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Strategies in Energy Conservation and Management of Heating, Ventilating and Air-Conditioning (HVAC) System of a Data Center

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ABSTRACT: *This paper addresses the issue of energy performance of data centers (Server Farms). The primary objective of the study is to understand an empirical energy use pattern of data centers under various conditions like tropical climatic conditions, thermal management problems (HVAC) which consumes about 60 – 70 % of the energy, and suggest strategies and give guidance for data centers' design, operation and maintenance and retrofitting to achieve better energy performance. Identification of different zones in a data center, actual energy use characteristics, the airflow and temperature patterns, cooling of electronic equipments, chilled air distribution, lightening system, design criteria, and energy and cost saving potentials were analyzed and compared. Methodology of energy performance evaluation of data centers was discussed. The study concludes that data centers were high energy consuming areas, substantially the HVAC area. Power demands were often grossly over-provided in these facilities. This leaded to substantial increase in capital, running cost, harmful environmental effects. Approximately 40% of energy consumption could be conserved through monitoring, evaluation of implemented conservation measures, efficient designs of base infrastructure and energy consuming systems, practical benchmarking, latest technologies and better practices.*

I. INTRODUCTION

A **data center** or **datacenter** (or **datacentre**), also called a server farm, is a facility used to house computer systems and associated components, such as telecommunications and storage systems. It generally includes redundant or backup power supplies, redundant data communications connections, environmental controls, which includes air conditioning, fire suppression and security devices.

II. APPLICATION AND COMPONENTS OF DATA CENTERS

The main purpose of a data center is running the applications that handle the core business and operational data of the organization. Often these applications will be composed of multiple hosts, each running a single component. Common components of such applications are databases, file servers, application servers, middleware, and various others. Data centers are also used for off site backups. In short, data center components include Compute servers, Communication devices, Tape storage, Storage servers, Workstations (standalone) and other rack- and cabinet-mounted equipments.

Five Major Functional Components of a Data Center are: -

=> Data Center Equipments Area => Data Center Cooling system
=> Data Center Electrical System => Data Center Fire Protection System
=> Data Center Physical Security

III. REQUIREMENTS OF DATA CENTER

The Telecommunications Industry Association (TIA) in April 2005 responded with the TIA-942 Telecommunications Infrastructure Standards for Data Centers, the first standard to specifically address data center infrastructure.

• Site space and layout • Cabling infrastructure • Tiered reliability • Environmental considerations

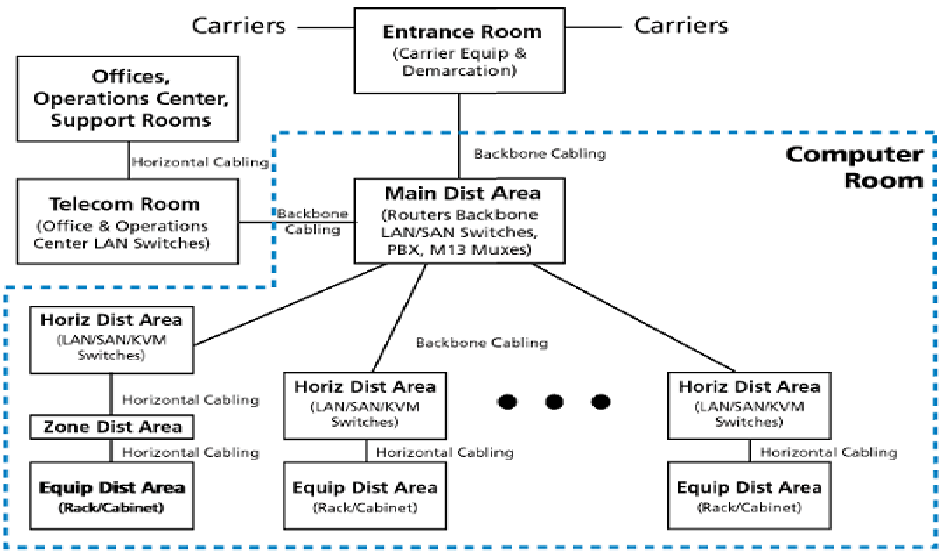

Figure I. Data Center Layout as per TIA –942 standards

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According to TIA-942, a data center should include the key functional areas: -

=> Main Distribution Area (MDA) => Equipment Distribution Area (EDA)
=> Zone Distribution Area (ZDA) => Backbone and Horizontal Cabling
=> Cabling Infrastructure

IV. TOP DATA CENTER CHALLENGES

- ♦ Power and Cooling,
- ♦ Space/Space planning and size limitations,
- ♦ Cost/budgets,
- ♦ Growth/change,
- ♦ Staffing/qualified staff
- ♦ Maintenance,
- ♦ Security,
- ♦ Technology,
- ♦ Outsourcing etc.

