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Analysis of an HVAC System & Operation for Retro-Fit Building with IOT (Internate of Things) & Solar Panel for Energy Efficient Application

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ABSTRACT

This thesis will describe the basic concepts of Energy efficient Retro-fit building and discusses the role of HVAC for ensuring high performance sustainable buildings in design and operation along with the application of IOT with weather forecasting data & smart grid technique in HVAC system. At the End, we also provide use of renewable source of energy i:e Solar Energy for providing electricity to HVAC system for making the building more energy efficient.

Energy is very important part of both growth & development, but as the world’s energy consumption is increasing day by day & expected to increase by 30% to 35% by 2010-2030, which lead to the energy crisis & challenges to the human development in this 21st century. This problem can be overcome by improving efficiency in commercial, residential and industrial sector, leading to high focus in energy efficient building.

The building accounts for 40% of the world’s energy consumption, the industrial sector, which consist of building, machines, process & loading accounts for 35 % of the world’s energy consumption. Industrial buildings are indicating increasing rates of energy consumption, with heating, ventilation, and air conditioning (HVAC) usually constituting over 50% of this consumption. Industrial buildings thus have great potential for reducing both energy requirements and environmental impact, but reducing their energy consumption could also affect cost savings that would play an important role in commercial success.

At last with application of the IOT (Internate Of Things) in schedule activities based on weather forecasting & more in HVAC system, Safety will increase along with the more reduction in cost & energy consumption with clients end to end satisfaction in service and maintenance.

This paper will describe the basic concepts of green building and discusses the role of heating, ventilating and air-conditioning (HVAC) for ensuring high performance, energy efficient in design and operation for Retro-fit buildings. The design strategies for effective and green HVAC systems are explained and the new emerging HVAC technologies incorporated with IOT for green buildings are described. The use of Solar panel is also provided at the end to have a better & depth understanding of the project in terms of socio-economic zone.

It is hoped that HVAC designers and other building professionals could develop a better understanding of green buildings and apply effective approaches and techniques for meeting the goal. With an integrated and high effort approach to HVAC and building design, a viable built environment can be achieved and the eco-friendly performance of buildings can be improved.

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1. INTRODUCTION

Heating, Ventilation, and Air-Conditioning (HVAC) systems control the indoor environment throughout the year to ensure comfortable conditions in homes, offices, and commercial facilities. Beside the fact that

HVAC systems are making human life healthier and more productive but various products could also be produced faster, better, and more economically in an appropriately controlled environment. Almost each residential, institutional, commercial, and industrial building has a year-round controlled environment in the developed countries of the world.

1.1. Definition of air conditioning

An air conditioner is a system or a machine that treats air in a defined, usually enclosed area via a refrigeration cycle in which warm air is removed and replaced with cooler and more humid air.

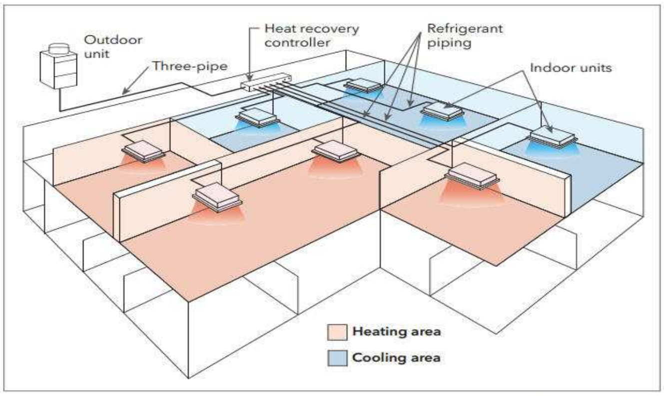
An air conditioner can change the temperature, humidity or general quality of the air. More specifically, an air conditioner makes your home cooler, by drawing heat energy out of the house and transferring that heat to the outdoors, then replacing the air inside your home with cooler air.

The air conditioner in a central heating and cooling system provides cool air through ductwork inside your home, by providing a process that draws out the warm air inside, removing its heat.

The awareness of the importance of living place and indoor air quality has increased for both health and comfort. The growing requirements for closely controlled working environments in laboratories, hospitals, and industrial facilities have rapidly increased overall energy demands. Therefore, the HVAC systems designers are challenged as never before to come up with the most energy efficient systems. One way of addressing the challenge is by optimizing conventional setups and introducing efficient innovative systems utilizing renewable energy resources [1].

1.2. What is Variable Refrigerant Flow (VRF) Systems?

Variable refrigerant flow (VRF) is an air-condition system configuration where there is one outdoor condensing unit and multiple indoor units. The term variable refrigerant flow refers to the ability of the system to control the amount of refrigerant flowing to the multiple evaporators (indoor units), enabling the use of many evaporators of differing capacities and configurations connected to a single condensing unit. The arrangement provides an individualized comfort control, and simultaneous heating and cooling in different zones.



Variable refrigerant flow systems can deliver cooling to some zones and heating to others, with no reheat needed (an air-source system is shown here).

Fig-1 VRF System Model

VRF systems are similar to the multi-split systems which connect one outdoor section to several evaporators. However, multi-split systems turn OFF or ON completely in response to one master controller, whereas VRF systems continually adjust the flow of refrigerant to each indoor evaporator. The control is achieved by continually varying the flow of refrigerant through a pulse modulating valve (PMV) whose opening is determined by the microprocessor receiving information from the thermostat sensors in each indoor unit. The indoor units are linked by a control wire to the outdoor unit which responds to the demand from the indoor units by varying its compressor speed to match the total cooling and/or heating requirements.

