COURSE NAME| Session No.4

ENERGY MANAGEMENT CONTROL SYSTEMS

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SESSION OBJECTIVES

- Identify and describe the basic types of control system, its components and the practical applications in a building both for commercial & industrial use.
- Achieve an optimal level of building HVAC system, lighting control and occupant comfort while minimizing energy use through the utilization of building automation system
- Explain the process of implementing Building Automation System and recognizing the opportunities for Energy Efficiency and Conservation.

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CONTROL SYSTEM

Is a system of getting an output by regulating, commanding, and directing the input and are an integral part of many energy related processes.

A control systems can be as simple residential thermostat, to a very complex computer-controlled systems for multiple buildings, to industrial process controls.

Two (2) Main Types of Control System
- Open-Loop Control System
- Closed-Loop (Feedback) Control system

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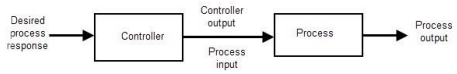
WHY CONTROL the SYSTEM?

- Reduce equipment capacity to maintain the desired ambient conditions, temperature, %RH, pressure, etc,.
- Reduce the amount of human error and labor needed.
- Keep processes operating at safe levels.
- Operate processes to maintain environment using the least possible amount of energy.

OPEN-LOOP CONTROL SYSTEM

A control system in which the control action is totally independent of the output of the system is called an open-loop control system. A **manual control system** is also an open-loop control system.



TYPICAL EXAMPLE OF OPEN-LOOP CONTROL SYSTEM

- **Electric Hand Drier** – Hot air (output) comes out as long as you keep your hand under the machine, irrespective of how much your hand is dried.
- **Automatic Washing Machine** – This machine runs according to the pre-set time irrespective of washing is completed or not.
- **Bread Toaster** – This machine runs as per adjusted time irrespective of toasting is completed or not.
- **Light Switch** – Lamps glow whenever the light switch is on irrespective of light is required or not.
- **Volume on Stereo System** – Volume is adjusted manually irrespective of output volume level.

OPEN-LOOP CONTROL SYSTEM

Advantages of open-loop control systems are:

1. Simple in construction and design
2. Economical
3. Easy to maintain
4. Generally stable
5. Convenient to use as output is difficult to measure

Disadvantages of open-loop control systems are:

1. They are inaccurate.
2. They are unreliable.
3. Any change in output cannot be corrected automatically.

EXAMPLE of an OPEN-LOOP CONTROL

Manual Control

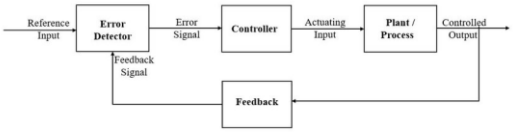
- Valve
- On/Off Switched

Basic Automatic Control

- Timers
- Dimmers

CLOSED-LOOP CONTROL SYSTEM

Control systems in which the output has an effect on the input quantity in such a manner that the input quantity will adjust itself based on the output generated is called a closed-loop control system. An open-loop control system can be converted into a closed loop control system by providing feedback.



TYPICAL EXAMPLE OF CLOSED-LOOP CONTROL SYSTEM

- **Automatic Electric Iron** – Heating elements are controlled by the output temperature of the iron.
- **Servo Voltage Stabilizer** – Voltage controller operates depending upon the output voltage of the system.
- **Water Level Controller** – Input water is controlled by the water level of the reservoir.
- **Missile Launched and Auto Tracked by Radar** – The direction of the missile is controlled by comparing the target and position of the missile.
- **Air Conditioner** – An air conditioner functions depending upon the temperature of the room.

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CLOSED-LOOP CONTROL SYSTEM

Advantages of closed-loop control systems are:

1. Closed loop control systems are more accurate even in the presence of non-linearity.
2. Highly accurate as any error arising is corrected due to the presence of a feedback signal.
3. The bandwidth range is large.
4. Facilitates automation.
5. The sensitivity of the system may be made small to make the system more stable.
6. This system is less affected by noise.

Disadvantages of a closed-loop control systems are:

1. They are costlier.
2. They are complicated to design.
3. Required more maintenance.
4. Feedback leads to an oscillatory response.
5. Overall gain is reduced due to the presence of feedback.

