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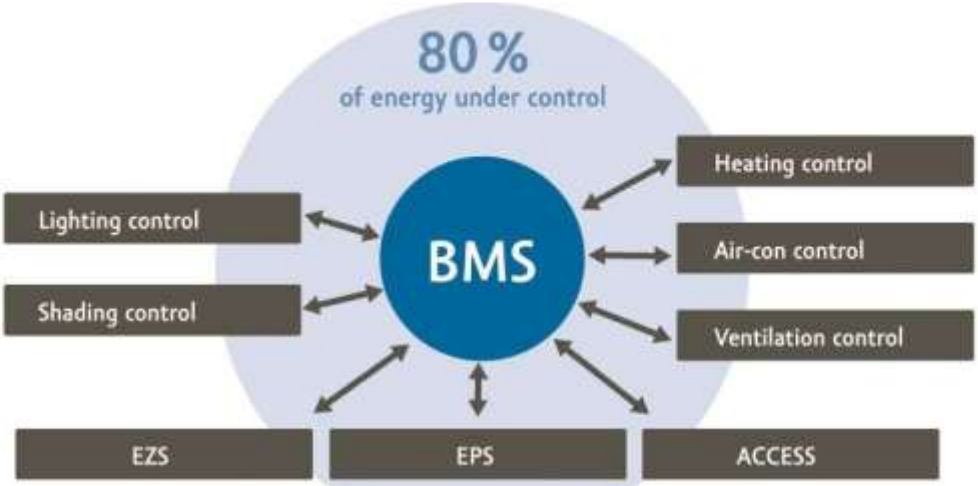
**SCHOOL OF BUILDING AND ENVIRONMENT**

**DEPARTMENT OF ARCHITECTURE**

# UNIT – I – Building Automation Systems – SAR1615

**INTRODUCTION**

Definition : Building automation is the automatic centralized control of a building's heating, ventilation and air conditioning, lighting and other systems through a building management system or building automation system (BAS).




The term building automation system, loosely used, refers to any electrical control system that is used to control a buildings heating, ventilation and air conditioning (HVAC) system. Modern BAS can also control indoor and outdoor lighting as well as security, fire alarms, and especially everything that is electrical in the building.

A building controlled by a BAS is often referred to as an intelligent building, "smart building", or (if a residence) a "smart home".

What is the function of a BAS?

The primary function of a BAS is to provide control of heating, cooling, ventilation, lighting and other critical building systems.

However, it also monitors individual components to alert building managers about detected problems because it has access to a full range of building data.

For example, BAS tracks temperature data which is critical for proper climate control and occupant comfort. It can use pressure and chemical sensors to uncover air quality issues in mechanical aspects of the building.

A building's security system relays data to the BAS to indicate potential intruders.

WHAT IS AN INTELLIGENT BUILDING?

A building incorporating :

-information systems that support the flow of information

-Allowing business automation

-Monitoring management and maintenance

-Ensuring flexibility ,simplicity and economy ……......IS AN INTELLIGENT BUILDING

**Origin & History of intelligent building**


"A building which provides a productive and cost-effective environment through optimization of four basic elements: structure, systems, services and management, and the interrelationship between them." -*Intelligent Buildings Institute*

- The term "intelligent building" has been in use since the early 1980s .

- Although several organizations have attempted to establish a universal definition, there are a multitude of definitions with different levels of detail and varying degrees of emphasis on various aspects of building intelligence.

- According to the initial definition, an intelligent building is one that optimally matches its four elements to the users' needs with an emphasis on the technology that makes the interrelationship between the element possible.

- As intelligent buildings began to take hold around the world in the late 1980s and 1990s, many competing definitions were put forward.

**Origin & History of intelligent buildings**

- In Europe, the European Intelligent Buildings Group coined a new definition stating that an intelligent building "creates an environment which maximizes the effectiveness of the building's occupants while at the same time enabling efficient management of resources with minimum life-time costs of hardware and facilities," tilting the spotlight towards the occupant's needs to be served by technology.

- In Asia, the definitions focused on the role of technology for automation and control of building functions.

- In the late 1990s and early 2000s, the intelligent building spotlight tilted towards energy efficiency and sustainability with the introduction of the BREEAM code (1990) and the LEED program (2000).

- In the late 2000s, given the increasing convergence of intelligence and sustainability, a Frost and Sullivan research paper commissioned by the Continental Automated Buildings

Association, coined the term “Bright Green Buildings” for buildings that are both intelligent and green.

Today, major shifts are occurring in the way buildings are designed, operated and used. Corporate real estate, facilities and IT departments stand to benefit greatly from the use of building intelligence in order to meet space optimization, energy efficiency and connectivity challenges at a time when changing workplace demographics come with increasing occupant expectations of modern and flexible space design, improved comfort, productivity, and pervasive connectivity.

Defining an intelligent building

“A building equipped with lighting, heating, and electronic devices that can be controlled remotely by Smartphone or computer.” Most commercial products can provide only the ability to use a remote control and predefine behaviour of different engineering systems. It has been shown that there is no any intelligence in such Systems.

"Instead of being programmed to perform certain actions, the house essentially programs itself by monitoring the environment and sensing actions performed by the inhabitants”(e.g., turning lights on and off, adjusting the thermostat), observing the occupancy and behaviour patterns of the inhabitants, and learning to predict future states of the house.


• Inhabitants comfort: "Smart" buildings learn from inhabitants behaviour and tries to maximize their comfort.

• Energy savings: "Smart" buildings can significantly reduce energy consumption. It is profitable for building owners as it leads to costs cut.

• Time saving: "Smart" buildings can save a lot of time by automating daily routines.

• Safety: "Smart" buildings can detect fire, water and gas leaks. "Smart" buildings have a self-diagnostic system and warns inhabitants when equipment becomes faulty or performance starts to decrease.

•	Health and care: In all "smart" buildings decisions health of inhabitants has the highest priority. It is reflected in appropriate temperature, light intensity, air condition parameters, etc.

•	Assistive domotics: "Smart" homes can improve the quality of life of the elderly and the disabled living alone by providing a safe and comfortable environment. Homes assist in daily routines, alerts social services and relatives. if emergency help is required, reduce a sense of isolation by connecting with other people through the internet and so on.

Intelligent building is the one which helps business owners, property managers and occupants to realize their goals in the areas of cost, comfort, convenience, safety, long-term flexibility and marketability

In a simple and clear term, one can summarise these definitions and explanations thus:

An intelligent building is a computer aided (automated) building that is designed and centrally managed to ensure safety, comfort and productivity for its occupants as well as energy efficiency, through sensing and communication devices, thereby enhancing long-term sustainability at minimal running cost.

Other terms which could be interchangeably used to describe intelligent buildings are Smart Buildings and Automated buildings

**Pneumatics**

- Pneumatics is the application of pressurized gases to create mechanical motion of some sort
- Prior to electrical and digital control, pneumatics were the primary means for controlling building HVAC systems
- Very reliable systems if routinely calibrated and if air supply maintained properly
- Difficult to maintain tight control
- Limited system access / Difficult to modify control sequences
- Many existing buildings still have at least some pneumatics

**Electric Controls:**

- Electric controls utilize relays, time delays, clocks, thermostats, actuators, and various other basic electrical devices to maintain building space comfort
- Electric control systems gained popularity in the 1970s and 1980s and began replacing pneumatic control components in buildings
- Less component calibration required
- Tighter control possible
- Easier to modify control sequences

**Direct Digital Controls:**

Direct Digital Controls is the application of microprocessor- based, networked distributed controllers to make control responses to changing systems parameters

- Less moving parts within the control syste
- More accurate control
- Better access to system information / trending capabilities
- Easier to modify control sequences
- Ability to route alarm conditions to multiple locations
- Simple to make scheduling changes

The first digital control systems for commercial buildings  were developed in the 1960s.The Honeywell 16 Series was one of the first (pdf packet).In the late 1980s, DDC systems began gaining wide  acceptance in commercial buildings. The 1990s saw the emergence of standard industry  protocols for communication (BACnet / LonWorks). In the last 10 years, integration between various  manufacturers has intensified (Tridium

**Modern Building Automation Systems**

- HVAC / Lighting / Access / Energy Tracking Often Combined
- Integration with fire alarm, security, renewable energy  systems
- Integration between equipment manufacturers
- Modern BAS systems serve as the central point of control and  monitoring of the facilities' most important and complex  systems- IBMS

**What are the components of BAS?**

BAS is a structural system and generally consists of five components: sensors, controllers, output devices, communication protocols and a terminal or user interface.

1.Sensors: These devices track temperature, humidity, the number of people in a room, the lighting level, and other values. The sensors transmit this information to centralized controllers.

2. Controllers: Act as the "brain" of the BAS. They collect data from sensors and then send commands to operating systems like HVAC units, the building's lighting systems, security alarms and other connected parts.

3. Output devices: Once the controller sends out a command, actuators and relays go into action to follow the requirements. For example, they can reduce or increase the heating in a particular part of the building, dim lights in unused offices, or turn on the air conditioning before people come to work.

4.Communication protocols: The BAS uses a specific language that's understood by the system's individual components to modify settings or execute commands. BACnet and Modus are the most commonly used options in communication protocols.

5. Terminal interface: Building and facility managers interact with the BAS through a terminal or user interface. It presents information in a way that a user can monitor the condition of the building and choose to override settings manually.

**Direct Digital Control (DDC)**

• In a basic control loop; a sensor, controller & controlled device interact to control a medium.

• Here, the controller is a distinct piece of hardware.

• In a Direct Digital Control (DDC) system, controller function takes place in software.

**Hardware**

"smart" buildings need an ability to recognize what's happening with an environment (inside and outside a building), something like human senses. For this purpose "smart" buildings are equipped with sensors and meters. So, a building can determine rooms' occupation, light intensity, inside and outside temperature, carbon dioxide level, noise level, detect a gas leak and so on.

Besides observing the environment, a building also should be able to change its state. For this purpose "smart“ buildings are equipped with devices and actuators that can control various engineering systems like lighting, heating, air conditioning, entertainment system and so on.


*Temperature sensors*


Noise sensors

**Hardware**

WEATHER SENSORS –

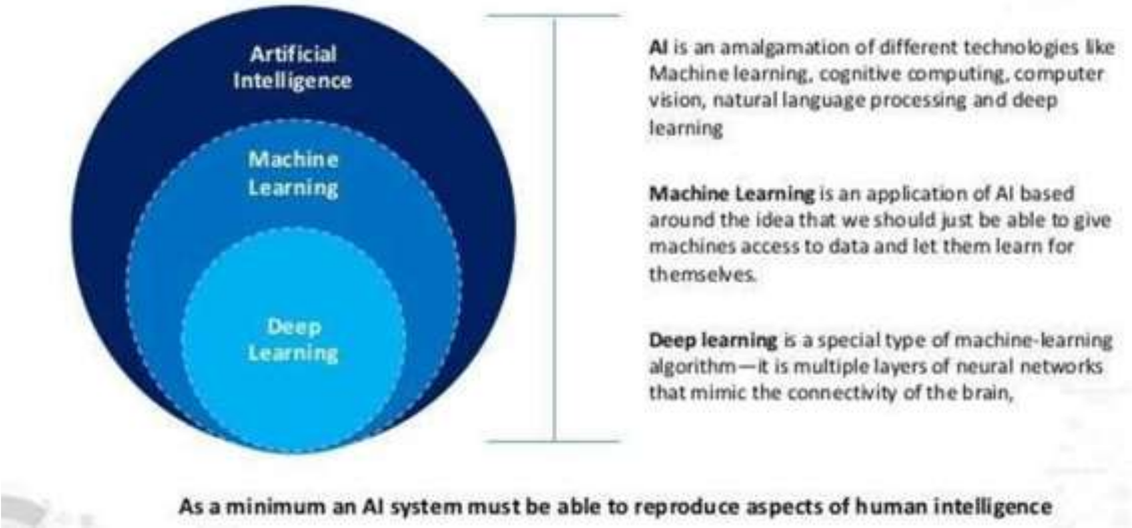
Measured parameters

- Air temperature
- Relative humidity
- Air pressure
- Wind velocity
- Wind direction
- Precipitation amount, intensity and type
- UV index
- Sun direction
- Brightness and twilight
- Global radiation.

**Software**

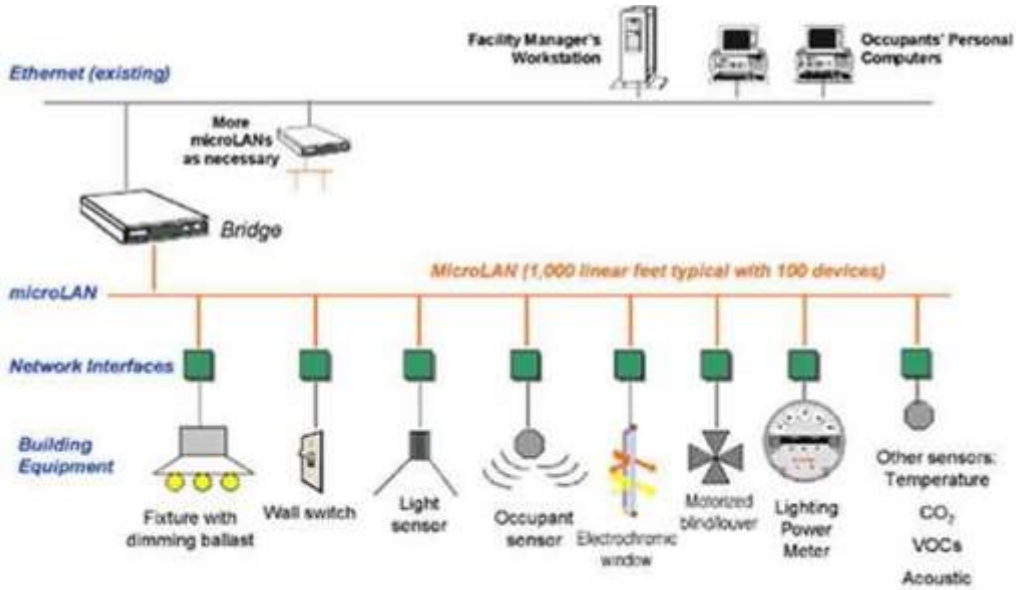
Sensors and meters provide only raw information. A "smart" building needs to extract useful information, learn from this information, make decisions and even predict future state of environment and people activities. It is done by special software which is an artificial intelligence of a building. One of the most widely used techniques is a machine learning.

Machine learning is a part of all modern developments of "smart" buildings.




**Network**

To allow the building to act as a whole- a communication network is required. It connects all devices between each other and with the artificial intelligence component. It is the nervous system of a building.



Building automation systems rely on standardized network protocols, the most commonly used of which are:

-BAC-net

- LonWorks

-KNX/EIB

-Internet based–wired and wireless

**BACnet**

BACnet (Building Automation and Control Networks) is a high-order protocol for building automation. It was developed in 1995, in conjunction with ASHRAE (the American Society of Heating, Refrigerating and Air-Conditioning Engineers). The aim was to create a manufacturer-independent communication protocol for intelligent components and systems in building automation.

BACnet allows automation stations from various manufacturers to exchange information with each other without incurring any licence costs for special data transfer hardware. BACnet is therefore used if several different manufacturers need to be linked in a network via a protocol.

