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A Study on Role of HVAC System in Data Center

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ABSTRACT: Data Centers are the facilities that will house the equipment in order to secure, store, and exchange data. Data center environment require precise, stable environment in order for sensitive electronics to operate optimally. IT equipment produces an unusual, concentrated heat load, and at the same time, is very sensitive to changes in temperature or humidity. Standard air conditioning is ill-suited for data centers, leading to system shutdowns and component failures.
Cooling system HVAC (heating, ventilating, and air conditioning technology) is designed for tight control over temperature and humidity. They provide year-round operation with the ease of service, system flexibility, and redundancy, which is necessary to keep the data center up and running 24 hours a day. This paper describes several procedures to improve energy efficiency, not only to allow a supportable industry growth but also to reduce operational costs.

KEYWORDS: Data Center, Cooling System, HVAC system

I. INTRODUCTION

A Data Center is a facility used to house computer systems and associated components, such as telecommunications and storage systems. It is a centralized repository, either physical or virtual, for the storage, management, and dissemination of data and information organized around a particular body of knowledge or pertaining to a particular business. Precisely controlling the environment in data center is critical to maximizing availability and performance of essential equipment. And the challenges of cooling these spaces mount as the move to smaller servers results in significantly higher power consumption and more heat generation. Hence they require spot cooling solutions that are designed to remove the total heat output of a room. Whether you are designing data center from the ground up or upgrading an existing data center.

II. RELATED WORK

The literature review was conducted for HVAC system by searching on the Internet. The review indicates that, for forced ventilation systems designed for offices, the conditioned air is transported either in the ceilings or under the floors. The overhead ceiling system is the conventional way to transport conditioned air. The review suggests that there are minimal flexible and adaptive options for the conventional overhead systems. Therefore, the flexible and adaptive HVAC distribution systems are generally restricted to systems where the conditioned air is supplied from under the floor. Several types of HVAC systems are identified from the literature review and components of HVAC types are described along with their functionality which helps to find suitable HVAC system for designing structure of Data Center. Researcher concluded that HVAC provide better thermal comfort by allowing personal comfort control and

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other air distribution benefits, enhanced thermal ventilation efficiency and indoor air quality, reduced energy usage and improved performance of Data Center.

III. DATA CENTER

Data centers are commonly run by large companies or government agencies. However, they are also increasingly used to provide a fast-growing cloud solution service for private and business applications. Computer system requires electricity, as well as protection from theft and the accidental or intentional manipulation of hardware. One has to safeguard data centers against external influences and provide them with sufficient cooling. After all, there is a lot of powerful hardware sitting in one place. In addition to these factors, one must also take into consideration organizational measures, such as periodic backups that ensure operability. As a rule, the more extensive and critical the hardware and software become, the more time and effort are required to provide optimal protection. For that reason, a data center preferably consists of a well-constructed, sturdy building that houses servers, storage devices, cables, and a connection to the Internet. In addition, the center also has a large amount of equipment associated with supplying power and cooling, and often automatic fire extinguishing systems. Data center management involves ensuring the reliability of both the connections to the data center as well as the mission-critical information contained within the data center's storage.

Data centers have two major types each designed for a specific business model:

1) **Corporate data centers:** Corporate data centers are owned and operated by private organizations or government agencies that are critically dependent upon information and communication technology. Their main purpose is to support data processing and web oriented services.

2) Web hosting data centers: Web hosting data centers providing computer infrastructure as a service. These data centers are primarily owned and operated by third party service providers. Their main objective is to provide IT services to their customers. The services may include wide-area communications, fastest and reliable internet access, web hosting, back-up storage, content distribution and load sharing with new variations which almost appearing daily. These kinds of services benefits large companies and other service providers who need back-up servers for business operations and also to face business risks.

There are three functional requirements of a data center:

1) Data center space planning for locating servers, storage and network devices.
2) Electric supplies and network connectivity provided to other devices.
3) Humidity control environment within the parameters needed.