VRF systems promise a more energy-efficient strategy (estimates range from 11% to 17% less energy compared to conventional units) at a somewhat higher cost.

Note the term VRF systems should not be confused with the centralized VAV (variable air volume) systems, which work by varying the air flow to the conditioned space based on variation in room loads.

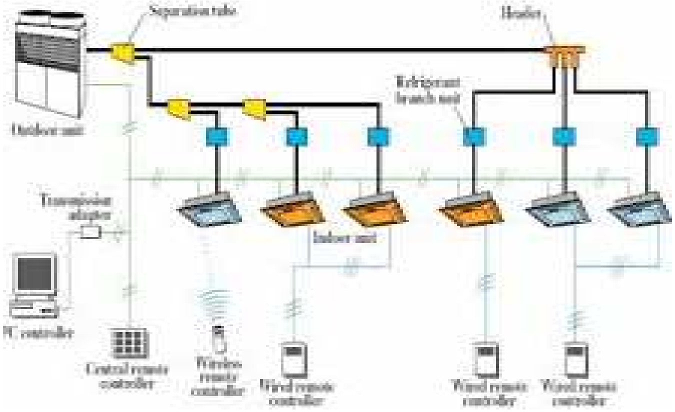


Fig-2: VRF Arrangement

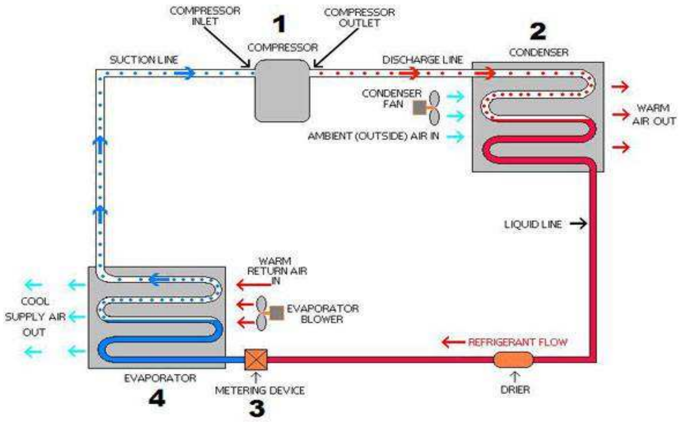


Fig-3: A View of Refrigeration cycle

1.3. How Does VRF Work?

Multi-splits include multiple indoor units connected to a single outdoor unit. Ductless products are fundamentally different from ducted systems in that heat is transferred to or from the space directly by circulating refrigerant to indoor units (evaporators or condensers) located near or within the conditioned space. (When the indoor units are in the cooling mode they act as evaporators and when they are in the heating mode they act as condensers.) In contrast, conventional ducted systems transfer heat from the space to the refrigerant by circulating air (in ducted systems) or water (in chillers) throughout the building. VRF systems are enhanced versions of ductless multi-split systems, permitting more indoor units to be connected to each outdoor unit and providing additional features such as simultaneous heating and cooling and heat recovery. VRF heat pump systems permit heating in all of the indoor units, or cooling of the all the units, not simultaneous heating and cooling. Heat recovery systems provide simultaneous heating and cooling as well as heat recovery to reduce energy use during the heating season.

Over the past 15 years the technology has advanced in a number of areas:

- Standard compressors to variable speed and capacity modulated scroll compressors.
- Direct driven outdoor fans to variable frequency drive, inverter-driven fans.
- Direct driven indoor coil motors to direct current or ECM-type motors.
- Variable capacity indoor units.
- Better heat exchanger surfaces with multi-segmented coils.
- Improved controls and diagnostics.
- R-22 to R-410A.
- Better refrigerant charge and oil management.

Other features include the addition of concealed ducted units and ceiling cassette configurations to the traditional wall-mounted units. Refrigerant piping runs of more than 200 feet are possible and outdoor units are available in sizes up to 240,000 Btu/ hr.

The term “variable refrigerant flow” refers to the ability of the system to control the amount of refrigerant flowing to each of the evaporators, enabling the use of many evaporators of differing capacities and configurations, individualized comfort control, simultaneous heating and cooling in different zones, and heat recovery from one zone to another. Most VRF condensers use variable frequency drives to control the flow of refrigerant to the evaporators. Refrigerant flow control lies at the heart of VRF systems and is the major technical challenge as well as the source of many of the system’s advantages (Goetzler, 2007). In most cases, two-pipe systems can be used effectively (in VRF heat pump systems) when all the zones in the facility require cooling or all require heating during the same operating period. Three-pipe (a heating pipe, a cooling pipe and a return pipe) systems work best when there is a need for some of the spaces to be cooled and some of them to be heated during the same period. (This often occurs in the winter in medium-sized to large-sized buildings with a substantial core.) One manufacturer has a two-pipe system than can be used to provide simultaneous heating and cooling as well as heat recovery operations.