The Network of BAS:

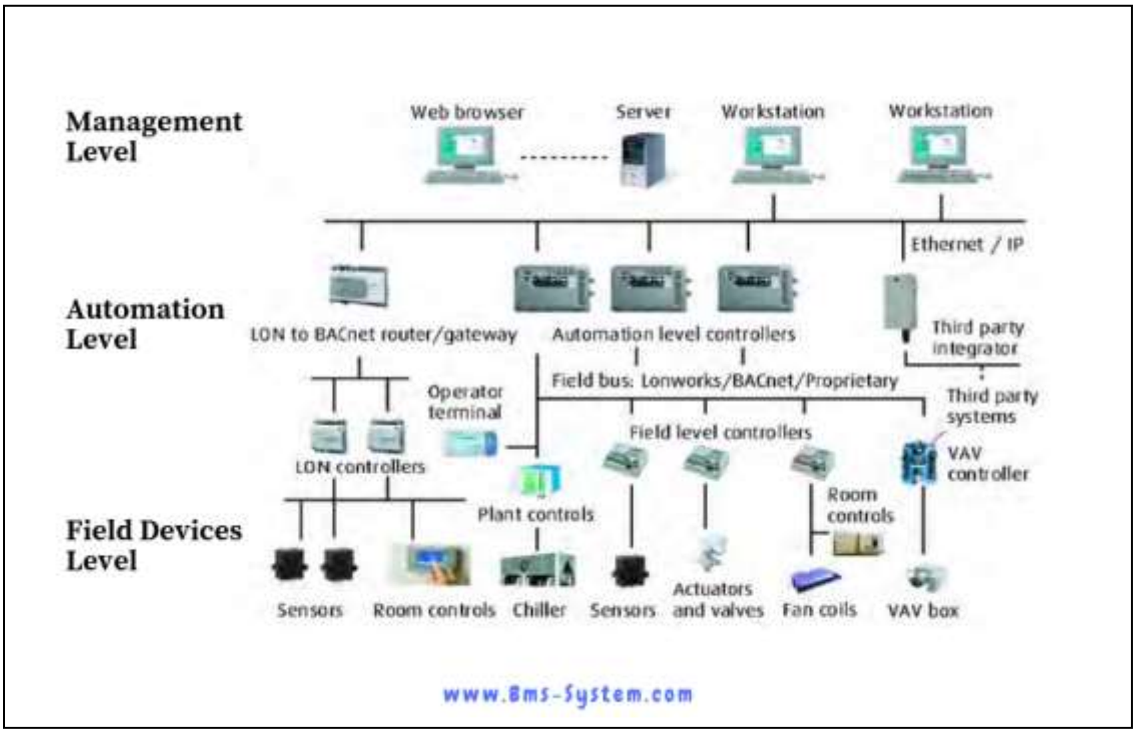
- Field Level
- Automation/ Application Level
- Management Level

The field level involves the design of all functions and measurement and reporting of data.

This data comes from sensors (for example temperature sensors, air quality sensors, luminosity sensors, movement detectors, window contacts, wind speed sensors, rainfall sensors) and actuators (servomotors for valves and flaps, switch and dimming equipment for the lighting, drives for sun shades, windows and doors) and other buttons and switches.
The application level concerns the collation and evaluation of information. Switch and positioning commands are sent back to field level. They can also be transferred to all of the other levels in the command level, however.

The management level monitors the system and optimises its mode of operation using special software, i.e. a building management system. The software visualises and saves information and data.

To transfer information from the sensors or positioning commands to actuators, the devices need to be linked in a shared network




An Intelligent building is one that is responsive to the requirements of occupants, organisations and society. It is sustainable in terms of energy and water consumptions besides being lowly polluting in terms of emissions and waste: healthy in terms of well-being for the people living and working within it; and functional according to the user needs.

Difference between Automated and Intelligent buildings:

Automation – Automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human labor.

Intelligence –

(1): the ability to learn or understand or to deal with new or trying situations

(2): the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (such as tests).

Building automation systems help a facility owner save energy and optimize performance through things like scheduling, controlling output based on occupancy, and more.

However, the capabilities of a traditional BAS stop there.

The major difference between a BAS and an intelligent building is the ability for an intelligent building to analyze data from multiple sources.

The control of our facility assets becomes 'intelligent' through the facility's ability to learn from that data and change operations accordingly.

A Building Automation system is essentially a self-contained system that is not always connected to the internet. They exist primarily for the benefit of the building owner or the management of that space. Their sought for benefits were reduced energy consumption, cost and maintenance.

Intelligent buildings go far beyond those building automation systems that primarily focus on energy savings. Intelligent Building has sensors and devices that allows us to represent physical objects, systems and spaces in a digital way. The data collected by IoT devices enable us to optimise the function of the building's systems and spaces within the building.

**Lighting Controls**

In BAS Lighting control systems can operate by a schedule (i.e., – turn off automatically at 10 pm and turn on automatically at 7 am), change their output based on occupancy or the presence of daylight in the space, and can have their programming changed through a software interface.

In an intelligent building, your facility will analyze occupancy data in each lighting zone and change your programming automatically. For example, if the historical data from one department shows that no one arrives before 8 am, your program will adjust so that the lights remain off until 7:30 am. At 7:30, they will turn on to 20% output and then ramp up to full output on detection of occupancy. Similarly, through a connection to your company's calendar, the facility can detect events like key customer visits and change the light output in specific departments or throughout the facility automatically before the customer arriving onsite. This data driven decision and operation within the system is Enterprise Management, which leads to intelligent building.ntelligent building / Responsive building.

Kinetic Façades in Responsive buildings:

A kinetic façade is one that changes dynamically rather than being static or fixed, allowing movement to occur on a building's surface.. A kinetic façade can be used to manage light, air, energy, and even information. They can act to reduce solar gain as well as allowing the passage of fresh air into the building, helping to alter the interior environment. The moving elements of the façade can be programmed to respond to climatic or other environmental factors, time, levels and type of occupancy and so on to improve performance and efficiency.

With advances in sensors, materials and building management technology, designers are increasingly able to consider kinetic components as design solutions.

The Al Bahr Towers in Abu Dhabi has a computer-controlled facade made of umbrella-like panels. These panels open and close throughout the day in response to the sun's movement, giving optimal shading and allowing light to enter the building as required.

BENEFITS OF SMART BUILDINGS:

Inhabitants comfort: "Smart" buildings learn from inhabitants behaviour and tries to maximize their comfort.

Energy savings: "Smart" buildings can significantly reduce energy consumption. It is profitable for building owners as it leads to costs cut.

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Case studies:

Capital Tower is home to several intelligent energy efficiency systems, inclusive of an energy recovery wheel system in its air-conditioning unit; allowing cool air to be recovered to maintain the chillers' efficiency. Capital Tower is fitted with motion detectors within the lift lobby and toilets to conserve energy To create a reduction in water usage, the building utilises condensation from the air handling unit, while specific devices monitor the carbon dioxide and carbon monoxide, ensuring optimal air quality and distribution. This building is an exceptional example of intelligent workplaces, which are designed to reduce their carbon footprint by addressing sustainable solutions for the impact of employee working habits and needs, and the natural climate

*Burj Khalifa,*

Burj Khalifa, Dubai

The Burj Khalifa team partnered with Honeywell Building Solutions to pilot Honeywell's Outcome Based Service (OBS) solution across the mechanical components of the heating, ventilation, and air conditioning (HVAC) system.

The OBS software as a service solution involves collating real-time field data, pushing this data to the Honeywell Sentience IoT Platform, identifying anomalies, and running smart algorithms for predictive and prescriptive maintenance of the building's mechanical assets.

This service has enabled Burj Khalifa's maintenance team to transform from a traditional planned and preventative maintenance regime to a predictive maintenance program for mechanical systems, which is also known as a Reliability Centered Maintenance (RCM) approach. The RCM approach At the core of OBS is Honeywell Sentience, a cloud-based IoT platform that delivers secure big data capabilities for all of Honeywell's connected solutions. The platform allows Burj Khalifa's facility managers to use building data analytics for predictive and prescriptive maintenance.

Honeywell highlighted that the pilot has resulted in a significant reduction in preventative mechanical maintenance tasks and an overall 40% reduction in total maintenance hours for mechanical assets, while improving the availability to 99.95%, enabling a significant reduction of unplanned reactive maintenance. Burj Khalifa also uses Honeywell's EBI system, a technology that provides a unified view of building systems and increases the connectivity of smart devices to improve efficiency, increase responsiveness and maximize operational control.

With access to real-time facility data, Burj Khalifa's facility management team is now able to detect incidents faster, respond more quickly and mitigate any impact, more cost effectively.optimizes maintenance costs and increases asset reliability,

CALCULATION OF VENTILTION IN BUILDINGS

Air changes per hour

Abbreviated ACPH or ACH, or air change rate is a measure of the air volume added to or removed from a space (normally a room or house) divided by the volume of the space. If the air in the space is either uniform or perfectly mixed, air changes per hour is a measure of how many times the air within a defined space is replaced.

In many air distribution arrangements, air is neither uniform nor perfectly mixed. The actual percentage of an enclosure's air which is exchanged in a period depends on the airflow efficiency of the enclosure and the methods used to ventilate it. The actual amount of air changed in a well mixed ventilation scenario will be 63.2% after 1 hour and 1 ACH. In order to achieve equilibrium pressure, the amount of air leaving the space and entering the space must be the same.

$$ACPH = \frac{60Q}{Vol}$$

Where:

ACPH = number of air changes per hour; higher values correspond to better

Q = Volumetric flow rate of air in cubic feet per minute (cfm), if using Imperial units, or cubic meters per minute

if using SI

Vol = Space volume( L × W × H) , in cubic feet if using Imperial units, or cubic meters if using SI

The conversion between air changes per hour and ventilation rate per person is as follows:

$$Rp = \frac{ACPH * D * h}{60}$$

Where:

Rp = ventilation rate per person (CFM per person, L/s per person)

ACPH = Air changes per hour

D = Occupant density (square feet per occupant, square meters per occupant)

h = Ceiling height (ft, meters)

Ventilation rates are often expressed as a volume rate per person (CFM per person- Cubiq feet per minute , L/s per person).

1. FOR GENERAL MECHANICAL VENTILATION

ventilation rate (cubiq m /s) = air change rate X room volume/ 3600

2. FOR FRESH AIR RATE CALCULATION

fresh air rate (cubiq m / s) = fresh air rate per person(litres per second per person) X no. of occupants

| Activity | Minimum ventilation requirement Litres /s per person | |
|---|---|---|
| | 0.5% $CO_2$ limit | 0.25% $CO_2$ limit |
| Seated quietly | 0.8 | 1.8 |
| Light work | 1.3 – 2.6 | 2.8 – 5.6 |
| Moderate work | 2.6 – 3.9 | N/A |
| Heavy work | 3.9 – 5.3 | N/A |
| Very heavy work | 5.3 – 6.4 | N/A |

The table gives ventilation rates required to limit CO2 concentration where the

type of activity is known.

Table 3.2 CIBSE Guide B2 (2001) ventilation rates

**Typical Air Changes Per Hour Table**

| | |
|---|---|
| **Residential** | |
| Basements | 3-4 |
| Bedrooms | 5-6 |
| Bathrooms | 6-7 |
| Family Living Rooms | 6-8 |
| Kitchens | 7-8 |
| Laundry | 8-9 |
| **Light Commercial** | |
| **Offices** | |
| Business Offices | 6-8 |
| Lunch Break Rooms | 7-8 |
| Conference Rooms | 8-12 |
| Medical Procedure Offices | 9-10 |
| Copy Rooms | 10-12 |
| Main Computer Rooms | 10-14 |
| Smoking Area | 13-15 |
| **Restaurants** | |
| Dining Area | 8-10 |
| Food Staging | 10-12 |
| Kitchens | 14-18 |
| Bars | 15-20 |
| **Public Buildings** | |
| Hallways | 6-8 |
| Retail Stores | 6-10 |
| Foyers | 8-10 |
| Churches | 8-12 |
| Restrooms | 10-12 |
| Auditoriums | 12-14 |
| Smoking Rooms | 15-20 |

Table 3.1 CIBSE Guide B2 (2001) Air changes required based on function of the space.

* Chartered Institution of Building Services Engineers (CIBSE)

CALCULATING INDOOR WIND VELOCITY

Rate of ventilation airflow (Q)

$Q = H/(60 * CP * \rho * \Delta t)$

$= H/1.08 * \Delta t$

Where

H = heat removed in Btu/hr

$\Delta t$ = indoor outdoor temperature difference (0F)

CP = 0.245 Btu/lb/0F $\rho$ = 0.075 lb/ft3

Infiltration calculation

Q = C* ($\Delta$P)n

Where

Q = volume flow rate of air ft3/min

C = flow coefficient (volume flow rate per unit length of crack or unit area at a unit pressure difference)

$\Delta$P = pressure difference

n = flow exponent 0.5-1 normally 0.65

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# UNIT – II – Building Automation Systems – SAR1615

ENERGY MANAGEMENT AND SERVICES

Demands on building:

- Illumination- daylight / artificial
- Thermal comfort- ventilation , air flow
- Heat reduction- wall, roof , shadow analysis
- Indoor air quality- air changes
- Continuous power supply
- Reduced enregy consumption- cut in energy bill
- Reduced maintanence charges

Demands in services:

- Mechanical:
- Optimised energy consumption
- Recycling techniques
- Minimal maintanence
- Minimal fuel consumption

Electrical:

- Even distribution of power
- Low transmission loss
- Optimised consumption
- Integrated with alternative-solar
- Efficient enrgy consumption-led
- Cut in cost

Plumbing:

- Reduction in wastage- supply and distribution
- Leakage detection
- Optimised water consumption
- Optimal power consumption
- Recycling options

ENERGY AUDIT:

An energy audit is an inspection survey and an analysis of energy flows for energy conservation in a building. It may include a process or system to reduce the amount of energy input into the system without negatively affecting the output.
An energy audit is an assessment of the energy consumed in a given location which is used to find the inefficiencies.

The first step to an energy audit is evaluating how much energy is being used so homeowners can identify the improvements that need to be made in order to increase energy efficiency. Only once the faults in the energy system are recognized, can they be corrected.
This leads to saving energy which ends up a decreased energy bill and improved efficiency.

Energy Management:
Energy management is the process of monitoring, controlling, and conserving energy in a building or organization. The energy management process starts with an energy audit of a given location. The goal is to find opportunities to improve efficiency. energy management involves taking the energy audit and putting it into action with a number of strategies.

For example, installing lights on a timer to turn off automatically at night.
After action is taken, tracking the progress of the changes made is the most important part. Eventually this cycle starts over, resulting in another energy audit. Building Energy Audit- a systematic, one-time procedure

Building Energy Management- a long-term strategy dedicated to continuous improvement and energy efficiency. Building Energy Management Systems (BEMS) are integrated, computerised systems for monitoring and controlling energy-related building services plant and equipment such as heating, ventilation and air conditioning (HVAC) systems, lighting, power systems and so on.

Building Management Systems can be used to monitor and control a wide range of building systems, including fire, smoke detection and alarms, motion detectors, CCTV, security and access control, lifts and so on. Building Energy Management Systems relate specifically to energy-related systems.
BEMS provide real-time remote monitoring and integrated control of a wide range of connected systems, energy use, environmental conditions and so on to be monitored and allowing hours of operation, set points and so on to be adjusted to optimise performance and comfort.

Records maintained for historical data on performance, enable benchmarking of performance against other buildings or sites and may help automate report writing.
Maintenance is also necessary to ensure systems continue to operate correctly, for example, replacing sensors and batteries, checking connections, checking the operation of dampers and valves, upgrading software and so on.