Parameters which help in planning phase of Data Center:

Data center design focuses on many aspects like Site selection, facility design, IT hardware, cooling, network, power distribution, etc. For a successful data center built project, few parameters needs to be kept at high priority and planned for effectively. This includes characteristics like reliability, availability, serviceability, capacity, scalability/growth plans, manageability and criticality. These factors will help design team and management to design a data center (facility and IT) effectively with required business needs.

Following are some of the parameters which will help in data center planning phase:

Reliability:

Reliability means ability of the system to perform its task and function under stated conditions for a specified time. While designing a data center, reliable components should be used like power supplies, cooling units, servers, storage units, network, etc.

Availability:

Availability refers to the time or proportion of time for which a system is available and operable. While designing a data center, high availability of servers, storage, network, application, power and cooling units, etc. should be considered. Based on requirements, clustering, load balancing, redundant systems needs to be designed.

Criticality:

Another important parameter in designing a data center is criticality of service provided to end customers. If service

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rendered is highly critical and its downtime is costly for the company, data center and IT infrastructure has to be designed accordingly. In contrast, if application is less critical and its downtime is acceptable to certain extent, data center has to be designed accordingly.

Capacity:

Capacity parameter is crucial to know the size of data center and other facilities to be designed. It represents maximum load a data center can handle. Goal of capacity parameter is to make sure that enough power and cooling is available at data center.

Growth plans:

Growth plan provide us information on what can be expected over a period of time in terms of load and requirement. It is important to factor-in growth plan as it will help to add hardware and facilities at required timelines, thus saving money by not keeping them idle.

Scalability:

Scalability is closely related to capacity and growth plans. Based on these two parameters, infrastructure and facility is designed which is scalable over years and can be adjusted smoothly. Servers, Storage, Network, power, cooling etc. should have provision for scalability. Scalability can be Horizontal or Vertical Scalability. Horizontal Scalability implies adding more and more separate independent systems to service the increased load. Vertical Scalability is adding resources within the box to cater to increased workload.

Efficiency:

Due to more and more development in green technology, companies are trying to achieve a target for greening and efficiency. For a better and robust design, it is recommended to freeze efficiency targets during design phase itself.

Density:

It refers to information on floor space available and number of racks in the same. In addition to that average and peak power consumption of each rack will be useful.

Serviceability:

Serviceability refers to how easy it is to find a root cause for an incident or problem and solve the same. During data center design, facilities, hardware and architecture should be finalized keeping serviceability characteristic in mind so that failed components can be replaced without bringing down the entire system.

Manageability:

It refers to how easy, efficient, less time consuming, detailed and effective ways are present to manage facilities and IT infrastructure. This factor will help to make data center operations, management and monitoring easier and secure.

With above characteristics, data center design will be stable, secure and secure enough to provide services as required. Each data center setup project is unique with different set of expectations from stakeholders, but if above mentioned is taken into consideration during design phase, chances of project success will be increased manifold.

IV. COMPONENTS OF DATA CENTER

A data center is a facility that houses IT equipment used to process, communicate, and store data for all our digital activities. A data center is the physical building. The term ‘data center’ can range from a small server closet located in an office building to a one-million square-foot multistory building. However in recent years, a data center typically means a large stand alone building which is designed for continuous IT equipment operation. Today we rely on this IT equipment, and its underlying software, for almost all of our daily activities such as communication, entertainment, navigation, finances, and security. This is why data centers are classified as mission critical facilities.

The major components that make up a data center are as follows:

1) Physical Infrastructure

The architectural and structural components of a data center are consisting of four walls and a roof. A data centers is very similar to a warehouse where the middle of the building is empty but will be filled up with IT equipment instead of boxes. Data centers are built using the same techniques and materials as typical office buildings; however the two structures differ in robustness. Their structural components will be bigger and stronger in order to sustain natural disasters or explosives.

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There are many open rack and cabinet solutions that could be considered part of the physical structure of a data center. The most critical elements are the rack structures housing IT equipment, physical room elements such as dropped ceiling and raised floors, and pathways to manage cabling considerations.

2) IT Infrastructure

The IT infrastructure is its own industry in itself includes different IT equipments: servers, communication gear, and storage equipment.

