ENERGY SOLUTIONS CENTER

Track: Commercial Natural Gas I
Unit 11: Building Automation Systems

Eric Burgis, Energy Solutions Center

An overview of Building Automation Systems for Commercial Facilities

Presentation Outline

- Terms and definitions
- Older buildings and systems
- Newer systems and considerations
- Equipment and configurations
- Monitoring and reporting capability
- Installations and energy savings
- Additional resources

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Terminology & Definitions

Terms and Definitions

- **Sensible Heat** – Energy released or absorbed that brings about changes in temperature of air or object with no phase change.
  - Hint: a thermometer 'senses' changes in temperture
- **Latent Heat** – Temperature remains constant, with energy released or absorbed bringing about phase change between liquids, gases, and solids.
- **Humidity (Relative)** - The amount of water vapor present in air expressed as a percentage of the amount needed for saturation at the same temperature.
- **Humidity (Absolute)** - The water content of air expressed as mass of water vapor per unit of air volume.

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Terms and Definitions

- **Dew Point** - The atmospheric temperature (varying according to pressure and humidity) below which water droplets begin to condense and dew can form.
- **Energy Recovery System** – Mechanical system designed and installed to capture energy that would otherwise be lost to the atmosphere and direct it to areas within the building that can use the energy, reducing the need for the primary energy source.

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Terms and Definitions

- **Variable Refrigerant Flow** – Refrigerant, as the cooling and heating medium, is sent from the outdoor condensing unit(s) to multiple indoor fan-coil units. Each zone is individually controllable. Systems modulate the refrigerant being sent from the condenser(s) and to each evaporator.
- **Variable Air Volume** – VAV Boxes incorporate dampers that control the volume of air to maintain desired temperature in each zone. Some boxes may also have hot/cold water coils to provide extra heating and/or cooling as needed.
- **Constant Air Volume** – System provides a constant air flow rate, varying the output air temperature to meet thermostat setting.

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Terms and Definitions

- **Communications Protocol** - System of digital rules for data exchange within and between computers. Uniform systems of Command, Network & Data formats developed so computers understand communications from other computers.
  - Differences in the complexity of functions of various control and communications systems lead to development of multiple protocols designed to meet the specific needs of each system.
  - Proprietary protocols: designed by manufacturers for their own systems
  - Common open protocols used in BAS include
    - BACnet – Communications protocol
    - LONtalk – Control protocol for networking devices over twisted pairs, power lines, fiber optics and RF
    - MSTP
    - DALI
    - Zigbee
    - MODbus

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Terms and Definitions

- **Building Commissioning** – methodical process of verifying the proper design, installation and operation of all systems and subsystems within the building to insure that the owner's requirements are met and are as designed by the building's architects, engineers and equipment manufacturers
  - Overall Commissioning process should last a full year to insure operation through all seasons to properly test all equipment and systems
  - Recommissioning is the methodical process of testing and adjusting the aforementioned systems in existing buildings

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Older Buildings & Systems

Control of Older Buildings

- Temperature – Thermostat in each zone
  - Typically simple pneumatic or low voltage electric
- Light switch on the wall – manual on/off
- Plant Operator to turn equipment on/off
  - Boiler operated in colder Winter Season
  - Chiller operated in warmer Summer Season
- Humidity – Why worry about it?

Huge Potential for Wasting Energy

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An All-Too-Common Problem In Commercial Buildings

Cold in Winter

Can also be too Hot in Winter and too Cold in Summer

Hot in Summer

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Common HVAC System Piping

- **Two Pipe System**
  - One Pair of pipes to distribute hot or cold water to air handlers and boxes
  - Operate Chillers **or** Boilers – based on which needed more
- **Four Pipe System**
  - Two pairs of Supply/Return pipes to distribute both hot and cold water to air handlers and boxes
  - Can operate both Chillers & Boilers at same time if needed
  - Each zone uses either Cold or Hot Water as needed
- **Efficiency**
  - Four Pipe provided greater overall comfort – but need Building Automation System to improve efficiency