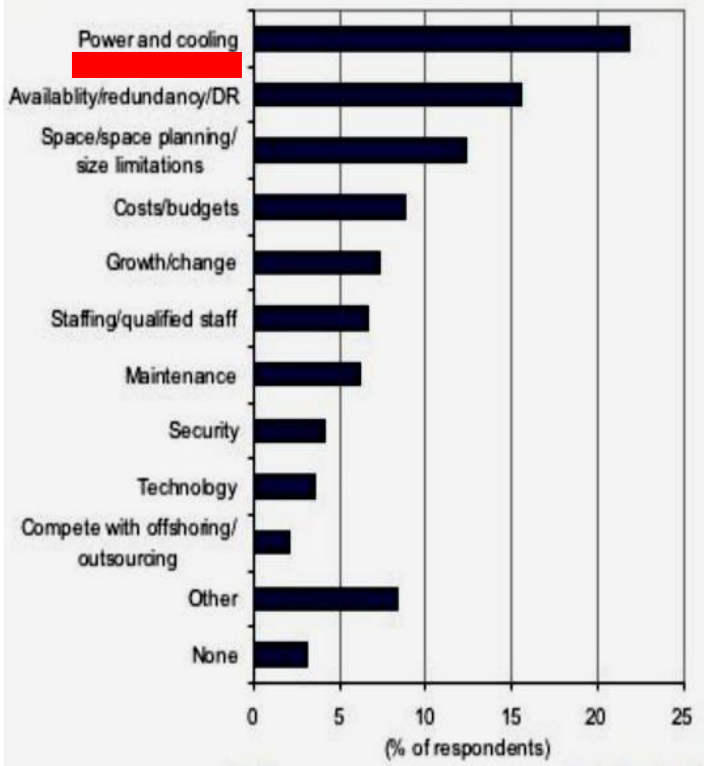

Table I. Data Center Challenges

The graph is self-explanatory and can be interpreted that Power and Cooling is the top most challenge to be faced while running, studying and improving data center efficiency.

V. WHERE GOES THE ENERGY?

1. Lightening 3 %
2. UPS Loss 5 %
3. HVAC 42 %
4. IT Equipments 50 %

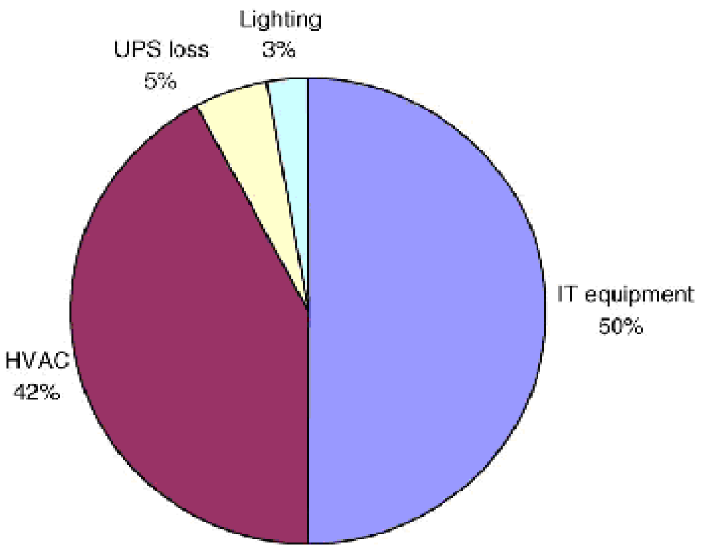

Figure II. Energy Consumption

VI. ENEGRY CONSERVATION AND MANAGEMENT

5.1 HVAC LOAD CONSIDERATIONS AND CHALLENGES

HVAC loads are a high internal sensible heat load from the datacom equipment itself and a correspondingly high sensible heat ratio. The effect of the other loads (envelope, lighting, etc.) becomes proportionately more important in terms of part-load operation. The part- and low-load conditions must be well understood and equipment selected accordingly. • Existing applications floor space • Performance growth of technology based on footprint • Processing capability compared to storage capability • Change in applications over time • Asset turnover • Ventilation and Infiltration • Electrical Equipment • Lights

5.2 AIR CONDITIONING SYSTEM DESIGN AND CAPACITY

Design Criteria: Environmental requirements of datacom equipment vary depending on the type of equipment and/or manufacturer. However, a consortium of manufacturers has agreed on a set of four standardized conditions (Classes 1 to 4). A fifth classification, the Network Equipment—Building Systems (NEBS) class, is typically used in telecommunications.

Class 1	Class 2	Class 3	Class 4	NEBS
enterprise servers and storage products.	small servers, storage products, personal computers and workstations.	personal computers, workstations, laptops, and printers.	industrial controllers, or computers and handheld electronics such as PDAs.	environment are switches, transport equipment, and routers.