BEMS may have remote outstations that can be interrogated locally, or may be accessible from mobile devices. Cloud-based analytics, and the ability to access and manage multiple buildings remotely. The ability to access live analytics, or receive alarm notifications from hand-held devices has great potential benefits.

ENERGY MANAGEMENT

**1 .Lighting**

Lighting can be turned on, off, or dimmed with a building automation or lighting control system based on time of day, or on occupancy sensor, photo sensors and timers.

One typical example is to turn the lights in a space on for a half-hour since the last motion was sensed. A photocell placed outside a building can sense darkness, and the time of day, and modulate lights in outer offices and the parking lot.

Lighting is also a good candidate for demand response, with many control systems providing the ability to dim (or turn off) lights to take advantage of DR incentives and savings.

Intelligent lighting energy management system is combined with six lighting control functions i.e.

- occupancy control,
- time scheduling,
- daylight control,
- task control,
- personal control and
- variable power shedding.

There are two modes in this lighting management system, which are the automatic and the personal control. Users can also control the system through the lighting management program and an internet web server. The lighting management system utilizing both natural and artificial light consists of the hardware, which is microcontroller and Raspberry Pi, and the software, which controls and manages the system.

Two basic criteria  -efficiency in performance and effectiveness in light energy conservation. This system can be used to avoid energy waste, and saving energy consumption by a maximum of 68% in both switching and dimming control during typical days.

In newer buildings, the lighting control can be based on the Digital Addressable Lighting Interface (DALI). Lamps with DALI ballasts are fully dimmable. DALI can also detect lamp and ballast failures on DALI luminaries and signals failures.


The main power consumers in most buildings are lighting and the heating, ventilation and air-conditioning systems.

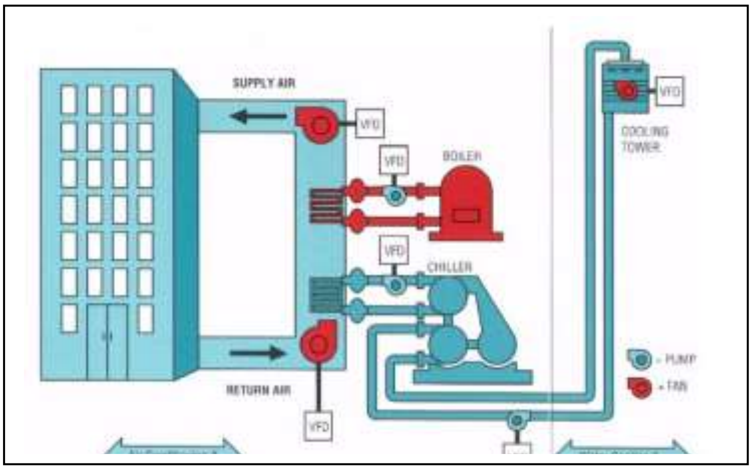
**2.Cooling load**

The first step in energy savings on HVAC systems is to reduce the cooling load. The amount of electricity air-conditioning systems use also depends on the cooling load – the amount of heat the system has to remove. There are several steps to reduce cooling load.HVAC loads vary at different times and in different parts of a building throughout the day. Well set time and occupancy controls should ensure that systems only operate when and where required during core business hours.

Installing a building energy management system (BMS or BEMS) which offers close control and monitoring of building services performance, including HVAC, allows automatic control of the HVAC system.

BEMS can reduce energy costs by allowing system performance to be monitored and settings to be changed

- Insulate the cooled space
- Minimise the use of appliances and lighting
- Variable speed drives on HVAC fans and pumps
- This allows motor-driven loads such as fans and pumps to operate in response to varying load requirements instead of simply operating in "on/off" mode.
- Large energy savings can be made by fitting Schneider Altivar 212 variable speed inverter drives to fan and pump applications particularly where valves or dampers are employed.
- Most new build is optimised, but thee are significant opportunities with fast pay-back times for existing buildings.
- According to estimates, motors consume 70% of the energy used by European industry. Therefore, using variable speed drives within HVAC systems is a major component of the energy-efficiency and cost-savings game.




The energy savings opportunities of variable speed drives in HVAC systems is an understanding of the operating cycle of the system versus the heating and cooling needs actually required. Most HVAC systems are designed to keep the building cool on the hottest days and warm on the coldest days. Therefore, the HVAC system needs to work at full capacity only on the 10 or so hottest days and the 10 or so coldest days of the year.

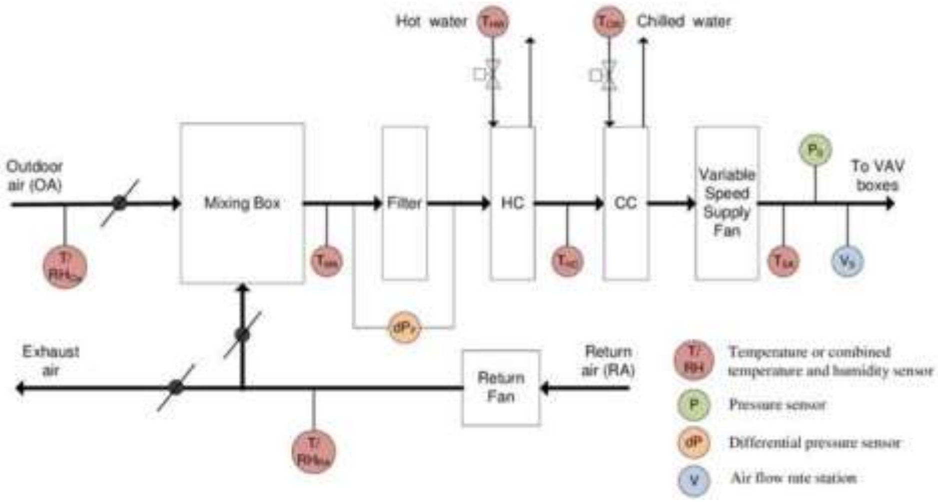
On the other 345 days, the HVAC system can operate at a reduced capacity.

This is where a variable air volume system with variable speed drives (also called variable frequency drives, or VFDs) can be used to match air flow to actual heating and cooling demands. The VFD can reduce the motor speed when full flow is not required, thereby reducing the power and the electrical energy used.

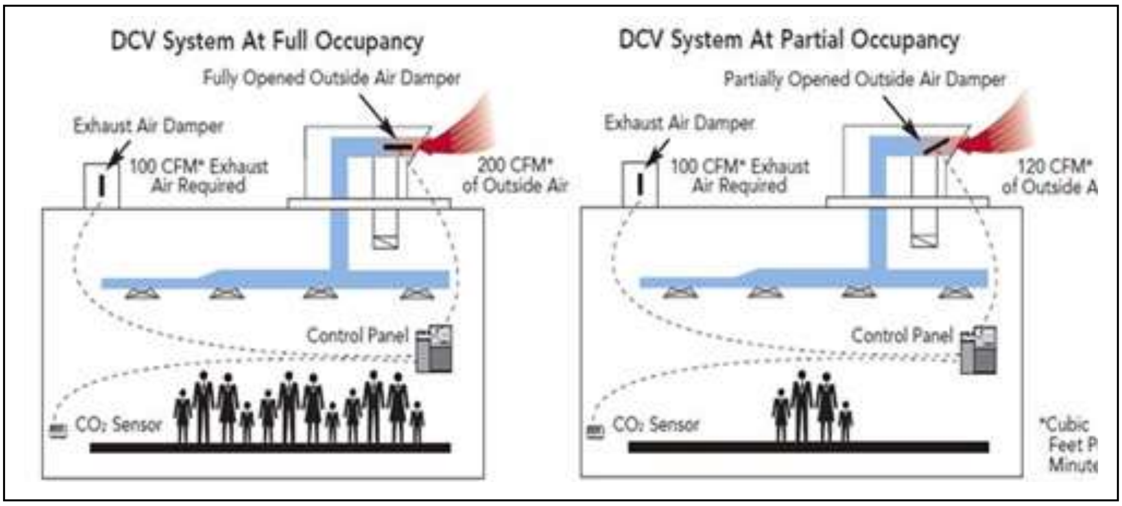
## 3. Air Handling units

Most air handlers mix return and outside air so less temperature/humidity conditioning is needed. This can save money by using less chilled or heated water (not all AHUs use chilled or hot water circuits). Some external air is needed to keep the building's air healthy. To optimize energy efficiency while maintaining healthy indoor air quality (IAQ), demand control (or controlled) ventilation (DCV) adjusts the amount of outside air based on measured levels of occupancy.

Analog or digital temperature sensors may be placed in the space or room, the return and supply air ducts, and sometimes the external air. Actuators are placed on the hot and chilled water valves, the outside air and return air dampers. The supply fan (and return if applicable) is started and stopped based on either time of day, temperatures, building pressures or a combination.




Demand Control Ventilation is recognized as a method of ensuring a building is ventilated, cost effectively, while maximizing indoor air quality. Generally, sensors are used to continuously measure and monitor ambient conditions in the conditioned space and provide real time feed back to the space controls which adjust dampers and in many cases, the fan speed by modulating the ventilation rate to match the specific use and occupancy of the building.



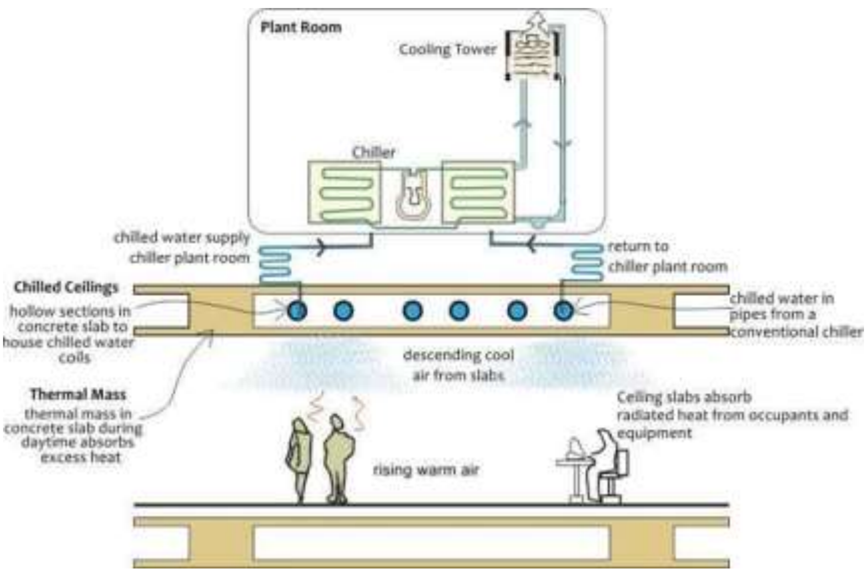
Building ventilation systems often operate at constant or pre-determined ventilation rates regardless of the occupancy level of the building. Ventilation rates are normally based on maximum occupancy levels resulting in consequent energy wastage. The energy wastage is not only due to the fan operation, but also includes the energy used to condition the air, whether in heating or cooling mode. Significant energy savings are made by effective DCV which ensures that the ventilation rate continuously matches the current occupancy rate and varying ambient conditions.

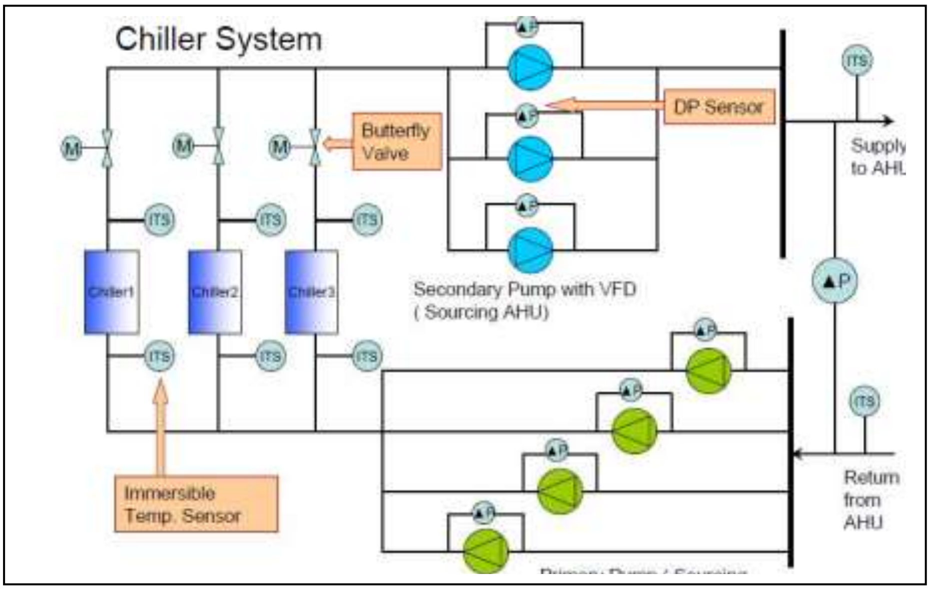
<u>VFD in Chiller plant</u>

It is used in secondary chilled water pumps which circulates water to AHUs, FCUs, FAHUs or other building air conditioning equipment like CCUs. The purpose of the VFD installed on secondary chilled water pump/motor is to increase or decrease the speed of motor in order to control(increase or decrease) water flow rate. This increase or decrease in motor speed and accodingly flow rate is governed by means of pressure sensors(pressure transducers).

## 3. Chilled water systems

Chilled water is often used to cool a building's air and equipment. The chilled water system will have chiller(s) and pumps. Analog temperature sensors measure the chilled water supply and return lines. The chiller(s) are sequenced on and off to chill the chilled water supply.
A chiller is a refrigeration unit designed to produce cool (chilled) water for space cooling purposes. The chilled water is then circulated to one or more cooling coils located in air handling units, fan-coils, or induction units.






*Chiller Plant with BMS sensor*

Heat Recovery and application

Carrier chillers with heat reclaim capabilities produce chilled water controlled to the necessary temperature while generating hot water as a by-product of the chilled water system. During cooling only operation, the chiller produces a controlled source of chilled water leaving the evaporator while dissipating heat through the condenser and ultimately to the environment. When there is a simultaneous need for chilled water and hot water, these chillers have the capability to operate in heat recovery mode. The recovered heat can be redirected for various heating applications, which saves energy while maintaining conditions.

**4. Condenser water system**

Cooling towers and pumps are used to supply cool condenser water to the chillers. Because the condenser water supply to the chillers has to be constant, variable speed drives are commonly used on the cooling tower fans to control temperature. Proper cooling tower temperature assures the proper refrigerant head pressure in the chiller. The cooling tower set point used depends upon the refrigerant being used. Analog temperature sensors measure the condenser water supply and return lines.

**5. Hot water system**

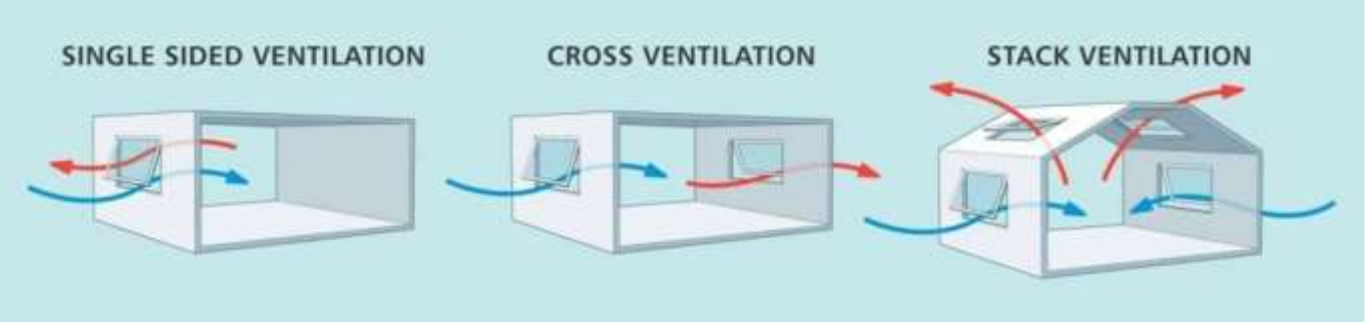
The hot water system supplies heat to the building's air-handling unit or VAV box heating coils, along with the domestic hot water heating coils .The hot water system will have a boilers and pumps. Analog temperature sensors are placed in the hot water supply and return lines. Some type of mixing valve is usually used to control the heating water loop temperature. The boilers and pumps are sequenced on and off to maintain supply.