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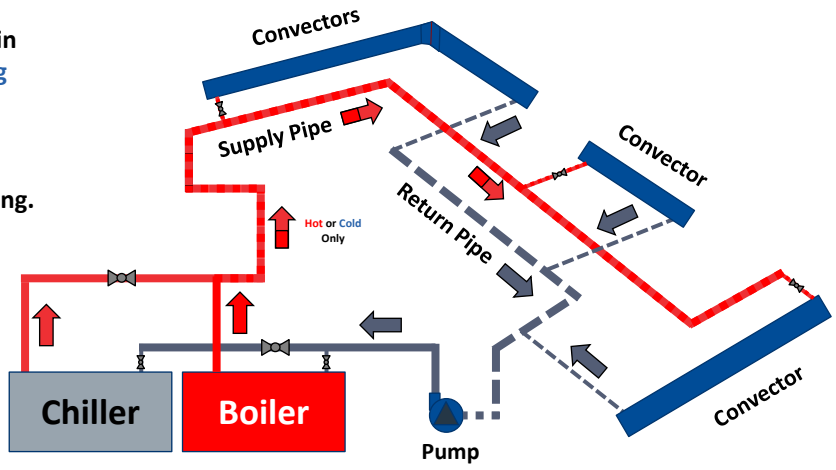
Two Pipe System

System operates in heating or cooling mode only.

No simultaneous Heating and cooling.



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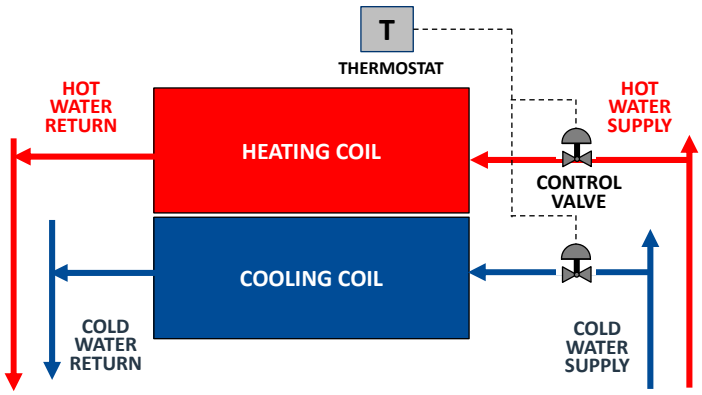
Four Pipe System



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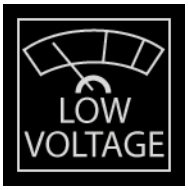
Simple Schematics of Earlier Systems

Very Basic - much like residential systems

Wall Mounted Thermostat

AC System Heating / Cooling



Usually Low Voltage Electrical Signal

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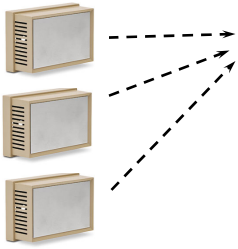
Simple Schematics of Earlier Systems

Next Generation - independent control of components



Thermostats

Often Pneumatic Stand-Alone System

Central HVAC Control

AC System Heating / Cooling

Manual On/Off Operation
Each has Independent Simple Control System

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Frequent Cause of Problems

- Building Design – Inadequate Insulation
- HVAC Equipment not operated or sized properly for the building
- Building not properly commissioned prior to occupancy
- Inadequate Maintenance

Better Building Automation System Needed

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Newer Systems & Considerations

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Frequent Root of Problems

- New Buildings are often designed by the Architect to look good - to impress the owner and the public
- Proper incorporation of HVAC systems and controls usually low on list of priorities and not properly funded

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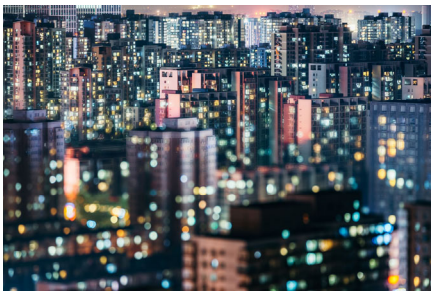
Factors Impacting Energy Use

- Location of Building - Climate
- Insulation
- Building Orientation to Sun
- Shading of Exterior
- Window Type
- Building Function – Office, Retail, etc.
- Occupancy Levels - varies during the day, days of the week and holidays



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Key Factors for HVAC Efficiency

- Overall Building Design
- Sizing & Selection of HVAC Equipment
- Zoned Operation of Floor space
- BAS

UNDERSTAND THE NEEDS OF OCCUPANT

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Benefits of Building Automation System (BAS)

- Reduces energy consumption
- Reduces energy costs
- Improves Indoor Air Quality
- Provides year-round comfort control
- … and most important … Improves the productivity of building occupants