(NEBS) -Network Equipment—Building Systems

Table II. Datacom equipment classes

Data Processing and Electronic Office Areas

Table 1 Class 1, Class 2, and Selected NEBS Design Conditions

Condition	Classes 1 and 2: Allowable Level	Classes 1 and 2: Recommended Level	NEBS: Allowable Level	NEBS: Recommended Level
Temperature control range	15 to 32°C[a,f] (Class 1) 10 to 35°C[a,f] (Class 2)	20 to 25°C[a]	5 to 40°C[c,f]	18 to 27°C[d]
Maximum temperature rate of change	5 K/h[a]		30 K/h[a,c] 96 K/h[a,d]	
Relative humidity control range	20 to 80%, 17°C max. dew point[a] (Class 1) 21°C max. dew point[a] (Class 2)[e]	40 to 55%[a]	5 to 85%, 28°C max. dew point[c]	Max 55%
Filtration quality	65%, min. 30% (MERV 11, min. MERV 8)[b]			Min. 85% (Min. MERV 13)[b]

Table III: Data Processing and Electronic Office Areas

5.3 TEMPERATURE MEASUREMENT IN DATACENTER

Measurement of temperature plays important role in analyzing, controlling and deciding the direction of cooling. The air temperature of the IT server room and the surrounding temperatures of the equipment were measured using a thermal infrared imaging camera and a digital thermo hygrometer.

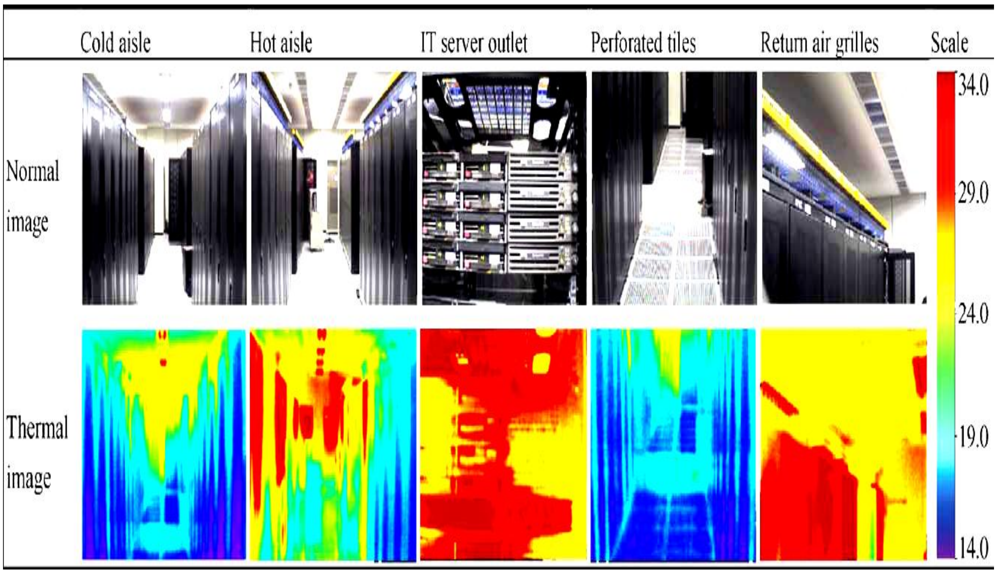

Figure III. Infrared thermography images of the IT server room.

Measurement of temperature with the help of Digital thermometers, Thermocouples, Sensors working in different temperature and environment may help to find correct temperatures.

5.4 INFRASTRUCTURE OBSERVATIONS AND MEASUREMENTS

• Cable Management • Fire Protection • Floor Layout • Overhead Ducting • Raised Floor
• Environmental Specifications • Temperature • Temperature Rate of Change Humidity • Filtration and Contamination • Ventilation • Envelope Considerations • Pressurization. • Space Isolation. • Vapor Retarders. • Sealing • Condensation on exterior glazing. • Human Comfort • Acoustics

5.5 ANALYSIS USING LATEST TECHNOLOGIES AND BENCHMARKS

• **CFD** (Computational Fluid Dynamics): **-** Use of CFD helps to identify and automate the HAVC system controls.
• **PUE / DCIE Benchmarking**
PUE(Power Usage Efficiency) = Total Facility Power / IT Equipment Power
DCiE (Data Center's Infrastructure Efficiency) = IT Equipment Power / Total Power **Develop a testing schedule:**
• Basic Efficiency Program: Monthly/Weekly •Intermediate Efficiency Program: Daily • Advanced Efficiency Program: Continuous (hour to hour) • Whether the calculations happen once a month or once an hour, any regular measurement is a step in the right direction.
• **Best Practice Assessment**
• Plan Your HVAC Efficiency Objectives • Know the HAVC power distribution components • Find your Total HVAC Power •Measuring data center HVAC performance •Recommended Data Center HVAC Performance • Measurements and Solutions • Ability to Track and Assess Equipment Availability • Ability to Assess Availability/Reliability of Critical Facilities • Meeting the Challenge • How Can The Latest Technologies Help You Improve Data Center HVAC Performance**?**

VII. CONCLUSION

- Coordinated and expertise efforts during early stage of designing as well as implementing (such as telecommunications, power, architectural in-outs, and supporting systems) helps to conserve and manage energy requirements for HVAC.
- For more detailed results, temperature and airflow closer to the electronic components have to be investigated using latest technology methods/procedures/equipments.
- CFD and Energy simulations tools find greater scope in research of energy conservation and management of HVAC systems.

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