Servers run software applications (like Gmail, Face book, or Angry Birds) and are almost exactly like your desktop except much faster and more powerful. They are about the size of a pizza box, mounted in racks within the data center.

Communication gear (or networking gear) manages how data is transferred in and out of the data center and between the IT equipment.

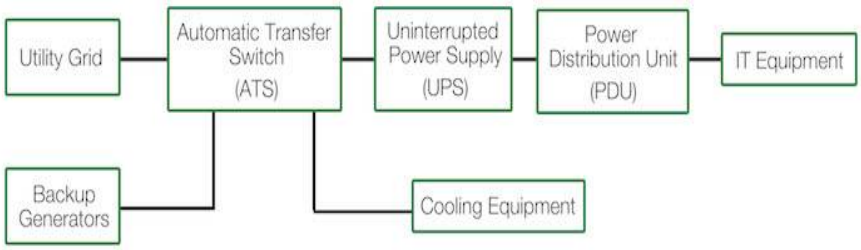
Storage equipment is where all the data, like your Face book photos, bank records, and old emails, is stored.

IT equipment needs two things to operate: (1) electricity for power and (2) cooling for removing the heat that it generates. It is the data centers job to provide both electricity and cooling 24/7/365 without any interruption. This is where the electrical and cooling infrastructure comes into play.

3) Electrical Infrastructure

The purpose of the electrical infrastructure is to take power from the utility grid and deliver it to the IT equipment without interruption ever. If the IT equipment loses power, it will shut down, and this is very costly. Therefore the design and operation of the electrical infrastructure is based on one thing…redundancy. The electrical distribution is designed and built so that if one system fails or a power connection is lost, there is another energy source to keep the power flowing and the IT equipment up and running. Data center staff spends a lot of time managing the health of the electrical infrastructure to prevent any failures.

Below is a general line diagram of the electrical infrastructure showing how power gets from the utility grid to the IT equipment. In practice this is more complex and may include further layers of redundancy, but the concept is the same.



Electrical Infrastructure Line Diagram

The **utility grid** provides the ultimate source of power for the data center. Some facilities are connected to two separate utility grids for redundancy if one goes down.

Backup generators are diesel powered electrical generators that produce electricity in the event the utility grid goes offline. Generators can provide power for hours or even days (however they will need to be refueled for ongoing operation) until the utility grid can provide power again. Backup generators are usually deployed in sets, especially for larger data centers.

Automatic Transfer Switches (ATS) are able to switch the source of power from the utility grid to the backup generators without interruption. In the event of a sudden utility outage, **Uninterrupted Power Supplies (UPS)** provide power to the IT equipment for the minute or two it takes to startup the backup generators.UPS systems typically consist of batteries or flywheels that store just enough energy to bridge the power gap.UPS systems cannot provide power to the IT equipment for a lengthy period of time.

Power Distribution Units (PDU) is the physical 'outlets' that the IT equipment plugs into at the rack level. PDUs are mounted in each rack and contain multiple outlets to be used by the IT equipment.

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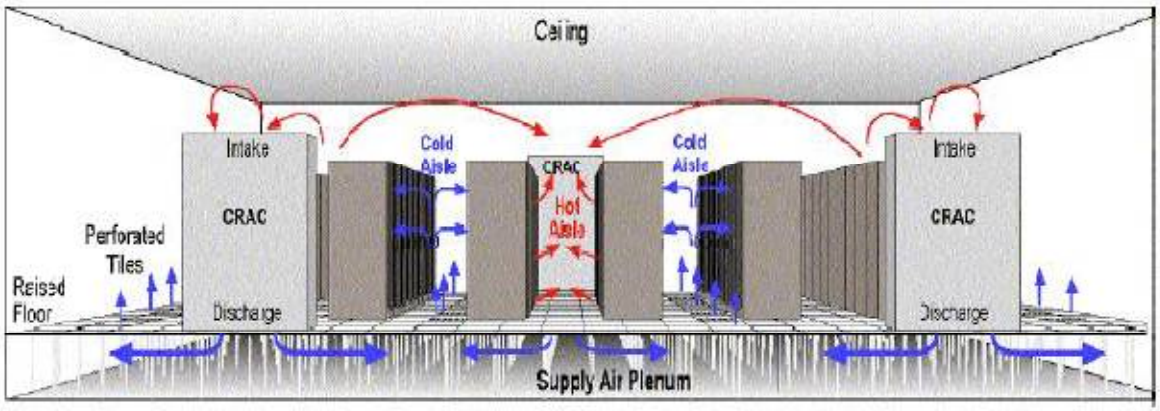
4) Cooling Infrastructure