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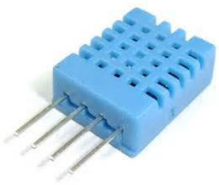
Equipment & Configurations

Typical Parameters Controlled

- Temperature
- Humidity
- Occupancy Sensor
- Building Operational Hours
- HVAC Equipment Operation



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Typical Parameters Controlled

- Bring In Outside Air when appropriate
  - For Temperature control
  - Introduce fresh air to reduce high CO_2 or VOC levels
- Lighting – levels & hours of operation

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ASHRAE Guidelines

Parameter	Averaging Time	Limit for Acceptable Indoor Air Quality
Carbon Dioxide	8 Hours	1000 ppm
Carbon Monoxide	8 Hours	9 ppm
Formaldehyde	8 Hours	0.1 ppm
Ozone	8 Hours	0.5 ppm

Occupancy Category	ASHRAE (CFM Required / Person)
Educational Classroom	15 cfm (ages 5-8) 13 cfm (ages 9+)
Public Assembly / Theater	5 cfm
Office Building - Office Space	17 cfm
General Conference Room	6 cfm
Hotel, Motel, Dorm Lobbies	10 cfm

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Zoning of Floor Space

- Multi-Floor Buildings – may have separate HVAC systems on each floor instead of centrally located in the basement or on rooftop
- Separate HVAC Systems within the building or floor – such as for areas that are in use 24/7
- Variable Refrigerant Flow to multiple devices – in each zone throughout the building
- Ducting with controlled dampers to direct conditioned air where needed

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HVAC Equipment Selection

- High Efficiency Equipment
- Varying Sizes to efficiently match needs
- Hybrid Plants – Gas & Electric – take advantage of energy pricing differences
- Variable Speed Motors / Multi-Stage Compressors – use only what is needed
- Heat Recovery Systems to transfer heat and cold within the building space

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Additional Capabilities

- Operate per predetermined schedule
- Anticipate impact of warmer/colder weather and adjust start/stop times accordingly
- Detailed tracking of building operation for management review
- Able to adjust operation to accommodate varying energy rate schedules – such as time-of-use rates and pricing differential changes

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Multi-Tenant Buildings Benefit

- Building HVAC system operated extra hours for the benefit of one tenant would condition the entire building
- BAS, with appropriate degree of zoning, allows owner to serve only the tenant wanting the extra service – not the entire building
- Can provide data to permit accurately billing to tenant for extra services provided

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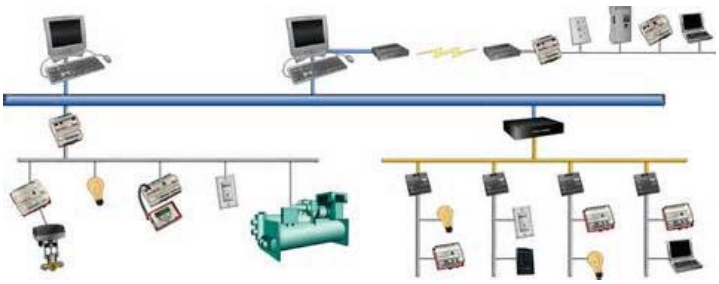
Need Building Automation System!

With all of those parameters needing to be controlled for comfort and efficiency –

MUST HAVE INTEGRATED COMPUTERIZED CONTROL SYSTEM TO MONITOR & CONTROL THE SYSTEMS



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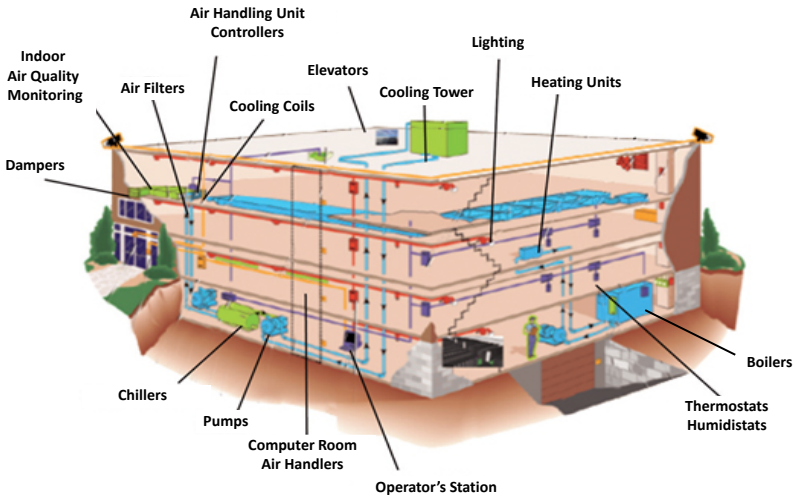
Typical Building with Automation



