectively adapt techniques which will beat the heat gain through roofs and walls. In this paper two approaches are proposed to reduce the heat gain and maintain interior air temperature. These two ways diminish heat gains and indoor air temperature, while the third option lowers the interior air temperature. Two components are necessary to successfully execute these strategies and restrict or remove heat from entering the structure: a heat sink with a lower temperature than the inside air, and an improved heat transfer mechanism. With the help of Reflective roof design concept we can eliminate the peculation of heat in building via roof up to some extend in summer. It is composed of a single or multiple layers consisting of various materials. Roof heat absorbing capacity is largely reduced by the physical qualities of the material surfaces. This Leads to saving energy and achieving comfort without Air conditioning system. A reflective roof is nothing but White or specific pigments are used to reflect more sunlight on the roof. These coatings are quite thick, preventing UV and chemical damage to the roof surface. This typical form of coating can be found on a variety of roof systems. The physical properties of various techniques are examined in this study to assist architects and building designers. The results show a significant decrease in operational costs. The heat performance and thermal comfort zone of building is changes as the colour and material property is changed. [10]

Vladimir G. Gagarina,b, Kirill I. Lushina suggested "Path of optimized engineering of HVAC systems" "In this work, the author outlines an unique approach to developing energy-efficient engineering solutions for HVAC systems in a variety of buildings, including businesses, shopping malls, and hotels. For efficient design it is necessary to select all design parameters properly which is the foundation of creating heat and mass balance within the HVAC system. It is also important to create an energy efficient and cost-effective heating ventilation system. Furthermore, the analysis of geometric characteristics of premises such as peak temperature in summer, humidity in winter and rainy season, and the thermal performance of the building envelope must be directly tied to calculating the heat and mass balances. In this paper a special means of heating load calculation & ventilation systems is taken into account. This technique gives improvement in the Heating losses calculations of the building. Heating losses in buildings can be reduced by reducing infiltration of air, solar radiation heat gain & by balancing the heat & mass. The method of optimizing the heat loads during extreme operating conditions is reviewed. Optimization

method is reviewed with the Help of a Commercial three-story building. On the first floor there is retail space. On the second floor there is the shopping area and a restaurant. There is an office area on the third floor. The building's heating losses are computed, and an improvised way of constructing HVAC systems for buildings is proposed. [21]

Nan Li, Jun-young Kwak, Burcin Becerik-Gerber, Milind Tambe in paper "Predicting Hvac Energy Consumption in Commercial Buildings Using Multi agent Systems" suggested the how much energy is consumed by the hvac system and how we scan monitor and regulate it and increase the efficiency of the system. This paper gives details about how we can predict the future requirement of energy consumption in commercial buildings and how we can manage energy in buildings according to the requirement. Energy consumption prediction aids in the analysis of consumption trends. These patterns are used to find out high energy requirements, average energy requirements and low energy requirements with time. It also helps to calculate efficiency of the system according to requirements. This aids in determining the most important energy conservation and waste objectives. A unique approach for estimating HVAC energy usage in commercial buildings is proposed in this research. The model interacts with a multiagent systems (MAS) based framework to mimic energy behaviours of HVAC systems in commercial buildings. Furthermore, the ability to estimate temporal energy consumption allows building managers to spread out energy use over time, move energy usage to off-season periods, and construct supplementary energy arrangements. [14]. A new technology called as building information modelling is also available (BIM).This method is used to study & detect the previous energy consumption points in building. The reusability of BIM technology is a significant benefit. Previous designs saved in a database utilising the BIM protocol may be utilised to determine the building's energy usage and Energy Saving Points. A basic concept for producing a default configuration from current building datasets was suggested with the help of this system. [11]

The MAS model could accurately predict up to 98.2 percent of real HVAC energy use, which is equivalent to or better than previous study findings. On a daily, weekly, and monthly basis, energy usage was projected and validated by comparing actual energy consumption data. This MAS model analysis revealed that cooling energy use prediction has to be enhanced further. [14]