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CLOSED-LOOP CONTROL

Programmable Controllers

Microprocessor-based Controllers/BAS/BMS

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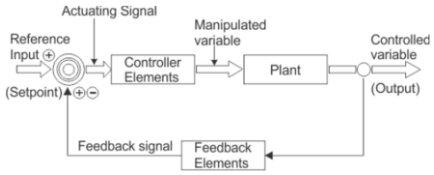
CLOSED-LOOP CONTROL SYSTEM

FEEDBACK LOOP in a CLOSED-LOOP CONTROL SYSTEM

Feedback is a common and powerful tool when designing a **control system**. The feedback loop is the tool that takes the system output into consideration and enables the system to adjust its performance to meet the desired result of the system.

In any control system, the output is affected due to a change in environmental conditions or any kind of disturbance. So, one signal is taken from the output and is fed back to the input.

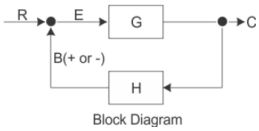
FEEDBACK LOOP in a CLOSED-LOOP CONTROL SYSTEM



This signal is compared with a reference input and the error signal is generated. This error signal is applied to the controller and the output is corrected. Such a system is called a feedback system.

FEEDBACK LOOP in a CLOSED-LOOP CONTROL SYSTEM

The following labels apply to this figure:
R = Input signal
E = Error signal
G = Forward path gain
H = Feedback
C = Output signal
B = Feedback signal



Block Diagram

Feedback has the following effects on a control system:
1.The error between system input and system output is reduced.
2.System gain is reduced by a factor 1/(1±GH).
3.Improved insensitivity (i.e. less reactive to change).
4.Stability is improved.

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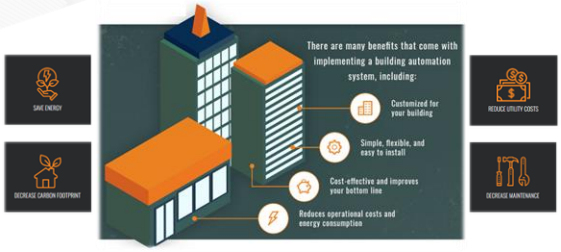
WHY Automate Building Systems?



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BUILDING AUTOMATION SYSTEM

- Early days buildings were very simple with few facilities and services
- With time, many services were introduced and crowded the building
- At present, buildings are very complex with many services & higher occupancy
- Central monitoring and controlling those services are needed.


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Building Automation System (BAS) also known as Building Management System (BAS) or BEMS or EMCS

- is a network designed to control, monitor, regulate and optimize the buildings electrical and mechanical systems, from air handling and cooling plant system, lighting, power system, fire & security, access control systems and other building services - all wired through one set of controls.

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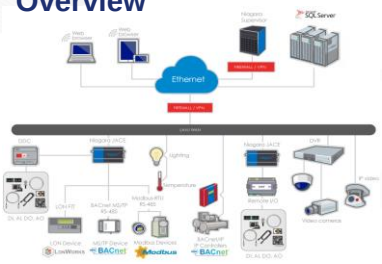
Overview



BACnet stands for **B**uilding **A**utomation and **C**ontrol **Net**works. It is a communication protocol standard designed specifically to provide a way to integrate building control products made by different manufacturers.

Java Application Control Engine (JACE) is the mechanism that provides this connectivity to systems within a building.

DDC enables a single control point for a building's various systems. DDCs are frequently used in HVAC, lighting, alarm systems, or automating an entire building's system.

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How Does a Building Automation System (BAS) Work?