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Building Systems that can be Controlled

BAS monitors, optimizes, interlocks and controls:

- Heating systems
- Cooling systems
- Make-up Air systems
- Humidity Control
- Lighting systems and blinds
- Fire and Security systems
- Elevators

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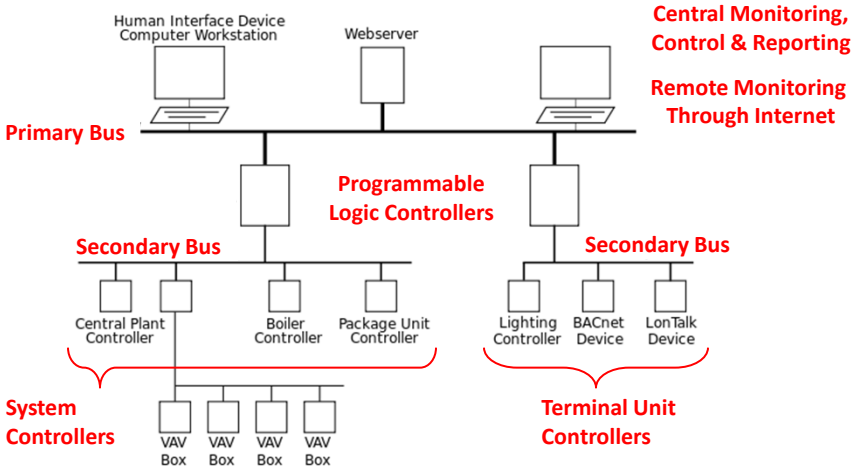
Typical BAS System Schematic



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Compatibility of Systems

- Earlier components and systems designed by manufacturers to work with their own equipment – so no mixing within a system
- IEEE standards developed to allow networking of various devices that will work together
- Communication network standards developed for power line, optical fiber, Ethernet and wireless interconnections

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Types of Sensing/Output Devices

- Analog – Variable Control
  - Sensors - Variable measurement – Temperature, Humidity & Pressure
  - Outputs – Control speed or position - Variable frequency drives, valve or damper position
- Discrete – On/Off
  - Sensors – Indicate device on or off – Relay contact, air flow switch, pressure switch
  - Outputs – Turn device On or Off

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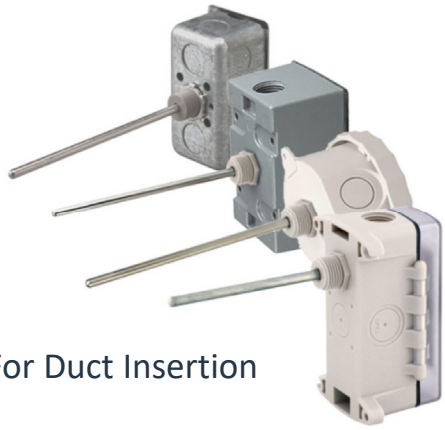
Temperature & Humidity Sensors

Wall Mount



For Duct Insertion

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Pressure Sensors & Switches

Outdoor Mount

Pressure Probe Duct Mount

Pressure Differential Sensors & Transmitters

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Wireless Equipment

Wireless Temperature Sensor

Wireless Receiver

Wireless Repeater

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Safety Systems

- Fire & Smoke Detectors
- Fire Alarm
- Building Security
- Access Control
- Emergency Pull Boxes
- Carbon Dioxide Monitors
- Carbon Monoxide Monitors

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Monitoring and Reporting

Local User Options Possible

- Monitor & Control
  - Temporarily Override Light Timer
  - Adjust Temperature Set point
  - Adjust Occupancy Sensor Sensitivity
  - Monitor Temperatures Inside & Outside