Sohair F. Rezeka, Abdel-Hamid Attia, Ahmed M. Saleh ``Management of air-conditioning systems in residential buildings by using fuzzy logic", The regulation of a building's air-conditioning system for efficient energy operation and a comfortable atmosphere is investigated in this study article. For the study purpose, cooling space is divided into the 3 types of rooms: one is a very important room, second is important rooms and third is normal rooms. Whatever the air we are distributed in these rooms depends on the fuzzy logic. Fuzzy Logic working depends upon room internal temperature, Humidity, occupant condition. To apply this fuzzy logic model, the author conducted a case study on Student's hotel having 5 floors. These 5 floors are considered as 5 zones Each floor has eighteen rooms, three paths and one hall. The first fuzzy system calculates the number of rooms that must be closed. In a closed room the air temperature remains same or not increased so flow of chilled water to that room is decreased. Another fuzzy logic is applied for chilled water temperature. If the chilled water outlet temperature is increased by more than 5 ^{0}C at that time supply of chilled water is automatically increased to keep that room cool. This all-fuzzy logic working with help of sensors and integrated with BMS (building management system) is a high-technology system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as air handling, fan-coil unit, cooling plant systems, lighting, power systems, fire systems, and security systems.[19]

Sadrul Ula, Alfredo A. Martinez-Morales published and studied the consultant report on "Evaluation of Energy Efficient Hvac Electrical Motor Systems In Buildings" In this paper the author put a summarized study on the building efficiency. Research was conducted on a California building for testing its energy efficiency. According to research it is found that the electrical motors used into the building for the air conditioning purpose is the main source of energy consumption. To give the comfort of conditioning it is necessary to run it for 24 hours. lighting and insulation are the major parts through which we can achieve higher energy efficiency. In case of HVac systems in commercial buildings it uses the electrical motors, which are used to supply fresh air and cool air to the conditioning space. This work continues throughout the year. If motors are older, it becomes inefficient and consumes a large sum of energy. This project looked at the software that architectural and engineering firms use to design HVAC system. In this paper testing and performance of Blower motors, water pump, AHU motors are done by on site visit. This testing done on commercial buildings like hospital, supermarkets, theatres, number of offices and Industrial. all the results performance and resorts are mentioned in this paper. [18]

Cheng, Zhenjiang, Forrest Meggers "Energy Efficient HVAC System with Distributed Sensing and Control" This article details the author's expertise in designing and implementing an energy-efficient cooling and air-conditioning system. For higher energy efficiency, the system employs the "low exergy" hypothesis and relies on high temperature water (180C) cooling [4]. Recent practises in HVAC designing systems based on the conservation of energy concept taken from the first law of thermodynamics. To achieve indoor thermal comfort, it is necessary to absorb internal heat or supply heat, supply fresh air with condoning space for ventilation. This means we absorb heat in the evaporator and heat is rejected in Condenser. The second law of thermodynamics explains thermodynamic equilibrium. As per kelvin statement it is not possible to convert heat into complete work in cyclic operation power, so some part of energy always goes into loss, The temperature gradient in the thermodynamic cycle, which is defined by the concept of "exergy" in building designs, is directly related to this part of energy consumption. The exergy, Ex, of a heat flux, Q, moved from a room at reference temperature, T0, compared to its working temperature, T, is defined as $Ex = Q(1-T/T_0)$. Lower exergy results in reduced energy use to transport the same quantity of heat, according to research. The exergy is determined by the temperature gradient, i.e., a larger difference between T0 and T will result in much higher energy consumption to complete the heat exchange.[6] In order to realize this, the system decomposes the cooling and dehumidification functionalities, and employs suburbanized air management for on-demand dehumidification and ventilation. The system comprises two control modules, namely, radiant cooling module and distributed ventilation module, help to provide the HVAC control by cooperating with each other. [8]

B.F. Yua, Z.B. Hua " Review of research on air-conditioning systems and indoor air quality control for human health" In this paper, recent research is reviewed on air-conditioning systems and indoor air quality control for human health. Few factors which are important for indoor air quality are temperature, humidity, air exchange rate, air movement, ventilation and their effect is explained in this paper. The development of air-conditioning systems has greatly improved indoor thermal comfort in recent years. Indoor pollutants cause poor quality of life, and health issues linked to poor IAQ are becoming increasingly common. The new-style air supply modes are incapable of providing either a comfortable or a healthy interior air environment. The present

research's difficulties are outlined, along with potential remedies. For a healthy indoor air environment, more research on air-conditioning systems and indoor air quality control is recommended. [2]