**Ventilation**

Ventilation moves outdoor air into a building or a room, and distributes the air within the building or room. The general purpose of ventilation in buildings is to provide healthy air for breathing by both diluting the pollutants originating in the building and removing the pollutants from it.

Types of Ventilation

- Natural ventilation
- Mechanical ventilation
- Mixed mode ventilation
- Infiltration




Importance of good ventilation in buildings:

1. Control impurities

A good ventilation system will help expel a build up of pollutants, bacteria, moisture and odours.

2. Air regulation & energy consumption

Without a ventilation system in place, there is no control of the air flow in a building. Too much fresh air can cost high energy bills, which is why devising a good ventilation system is important

3. Prevent condensation

Condensation can lead to mould and rotten surfaces .Damp conditions and condensation can cause health issues such as allergic reactions and respiratory problems for many people. Good ventilation will help reduce these risks.

4. Improve occupant comfort

When lots of people are in confined space, the environment can become hot and sultry. A ventilated room will provide an elevated level of human comfort - making for a more productive workplace.

5. Health & wellness

Indoor air pollution coupled with bad ventilation can lead to a number of health problems including headaches, allergies, asthma, rashes and sinusitis. Overall health and wellbeing of the occupants is directly related to ventilation provided in a building.

Natural ventilation:

Natural ventilation harnesses naturally available forces to supply and remove air in an enclosed space. There are three types of natural ventilation occurring in buildings: wind driven ventilation, pressure-driven flows, and stack ventilation.

The ability for a system to remove pollution is described as its "ventilation effectiveness". However, the overall impacts of ventilation on indoor air quality can depend on more complex factors such as the sources of pollution, and the ways that activities and airflow interact to affect occupant exposure.

- Techniques and architectural features used to ventilate buildings and structures naturally include
- Operable windows Pressurised air pumps Night purge ventilation
- Clerestory windows and vented skylights Building orientation
- Wind capture façades

Mechanical ventilation

Demand-controlled ventilation (DCV)

Demand-controlled ventilation (DCV, also known as Demand Control Ventilation) makes it possible to maintain air quality while conserving energy. In a DCV system, CO2 sensors control the amount of ventilation. During peak occupancy, CO2 levels rise, and the system adjusts to deliver the same amount of outdoor air as would be used by the ventilation-rate procedure. However, when spaces are less occupied, CO2 levels reduce, and the system reduces ventilation to conserves energy.

Personalized ventilation

Personalized ventilation is an air distribution strategy that allows individuals to control the amount of ventilation received. The approach deliver fresh air more directly to the breathing zone and aims to improve air quality of inhaled air.

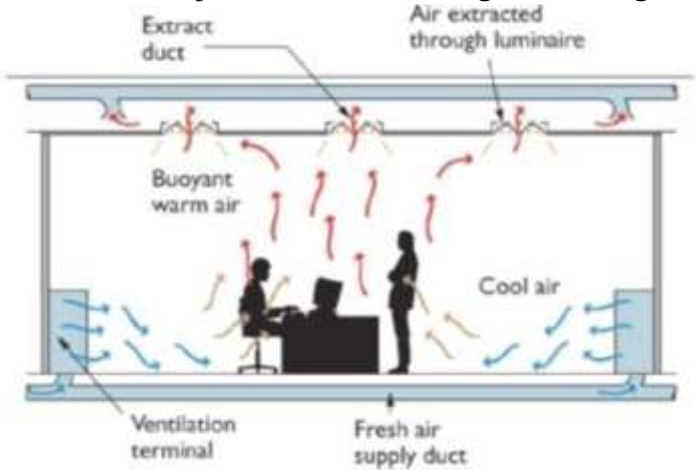
Personalized ventilation provides a much higher ventilation effectiveness than conventional mixing ventilation systems by displacing pollution from the breathing zone far less air volume. Beyond improved air quality benefits, the strategy can also improve occupant's thermal comfort, perceived air quality, and overall satisfaction with the indoor environment. Individual's preferences for temperature and air movement are not equal, and so traditional approaches to homogeneous environmental control have failed to achieve high occupant satisfaction.

Displacement ventilation (DV)

It is a room air distribution strategy where conditioned outdoor air is supplied at a low velocity from air supply diffusers located near floor level and extracted above the occupied zone, usually at ceiling height. A typical displacement ventilation system, such as one in an office space, supplies conditioned cold air from an air handling unit (AHU) through a low induction air diffuser.

The cool air accelerates because of the buoyancy force, spreads in a thin layer over the floor, reaching a relatively high velocity before rising due to heat exchange with heat sources (e.g., occupants, computers, lights).Absorbing the heat from heat sources, the cold air becomes warmer and less dense. The density difference between cold air and warm air creates upward convective flows known as thermal plumes.

Instead of working as a stand-alone system in interior space, displacement ventilation system can also be coupled with other cooling and heating sources

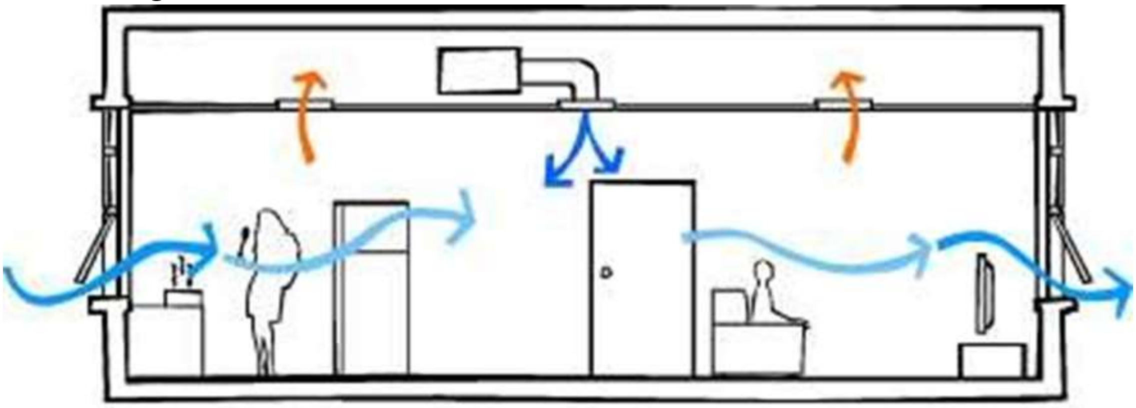


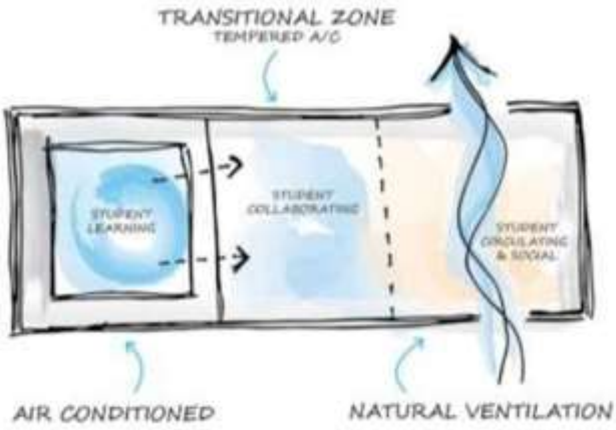

Local exhaust ventilation

Local exhaust ventilation addresses the issue of avoiding the contamination of indoor air by specific high-emission sources by capturing airborne contaminants before they are spread into the environment. This can include water vapour control, lavatory bio effluent control, solvent vapours from industrial processes, and dust from wood- and metal-working machinery. Air can be exhausted through pressurized hoods or through the use of fans and pressurizing a specific area.

Mixed-mode ventilation

Refers to a hybrid approach to space conditioning that uses a combination of natural ventilation from operable windows (either manually or automatically controlled), and mechanical systems that include air distribution equipment and refrigeration equipment for cooling. A well-designed mixed-mode building begins with intelligent facade design to minimize cooling loads. It then integrates the use of air conditioning when and where it is necessary, with the use of natural ventilation whenever it is feasible or desirable, to maximize comfort while avoiding the significant energy use and operating costs of year-round air conditioning.



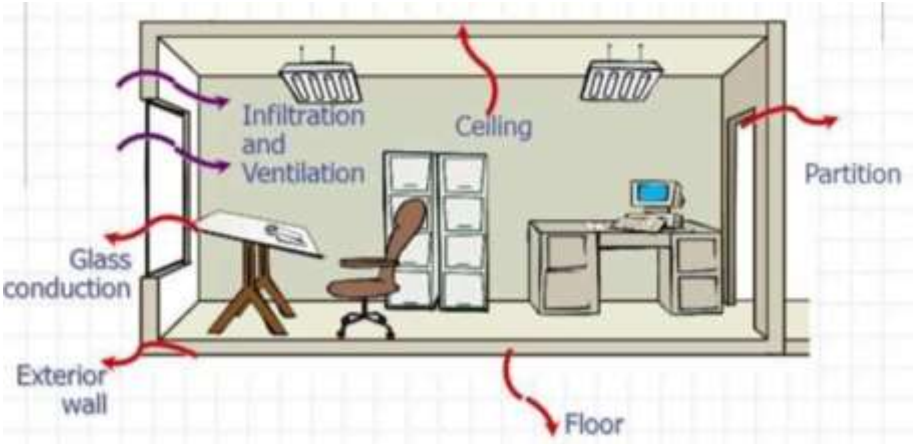



Infiltration

It is the uncontrolled flow of air from outdoors to indoors through leaks (unplanned openings) in a building envelope. It is unintentional and uncontrolled entry of outdoor air into an enclosed space.

Infiltration occurs through cracks in the building envelope and due to pressure differences between inside and outside. The outdoor air entering through open doors and windows is considered infiltration although the purpose of opening the door or window might be ventilation. Infiltration occurs mainly in winter when the air outside is colder and heavier than the air inside. It depends on wind velocity, wind direction and the air-tightness of the building envelope. In the case of high-rise buildings the stack effect

also causes infiltration




Factors affecting energy use in building:

Various factors, including climate, building envelope and energy services systems, operation and maintenance, indoor comfort conditions, and occupant behaviour, affect energy use in buildings.

Five important factors related to energy consumption of buildings that

need to be considered:

Heat loss by conduction through building envelope

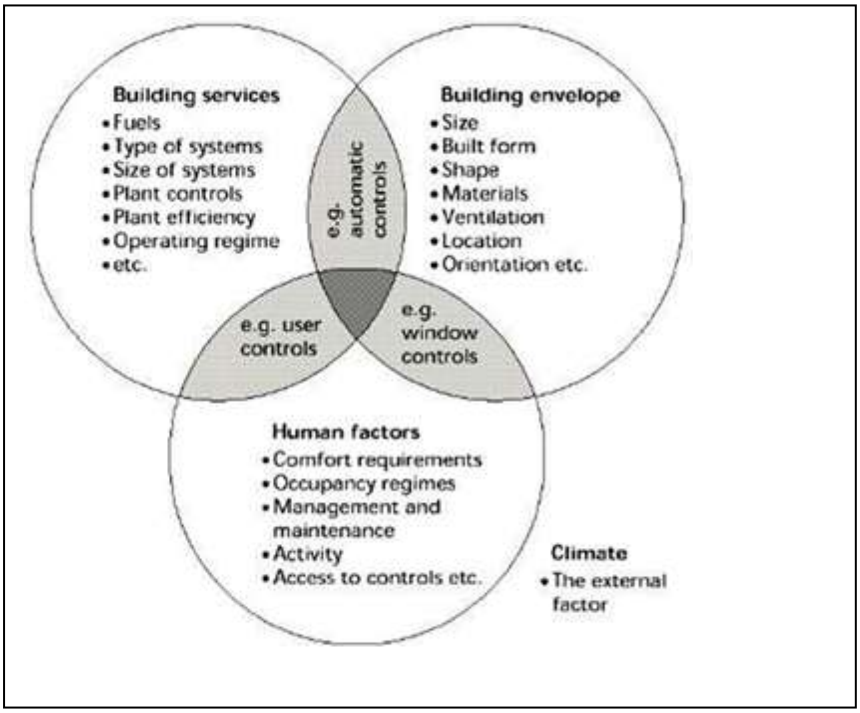
• Energy used by ventilation systems

• Savings from ventilation air heat recovery

• Air tightness of building envelope

• Impact of the occupants

Factors affecting energy use in buildings

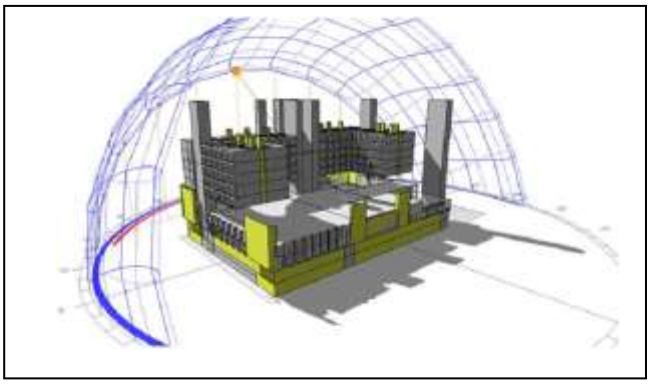


**Fenestration Design for optimal Day lighting:**

Clerestory -upper part of an interior wall, containing openings for daylighting of interiors. Lightshelf - an exterior horizontal shelf positioned (usually above eye level) to reflect daylight onto the ceiling and to shield direct glare from the sky.Lightwell- , is a shaft and open roof space provided within the volume of a large building to allow light and air to reach what would otherwise be a dark or unventilated area.

Skylight - A relatively horizontal glazed roof aperture for the admission of daylight.

- ❖ Integrating with BAS, BEMS
- ❖ Positioning sensors based on the sources of daylighting…
- ❖ Creating a Daylight model
- ❖ Daylight Simuation Model



**Daylight Modelling**

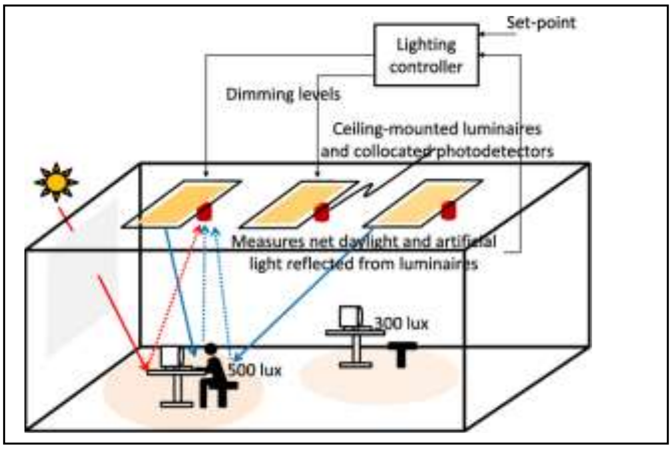
NORESCO successfully integrates innovative daylighting techniques and strategies into buildings to reduce electrical and mechanical energy consumptionUsing TracePro® and Radiance software, two of the most advanced lighting/daylighting analysis tools available, to evaluate and refine daylighting design solutions.Working from 2-D or 3-D CAD or Autodesk® Revit® files provided by the design team , a geometrically accurate representation of the space including glazing properties, surface reflectance, furniture layout, shading, and light distribution strategies are created.