Most BAS have five main components:

- **Input devices (sensors)**
- **Controllers**
- **Output devices (actuators)**
- **Communications protocols**
- **User interfaces (UI)**

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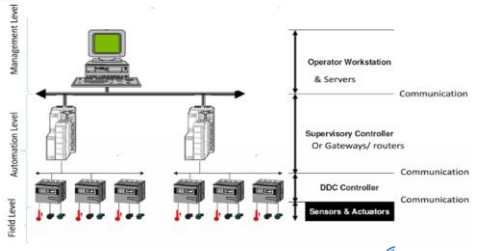
Building Automation System Architecture



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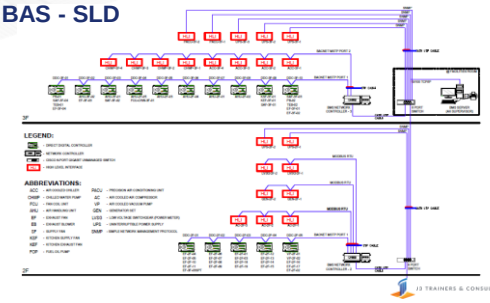
BAS - SLD



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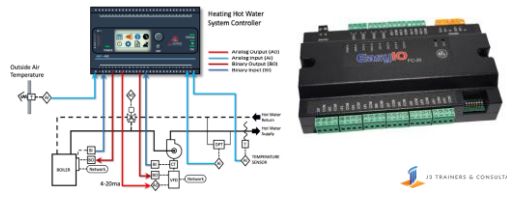
What is a DDC Controller?

A DDC controller is a type of computer-based control system that is used to control the environment of a building. It is designed to monitor and control the operation of a variety of systems, including HVAC, lighting, and security systems. The system is connected to sensors, actuators, and other monitoring devices that it then uses to regulate the environment of the building.



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Benefits of DDC Controller in a Facility

DDC controllers provide numerous benefits for facilities management. Because **the system is computer-based, it is capable of making decisions in real-time**, meaning that it can react quickly to changes in the environment. This makes it an **effective tool for managing energy consumption and ensuring that the building is operating efficiently**.

Additionally, DDC controllers provide a **high level of accuracy**, which means that they can make decisions that are **more precise than manual operation**. This can help to improve the safety and comfort of the building's occupants while also helping to reduce energy costs.

Finally, DDC controllers can be easily integrated with other systems, such as security and **building automation systems (BAS/BMS)**.

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Sensors and Actuators

Sensors are used to detect changes in temperature, humidity, air quality, light levels, and other environmental parameters. These sensors can be wired or wireless and typically communicate with the central control system through standard communication protocols such as BACnet, Modbus, or LonTalk.

Actuators are used to adjust parameters such as temperature, humidity, air flow rate, pressure levels, and other variables which would otherwise be difficult to control manually. This could include motors, switches, valves, or other devices which are used to adjust the temperature, airflow rate, pressure levels, etc.

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BAS/BMS Major Communications Protocol

BACnet™, comm protocol for building automation and control (BAC) networks that use the ASHRAE, ANSI, and ISO 16484-5 standards

LonWorks or Local Operating Network is an open standard (ISO/IEC 14908) for networking platforms created to address the needs of control applications

Modbus is a client/server data comms protocol. It was originally published by Modicon (now Schneider Electric) in 1979 for use with its programmable logic controllers (PLC's)

Looking at a few heating, ventilation & air conditioning (HVAC) industry leaders:

- North American **ASHRAE** uses Building Automation Systems (BAS/BMS)
- Europe's **REHVA** uses Building Automation and Control Systems (BACS)
- Australia's **AIRAH** uses Building Management and Control System (BMCS)

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The User Interface (UI)

The user interface (UI) is **the point of human-computer interaction and communication in a device.** This can include display screens, keyboards, a mouse and the appearance of a desktop. It is also the way through which a user interacts with an application or a website.

The goal of effective UI is to make the user's experience easy and intuitive, requiring minimum effort on the user's part to receive the maximum desired outcome.

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Key Factors to Consider when Choosing BAS in Energy Efficiency

- **Scalability and Flexibility**
  Consider systems that allow the integration of new devices and technologies
- **Energy Monitoring and Analytics**
  Features such as real-time energy consumption data, trend analysis, and benchmarking tools
- **Integration and Compatibility**
  Systems that support open protocols and standards, as they allow easy integration
- **User-Friendly Interface**
  Customizable dashboards, mobile accessibility, and remote monitoring
- **Maintenance and Support**
  Reliable maintenance and support system is essential to ensure the smooth operation of BAS

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The Role of Building Automation Systems in Energy Efficiency & Conservation