Raad Z. Homod " Review on the HVAC System Modelling Types and the Shortcomings of Their Application" The gray-box model is the best for depicting interior thermal comfort, according to this study, which looked at a variety of HVAC models and their merits and downsides for various uses. Its application, on the other hand, fails at the combining methodology if its response deviates from reality. The modelling of the HVAC system is an important topic as its results & relationship with energy savings and environmental, economic, and technological issues. HVAC system sense about the indoor thermal comfort which includes AHU, air temperature& humidity. Until recently, a variety of HVAC system modelling methodologies were available, and as a result, the techniques had matured However, several application and integration solutions for the many variants of the HVAC model have limitations. For each AHU equipment and building model, the designing and integration procedures might function to collect faulty features such as deviation in system, pure lag time, observing & radiating heat at different time, unpredictable disturbance sources, large-scale systems, and restrictions. [17]

A.C. Menezes, A.Crippsa, Buswellb, J. Wright, D. Bouchlaghemc."Estimating the energy consumption and power demand of small Power equipment in office buildings" The usual power demand patterns of consumption are detailed in this work, along with two models for predicting minor power consumption in office buildings. The initial model based on this approach relies on monitoring data that was collected at random or used for further analysis and heat gain determination. Table 1 gives a list of the monitored equipment in the database that is used to forecast power demand profiles and energy usage. Data was collected to depict an office area with a specific number of different sorts of small power equipment.

Table 3.1: : Model Equipment installed in the office space under investigation

Equipment type	Quantity of monitored equipment	Weekday profiles	Weekend profiles
Laptop computer	8	512	240
High-end desktop computer	3	180	78
Low-end desktop computer	2	120	52
19 LCD screen	2	120	52
21 LCD screen	1	60	26
Large photocopier	1	60	26
Plotter	1	60	26
Coffee machine	2	40	16

Now moving toward, the second model is named as "bottom-up" which is an approach to determine possible power demand and operational energy use. The parameters and methodology used in this model is taken from TM54. A technical report named TM54 was published by CIBSE. This report addresses that the value or performance predicted by HVAC designers is fluctuating with the installation techniques and methods. This is applicable to energy consumption in chillers, ahu and electrical motors. The major and static factor is ducting installation plays an important role during installation. TM54 gives building designers and owners detailed instructions on how to more comprehensively and properly analyse operational energy use at the design stage. This allows for more comprehensive operation hours and occupancy accounting based on the building's intended function. [17]

Jorn K. Grubera, Milan Prodanovic, Raul Alonsob, "Estimation and analysis of building energy demand and supply costs" which is presented in 7th International Conference on Sustainability in Energy and Buildings. This research provides a method that accurately estimates a building's energy consumption and supply costs by combining field parameters on the one hand and user activities on the other hand. The programme also determines the sensitivity of energy use and related costs to changes in building configuration or energy tariffs. The objective is the development of a tool to estimate the building energy consumption and the supply costs. The identification of critical factors enables building managers to take reasonable steps to improve a facility's energy efficiency. One of the methods by this tool is named the statistics method. Regression techniques are used in these building energy consumption modelling methodologies. Then, to link energy demand with the affecting variables, use conditional demand analysis or neural networks. Variables like ambient temperatures, relative humidity, and daylight are frequently included into these models. This method is used to create an Artificial neural network which is used to find out peak temperatures in day, weekly & monthly scenario and according to that show us energy Consumption. [9]

Second model given in this paper is an engineering model which estimates energy usage at the building level or for sub-level components using physical principles [6]. Models based on engineering approaches include a wide range of topics, ranging from modest ideas to more complex constructions, and include principles like heat and mass transport, thermal engineering, and fluid machines and mechanics.