Daylighting analysis results include average illuminance throughout the daylit space, illuminance on work surfaces, and surface luminance ratios. Renderings of the daylit space help the design team determine whether the daylight and lighting design criteria have been achieved, and whether further design refinements are necessary.

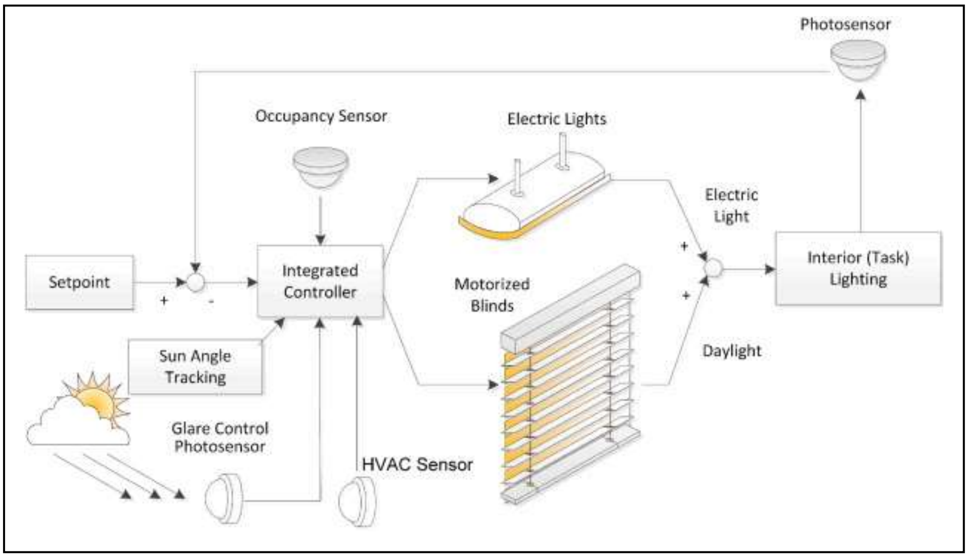
**Integrating with BAS, BEMS**

Incorporating the electric lighting system into the daylight model using the fixtures' photometric files to accurately represent light distribution characteristics.

The model calculates the integrated day lighting and electric lighting performance under both daytime and night time design conditions




**Positioning sensors based on the  sources of daylighting**




**Daylight Simuation Model**

Daylighting simulation tools -The daylighting programs on the other hand were mostly concerned with accuracy. Most of these programs initially did not output any rendered images of the scene, giving only numerical or iso-lumen output.  Computer rendering programs usually give a photo-realistic output,

The latest generation of these programs is attempting to bridge the gap between lighting simulation and photo-realistic rendering. Three types of design tools have been used to predict

- interior daylight illumination:

- physical scale models,

graphic techniques  and calculations

1) Simplified Calculation Programs

2) Computer Simulation Programs

DAYSIM

DAYSIM is a validated daylighting analysis software that calculates the annual daylight availability in arbitrary buildings based on the RADIANCE backward raytracer.

It uses the Lightswitch occupant behavior model to mimic occupant use of personal controls such as light switches and venetian blinds and to predict energy savings from automated lighting controls such as occupancy sensors and photocell controlled diming systems.

IES Virtual Environment (IESVE)-

IESVE is an in-depth suite of integrated analysis tools for the design and retrofit of buildings. It is an essential digital construction tool for top architects, engineers and contractors.

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**SCHOOL OF BUILDING AND ENVIRONMENT**

**DEPARTMENT OF ARCHITECTURE**

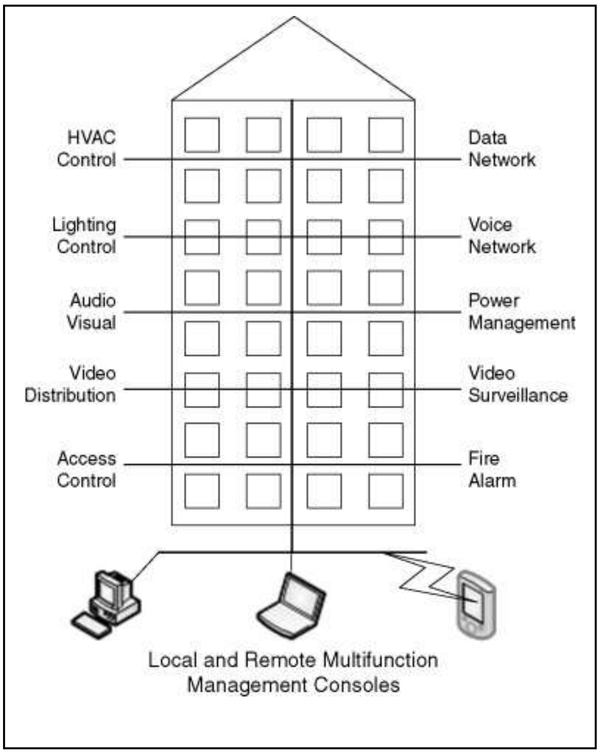
# UNIT – III– Building Automation Systems – SAR1615

**KEY ISSUES FOR INTELLIGENT BUILDINGS**

- Multiple Activity Settings- O&M
- Space Utilisation Analysis- Investment
- Shared Space Use model- Space planning
- Design Briefing Process- IDP
- Building Life Cycle - FM
- Issues related to Site, Shell, Skin

Multiple Activity Settings:

During the operation of the building, the building technology systems are integrated horizontally among all subsystems as well as vertically—that is subsystems to facility management systems to business systems—allowing information and data about the building's operation to be used by multiple individuals occupying and managing the building.




Integrated Building Management System (IBMS)- is a centralized system will enable real time centralized monitoring and control of Infrastructure systems such as building systems (HVAC equipment, Thermostats, Lighting, Life Safety & Security Systems, Physical Security, Elevators, Meters – Energy, Water and Gas, Sewer etc.).

- It will be a comprehensive, standards based, communications network-based solution for intelligent building automation and enterprise management.

-Using advanced software tools, the IBMS provides a smart building the long term capabilities needed to save costs, efficiently manage and optimize building operations and ensure long term sustainability.

-Combining Multiple Systems-

Typically, an IBMS can monitor and manage every data point from every building system.

-The integration of all the data points of all the building subsystems relatively new and has great potential to monitor and manage a building's performance.

IBMS systems will incorporate all the traditional building management functions such as document management, trending, system scheduling and data archiving.

-However, in addition there is integration into the Facility Management (FM) systems such as work orders, asset management, inventory, and maintenance. -Further integration with the Building Information Management (BIM) systems of the building will map the building, its systems and components in 3D. BIM 4D, 7D,11D.This will allow for a truly integrated and optimized building where in an alarm in the IBMS triggers the FM system and the BIM system provides a real time 3-D view of the situation, its location and possible fix. This creates a "meta" building database to help improve building operations and engineering.

IBMS system include performance analytics which tie in automatic fault detection and diagnostic (FDD) applications to optimize the performance of the building systems. It provides on-going commissioning, keeping the largest energy consumption system at optimal performance.

**Analytics**

A state of the art smart building typically will have analytics as part of the software suite along with the IBMS and dashboards. Once data is available in a building, the next step is to analyze the data and then determine how to improve the building performance using that data.

This analysis is achieved through dedicated analytics software. Such software will help organize, manage, analyze data collected from various building systems and present them in a clear and concise manner via the dashboard. This provides a good insight into the operational performance of the building. Analytics provide results that show how the building actually operates versus how it was either designed to operate or expected to operate.

Examples of benefits include immediate notification of system anomalies for proactive maintenance, building equipment lifecycle extension, reduction in energy consumption, identification of energy savings opportunities, and validation of energy savings

**Research based Models:**

The scheduling-based control models have been implemented in many home automation systems. In an automation system has been built based on user schedule using a wireless sensor actuator network (WSAN) in an office environment.

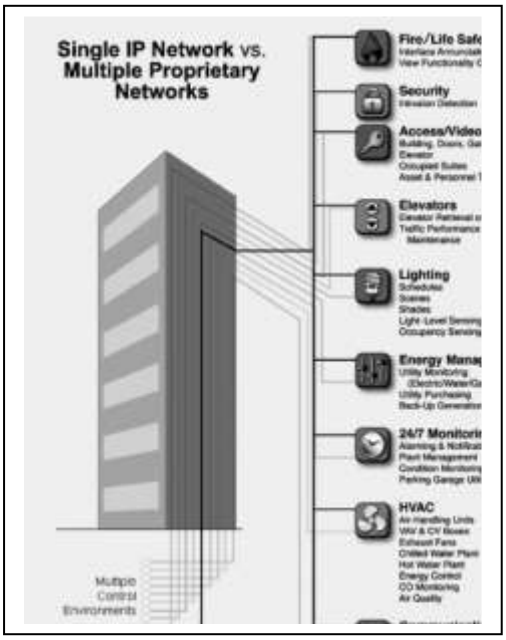
The scheduling-based control model has been also developed with smart meeting scheduling and monitoring and controlling systems in an office environment to minimize operational costs. The meeting scheduling algorithm in the room has made the automation system aware of energy consumption because is able to automate meeting scheduling based on the time and space capacity .

**Meeting scheduling algorithm**

Monitoring and control of devices using operating schedules within buildings have been able to perform energy efficiency in accordance with user-defined policies to minimize operating costs of devices in an office environment

The remote control system of electrical devices using user schedules in office environments have been providing convenience to users in controlling devices anywhere to improve energy efficiency

**Control design based on multi-user preference and activity**




The concept of controlling in the smart building based on user preferences, user location activity, and detection of occupancy-HAR.  Then the device will operate in accordance with the user location and preference users and will not be based on maximum occupancy. This differs from the scheduling-based control model where occupancy in the room is considered maximum and ignore user preferences even though the device operation is based on the user schedule.

The model of the control device on the smart building by utilizing multi-user preference is supported by three systems which include occupancy detection, indoor localization, and activity recognition. The mechanism of presence systems works through presence sensors (e.g., radio frequency identification (RFID) tags and reader's sensors). RFID tags are worn by the user.  When the user enters the room, the RFID tag transmits signals that are read by the RFID reader installed in the room.

The localization system aims to estimate the location obtained from measured data values collected in a vector and received from a mobile device. Bluetooth, RFID, Zigbee, UWB and IEEE 802.1x are examples of technologies applied for indoor localization.

Activity recognition can be performed by utilizing the built-in camera sensor, wearable sensors, or object sensors. Furthermore, the activity recognition algorithm will perform the detection process to inform the system regarding user activity .

One of the key issues related to any intelligent building is that on-going maintenance of the facility is absolutely critical to maintaining the benefits of building intelligence. While most intelligent buildings will operate using less energy and water, equipment throughout the building needs constant maintenance to ensure that optimal performance is maintained. The key is also to ensure that sensors are cleaned and calibrated on a regular schedule. Poorly performing sensors can be one of the main reasons that an investment in building intelligence does not result in reductions in energy and water usage.

**Analysis of Space Utilisation**

Office space is one of the largest investment that a company makes. With today's soaring costs for real estate property acquisition and maintenance, it can pay big dividends to improve control over your facility expenses through accurate space requirements analysis and utilization improvements. it is important to effectively and efficiently use the space you already have.

What is space utilization? Space utilization defines how available corporate real estate, be it workspace, meeting rooms, or other assets, are being used. Analyzing data from a space utilization analysis can be used to calculate metrics like actual use of space (AUS) and utilization rate. It is extremely important for business operations that facilities managers and space planners be able to accurately calculate actual use of space (AUS). Actual use of space data from a space utilization analysis can help organizations reach cost management and sustainability goals.

Space utilization analysis

Desks or Workspaces: The number of individual total seats (whether private offices or open workstations)

Occupancy: The percentage of desks that are assigned to a person or dedicated to a function

Utilization: The percentage of occupied desks (or conference room seats) that are “in use” at any moment during the workday

Head Count: The number of people to be accommodated, but not necessarily at same time

Capacity: The seat count or number of people that a space can support at one time

Worker-to-Workspace Ratio: The number workspaces to the total number of employees who may need to use them at any time

A software delivers actual use of space data on a daily basis and assesses human presence events throughout the organization, badge swipe data from the front door, turnstile data from the street entrance, login events and virtual private network (VPN) packets from the network, keyed entry from VOIP phones, and more.

Criteria for space utilisation

Thermal Comfort and Temperature

office space must have  the right combination of airflow, temperature, and humidity.

Access to Daylight, Nature, and Views

People love working in areas surrounded by nature. They also need to spend some time outside during the day and break away from fluorescent lighting.

Sensory Change and Variability

Include visual stimulations through window views and access to daylight. You can also use natural materials like plants, natural fibers, and wood. Others ideas include colours, graphics, patterns, art, and texture changes.

Colour

Choose your colours wisely and strategically when designing different workspaces. For example, blue can be used for focus areas since it’s calming and it promotes clarity and mental control. Red is ideal for common rooms since it enhances strength and energy.

Noise Control

Some employees thrive in noisy environments, while others dread them. Separate noisy places from quiet spaces

Workplace Psychology

Workplace psychology focuses on workplace safety, ergonomics, product design, human error reduction, human-computer interaction, and human capability

Choice and Employee Engagement

Adopt a working space where employees can choose their workplaces depending on their needs. Also, engage employees to ensure satisfaction, innovation, and productivity.

Benefits of Space Utilisation Analysis

1.Cost Control

-Office spaces contribute to a high percentage of office expenses.

-Conducting an office space utilisation study helps a company determine if they are using the right premises and whether they need all the space they are currently using or not.

The study gives you precise data and helps you scale office space correctly.

2. Change Management

-The study is designed to gather data on employee working habits.

-Their individual work, their collaboration, and their meetings.

-After the study, you have all the insights you need to decide whether change is necessary or not.

-This will also improve communication between personnel and management.

3. Helps Create Work Profiles

Work profiles help you determine what kind of workstations you need. They help in planning space, knowing what IT requirements are needed where, and in understanding the remote working practices of employees. A space utilisation study also sheds light on how much time an individual employee spends in the office and when they spend it at their workstation.

4. Easily Determine Space Requirements

IoT Space has an Office Occupancy Measurement System that allows you to review the efficiency of your office space. IoT Space can help you save up to half the rent you are currently paying by optimising your space and providing the right insights into how your current space is actually used.

5. Determine if the Changes You Made Have Actually Achieved Their Target

A space utilisation study will help you analyse whether you have managed to save on cost and whether the changes have improved employee working habits. You can use the results of the study to plan your future expansion or go even deeper with optimisation

6. Identify Areas for Development in Activity Based Working Spaces

-Activity based working offices have designated areas for quiet working, shared workplaces, conference rooms, and break rooms. Employees choose their workspace depending on the tasks they are assigned. Measuring space utilisation helps identify areas that need change and areas that can be further developed.

A space utilisation study can identifies the shortcomings of your office space setup. Consequently, it enables the company to correct certain situations before they affect the productivity of employees.