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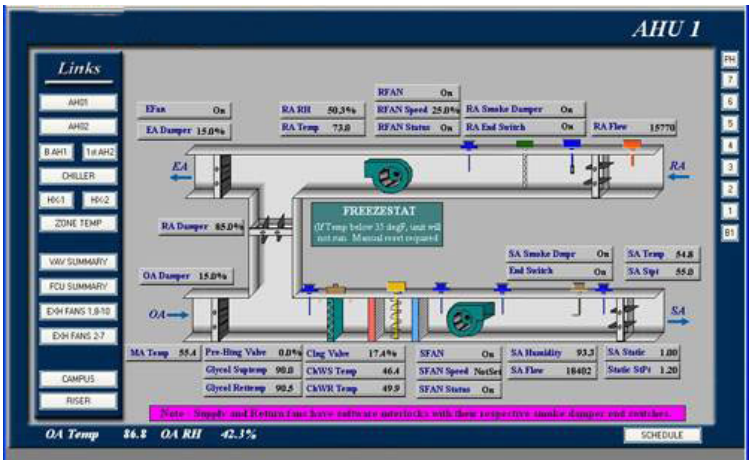
Screen View – Air Handler Unit



See Monitoring & Control Points

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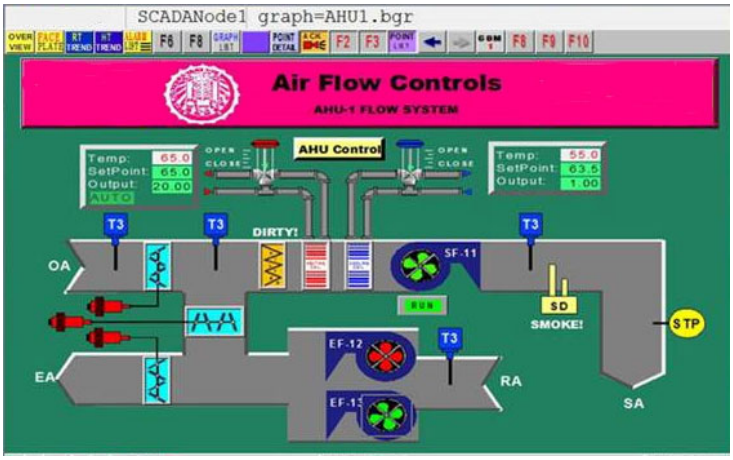
Screen View - Air Handler System



- Monitor & Control
  - Measure Temperatures
  - Specify Temp Set points
  - Smoke Sensors
  - Sense Clogged Filters
  - Operate Variable Dampers
  - Operate Fans

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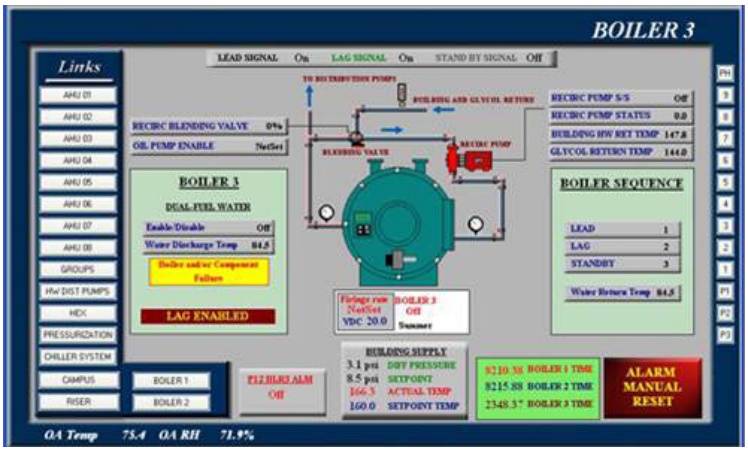
Screen View – Boiler System



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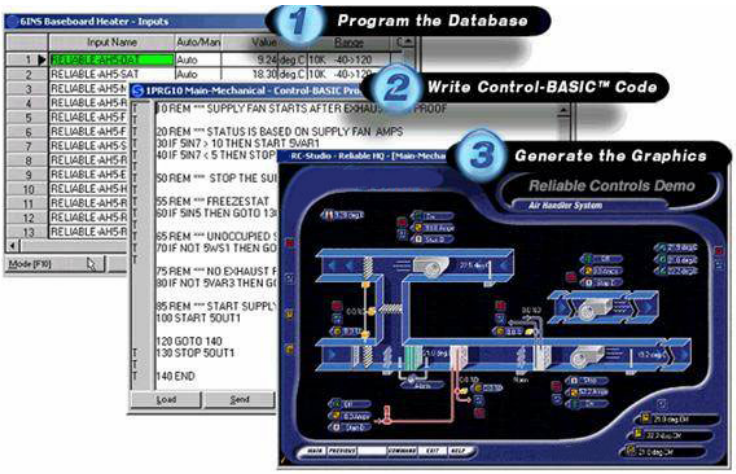
Development of Screen Views