Laptop gets hot when we use it a lot, so do servers, communication gear, and storage equipment in a data center. The purpose of the cooling infrastructure is to remove the heat generated by the IT equipment. If this heat is not removed, the IT equipment will get too hot and shut down which would be very costly. Just like the IT infrastructure, cooling redundancy is extremely important in order to provide ongoing cooling operation.

The cooling infrastructure consists of air conditioning units called Computer Room Air Conditioners (CRAC) or Computer Room Air Handlers (CRAH).

Cooling infrastructure includes computer room air conditioners and their associated subsystems—chillers, cooling towers, condensers, ductwork, pump packages, piping—and any rack- or row-level cooling or air distribution devices. Data center cooling equipment is deployed in the same physical space as the IT equipment.



Issues raised in Data Centers:

A poorly maintained data center environment will have a negative impact on data processing and storage operations, which leads to following issues:

High or Low Temperature: A high or low ambient temperature, or rapid temperature swings, can corrupt data processing and shut down an entire system. Temperature variations can alter the electrical and physical characteristics of electronic chips and other board components, causing faulty operation or failure. These problems may be transient or may last for days which are very difficult to diagnose and repair.

High Humidity: High humidity can result in tape and surface deterioration, head crashes, condensation, corrosion, paper handling problems, and gold and silver migration leading to component and board failure.

Low Humidity: Low humidity greatly increases the possibility of static electric discharges. Such static discharges can corrupt data and damage hardware.

V. HVAC IN DATA CENTER

The data center equipment generates a large amount of heat in a relatively small area, because every watt of power used by a system is dissipated into the air as heat. Unless the heat is removed, the ambient temperature will rise, eventually beyond design specifications which may result in electronic equipment failure. Especially in enterprise data centers, HVAC systems control the ambient environment which includes temperature, humidity, air flow, air filtering so must be planned for and operated along with other data center components such as computing hardware, cabling, data storage, fire protection, physical security systems and power. The selection of an HVAC system is an important step in planning a data center. These systems account for nearly half of the energy used in a typical commercial building.

HVAC system is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. Refrigeration is sometimes added to the field's abbreviation as HVAC&R or HVACR, or ventilating is dropped as in HACR. HVAC is important in the design of residential structures such as family homes, apartment buildings, hotels and senior living facilities, medium to large industrial and office buildings and hospitals, onboard vessels, and in marine environments such as aquariums, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors.

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The three central functions of HVAC system are interrelated, especially with the need to provide thermal comfort and acceptable indoor air quality within reasonable installation, operation, and maintenance costs. HVAC systems provide ventilation, reduce air infiltration, and maintain pressure relationships between spaces. The means of air delivery and removal from spaces is known as room air distribution.

HVAC systems are classified into self-contained unit packages or central systems. Unit package describes a single unit that converts electricity or gas and provides final heating and cooling to the space to be conditioned. Examples of self-contained unit packages are rooftop HVAC systems, air conditioning units for rooms, and air-to-air heat pumps. In central systems, the primary conversion from gas or electricity takes place in a central location, with some form of thermal energy distributed throughout the building.

The HVAC system is typically distributed across three areas:
1) The HVAC equipment and their controls located in the main mechanical room. Equipment includes chillers, boiler, hot water generator, heat exchangers, pumps etc.
2) The weather maker or the "Air Handling Units (AHUs)" may heat, cool, humidify, dehumidify, ventilate, or filter the air and then distribute that air to a section of the building. AHUs are available in various configurations and can be placed in a dedicated room called secondary equipment room or may be located in an open area such as roof top air-handling units.
3) The individual room controls depending on the HVAC system design. The equipment includes fan coil units, variable air volume systems, terminal reheat, unit ventilators, exhausters, zone temperature devices etc.