7. Save on Energy

-Remote working has made it possible for people to work away from the office.

-The space utilisation study will help you recognise the days or months your personnel typically chooses to work remotely.

8. Encourage Strategic Decision Making

-The workplace analysis helps the company collect data on work patterns, preferences, and communication methods. This information can help in strategic decision making that takes into account cost control, productivity and employee satisfaction.

9. Improve the Work Environment

Adapting apps help a company integrate data on work activities with data from the study. These apps help employees find and book free workspaces, locate colleagues, and share information. Briefly put, they help improve work environments for both employees and employers.

**Five space utilization metrics every facility manager (FM) should know:**

**1.** Capacity and occupancy**.**

Capacity and occupancy dictate how many people a space supports and how many people are using it at a given point in time. A collaborative space may have a capacity of 10, but only four people occupying it right now. Tomorrow, eight people might use it. Capacity never changes; occupancy does.

Measuring capacity gives FMs a sense of how many people can feasibly use a workspace at any given time. Looking at the total capacity of all workspaces determines overall workplace capacity, which is useful for other metrics like utilization. Meanwhile, looking at occupancy trends—by the hour, day of the week, or over a longer period of time—shows usage trends.

Capacity and occupancy are the core building blocks for most space utilization metrics.

2. Overall/space-specific utilization

Overall office space utilization is a simple equation: Number of employees divided by total workplace capacity. If you have 75 employees in a space designed for 100, you're utilization is 75%. This metric doesn't show space efficiency, but does paint a clear picture of the workspace as a whole.There's more opportunity to glean information from space-specific metrics. These can include point-in-time trends, peak usage data, areas of underutilization, and workstation occupancy calculations. Understanding total workplace utilization and individual workspace use drives greater efficiency and productivity.

3. Density

-Density is a more granular utilization metric—one that's useful in looking at departments, floors, and business segments. Density data shows when a group has outgrown its space or when business demands outstrip available workspace types.

Example:A  Marketing has 20 people. Utilization statistics show their demand for conference rooms is exceedingly high—as many as 14 department members may be in project meetings at any given time. But Marketing only has access to two conference rooms with a total capacity of 10 seats. This is an example of density benchmarking at work. It shows not just demand for space, but demand for specific space by a specific group for a specific purpose.

4. Cost per head/seat

Utilization is more than balancing the number of employees and types of workspaces offered. It's also about cost control and creating a floor plan that accommodates everyone—without hampering the balance sheet.Calculating cost per head/seat breaks the fixed lease down to a granular figure that helps FMs understand the cost of housing employees within available space. This data helps project the cost of facility growth, model productivity of a workspace, and highlight inefficiencies in particular desking arrangements. Everything in business comes back to numbers, which makes cost per head an essential utilization metric for quantifying the workplace.

5. Mobility ratios

The workplace is far from static. Accounting for workforce mobility is important in measuring true space utilization. How many remote workers do you have? How many part-time vs. full-time employees are on the payroll? How many visitors do you average on a day or week? These people may not need a desk every day, but they impact utilization. Measuring the variable demands of a mobile workforce is separate from general utilization and occupancy metrics.

Your workplace may have 100 seats and 75 regularly occupied desks (75% utilization), but what about those 25 part-time and remote employees? Can your workplace function at 100% total capacity in the unlikely event that everyone in the office at the same time? Factoring in mobility ratios—different groups with variable desking needs—is an important extension in understanding total workplace utilization.

A shared workspace" vs. "a collaborative workspace"

The biggest misconception about shared workspace is that it's shared by many people at the same time. This is actually what's referred to as "collaborative space." Understanding the difference means understanding the qualifiers: shared workspace vs. collaborative workspace. A shared workspace is shared by many people at different times. The workplace is static; the occupants are dynamic. In a collaborative workspace many people use at the same time for the purpose of working together.A shared workspace implies an individual occupant using space for a limited time. When they leave, that workspace will become occupied by someone else, instead of sitting idle.

Co-working spaces

Coworking spaces are generally ideal for start-up businesses and entrepreneurs looking for a better alternative to working from home. These spaces are often home to freelancers, some of whom are just getting their name out and are not tied to any specific business or industry.The benefits to these spaces is that they afford start-ups with an opportunity to stay lean, an inexpensive avenue for community and collaboration, as well as a lively and dynamic atmosphere that inspires productivity.

Shared workspaces vs Coworking spaces

A shared workspace differs in that they usually cater to and house more established businesses. They often provide more traditional amenities to meet the needs of their clientele.While corporate coworking is on the rise, shared office spaces are more focused on having more equipment such as fax machines, copiers, audio-visual equipment, as well as professional looking office furniture. Some shared offices operate as executive suites, with amenities such as full reception services, a kitchen, as well as private offices cut off from the rest of the space. In contrast, Coworking spaces  will have a coffee shop only.Coworking spaces usually l ase to members for a period of 3-to-6 months whereas Shared office spaces such as executive suites usually lease for a period of 12 months.

Collaborative workspace: maintain the space in-house, allowing you to use it however best suits your company's current needs. collaborative workspaces used to stage a big project, ping-pong ideas back and forth, meet with high-profile clients, teach a seminar, or any other task that involves multiple people in the same accommodating space.

Shared workspace: Employees without a permanent desk get access to an individual space where they can work supported on an ongoing or as-needed basis. They get the freedom to use the workspace on their terms, while companies unburden themselves of costly commercial leases

Coworkingspace: Startups and agile companies without the need for permanent office space can keep overhead costs low, while still utilizing a traditional workplace setting. They also get access to workplace resources and a professional setting that's useful for meeting with clients or collaborating on large initiatives.

**Briefing Process:**

Briefing is the process by which client requirements are investigated, developed and communicated to the construction industry. Briefing of some kind always occurs during a project, though the quality can vary considerably. Good briefing is not easy to achieve, yet a number of studies have suggested that improvements to briefing lead to clients getting better buildings. A design brief is a document for a design project developed by a person or team (the designer or design team) in consultation with the client/customer. They can be used for many projects including those in the fields of architecture, interior design and industrial design.

Design briefs are also used to evaluate the effectiveness of a design after it has been produced and during the creation process to keep the project on track and on budget.They outline the deliverables and scope of the project including any products or works (function and aesthetics), timing and budget. Briefing process seeks to minimise the likelihood of a client receiving an unsatisfactory building by ensuring that project requirements are fully explored and communicated as clearly as possible to the client.Whilst good briefing cannot guarantee that a building will be perfectly suited to its occupants, it can help avoid serious mistakes.

**Two basic factors that contribute to cost and time overrun,**

a)Variations in construction projects .

b) Design changes (which is as a result of changes made due to mistakes or client request).

The sources of variations and extra work can be classified into client initiated variations and unforeseeable variations. The main reasons behind the higher percentages in variation and design changes or extra work are identified as changes during the construction stage which could arise as a result of improper management, ineffective communication and incorrect assessment of the design brief.Importance of Briefing Process:

The RIBA plan of work limits brief development to the detailed proposal stage. Barrett (1996) state that this approach has a number of problems.Barrett and Stanley (1999) defined the briefing process as "the process running throughout the construction project by which means the client's requirements are progressively captured and translated into effect".Many clients are in a state of dynamic development; hence, their requirements may change during the course of the project.

A static brief will prevent these changes from being accommodated. clients prefer to consider the briefing process as extended until almost the final stage of construction to ensure that the final product meets and fulfils their requirements and objectives.Dynamic Brief Development definition assumes that the process is continuing until the client's requirements are translated into effect (i.e. the final building) which suggests that the briefing process is extended to the end of construction stage.This has the advantage of getting the requirements of the clients at a relatively early stage and allows proceeding to the next stages with confidence in the data/information gathered.

Briefing is often regarded as an early stage in the construction process during which the client's requirements are written down in a formal document called the brief. The brief then provides a fixed reference for the subsequent design of the building. This traditional view of briefing is highly constraining in many ways. The client, particularly the inexperienced client, cannot be expected to know everything that will be required of the building at the outset of the project. Requirements are only developed in detail as the project progresses. This means the client cannot sit back after the initial brief has been written and expect a satisfactory design to emerge without further effort. Full participation throughout the project is important. Whilst a clear initial brief can be a great asset, it is not the end of the story. The important thing is to make decisions appropriate to the particular stage of project development. Strategic decisions will need to be made early on and the detail left until a later stage. The client should not withdraw from the process once an initial brief has been drawn up.

Integrated/ Collaborative Briefing process:

Redefine the process to be "the process running throughout a construction project by which the requirements of the client and other relevant stakeholders are progressively captured, interpreted, confirmed and then communicated to the design and construction team". This definition is believed to be more suitable as it widens the customer base; emphasises the cyclic nature of understanding what is really needed; and delineates briefing activity (which must always involve deliberation of needs/requirements and therefore involve the stakeholders in some way) from the design activity which produces potential solutions in response to the brief .

Characteristics of the briefing process

The briefing stage is critical to the success of construction projects, but it is widely recognized that improvements are needed in this process in order to reduce the cost and optimize quality of buildings.The briefing process involves understanding the client's needs and expressing them in a way that will ensure compatibility between the client's vision of the project and the resulting product.There is little guidance and support for clients, whilst designers have difficulties both in capturing clients' needs and conveying conceptual design options to them. There is a central difficulty, associated with language, communication and the exchange of information between clients and design teams, In many situations, different parties are working simultaneously on the same piece of information.Participants of the briefing process (i.e. client/user/brief-taker) are, in general, experts in their own specialists but not experts in all fields related to the project and in many cases have to make decisions in areas out of their speciality. Some parties of the briefing process are neither familiar with engineering or construction terms nor able to read engineering drawings and they need supporting aids to convey and clarify the technical terms.

All possible options should be comprehensively examined at this stage to ensure that no potential alternatives have been missed. However, and due to the short time allocated for this process, such examinations can not be in depth ,in detail. Many changes and revisions occur during the briefing stage; critical changes which affect the decision making, should be effectively reflected and monitored to all relevant partiesUnlike the design stage where most of the design teams are located closely within the same geographical zone, the different parties involved in the briefing process are geographically apart or located in different .organisations.Regarding cost and work programme, the briefing stage is a very critical stage – most decisions affect the total cost of the project and the work programme – any decision has to be properly monitored and traced.

Very short time is, generally, allocated to the briefing process and the time to examine details is very tight - previous experiences support and aid to avoid repeating work.Needs of the client have opposite impacts (especially in large projects) on the design attributes. Requirements need to be rated and ranked to identify the most important requirements to be fulfilled (in case of contradictions) and, hence, maximise clients' satisfactions- Value analysis.

COMMUNICATION OF IDEAS TO USER

Traditional forms of communications

- Verbal communications -such as conversations, meetings and presentations. Significant verbal communications should always be confirmed in writing.
- Reports - Briefs, stage reports, feasibility studies, risk management, value management, health and safety, cost plans .
- Drawings - Concept drawings or sketches, design intent drawings, general arrangement
- drawings, technical drawings, working drawings.

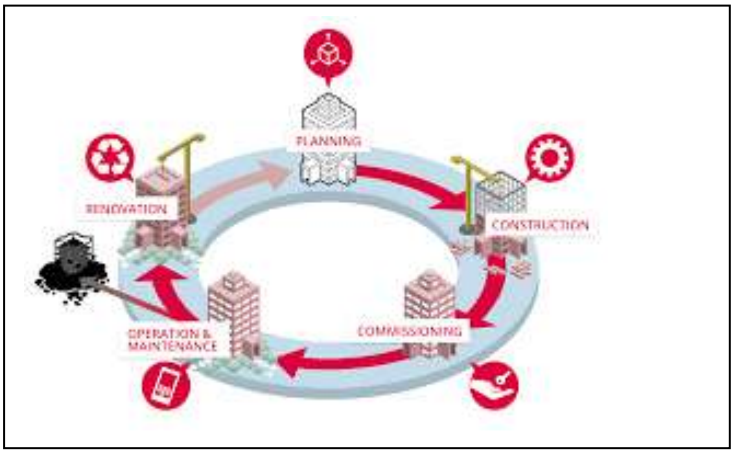
- Photography - Providing a visual record of status, progress, events or defects.
- Models, samples and mock ups - These can be easier for clients and other stakeholders to understand than drawings.
- Specifications- Describing the materials and workmanship required for a development.
- Tender documents - tenders (offers) from suppliers required to complete construction works.
- Contract documents - Setting out the obligations and responsibilities of the parties to the contract.
- Requests for information- A formal question asked by one party to a contract to the other party.

As design projects have become more complex, technological developments have revolutionized the means by which architects can draw, model, test and communicate. Modern modes of architectural communication include:

- Computer aided design (CAD).
- Building information modeling (BIM).
- Fly-throughs and films.
- Virtual reality and augmented reality.
- 3D printing.

BUILDING LIFE CYCLE:

Building life cycle refers to the view of a building over the course of its entire life. It not just as an operational building, but also taking into account the design, construction, operation, demolition and waste treatment.

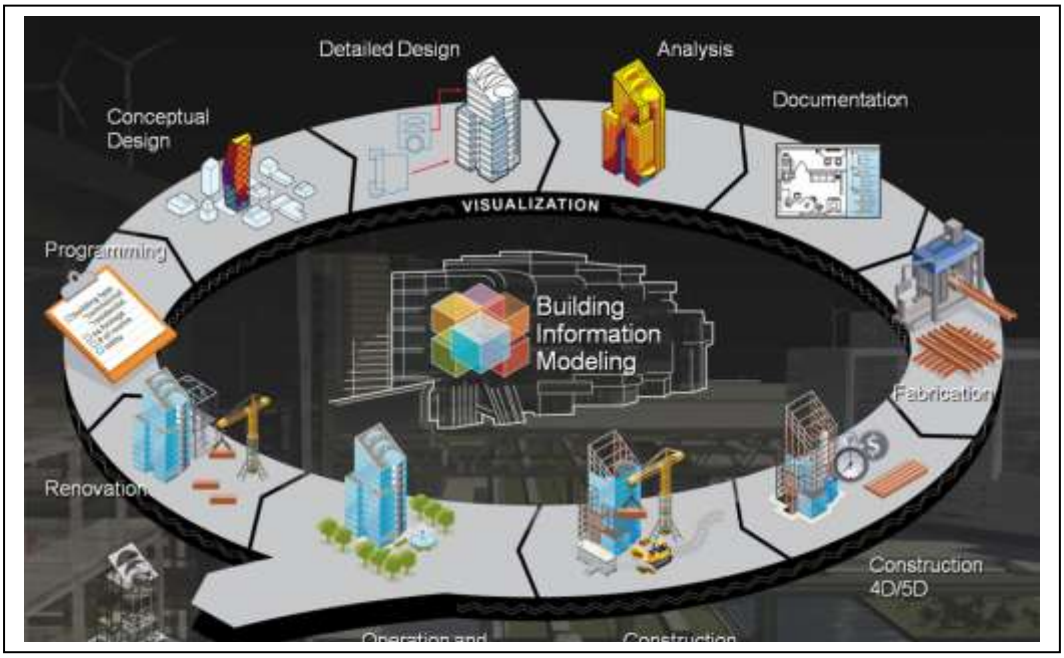


It is useful to use this view when attempting to improve an operational feature of a building that is related to how a building was designed. For example, overall energy conservation.

Less effort is put into designing a building to be energy efficient and large inefficiencies are incurred in the operational phase. Current research is ongoing in exploring methods of incorporating a whole life cycle view of buildings, rather than just focusing on the operational phase as is the current situation.