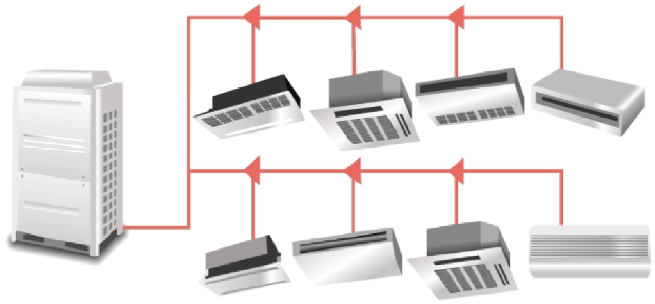


Fig- 4: Major Components of A VRF System Including the Range of Possible Indoor Unit Configurations and A Typical Outdoor Unit.

Heat recovery can be accomplished by transferring heat between the pipes providing refrigerant to the cooling and heating units. One way is to use heat exchangers to extract the superheat from the units in the cooling mode and route it into refrigerant entering a heated zone. One manufacturer sends the refrigerant first to the units that require heating, allows the refrigerant to condense, collects it at a central point and then sends it to the indoor evaporators to do cooling. Most manufacturers have a proprietary design for the heat recovery plumbing and operation with special valving arrangements, heat exchangers, controls, receivers and distribution boxes.

1.4. What is IOT (Internate of things)?

Industrial buildings are indicating increasing rates of energy consumption, with heating, ventilation, and air conditioning (HVAC) usually constituting over 50% of this consumption. However, these energy requirements are heavily subjective by weather conditions based on the season, the time of day, and different in-building activities. These activities take place in industrial setup over 24 h and have different HVAC energy requirements. By the application of IOT in integer linear programming approach to efficiently schedule activities based on weather forecasting, thus minimizing the energy required by HVAC. Experimental results show that energy consumption can be reduced by up to 20-30%.

Smart grid is one of the main applications of the Internate of Things (IoT) model. Within this context, the IOT application addresses the efficient energy consumption management of heating, ventilation, and air conditioning (HVAC) systems in smart grids with variable energy price. First, we propose an energy scheduling method that minimizes the energy consumption cost for a particular time interval, taking into account the energy price and a set of comfort constraints, that is, a range of temperatures according to user's preferences for a given room. Then, we propose an energy scheduler where the user may select to relax the temperature constraints to save more energy. Moreover, with the IoT model, the user may interact remotely with the HVAC control system. In particular, the user may decide remotely the temperature of comfort, while the temperature and energy consumption information is sent through Internet and displayed at the end user's device, thus highlighting the potential gains that can be achieved in terms of both energy and cost.

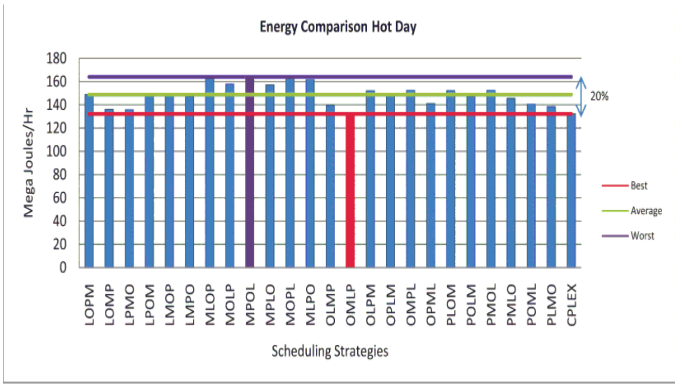


Fig- 5: Energy Comparison Hot Day.

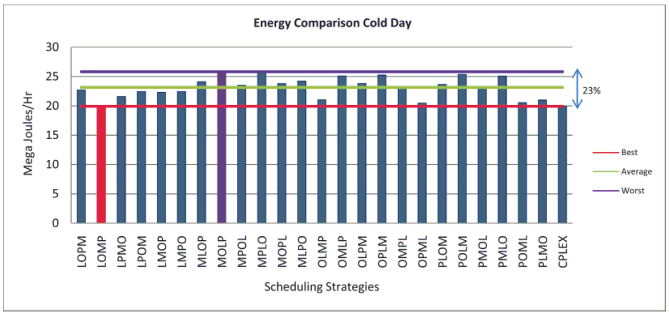


Fig- 6: Energy Comparison Cold Day

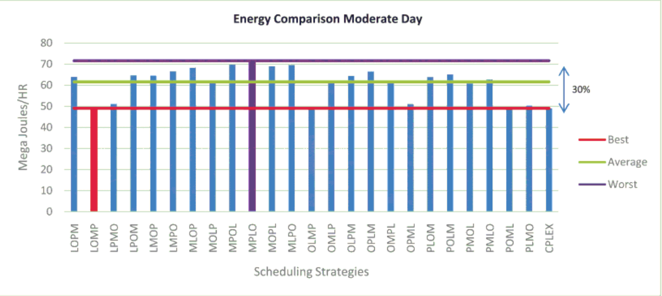


Fig- 7: Energy Comparison Moderate Day

1.5. Renewable Sources

The high energy demand on buildings requires efficient installations and the integration of renewable energy to achieve the goal of reducing energy consumption using traditional energy sources. Usually, solar energy generation and heating loads have different profiles along a day and their maximums take place at different moments. In addition, in months in which solar production is higher, the heating demands are the minimum (hot water is consumed only domestically in summer). Cooling machines (absorption and adsorption) allow using thermal energy to chill a fluid. This heat flow rate could be recovered from solar collectors or any other heat source. The aim of this study is to integrate different typologies of solar hybrid (photovoltaic and thermal) collectors with cooling machines getting solar regeneration and concluding the optimal combination for building applications. The heat recovered from the photovoltaic module is used to provide energy to these cooling machines getting a double effect: to get a better efficiency on PV modules and to cool the building.