VI. TYPES OF HVAC SYSTEM

1. Heating and Air Conditioning Split System
These types of HVAC system have components of the whole system that are both inside and outside the building. HVAC split systems will typically have:

- An air conditioner that cools the refrigerant
- Furnaces and a fan or evaporator coil to convert the refrigerant and circulate the air
- Ducts that carry air all through your building
- A control panel/thermostat to manage the system
- The occasional optional accessories for quality indoor air such as air cleaners, purifiers, humidifiers, UV lamps and so on

2. Hybrid Heat Split System
These systems have improved energy efficiency. In these systems, a heat pump will allow the option of having an electrically fueled HVAC up and above the typical gas furnaces. Hybrid heat split system that is cost effective will have:

- A heat pump that heats or cools the refrigerant
- Furnaces plus the evaporator coil for conversion of the refrigerant and circulation of air
- The ducts to channel the air around your building
- Your interface for adjusting and controlling the system
- Optional accessories for more quality indoor air

3. Duct-Free Split Heating & Air Conditioning System
A duct-free HVAC provides good installations for places and areas where the convectional systems with ducts can't go. Duct-free systems will have the following;

- The heat pump or an air conditioner to heat\cool the refrigerant
- A fan coil that is compact
- Wires and tubing for the refrigerant, connecting the outdoor unit to the fan coil
- The thermostat or control panel
- Optional accessories to clean the air and make it more pleasant before its distribution through the house

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4. Packaged Heating & Air Conditioning System

A packaged HVAC system is the solution to those homes and offices without adequate spaces for all the separate multiple components of the split systems. Packaged HVAC systems will contain:

- The air conditioner/heat pump together with the evaporator/fan coil in one unit
- Thermostat/control interface for a complete control of the system
- Optional air quality improvers. Things like the air purifiers, cleaners, ventilators or UV lamps, which gear towards making the air extra clean before it circulates your home or office.

VII. HVAC SYSTEM PURPOSE AND BENEFITS

Purpose of HVAC systems:

- To maintain comfort by controlling temperature and humidity within acceptable limits.
- To maintain air quality within acceptable limits of carbon dioxide, oxygen and odor content.
- To remove airborne contaminants produced by processes and occupants.
- To remove internal heat gain produced by processes, building services and occupants.
- To provide special environment control for equipment and processes.

Benefits of HVAC Systems:

With the arrival of green technologies, new HVAC systems have become sustainable and environmentally-friendly while being both energy and cost efficient. Here are some of the benefits of a great HVAC system:

1) Energy Conservation: HVAC unit possesses both heating and cooling capability in a single unit, resulting in immediate savings on construction space, power usage and installation fees. Also, HVAC systems run on renewable energy sources such as wind or solar, enabling you to take full advantage of alternative-energy savings.

2) Better Air Quality: With the installation of an HVAC system, not only is the outside air in the system filtered, the inside air also gets cleansed, clearing out germs and allergens.

3) Proper Moisture Regulation: Moisture regulation is important for both building and personal health. Too much moisture can result in mold and mildew growth, and too little creates discomfort and heat loss. With an HVAC system, moisture regulation is part of the system's operation, ensuring that an optimal moisture level is regulated and consistent.

VIII. CONCLUSION

The growing number, size, complexity and energy density of data centers due to increasing demand for storage, networking and computation bring a considerable energy challenge. Cooling energy consumption constitutes a large portion of the total consumption of data centers in commercial business, which can account up to 40% in the case of inefficient cooling systems. Businesses can manage their energy budget by focusing on this important area.

HVAC systems are complex, but understanding the language of HVAC and principles of operation will help you achieve optimum indoor air quality while minimizing energy use. A well-executed preventive-maintenance program, combined with building upkeep and equipment upgrades, can provide substantial energy-cost savings.

In this paper we described different types of HVAC system. With this knowledge of the available types and an understanding of specific needs, it is easy to know which kind of heating, ventilation and air conditioning system is to be needed.

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