INTEGRATED DESIGN PROCESS:

The Integrated Design Process (IDP) is a method for realizing high performance buildings that contribute to sustainable communities. It is a collaborative process that focuses on the design, construction, operation and occupancy of a building over its complete life-cycle. During the integrated design process, the time taken for the earlier design stages i.e., conceptual and schematic design, is inevitably longer than that of the conventional linear design process. However, this additional time is made up for by the shorter coordinating time at later design stages i.e., detailed design and documentation for construction.




Typical IDP elements include the following:

Inter-disciplinary work between architects, engineers, costing specialists, operations ,management and other relevant fields right from the beginning of the design process;Discussion of importance of various performance issues and the establishment of a consensus on this matter between client and designers; Budget restrictions applied at the whole-building level. ( For example ,extra expenditures for one system, e.g. for sun shading devices, may reduce costs in another systems, e,g, capital and operating costs for a cooling system);

Testing of various design assumptions through the use of energy simulations throughout the process, to provide relatively objective information on this key aspect of performance;Addition of subject specialists (e.g. for day lighting, thermal storage, comfort, materials selection etc.) for consultations with the design team; Clear articulation of performance targets and strategies, to be updated throughout the process by the design team.

**Building life cycle & integrated design process – approaches Life cycle & IDP**

The life cycle and integrated design process is a design process to deliver a building, in which its relationship to the surrounding context, technical components and technologies are parts of a whole system. This objective can be obtained once interdisciplinary professional team members work collaboratively right from the inception and conceptual design to make strategic decisions and address all design issues.In this way, energy efficient technologies and strategies can be incorporated into the building design in a way that is integral to life cycle considerations. Such results are often not achievable using a conventional linear design process, which usually begins with the architect and the client agreeing on a design scheme.

Different approaches between Life cycle and IDP :

- Interdisciplinary and interactive approach.
- Lifecycle based decision making.
- Computer assisted design tools.

Interdisciplinary and interactive approach: An interdisciplinary team to be formed right from the project's inception. The involved parties, depending on the complexity of the project, are the client, architect, engineers, quantity surveyor, energy consultant, landscape architect, facility manager, contractor (builder) etc. The team members first establish a set of agreed performance objectives, and work collaboratively to achieve these objectives.

Lifecycle based decision making: Decisions made during the design process, such as built form, orientation, design features, building materials, structural systems, mechanical and electrical equipments, should be based on a lifecycle assessment. The assessment should take into account the products' or systems' embodied energy, performance, lifecycle cost, lifespan and end-of-life.

**Life-cycle assessment** or life cycle assessment (LCA, also known as life-cycle analysis)

For instance, in the case of a manufactured product, environmental impacts are assessed from raw material extraction and processing (cradle), through the product's manufacture, distribution and use, to the recycling or final disposal of the materials composing it (grave) Life cycle assessment (LCA) is one of the best mechanisms for allowing architects and other building professionals to understand the energy use and other environmental impact associated with all the phases of a building's life cycle: procurement, construction, operation, and decommissioning. The output of an LCA can be thought of as a wide-ranging environmental footprint of a building — including aspects such as energy use, global warming potential, habitat destruction, resource depletion, and toxic emissions.

Computer assisted design tools: . This approach includes the tools that simulate building environmental performances, and calculate the energy required for cooling or heating, $CO_2$ emissions, life cycle analyses and so on. Simulation tools predict building environmental performance, usually for aspects such as sun path and sun shadow, daylight, computational fluid dynamics for air movement, etc. The tools make design strategies visible through graphic-based user interfaces.

Uses of Computer assisted tools :

Providing feedback to inform the design process. For example, a sun path analysis provides outputs that allows the design team firstly to identify the areas requiring sun shading devices, secondly to design the form and dimensions of sun shading devices for them to be effective, and thirdly to simulate and verify the performance of sun shading devices on the building model. Comparing different design options, strategies, and technologies to facilitate the interdisciplinary team's decision making process.

Example : Daylight simulation of various design options to facilitate decision making process. Computational simulation technologies have also been rapidly developed to facilitate decision making during the design process to enhance the environmental performance and cost effectiveness of buildings. The five main areas for which computational simulations are usually applied are listed below, with examples of software:

Sun path and sun shadow simulation: ECOTECT.

Daylight and glare simulation: Radiance, Daylight, DAYSIM Thermal simulation: TAS, IES

Computational fluid dynamics (CFD): CONTAM, FLOVENT, FLUENT, IES Energy demand and supply balance: Energy Plus, eQuest.

In recent years, individual computer assisted design tools have gradually been replaced by an integrated, one-stop computational platform, that can serve as a drafting tool, visualisation tool, simulation of various environmental performance, local code compliance checking tool, and even a facility management tool.

An example is Bentley Tas Simulator software V8i.

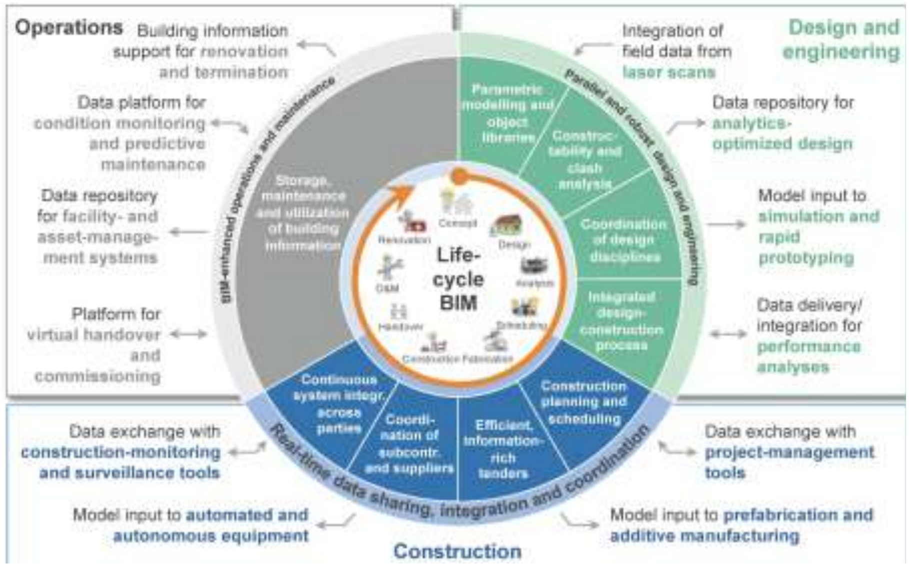
The software provides:

- A design tool (to simulate natural ventilation, room loads, energy use, plant sizing, $CO_2$ emissions, and running costs).
- A compliance tool (i.e., simulation and calculation compliance with ISO and are approved for calculation methods).
- A facility management tool (for computing detailed and accurate energy use predictions, energy and cost savings for operational and investment options.

Computational simulations should not just be used at the end of the design stage for verification and presentation purposes. They are particularly useful to simulate the performance of various design strategies and technological systems for comparison. Therefore, computational simulations should be deployed during the integrated design process as a design assisted tool to provide feedback to the team for design improvement and decision making. To be human resources- and time efficient, computational simulation can be applied at the macro level at conceptual design stage to show general/overall building volume for quick outcomes and overall direction. When moving to schematic and detailed design stages, more detailed computational simulations are required to support design improvements and fine tuning.

BIM in particular is intended to ensure the right people get the right information at the right time so they are able to make effective decisions.

Building Life Cycle – BIM




BIM software impacts each phase of Building Lifecycle Management.

Phase 1: PLAN

During the planning phase, all architects and designers have access to the same digital models. This promotes coordination and communication between parties, so any issues or inconsistencies can be worked out before you even break ground.Project management strategies, scheduling, and budget information can be addressed during this phase with the help of the BIM data.Design options, such as material choices, can be compared by viewing them on the digital 3D model. For example, you could do a side-by-side comparison of two deck or roofing materials, allowing you to visualize how each would affect the appearance and feel of the finished project. This can potentially help with both cost control and long-term maintenance concerns.Information about who held responsibility for each element of the building design should be included in the BIM data during this phase, as well as up-to-date contact information for those individuals.

Phase 2: BUILD

Changes to the structure that come up during the construction phase will be: Reduced significantly by planning and designing the structure using BIM software. Automatically updated in the digital model so everyone involved in the project will be aware of the changes Because the details of the project — think scope, budget, and schedule — were coordinated during the planning phase and are updated as any tweaks are made, contractors can take advantage of Just-in-Time delivery. This means building materials will be delivered only when it's time to install them, saving you money by eliminating the delivery of unnecessary items and keeping materials from being destroyed or stolen while they sit around on the job site.

Phase 3: USE

When the building is complete and the commissioning process begins, the BIM data is transferred from the construction crew to the new facility management team. Important information about the configuration of the building's interiors is included in the updated models. Details such as where cables and outlets are located may be included, as well as where offices/units are located, so the space can be used to its full potential by its occupants.Similar to the planning phase, information about who is responsible for the work and completion of different parts of the building should be included here, as well as up-to-date contact information for those individuals.

Phase 4: MAINTAIN

All operation and maintenance (O&M) documents can be included in, or at least referenced from, the BIM model. Building maintenance that takes place — both planned and unexpected — is updated in the BIM file. Including this type of information allows the site management team to determine their own best practices for maintaining the structure. An added benefit: If the structure is part of a larger complex, the teams from the different buildings can share these best practices within the shared BIM information.

Phase 5: REPAIR and IMPROVE

Whenever a repair or improvement is made to the building, it is noted or updated within the BIM model. This includes information about who completed the work, what was done and when, and where the update or repair was located within the building. If changes were made to the structure or function of the building, those alterations should be noted in the BIM software as well. If, down the road, it is discovered that part of the building was constructed in a way that does not meet local standards or codes, or if the building is not performing to its full potential, the current management team or occupants can refer to the BIM information to find who designed, approved, supervised, executed, and inspected the building at different stages. This allows for any disputes to be addressed with the appropriate contacts.

Phase 6: LEARN

Because the BIM data is saved within the software, people can use that information to make informed decisions about the building over the course of its lifecycle. They can also use that information for constructing similar structures. All the information the model contains — in terms of building parts that needed to be replaced or repaired, modifications that were made to the building, or long-term maintenance options that have worked or not worked — will help create best practices for each structure and management team

Phase 7: DECOMMISSION

The decommission stage of a building’s lifecycle refers to when the structure is either dramatically updated or renovated, or demolished. Often, the decision to change or tear down is a difficult one to make, but it is made easier when you have the information at hand to complete a thorough A-to-Z analysis of the building. Having all this information stored in the BIM software makes coming to an educated decision much easier.Working with BIM software from the onset of your project not only provides benefits during the design and construction phases of your build, but throughout the structure’s entire lifecycle. Having easy access to every piece of information about the building from start to finish is an invaluable long-term asset and one that can be achieved through the innovative technology of BIM software.

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**SCHOOL OF BUILDING AND ENVIRONMENT**

**DEPARTMENT OF ARCHITECTURE**

# UNIT – IV – Building Automation Systems – SAR1615

INTELLIGENT DESIGN AND CONSTRUCTION:

Effective Space Utilisation

Space utilisation is a strategically important space management measure.

Utilisation studies provide information on how space is being used and help to inform decisions about the type and scale of facilities needed.

Benefits of Space Management

Space is at the heart of facility management and effective space management is key to professional facility management. Understanding the types of spaces within a real estate portfolio and knowing how they are used is essential in a well-managed facility operation

A good space management system will provide three major benefits:

Efficiency: Reduce real estate expenses by understanding how your space is being used.

Effectiveness: Use your space better by getting a better fit between workstations and jobs or locating departments better.

Foundation: Space is the foundation for many other things you want to do in facility management such as move management, maintenance management, scenario planning, real estate and leasing and list goes on–but it all starts with space, without it, you can’t do any of these other things.

Office management software:

- Visualize occupancy and space utilization on real-time floor plan views
- Make informed space utilization decisions with real-time reports, customized to your needs
- Leverage the power of scenarios and plan complex moves ahead in detail
- Maintain the quality of your seating data with editable management reports

Visual Directory for kiosks displays interactive maps of your facility on touchscreens everyone can use.

    - Changes display in real-time, meaning your people always have the right information at their fingertips.
    - See where coworkers are sitting
    - Find and book meeting rooms and break-out rooms
    - Track down resources like printers and medical equipment
    - View changes to seating availability in real-time

OfficeSpace clients are using Distancing Planner to create a safe seating plan for employees.

This new feature uses AI technology to automatically create distanced seating configurations that optimize your reduced workplace capacity.Use AI to develop a seating plan that optimizes for capacity while maintaining appropriate distancing. Visualizes the physical distancing radius around seats and easily determine which desks need to be made inactive.

Tracks seating capacity in real-time and understand the impact of different spacing configurations. Takes action on safe selected seats - including converting them into bookable desks

Visualize your data

OfficeSpace turns your floor plan into a powerful reporting tool. Search for people, rooms and resources. Filter and visualize workplace data any way you like. Print customized views of your floor plan that highlight exactly what you need to see. OfficeSpace is more than just workplace management software

It's a search engine for your workplace.
It's insights that reduce real estate costs.
It's a way to optimize your facility and engage employees.

OfficeSpace is the workplace management platform of choice for companies managing the current disruption to the workplace. We simplify everything from desk booking to social distancing – so you can create a better place for everyone.

Free addressing with sensors

Free addressing is a great way to increase desk availability without requiring your workplace team to manually oversee the booking process. Sensors automatically monitor and update free addressing desk availability on your floor plan in real-time.Anyone can see desk availability in real-time. Employees can sit at any available desk without needing to check-in. Sensors automatically update the floor plan to show which desks are available, soon to be available, or occupied.

Integrated Workplace Management Software – IWMS

Integrated facilities management (IFM) is a method of consolidating many office-related services and processes under one contract and management team.

IFM is all about integration, and technology is its foundation. Software solutions that support IFM bring all the disparate components of facilities management onto one platform.There are several kinds of facilities management software that support integration in the facilities management industry, including Computer-Aided Facility Management (CAFM), Computerized Maintenance Management System (CMMS), Enterprise Asset Management (EAM), and perhaps the most all-encompassing, Integrated Workplace Management System (IWMS).

IWMS is perhaps the most all-encompassing of these softwares. It can be described as a combination of all the systems above, plus more. An IWMS like OfficeSpace will include many of the features mentioned thus far, plus a host of other abilities that make it much easier to manage the office environment. For example, a good IWMS can help employees find. For example, a good IWMS can help employees find whatever resources they need—from printer drivers to open seating. With an integrated Mobile Visual Directory, employees can use their phones to find fellow employees and resources like copiers, while a mobile-friendly Request Manager feature allows for quick submissions of work orders.Using an IWMS as a software platform helps companies optimize the use of all the different elements of facilities management in order to integrate all parts. This includes the optimization of workplace resources, the management of a company's real estate portfolio, plus building infrastructure and facilities assets.

In the past, these elements have been siloed, but with the proliferation of technology, the facilities management industry is now able to integrate them. An IWMS can help employees find whatever resources they need—from printer drivers to open seating. With Mobile Visual Directory, employees can use their phones to find co-workers and resources like copiers, while a mobile-friendly Request Manager allows them to quickly submit work orders and even attach images that highlight the relevant issue.

Space Management

Space management can be understood as various management tasks related to building space, including spatial information management, lease management, and event management. GIS and BIM are information technologies directly related to space. They can provide direct carrier for space management. And through the association of spatial basic information, rental information, and event information, a more convenient space management visualization tool can be formed.