Energy demand for buildings is growing, according to a report by the world energy agency. According to the report, building energy accounts for up to 45 percent of primary energy use in some nations. It also found that renewable energy sources and storage systems could be used to create new business models. The developed tool is then used to a case of an office building in

Madrid for demonstrating and verification of the proposed approach (Spain). It is detailed discussed how the building energy usage and estimated costs were generated, as well as the sensitivity analysis. [1]

Tianyuan Li, Masih Alavy, Jeffrey Siegel "Measurement of residential HVAC system runtime" The central type forced-air conditioning (HVAC) systems are the most popular kind of cooling systems in residential buildings in North America, per this research.Energy used by HVAC systems accounts for the majority of total energy consumption. Air Filters are used in HVAC systems to avoid & protect the equipment against contamination and occupant exposure. This article discusses the equipment's runtime. At runtimes, the filter and fan's performance is evaluated. The volumetric flow rate should be calculated and particle loading on the filter should be forecasted using runtime measurements. It is also important to determine cycle length & system sequencing. The study done on buildings in North- America shows that system sequencing is essential to control runtime HVAC. System sequencing use to start ventilation during morning time, controlling temperature during peak load on buildings and shut off the system during low or no load. Runtimes are impacted by climate and housing location. Even at the same location and in the same structure, the runtime of HVAC will vary according to the indoor temperature which may increase due to the occupancy inside house, kitchen or electrical equipment use, window and door opening. [20]

P. Depecker , C. Menezo "Design of buildings shape and energetic consumption" The major goal of this research work is to identify a cost-effective solution for building energy consumption by linking building heating demand to their shape & design. Architects and engineers face a variety of social, economic, environmental, technological, and aesthetic limitations while developing structures. [15]

IV. FUTURE SCOPE

According to the research and study of above paper it is found that Optimization and modification into HVAC system designing on its peak because of high energy consumptions. The future work in HVAC system is adding some extra parameters like paint color, natural lights and ventilation or covering roof with refractive coats will help to minimize consumption of energy into Hvac system. In case of retrofitting of Hvac system in old buildings new SOP will need to develop to ease of designing & installation of Hvac.

V. CONCLUSION

HVAC systems are the most Energy Consuming services. This paper describes energy consumption by HVAC and losses of Energy in HVAC systems. This review paper shows the efficient way to minimize the HVAC loss & increase the thermal efficiency. It also gives details about how much energy is consumed by the hvac system and how we scan, monitor and regulate it and increase the efficiency of the system. The impact of HVAC energy consumption on buildings is discussed. Few models are given for calculation. With the help of this model, we can estimate power demand of small equipment in buildings & their power consumption. This model gives ideas about estimating energy consumption and power demand profiles.

Now to find out existing HVAC system energy consumption and error, some of the papers are reviewed. With the aim of figuring out which type of model is the most suitable to represent the behavior of the real HVAC system. These findings will help researchers to develop the best and rational solutions for the problem statements of the current HVAC system modelling. Indoor air quality is also a significant component in hvac system modelling, as it has a significant impact on human health.

One of the parts of this paper is representing techniques of saving Energy in HVAC systems. It includes energy saving methods in HVAC with the help of balance of heat and masses as per path of optimization, because heat and mass balances must be closely related with the geometric parameters of premises like peak temperature in summer, The highest humidity levels are found in the winter and rainy seasons, as well as the building envelope's thermal performance. Heat and mass balance shows the amount of conditioning air enters in a given area and how much air is returned to the system. This helps to understand leakage and losses of air or requirement of air required to the conditioning. Above optimization method shows how to heat load computing of systems in an easy way. A technique which permits refinement of the calculations of heating losses of the building.

The modified bin approach, which is represented as a function of the external temperature, is another way to save energy (a linear function). This leads to the conclusion that, due to errors in the cooling load estimation, the actual cooling load profile will deviate from that predicted in design. The energy efficiency ratio (EER) of the cooling system was enhanced using a modified bin technique in this work. According to the study, it will benefit the overall energy efficiency ratio by 45.57 percent over the CLTD/SCL/CLF approach.

Energy saving, improving the energy efficiency of equipment & promotion of renewable energy sources for HVAC is the key factors to save losses in HVAC systems. The information obtained from this literature study would be helpful in further research.

REFERENCES

[1] A.C. Menezesa, A.Crippsa, Buswellb, J. Wrightb, D. Bouchlaghemc, 2014, Estimating the energy consumption and power demand of small Power equipment in office buildings" Energy and Buildings 75 199–209, Department of Civil and Building Engineering, Loughborough University, Loughborough, UK.