The structure of the modern society has been built based on the technological developments where energy is one of the vital demands of this system. Without using available energy in the world, the comfort and convenience provided by the growing technology would not be realized. Thus, vast amount of research has been done and money have been spent to resolve energy problems. Total energy requirement to maintain today's modern life have been primarily met by the use of fossil fuels but this leads to serious environmental problems (IEA, 2016b). World attention was turned to renewable energy resources over the years due to high oil prices and increase in pollution. Recently, governments agree that renewable sources should be utilized at maximum level. Today, these sources can approximately meet 14% of the world's total energy demand, however, their future potential is gradually increase (IEA, 2017.

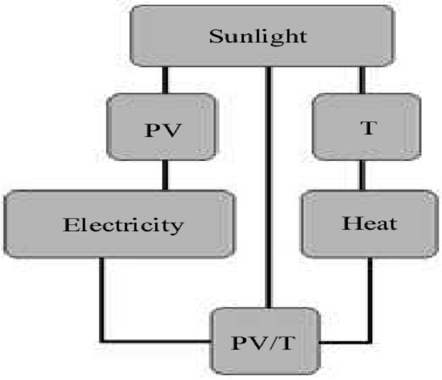


Fig- 8: Components of Photovoltaic/Thermal (PV/T) systems

1.6. What is a Retro-fit Existing Building?

Renovation, retrofit, and refurbishment of existing buildings represent an opportunity to upgrade the energy performance of commercial building assets for their ongoing life. Often retrofit involves modifications to existing commercial buildings that may improve energy efficiency or decrease energy demand. In addition, retrofits are often used as opportune time to install distributed generation to a building. Energy-efficiency retrofits can reduce the operational costs, particularly in older buildings, as well as help to attract tenants and gain a market edge.

The Building Technologies Office provides resources that allow planners, designers, and owners to focus on energy-use goals from the first planning stages through post-retrofit monitoring. The Advanced Energy Retrofit Guides outline how to conduct an energy-efficient retrofit. Energy Modelling Software helps identify the most impactful measures through simulations. And the Technology Portal can be accessed to make fact-based procurement decisions during a retrofit.

Fig 9 Pic of Vikash Minar for Retro-fit Building

2. LITERATURE REVIEW

Kartik Patel et al studied that Energy requirement of India particularly heating & cooling in space is likely to increase by for fold within the span of 20 years. So energy efficiency has been prime importance in HVAC system. There are various other options available for energy saving in HVAC systems and Variable Refrigerant Flow (VRF) technology is one of them. In heating/cooling space VRF technology is having considerable potential for energy saving (10% to 40%). Ammi Amarnath et al reviewed that the attributes of an emerging space conditioning technology. variable refrigerant flow (VRF) systems. Material presented in this paper was synthesized from the open literature, private interviews with industry experts and data (sometimes proprietary data) obtained from manufacturers. VRF systems are enhanced versions of ductless multi-split systems, permitting more indoor units to be connected to each outdoor unit and providing additional features such as simultaneous heating and cooling and heat recovery. VRF technology uses smart integrated controls, variable speed drives, refrigerant piping, and heat recovery to provide products with attributes that include high energy efficiency, flexible operation, ease of installation, low noise, zone control, and comfort using all-electric technology. VRF systems are very popular in Asia and Europe and, with an increasing support available from major U.S. and Asian manufacturers are worth considering for multi-zone commercial building applications in the U.S.

This paper provides an overview of variable refrigerant flow system technology, including the market situation, advantages and disadvantages for the customer, possible impact on the electric utility, applications recommendations, and technology attributes. Also addressed are what is holding back the technology, including lack of verified third party field data; codes and standards issues; technology improvements needed; and market actions needed to increase penetration of these systems.

Based on today's practical technology for cooling, the major components of a chiller plant are (1) compressors, (2) cooling towers, (3) pumps (chilled and cooling water) and (4) fans in air handling units. They all consume mainly electricity to operate. When specifying the kW/R ton of a plant, there are two levels of monitoring cooling efficiency: (1) at the efficiency of the chiller machines or the compressors which consume a major amount of electricity; and (2) at the overall efficiency of cooling plants which include the cooling towers, pumps for moving coolant (chilled and cooling water) to all air-handling units. Pragmatically, a holistic approach is necessary towards achieving a low energy input per cooling achieved such as 0.6 kW/R ton cooling or lower by considering all aspects of the cooling plant.

In this paper, we present a review of recent innovative cooling technology and strategies that could potentially lower the kW/R ton of cooling systems – from the existing mean of 0.9 kW/R ton towards 0.6 kW/R ton or lower. The paper, broadly divided into three key sections (see Fig. 2), begins with a review of the recent novel devices that enhances the energy efficiency of cooling systems at the component level. This is followed by a review of innovative cooling systems designs that reduces energy use for air conditioning. Lastly, the paper presents recent developments in intelligent air-control strategies and smart chiller sequencing methodologies that reduce the primary energy utilization for cooling.