Energy-efficient buildings have a **significant impact** on ***reducing energy consumption*** and ***carbon footprint***. According to the United States Environmental Protection Agency (EPA), buildings account for 39% (47.64% in the Philippines for both commercial & industrial bldgs.) of total energy consumption in the country. By integrating BAS into energy-efficient buildings, businesses and individuals can **save on energy costs, improve operational efficiency, and contribute to a sustainable future.**

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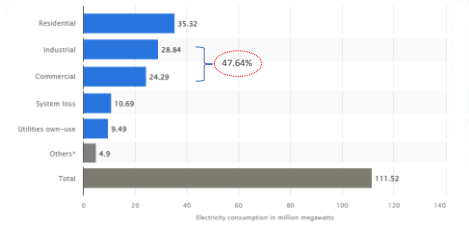
Total electricity consumption in the Philippines in 2022, *(in million megawatts)*



https://www.statista.com/statistics/1266853/philippines-electricity-consumption-by-sector/

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Conducting Energy Consumption Survey and Establishing Energy Efficiency Indicators for the Industrial and Commercial Sectors of the Philippines

ERIA
Economic Research Institute for ASEAN and East Asia

According to the latest EAS energy outlook updated by ERIA, it is projected that the Philippines' energy demand will expand more than threefold by 2050.

In response to this growing energy demand, the Department of Energy, Philippines (PDOE), took a proactive step by enacting the 'Energy Efficiency and Conservation Act' in April 2019 to promote energy-saving practices compared to Business As Usual (BAU).

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The Role of BAS/BMS in EE&C

1. **Energy Monitoring and Analysis**

BAS can gather real-time data from energy meters, sensors, and other devices installed throughout the building. This data is then analyzed to identify energy consumption patterns, peak usage periods, and areas of potential energy wastage. By having a clear understanding of energy usage, facility managers can make informed decisions and implement appropriate strategies to minimize energy waste.

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The Role of BAS/BMS in EE&C

2. Efficient HVAC Control

Heating, ventilation, and air conditioning (HVAC) systems are major contributors to energy consumption within buildings. BAS enable precise control and scheduling of HVAC systems, ensuring optimal performance based on occupancy, weather conditions, and specific requirements of different areas within the building. This eliminates unnecessary energy consumption and reduces operational costs.

The Role of BAS/BMS in EE&C

3. Lighting Optimization

Lighting is another crucial aspect of energy conservation in buildings. Building Automation Systems utilize lighting control strategies such as occupancy sensing, daylight harvesting, and intelligent scheduling to ensure that lighting is only active when needed. Thus, unnecessary energy consumption is minimized, and energy savings are achieved.

The Role of BAS/BMS in EE&C

4. Integration of Renewable Energy Sources

Integrating renewable energy sources like solar panels or wind turbines into building operations can significantly lower energy consumption from the grid. Building Automation Systems can intelligently manage these renewable energy sources by monitoring their performance, optimizing their utilization, and distributing the generated energy efficiently. This reduces reliance on non-renewable energy sources and results in both economic and environmental gains.

Implementing Building Automation Systems in buildings provides several advantages:

- Significant reduction in energy consumption and operational costs
- Improved occupant comfort and productivity
- Reduced carbon emissions and environmental impact
- Remote monitoring and control capabilities for enhanced efficiency
- Increased reliability and lifespan of building systems

Strategies for Energy Optimization

Building **A**utomation **S**ystems have emerged as a game-changer in the domain of energy conservation. By effectively managing and controlling building operations, these systems offer immense potential for (1) **reducing energy consumption**, (2) **lowering costs**, and (3) **enhancing sustainability**. As technology continues to advance, the future of Building Automation Systems looks promising, providing opportunities for a greener and more energy-efficient world.

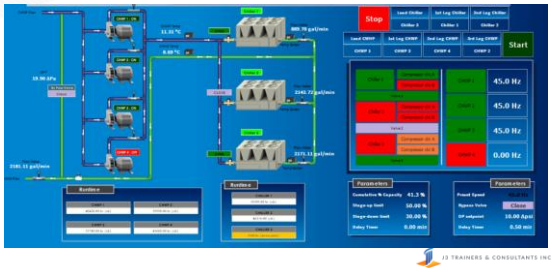
Strategies for Energy Optimization

1. Demand-based Control

Implementing demand-based control ensures that energy-consuming systems are activated or adjusted only when required.