[2]B.F. Yua, Z.B. Hua, M. Liua, H.L. Yangb, Q.X. Kongb, Y.H. Liub, May 2008 . Review of research on air conditioning systems and indoor air quality control for human health" Accepted 9 May 2008 Published online in Science direct.

[3] Cheng Li; Zhenjiang Li,Mo Li,Forrest Meggers "Energy Efficient HVAC System with Distributed Sensing and Control School of Architecture, Princeton University, Department of Architecture, ETH Zurich.

[4] European Parliament, Directive 2010/31/EU of The European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), Off J. Eur. Union (2010).

[5] Energy Information Administration (EIA), 2012. International Energy Outlook 2011," Washington.

[6] F. Meggers, V. Ritter, P. Goffin, M. Baetschmann, and H. Leibundgut, 2012. Low exergy building systems implementation. Energy.

[7] H.W. Samuelson, A. Lantz, C. Reinhart, 2012, identifying non-technical barriers to energy sharing and reuse, in: Proceedings of Building Simulation : 12th Conference of International Building Performance Simulation Association, 2011, pp. 569–576.

[8] Increasing Efficiency of Building Systems and Technologies, an assessment of energy technologies and research opportunities, Department of Energy USA report, September 2015.

[9] Jorn K. Grubera, Milan Prodanovica, Raul Alonsob, 2015, Estimation and analysis of building energy demand and supply costs, 7th International Conference on Sustainability in Energy and Buildings, Energy Procedia 83 ,216 – 225.

[10] Karam M.Al-Obaidi, Mazran Ismail, Abdul Malek Abdul Rahman, 2014. Passive cooling techniques through reflective and radiative roof in tropical houses in Southeast Asia: A literature review, Frontiers of Architectural Research(2014) 3, 283–297 Science Direct.

[11] Kyosuke Hiyamaa,Shinsuke Kato, 2014. A new method for reusing building information models of past projects to optimize the default configuration for performance simulations "Energy and Buildings 73, 83–91.

[12] Lathia, Rutvik,Agrawal Tarun, Dobariya Kevin, Parmar Vishal, Patel Ankit, 2015. International Conference on Innovative Research in Engineering, Science and Management (ESM-15), Tata McGraw-Hill, New Delhi, 2015, pp. 162e166, http://dx.doi.org/10.13140/ RG.2.1.4158.2485.

[13] Mohamed Elhelw, 2015. Analysis of energy management for heating, ventilating and air-conditioning systems, Mechanical Engineering Department, Faculty of Engineering, Alexandria University, Egypt

[14] Nan Li, Jun-young Kwak , Burcin Becerik-Gerber, Milind Tambe,2013. Predicting Hvac Energy Consumption In Commercial Buildings Using Multiagent Systems, Sonny Astani Department of Civil and Environmental Engineering, University of Southern California 201.

[15] P.Depecker , C. Menezo, J. Virgone, S. Lepers, 2001. Design of buildings shape and energetic consumption Building and Environment 36 (2001) 627–635.

[16] R.V.Lathia, 2016. Book review of sustainable transportation options for the 21st century and beyond , http://dx.doi.org/10.1016/ j.jclepro.2016.09.030.

[17] Raad Z. Homod, 9 February 2013. Review on the HVAC System Modeling Types and the Shortcomings of Their Application" Hindawi Publishing Corporation Journal of Energy Volume 2013, Article ID 768632.

[18] Sadrul Ula, Alfredo A. Martinez-Morales, March 2015. Evaluation Of Energy Efficient Hvac Electrical Motor Systems In Buildings Prepared by: UCR Riverside Center for Environmental Research and Technology for California Energy Commission in .

[19] Sohair F. Rezeka, Abdel-Hamid Attia, Ahmed M. Saleh, April 2015. Management of air-conditioning systems in residential buildings by using fuzzy logic", Alexandria 21544, Egypt science direct journal.

[20] Tianyuan Li, Masih Alavy, Jeffrey Siegel, January 2019. Measurement of residential HVAC system runtime" Accepted Manuscript

[21] Vladimir G. Gagarina, Kirill I. Lushina, Vladimir V. Kozlova, Alexander Yu. Neklyudova, 2015. Path of optimized engineering of HVAC systems, 8th International Cold Climate HVAC 2015 Conference, CCHVAC 2015, Procedia Engineering 146 103 – 111