The energy efficient cooling technology, innovative systems designs, and intelligent control strategies described in the paper have been recently researched or are on-going studies. Several have been implemented on a larger scale and, therefore, are examples of practical solutions that can be readily applied to suit specific needs.

Liujia Dong et al discussed that proposes extremism seeking control (ESC) schemes for different operational modes of a Multi-functional Variable Refrigerant Flow (MFVRF) system as well as a mode switching scheme, in order to optimize energy efficiency in real time without using detailed plant models. Five operational modes are considered: Cooling Only, Heating Only, Cooling Dominated, Heating Dominated, and Heat Recovery. The zone temperature set point is achieved by controlling the respective indoor unit (IDU) fan speed, and the feedback required is the total power consumption of the compressor motor, outdoor unit (ODU) condenser fan and IDU evaporator fans. For different operational modes, the ESC inputs are chosen to be different combinations of compressor suction pressure set point, ODU fan speed, bypass flow valve opening, superheat set points for IDU's and ODU. Also, a set of switching logic has been developed for changing the operation modes of ODU and IDU, along with bump less transfer schemes. To evaluate the proposed control and mode-switching strategies, a Modelica based dynamic simulation model is developed for the MFVRF system. Simulation results demonstrate the capability for the ESC to achieve the optimal operation in model-free fashion, as well as the effectiveness of the proposed mode switching scheme.

Jordi Serra et al studied that Smart grid is one of the main applications of the Internate Of Things (IoT) paradigm. Within this context, this paper addresses the efficient energy consumption management of heating, ventilation, and air conditioning (HVAC) systems in smart grids with variable energy price. To that end, first, we propose an energy scheduling method that minimizes the energy consumption cost for a particular time interval, taking into account the energy price and a set of comfort constraints, that is, a range of temperatures according to user's preferences for a given room. Then, we propose an energy scheduler where the user may select to relax the temperature constraints to save more energy. Moreover, thanks to the IoT paradigm, the user may interact remotely with the HVAC control system. In particular, the user may decide remotely the temperature of comfort, while the temperature and energy consumption information is sent through Internet and displayed at the end user's device. The proposed algorithms have been implemented in a real testbed, highlighting the potential gains that can be achieved in terms of both energy and cost.

3. RESEARCH METHODOLOGY

3.1. Analytical approach to existing system & Proposed system.

3.1.1. Heating ventilation and air conditioning system

3.1.1.1. Preamble

- The section outlines HVAC system design parameters, system selections and extent of provisions for the project.
- The ventilation system for the development should be able to maintain the desired air quality.
- The Basement ventilation system will be designed and developed according to contaminant removal requirements of the parking spaces.
- The air conditioning will be designed to maintain specified temperature, humidity and supply of outdoor air within occupied spaces. Individual's temperature controls for each area.
- This will include staircase, lift well, lift lobby pressurization system to limit smoke movement in case of fire emergency.
- Toilet ventilation will be designed as per relevant standard National Building Code (NBC-2016).
- All Ventilations and air conditioning systems shall be in conformity with the NBC-2016.

3.1.1.2. Design Intent

- To create a comfortable and safe HVAC environment for the development Prime objective
- To maintain good indoor environment in terms of temperature, humidity and air movement.
- To create a relatively quiet and low vibration control AC system.

- To make the HVAC system energy efficient eco-friendly & easily maintainable.

3.1.1.3. Scope of Works

Scope of works will include the following:

- Design the complete system that is making layout and dwg. Of each floor I:e GF + 21st Floor.
- Heat load calculation and Electrical Load Calculation of each Floor & Section.
- Calculation of Tonnage /HP of Outdoor Unit and Indoor Unit & Type of Indoor system (unitary or Duct Based).
- Location and Identification of Outdoor Unit.
- Design the No. of Outdoor and Indoor Unit of Each Floor & section.
- Design the VRV/VRF Copper Pipe, Drainpipe, Control Cable, Power Cable, Route circuit for Indoor Unit and Outdoor Connectivity.
- Ventilation Scheme for toilet, Pantry and Basement, Lift & Staircase with necessary Air changes as per mandatory Govt. Norms.

3.1.2. General

- This report outlines the design features, basis of design etc. of the HVAC system.
- The system requirement, basis of design and general outline of the Ventilation system are also given.
- This report is based on details of the three type of cooling system I, e, Option-1:- VRF system with Cassette unit, Option-2:- VRF system with Duct able unit and Option-3:- VRF system with AHU. The detail design scheme is given later.

3.1.3.1. Design Considerations

It is often a practice to design an Air-conditioning system for peak load conditions. However, the average usage of an Air-conditioning system during a year is between 70% to 90%. Therefore, an appropriate system must be capable of operating efficiently without wastage of energy from an Air-conditioning load as little as 30% to a maximum of 90% (Note: The 100% conditions occurs for a very short duration and needs to be discounted).

Hence, the option proposed to be adopted for this project, will be planned and selected for:

- Modern Technology
- Energy efficient throughout the varying load patterns.
- Providing required Indoor air quality (IAQ) with reduced operating cost.
- Maximum flexibility of operation.

3.1.3. Modern Technology

- The selection of equipment is designed to achieve energy efficient modern technology.
- The choice of equipment and specifications will provide the best possible system at a reasonable price.