ENERGY CONSERVATION THROUGH-

- SITE SELECTION / SITING
- ORIENTATION
- SITE PLANNING
- BUILDING DESIGN
- INTEGRATING SITE AND BUILDING DESIGN FOR ENERGY EFFICIENCY.

Site Planning and Orientation

Building orientation and site planning are amongst the important factor in determining the building eco-friendliness Accordingly they can help the designers to determine which area will be affected by receiving direct sunlight to the building façade or atrium design. An important clue in developing energy efficient facades for energy efficient building is the knowledge about the distribution of solar radiation due to orientation.

The site planning has a relationship with orientation of the building. The orientation of the building should be accumulated with sun path. Sun path is the sun's position on the sky hemisphere .

It can be specified by two angles:

i. Solar altitude angle (y). e.i. the vertical angle at the point of observation between the horizon plane and the line connecting the sun with the observer.

ii. Solar azimuth angle (a). e.i. the angle at the point of observation measured on a horizontal plane between the northerly direction and a point on the horizon circle, where it is intersected by the arc of a vertical circle, going through the zenith and the sun’s position. It frequently happens that the geometry of the site does not coincide with sun path geometry.

In these cases, the other built elements may, if expedient for planning purposes, follow the site geometry (for example, to optimize basement car-parking layouts). Typical floor window openings should generally face the direction of least insulation (north and south in the tropics). Cornershading adjustments or shaping may need to be done for sites further north or south of the tropics or for non-conformity of the building plan to the solar path

Building orientation affects the air-conditioning or heating energy requirements in two respects by its regulation of then influence of two distinct climatic factors .Solar radiation and its heating effects on walls and rooms facing different directions .Ventilation effects associated with the relation between the direction of the prevailing winds and the orientation of the building. From the above two, solar influence on energy is the most significant in the tropics and is extensively covered by many others.

Tools for Site selection:

A BIM model consists of the virtual equivalence of the actual building sections used to create a building. These intelligent elements are the digital prototype of the physical elements, such as walls, columns, windows, doors, and stairs. This prototype makes it possible to simulate the building and understand its behavior before the actual construction begins. BIM models contain more than architectural data since information about different engineering fields, sustainability information, and other characteristics can be easily simulated well in advance of the actual construction.

BIM is considered as one of the most effective tools for sustainable design.

It could be linked to the performance analysis tools to assess different sustainable design alternatives and to choose the most efficient alternative at the pre-construction stage.

BIM has been used as a tool to achieve maximum sustainability on projects through energy modelling.Today, sustainability considerations require that we determine the most efficient and best methods for designing a building, including its mechanical, electrical, and plumbing (MEP) systems.

BIM Use: Site Analysis

Site Analysis

Description:

A process in which BIM/GIS tools are used to evaluate properties in a given area to determine the most optimal site location for a future project. The site data collected is used to first select the site and then position the building based on other criteria.

Potential Value:

- Use calculated decision making to determine if potential sites meet the required criteria according to project requirements, technical factors, and financial factors
- Decrease costs of utility demand and demolition
- Increase energy efficiency
- Minimize the risk of hazardous material
- Maximize return on investment

Resources Required:

- GIS software
- Design Authoring Software

Team Competencies Required:

-Ability to manipulate, navigate, and review a 3D model

-Knowledge and understanding of local authority's system (GIS, database information

ArcGIS for AEC Site Selection-Simplify the design process with location intelligence.This collection provides location intelligence for planning and site selection. Combine existing conditions with demographic, lifestyle, and spending data with map-based analytics for accurate site assessments and feasibility studies.

GIS technology has advantages in the analysis of commercial site selection.

By analyzing the overlapping of commercial data and spatial location in population, passenger flow, transportation, market competition, etc., it forms a reference for site selection, which can support the decision making for building operations such as distribution planning and investment management in a visual way.

Geographic information is an important component of the entire decision-making process in construction and nothing else than a GIS can enable everyone involved to become spatially aware most effectively. Using GIS enables people from different segments of the construction lifecycle to share a common picture of the project, provided by the GIS-generated maps. GIS must necessarily become the common visualization tool in the development of sites. GIS extends the value of digital BIM through visualization. Integration of BIM and GIS with time information, allows project participants to better understand the impacts of decisions before, during and after the construction of a project.

Assessing project sites viability

Gain valuable insight into your proposed design by comparing thousands of variables including demographics, traffic counts, and consumer spending—ultimately ensuring your design best supports your stakeholders' needs.

- Validating design decisions
- Create comparison reports of demographics, consumer expenditure, and lifestyle segments.
- Walkability and drive time reports ensure client success and allow you to design the best site possible.
- Visualize and share conceptual models in context for better understanding to get stakeholder buy-in.

Energy Analysis

BIM Use

Description

A process in the design phase which one or more building energy simulation programs use a properly adjusted BIM model to conduct energy assessments for the current building design.

The core goal of this BIM use is to inspect building energy standard compatibility and seek opportunities to optimize proposed design to reduce structure's life-cycle costs.

Potential Value

• Save time and costs by obtaining building and system information automatically from BIM model instead of inputting data manually

• Improve building energy prediction accuracy by auto-determining building information such as geometries, volumes precisely from BIM model

• Help with building energy code verification

• Optimize building design for better building performance efficiency and reduce building life-cycle cost

Choose the materials that need to be applied in the construction, and then import the data information into the simulation software for analysis, including the construction safety inspection and building code inspection, such a simulation test or analysis, to enhance the quality of the project to a great extent.

Resources Required

• Building Energy Simulation and Analysis Software(s)

• Well-adjusted Building 3D-BIM Model

• Detailed Local Weather Data

• National/Local Building Energy Standards (e.g. ASHRAE Standard 90.1)

Team Competencies Required

• Knowledge of basic building energy systems

• Knowledge of compatible building energy standard

• Knowledge and experience of building system design

• Ability to manipulate, navigate, and review a 3D Model

• Ability to assess a model through engineering analysis tools

BIM and energy efficiency

How does BIM allow us to achieve gains in energy efficiency?

Materials analysis, thermal simulation, equipment maintenance, and so on.

From the early design phase right through to maintenance of the completed build, the digital avatar is used to collect precise measurements of thermal and energy performance. It provides an accurate overview of the building and all of its technical characteristics for each different stakeholder in the build process. Inarguably, BIM is a valuable support tool for the design and decision-making processes, and is effective in reducing the carbon footprint of our buildings.The relevance of this type of methodology will surely increase in step with the emergence of connected buildings. The data collected by the different sensors in a smart building will indeed give an even more detailed insight of a building’s lifecycle.

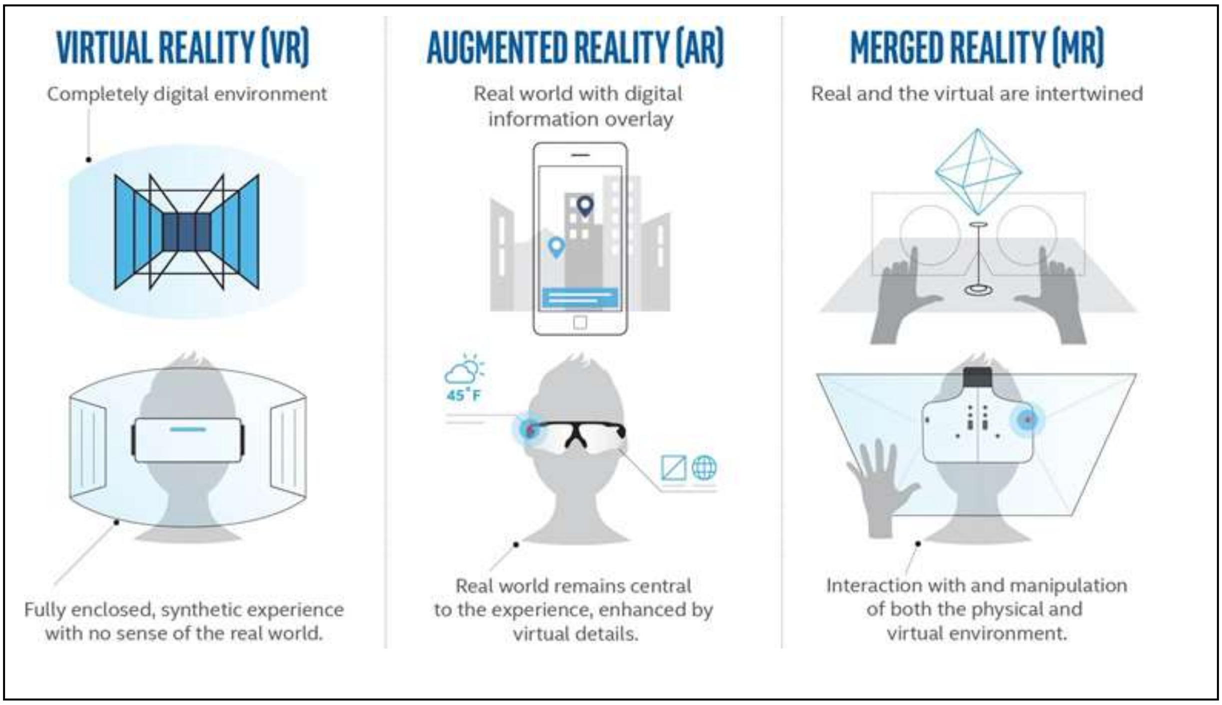
Additional tools within the AS+P BIM toolbox are virtual reality applications. The planning becomes virtual reality: traceable, detectable and tangible. The client can move through his future building, interact with it and orient himself. BIM can be augmented by emotions, such as familiar background noise and personal or typical company equipment. Interactive elements, such as accurate light direction or the future view from a window and much more can be included in the digital building model. Thus a high degree of immersion can be generated by very simple means, giving the client a comprehensive and intuitive image of his future building.

Virtual Reality, Augmented Reality, and Mixed Reality are similar but have different capabilities.

VR:is the immersive, full-headset experience that most people associate with this technology. “With virtual reality, you’re immersing yourself into a virtual environment and closing yourself off completely from the outside world,” ……Enitrely Digital Environment

AR: With augmented reality, data and/or instructional information are animated over the real-world view, often through smaller devices such as a mobile phone or tablet. Pokémon Go is a popular consumer example of an augmented-reality app; a professional use case would be an engineer remotely teaching a mechanic how to repair something.

MR: Mixing together aspects of VR and AR, MR takes virtual objects and overlays them onto the real world. Two people (say, an architect and a structural engineer based in another country) can be networked into a virtual world where they can interact together with a virtual building on a real site.

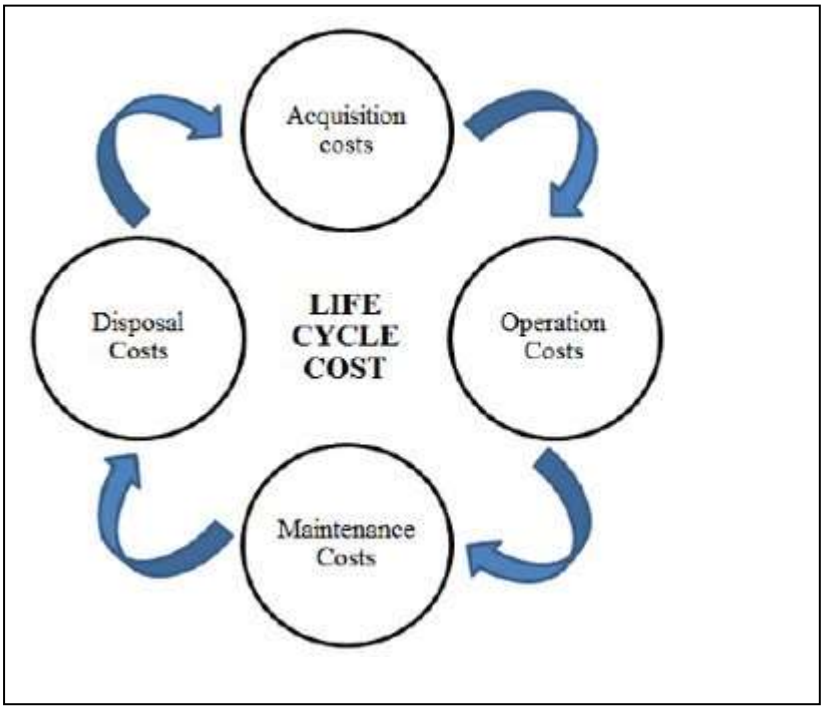



Virtual reality replaces the real world with a simulated one whereas augmented reality takes the real world and adds to it with—in the case of architecture—a 3D model of your design.

VR  allows architects to experience their designs before they are built. This provides them, and their clients, with a sense and feel of the space. With AR, designers are even able to see their building designs in the exact location in which they will be built. This allows architects to visualize their designs within the natural topography and provides them with data about the site that wasn't previously available to them.

Life cycle cost (LCC) is an approach that assesses the total cost of an asset over its life cycle including initial capital costs, maintenance costs, operating costs and the asset's residual value at the end of its life.

Life-Cycle Cost Analysis (LCCA) Method. The purpose of an LCCA is to estimate the overall costs of project alternatives and to select the design that ensures the facility will provide the lowest overall cost of ownership consistent with its quality and function.




Life-Cycle Cost Analysis (LCCA) Method:

The purpose of an LCCA is to estimate the overall costs of project alternatives and to select the design that ensures the facility will provide the lowest overall cost of ownership consistent with its quality and function.The LCCA should be performed early in the design process while there is still a chance to refine the design to ensure a reduction in life-cycle costs (LCC).

LCCA can be applied to any capital investment decision in which relatively higher initial costs are traded for reduced future cost obligations. It is particularly suitable for the evaluation of building design alternatives that satisfy a required level of building performance but may have different initial investment costs, different operating and maintenance and repair costs, and possibly different lives. LCCA provides a significantly better assessment of the long-term cost-effectiveness of a project than alternative economic methods that focus only on first costs or on operating-related costs in the short run.

LCC is a process that consists of three key steps:

- In a clear, structured cost analysis you can easily see what cost sources influence your total cost of ownership the most.
- When the major expenditure sources are clear, you can quickly identify hotspots for improvement in your baseline design and test different solutions for the existing objectives.
- Knowing your alternatives, you can compare their benefits and accordingly relocate the costs to gain maximum value out of your project.
- Therefore, LCC is an objective, down-to-earth approach. Obviously, the earlier is performed the better the result, since it is easier to make changes in the design stage.

- And the more options and freedom you have, the more value you can get from your LCC analysis.
- The understanding of life cycle costs can lead to a drastic reduction of the total cost of building ownership.
- LCC allows you to find the most optimal costing solution for your building project, to compare between design alternative, and to choose the one that will boost your project's value.

Building efficiency:

Building efficiency must be considered as improving the performance of a complex system designed to provide occupants with a comfortable, safe, and attractive living and working environment.

BUILDING EFICIENCY AND LIFE CYCLE COSTS

Energy efficient approach in a commercial building as example:

In order to reduce LCC of building, energy consumption cost has been considered as key component as this being major annual expenditure in commercial buildings.

Cost of energy consumption can be reduced by using renewable sources as well as by using modern techniques. Renewable techniques Opted- Solar PVC Panels.

Results:

- Energy efficient approach with solar panel system requires initial investment in the range of 1.3–16%.
- With minimum initial investment on solar power panel, 4.3% of total cost can be saved over span of 30 years.
- With proposed solar power panel 54.64% of total cost can be saved over span of 25 years.
- Energy efficient approach using solar power panels can reduce LCC of existing building effectively.