Develop Overall Building and Individual System Diagrams as desired

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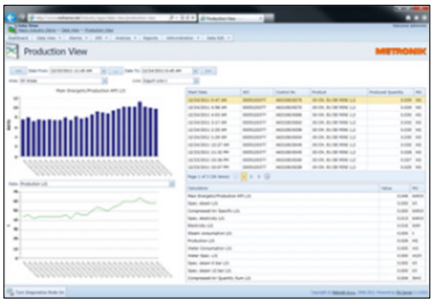
Energy Consumption Summary



Program reports on Annual, Monthly, Weekly, Daily, Hourly and Minute basis as desired. Smaller time increments will require much higher sampling rate and a lot more data storage – while in many cases not providing real benefit in reviewing the data.

- Monitoring, analyzing and predicting energy consumption and cost
- Automatic or manual acquisition of information which can affect operation – such as weather including the use of predictive control algorithms
- Full access from anywhere to information possible through web application on PCs or mobile devices
- On Screen and Printed Report Outputs

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Screen View of Energy Analysis

Companies with many locations can feed info to a central location such as home office for monitoring, tracking and reporting.

Compare data from several buildings to spot those operating outside the normal parameters – so owner can focus on those showing lesser efficiency and work on improving them – to reduce inefficiencies and save on operating costs.

- Monitor energy consumption & cost
- Define energy objectives and monitor their implementation
- Energy indicators calculate according to degree days, building floor space, number of overnight stays for hotels, etc.
- Comparison of several facilities and time periods from Central location
- Optimum solution to monitor specific ambient conditions, such as in hospitals, spas, hotels, stores, etc.

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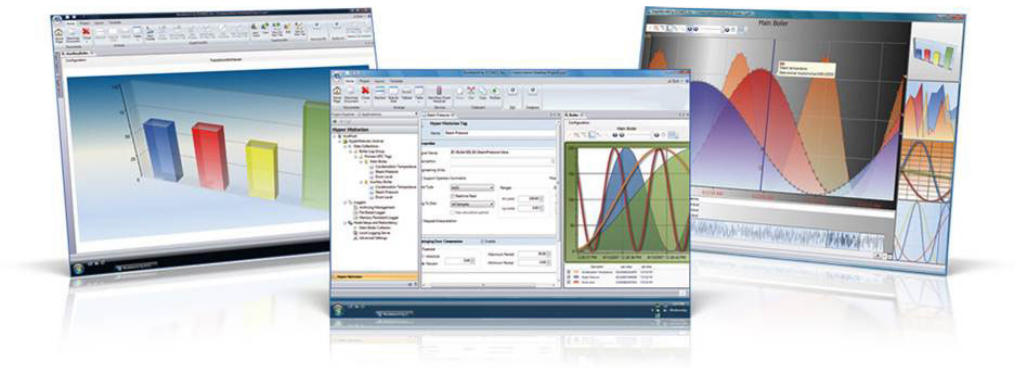
Trending & Data Analysis – Many Options



If you want to know something about the Building's Operation – you can get the information displayed in a variety of useful formats.

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Installations & Energy Savings

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Retrofit Installations

BAS might go into an existing building

1. That has no existing systems
2. To replace outdated pneumatic controls, or
3. To replace an existing direct digital control system

Wireless sensors and transmitters can be useful in retrofit applications if there are structural obstacles to installation.

There are several controls companies that can be consulted concerning retrofits – as well as to advise on new building construction.

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New Building Construction

Building, HVAC System Components and BAS can be designed and installed for optimum benefit and maximum energy savings for a new building.

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Energy Savings Potential

Ultimately, the energy savings will depend on the inefficiency of the building operations before installation of the BAS

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Associations & Resources

Numerous Trade Associations and web resources are available to assist and provide you additional control equipment, market information and resources.

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Associations & Resources

- ESC – Energy Solutions Center
  - www.escenter.org
- ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers www.ashrae.org
- AEE - Association of Energy Engineers
  - www.aeecenter.org

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Associations & Resources

- CABA – Continental Automated Buildings Association
  - www.caba.org
- ISA – International Society of Automation
  - www.isa.org

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