3.1.4. Energy Efficient

- Hence, the selection proposed is such that the overall power requirement remains consistent with the demand, avoiding all possible waste.
- The outdoor units are located in two part I:e on Ground and Terrace to avoid the Max. Vertical distance, so that the system will go through min. Duration.
- The Variable Frequency Drive (VFD) will be proposed where-ever required, resulting in very high reduction in power consumption.

3.1.5. Indoor Air Quality

- ASHRAE (USA) standard call for maintaining a desirable Indoor Air quality (IAQ) in a tightly sealed building.
- This is to prevent sickness syndrome in people who occupy these buildings for a long period. This will also help to control the concentration of harmful bacteria to provide a comfortable environment, to save energy, to prevent exhilaration / infiltration of pathogens etc.
- There will be bi-polar air ionization system proposed in Indoor Unit to control the indoor air quality and minimize the requirement of fresh air that will also result in energy efficient system.

3.1.6. Flexibility

- There will be individual Outdoor unit for each floor.
- In addition, each floor will have independent Indoor Units.
- This will ensure that the equipment in operations is as per demand without any wastage of power.

3.2. System Design

- Car Park Ventilation (Emergency / Normal)
- EXISTING SYSTEM: There are 4 nos. of Axial Flow Fan are available for basement ventilation having capacity of 10200 cfm Each. The air is uniformly getting exhausted through the duct connected to these 4 fans. The Provision for fresh air is taken from the 3 existing Ramps.
- PROPOSED SYSTEM: These existing Fans (4 nos.) are sufficient for basement ventilation with some technical alteration & modification along with the duct size and route, after considering the

following basis of design for car parking ventilation system.

- The entire car park shall be ventilated in one zone.
- Each Zone has its independent fresh air & exhaust system. The car park zone area should not exceed 3000 sq. m. as per National Building Code-2016.
- The entire cark park ventilation shall be carried out by using axial fans for each zone.
- There shall be 6 ACPH exhaust (Normal) and additional 6 ACPH exhaust (Emergency) with Equal capacity of fresh air. The exhaust fans for all basements are split in the following configuration:
- 1 No's x 6 ACPH Capacity Each totaling 6 ACPH (Ducted)
- 1 No's x 6 ACPH Capacity Each totaling 6 ACPH (Ducted)
- The fresh air for basement is taken from the 3 Ramps.
- The axial fan shall be suitably selected for best efficiency, low noise, optimum operating
- Speed and lowest possible power consumption.
- The axial fan shall have back draft dampers and all protective coverings (like inlet wire mesh Etc.) so that any possible mis happening may be avoided.

3.3. D.G ROOM VENTILATION

- EXISTING SYSTEM: There is an Exhaust Fan In DG Room which discharge the D.G exhaust in Plant Room with insufficient amount of exhaust air and ducting, which is not feasible and successful.
- **PROPOSED SYSTEM:** The new proposed system will be proposed on the basis of following parameters-
- The DG Room shall be ventilated by using Air washers for fresh air and Axial Fans for exhaust.
- The design shall be based on minimum 28 CFM/ KVA Exhaust of the DG capacity.
- Final exhaust requirement will be as per DG vendor requirement.
- The fresh air shall be delivered at minimum 30 CFM/KVA. This will keep the DG Room
- Slightly under positive pressure. Final fresh air requirement will be as per DG vendor requirement.
- The Fresh air in the DG Room shall be ducted. The air shall perfectly be discharged at
- Floor level by using suitable dropper (wherever possible).
- However, the exhaust shall preferably be direct / ducted as required for the betterment of the project.

3.4. LT, HT& Transformer Rooms Ventilation

- EXISTING SYSTEM: There is no any provision for LT, HT & Transformer room ventilation.
- PROPOSED SYSTEM: The new system will be proposed on the basis of following parameters-
- 3.3.1 LT, HT & Transformer room is ventilated as per NBC-2016 i:e 6-8 ACPH.

3.5. Toilet Ventilation

- EXISTING SYSTEM: There are two toilets in the building.
- Male Toilet: An exhaust fan is proposed on terrace for male toilet ventilation. The fan is connected to the toilet directly through the masonry shaft not through the duct which resulting the improper ventilation and odor/toilet smell are spread on ground and other floors.
- Female Toilet: The same system is proposed in female toilet as proposed in male toilet.
- PROPOSED SYSTEM: The new system will be proposed on the basis of following parameters-
- Toilets ventilation are as per NBC-2016 i.e. 10 ACPH.
- There will be two fan section for male and female toilet placed on terrace.
- The ventilation of toilet will be ducted through the shaft.

3.6. Pump & Fire Room Ventilation

- EXISTING SYSTEM: There is no provision for the Pump & Fire Room Ventilation.
- PROPOSED SYSTEM: The new system will be proposed on the basis of following parameters-
- It is proposed to provide exhaust in pump room at 20 ACPH by using axial fans. There Shall be 01 No Axial Fans for exhaust. The exhaust shall be discharged through anear by available exhaust shaft up to ground level.
- To compensate the exhaust air quantity, it is proposed to provide fresh air by using Axial fan of suitable capacity.
- Proper ductwork shall be done to ensure uniform supply of fresh air and exhaust from the plant room.