- Energy savings by reducing unnecessary usage during unoccupied periods.
- Improved comfort and productivity through personalized control settings.
- Identification of energy-wasting areas or equipment for targeted improvements.

Strategies for Energy Optimization



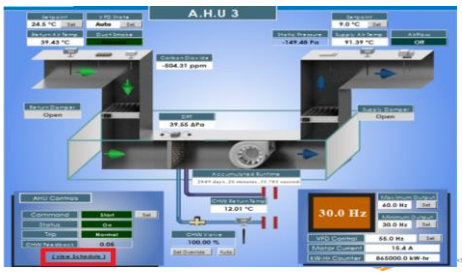
Strategies for Energy Optimization

2. Time-based Control

Time-based control involves scheduling energy-consuming systems to operate during specific time slots when they are most needed. With this strategy, you can optimize energy usage based on occupancy patterns and peak demand periods. Key advantages of time-based control include:

- Energy savings by avoiding energy consumption during periods of low demand.
- Optimal operation of systems based on specific time requirements.
- Reduction in peak demand charges by managing load profile more efficiently.

Strategies for Energy Optimization



Strategies for Energy Optimization

3. Integration and Analytics

Integrating your building automation system with advanced data analytics platforms enables you to gain valuable insights and make data-driven decisions for further optimization. Smart analytics can identify trends, patterns, and anomalies in energy usage, allowing you to pinpoint inefficiencies and implement corrective measures. Key advantages of integration and analytics include:

- Optimized energy consumption based on real-time data analysis.
- Proactive identification and resolution of energy inefficiencies.
- Improved asset management and predictive maintenance through data insights.

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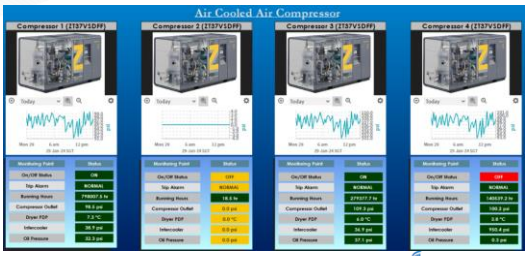
Strategies for Energy Optimization



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Strategies for Energy Optimization

4. Continuous Monitoring and Maintenance

Regular monitoring and maintenance of building automation systems ensure their optimal performance and longevity. By implementing a proactive maintenance strategy, you can identify and address potential issues before they escalate and result in energy wastage. Key advantages of continuous monitoring and maintenance include:

- Increased system reliability and reduced downtime.
- Extended equipment lifespan, saving on replacement costs.
- Energy savings by detecting and repairing system inefficiencies promptly.
- Improved overall building performance and occupant satisfaction.

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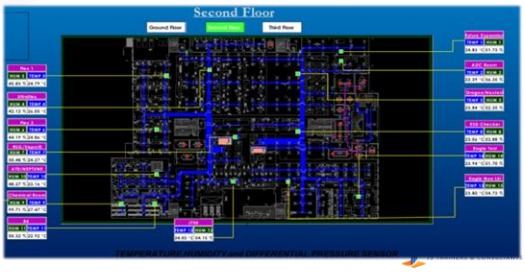
Strategies for Energy Optimization



KEY POINTS:

- ✓ **Energy Efficiency:** BAS optimize energy consumption by automatically adjusting heating, cooling, and lighting based on occupancy, time of day, and other factors. This results in significant energy savings.
- ✓ **Improved Comfort:** BAS ensures optimal indoor conditions through precise temperature control, efficient ventilation, and customized lighting. Occupant's experience consistent comfort and air quality, leading to increased productivity and satisfaction.
- ✓ **Reduced Maintenance Costs:** By continuously monitoring and analyzing system performance, BAS can detect and diagnose issues in real-time. This proactive approach minimizes downtime and reduces maintenance costs.
- ✓ **Enhanced Sustainability:** BAS allows for better monitoring and management of a building's energy consumption. By optimizing usage, buildings can reduce their carbon footprint and contribute to a more sustainable future.

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THANK YOU!

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