3.7. Lift well Pressurization

- EXISTING SYSTEM: There is no provision for the Lift well Pressurization.
- PROPOSED SYSTEM: The new system will be proposed on the basis of following parameters-
- All Lift wells shall be pressurized at terrace level.
- The pressurization shall be done to achieve a 50 Pascal Pressure Differential in the lift shaft as per NBC. This ensures that in case of fire in the building, the persons in the lift are able to get down to ground floor level without being affected by the smoke from the fire at any floor.
- The calculation shall be based on leakage through doors at all floor and one open door at ground level. The lift well pressurization shall be carried out by using axial fans placed at terrace level.

3.8. Staircase Pressurization

- EXISTING SYSTEM: There is no provision for the Staircase Pressurization except at Ground and top Floor.
- PROPOSED SYSTEM: The new system will be proposed on the basis of following parameters-
- All the staircases shall be enclosed and pressurized. The pressurization shall be done to achieve a 50 Pascal Pressure Differential in the staircase as per NBC.
- Suitable shaft shall be made adjacent to staircase and axial fan placed at
- Terrace/basement shall be used to pressurize the staircase.
- There shall be openings at every landing and air which is brought down through a
- duct shall be discharged at each landing through suitable size grills.

3.9. Lift Lobby Pressurization

- EXISTING SYSTEM: There is no provision for the Lift lobby Pressurization.
- PROPOSED SYSTEM: The new system will be proposed on the basis of following parameters-
- The lift lobbies in the basement and on the floors shall be enclosed type. Therefore, it is mandatory to pressurize the lift lobbies. There shall be a common fan placed at terrace to pressurize the lift lobby. In the eventuality of Fire, the lift lobby of the affected floor, one floor above and one floor below shall be pressurized. There shall be a common duct connecting all loft lobbies (through a shaft) . On all floors, there shall be Motorized ON/ OFF Dampers (Normally Closed) . In case of Fire, on receiving signal from the fire panel, only three dampers will open (affected floor, one floor above and one floor below).

3.10. Co Sensors:

- EXISTING SYSTEM: There are 4 co-sensors at basement connected to a Panel.
- PROPOSED SYSTEM: The new system will be proposed on the basis of following parameters-
- CO Sensors shall be installed for car park ventilation area zone wise.
- They shall sense the level of CO in a particular zone and shall trigger the Exhaust/fresh air fan accordingly.
- The basis of triggering can be obeyed as
- CO level < 30 ppm – All fan off
- 30 ppm< CO level <100 ppm – Normal Exhaust and fresh air fan
- CO level > 100 ppm – Both Normal and Emergency Exhaust/Fresh Air fans are on.

3.11. Basis of Design

- Design Parameters
- Outside Conditions Summer: 110°F DB; 75°F WB
- Monsoon: 95.0°F DB; 83°F WB
- Inside Conditions: 74°F ± 2°F DB
- (Summer): (RH not exceeding 60% in all areas.)
- Lighting Load : 1.2 Watt/Sqft Or As per ASHRAE
- Standard 90.1-2010.
- (Fresh Air): As per ASHRAE Standard 62.1-2010.
- Occupancy: As per seating Plan.
- General Ventilation
- Toilet Exhaust: 10 ACPH
- Hours of Operation: 10 hours per day

3.12. References for Design Parameters:

Table -1 Design Parameters and reference

S. No.	Design Parameters	References
1	Outside Conditions	ISHRAE-2007
2	Fresh Air/Occupancy	ASHRAE-62.1-2007
3	Ventilation Rate (ACPH)	NBC-2005

3.13. System Requirement

Table-2 Based on the above requirements, A.C. loads are as follows:

Heat load summary				
GROUND FLOOR				
S.NO.	Building	Floor area (in Sqft)	Summer (TR)	Monsoon (TR)
1	Reception	532.8	5.73	5.24
2	SECURITY	231.5	4.37	3.92
3	OFFICE	877.3	9.2	8
TOTAL		**1641.6**	**19.3**	**17.2**

Table- 3: 1-4 & 6th floor measurement

Heat load summary				
First to fourth & sixth FLOOR. (1-4 & 6th floor)				
S. No	Building	Floor area (in Sqft)	Summer (TR)	Monsoon (TR)
1	Reception (1)	228	1.2	1.09
2	M-6(1)	86	0.87	0.85
3	DIR (F & H)	108	1	0.9
4	OFFICE CUBICALS-1	855	4.4	4
5	RECEPTION-2	166.8	1.1	1
6	M-6(2)	88.3	1.3	1.1
7	DIR.(AP-II)	95.8	1.6	1.2
8	OFFICE CUBICAL-2	955	5.3	4.6
9	REPROGRAPHY	273.4	1.7	1.4
10	AC-3(2)	108	1.8	1.7
11	M-6(3)	88.3	1.6	1.5
12	RECEPTION-3	167	1.8	1.7
13	DIR(AP-III)	95.8	1.9	1.7
14	M-6(4)	86	1	0.9
15	OFFICE CUBICALS(4)	874	4.9	4.2
16	RECETION(4)	228	1.4	1.2
TOTAL		**4503.4**	**33**	**28.9**
SUB-TOTAL(5 FLOORS)		**22517**	**165**	**144.5**

Table-4: Seventh and 13th floor measurement

Heat load summary				
SEVENTH & THIRTEENTH FLOOR (7TH& 13TH FLOOR)				
S.NO.	Building	Floor area (in Sqft)	Summer (TR)	Monsoon (TR)
1	GYM	1123	6.28	5.96
2	LIBRARY	1123	5.78	5.27
3	N-E CABIN	323	2.1	1.7
4	S-E CABIN	323	2.1	1.7
5	N-W CABIN	323	3.9	3.5
6	S-W CABIN	323	4.2	3.7
7	OFF. CUBICAL (WEST)	796.5	8.3	7.5
8	OFFICE CUBICAL(EAST)	796.5	4.7	3.9
TOTAL		**5131**	**37.3**	**33.3**
SUB-TOTAL(2 FLOORS)		**10262**	**74.6**	**66.6**

4. CONCLUSIONS

In the current work, a systematic simulation-based optimization approach is proposed for the automated optimal selection of HVAC system configurations at the initial design stage. The particular conclusions for each chapter are provided in the closing remarks. However, in present chapter the key outcomes are compiled to give an overview of the research work.

The overall world 's energy demands are increased remarkably in last few decades and projected to ascend by almost 50% from 2009 to 2035. In the total energy consumption, the share of buildings is significant that accounted about 21% of total energy requirements at the world level. In the developed countries and regions, such as USA and EU the buildings energy demands are around 41% and 40% of the total energy consumption, respectively. While, in the underdeveloped countries like India, Pakistan, buildings share is about 44%. In the buildings energy demands, the key contribution is from HVAC systems that maintain the desired comfort conditions. Therefore, optimization of HVAC systems has great potential for energy savings in the buildings sector.

VRF technology is relatively new in India and gained the momentum after 2007. So, this has been relatively new and efficient way to design HVAC system with VRF technology. VRF technology uses smart integrated controls, variable speed drives, refrigerant piping, and heat recovery to provide products with attributes that include high energy efficiency, flexible operation, ease of installation, low noise, zone control, and comfort using all-electric technology. Still efficiency and energy saving depend on many variables which controls heat load of the building. So, energy saving from VRF technology may vary from 10% to 40%.

Other applications well suited to VRF systems include any case in which there is an advantage to delivering personalized, compartmentalized comfort conditioning, such as: office buildings, strip malls, hotels and motels, hospitals and nursing homes, banks and schools. Offices and strip malls have occupants with different space conditioning requirements, making the zoning opportunities of VRF attractive for these applications. Hospitals and nursing homes can be good candidates since the VRF system makes it easy to avoid zone to zone air mixing. Banks have favored the system for security because the egress paths into the bank are minimized due to the minimal smaller diameter ductwork. Even in schools, which because of high occupancy often have a 100% outside air requirement, VRF units can be used (often with heat recovery ventilators) to meet the load.

Industrial buildings are indicating increasing rates of energy consumption, with heating, ventilation, and air conditioning (HVAC) usually constituting over 50% of this consumption. However, these energy requirements are heavily subjective by weather conditions based on the season, the time of day, and different in-building activities. These activities take place in industrial setup over 24 h and have different HVAC energy requirements. By the application of IOT in integer linear programming approach to efficiently schedule activities based on weather forecasting, thus minimizing the energy required by HVAC. Experimental results show that energy consumption can be reduced by up to 20-30%.

Smart grid is one of the main applications of the Internate of Things (IoT) model. Within this context, the IOT application addresses the efficient energy consumption management of heating, ventilation, and air conditioning (HVAC) systems in smart grids with variable energy price. First, we propose an energy scheduling method that minimizes the energy consumption cost for a particular time interval, taking into account the energy price and a set of comfort constraints, that is, a range of temperatures according to user's preferences for a given room. Then, we propose an energy scheduler where the user may select to relax the temperature constraints to save more energy. Moreover, with the IoT model, the user may interact remotely with the HVAC control system. In particular, the user may decide remotely the temperature of comfort, while the temperature and energy consumption information is sent through Internet and displayed at the end user's device, thus highlighting the potential gains that can be achieved in terms of both energy and cost.

The energy consumption management of HVACs, for a given smart pricing tariff and users' comfort constraints. Moreover, the integration within the IoT framework has been studied. To that end, we developed a real testbed consisting of (i) heaters, (ii) sensor nodes that measure the temperature, and (iii) a gateway, which provides connection to the Internet and includes a web application that permits the interaction with the user through Internet. Moreover, the gateway implements the algorithms that control the energy consumption. Regarding the proposed methods, first, we devised an energy scheduler that optimizes the energy cost in a time interval basis, for a given energy price tariff and for a given set of temperature of comfort constraints that are associated with different locations inside a room. Then, we proposed a more flexible energy scheduler, which relaxes the temperature constraints to further reduce the energy consumption. Namely, a new objective function has been considered, which consists of a convex combination of the energy cost and a penalty term that reflects the comfort. This permits to consider both the case where the user is very concerned with the comfort and the case where he allows relaxing the comfort constraint to further reduce the energy consumption.

The overall performance of the HPV/T unit is always higher than that of the single PV or solar thermal unit. However, the differences in overall performances of these systems are strongly affected by the environmental conditions such as ambient temperature, humidity and altitude. In most cases, solar thermal unit produces more thermal energy than HPV/T system. The electrical efficiency of the solar PV system or HPV/T system is observed in the range of 8-14% and it is not highly affected by the ambient conditions. But, for concentrating systems, the value of the instantaneous electrical efficiency can reach up to 30% level or even more. On the other hand, thermal efficiency is a function of ambient parameters and instantaneous values can show significantly fluctuations.

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