Retro-Commissioning to Improve Building Performance and Reduce Cost

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BCxA™ Building Commissioning Association

What is the BCA?

- The Building Commissioning Association is a non-profit international organization formed in 1998. Members include Cx providers, building owners, energy companies, facility managers, architects, engineers and contractors.

- The BCA's goal is to achieve the highest professional standards for commissioning practice, while allowing for the diverse and creative approaches to building commissioning that benefit our profession and clients. The BCA has established performance standards for commissioning (Essential Attributes) that all members have agreed to abide by when they serve as Commissioning Authorities.

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What is Building (Retro)- Commissioning?

What are the benefits?

RCx process and phases

Relationship to LEED™ EB O&M Requirements

Thermal and Use Zones

Temperature Control Sequences

Testing

Typical findings

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What is Building Commissioning?

"The Commissioning Process is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria."

- ASHRAE Guideline 0

- The process is performed specifically to ensure that the facility operates in accordance with the Owner's Project Requirements (OPR).
- For existing buildings, investigate building systems to optimize performance relative to the Current Facility Requirements (CFR).

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Systems to be Commissioned

The scope of work is usually determined by the owner; however the following systems/equipment are often included:

- **Mechanical Systems**
  - HVAC (Heating, Ventilation, Air Conditioning, Ducting & Accessories)
  - Piping Systems (Pipe, Valves, instrumentation, etc.)
  - Plumbing (Piping and Fixtures)
  - DDC Controls (Software programming and Hardware)
- **Electrical Systems**
  - Switchgear/Transformers
  - Grounding/Bonding
  - Lighting and lighting control
- **Specialty Systems**
  - Security and Fire Alarm Systems
  - Voice/Data Systems
  - Standby Power Systems
  - Building Envelope

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How does Commissioning apply to existing buildings (EBCx)?

- Retro-commissioning – Commissioning a building which has not previously been commissioned.
- Re-commissioning – Commissioning a building which has previously been commissioned or retro-commissioned.
- Ongoing Commissioning - Periodic commissioning for continuous improvement.

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Why is commissioning needed?

- Verify Current Facility Requirements (CFR)
- Improve health, safety, via indoor air quality
- Energy conservation and cost reduction
- Identify and resolve operational problems
- Improve comfort (productivity)
- Extend equipment life-cycle
- Minimize risk and liability
- Assist in LEED™ Certification

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How does Commissioning help?

- Identifies issues & corrects deficiencies
  - Changed use requirements
  - Failed equipment
  - Improper installation
  - Poorly tuned controls/improper sequences
  - Design “errors”

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How does Commissioning help?

- Identifies opportunities to improve:
  - Energy performance
  - Comfort
  - Air quality
  - Occupant productivity
  - Equipment life
  - Maintainability
  - Facility staff preparedness

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What results can I expect?

- **Studies indicate 8 to 20 percent savings in building operating costs over those in a non-commissioned building*.**

*Source: Building Commissioning Guide, GSA/DOE

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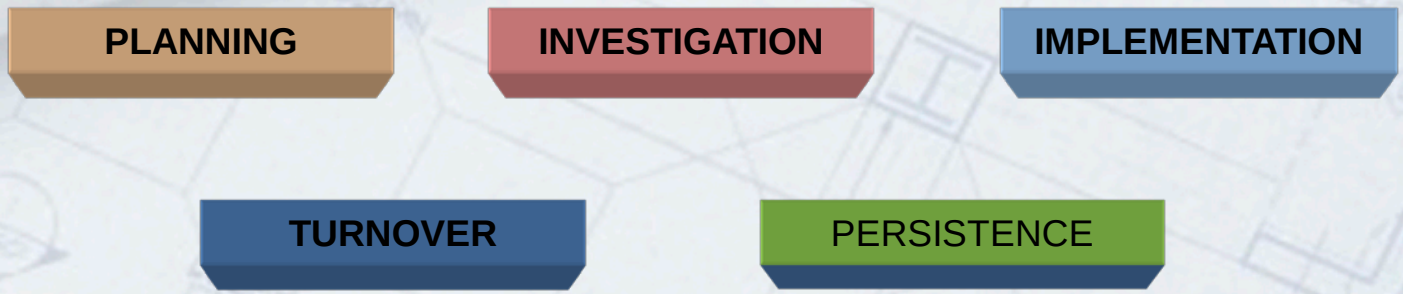
The Retro-Commissioning Process

The RCx Process is performed in phases:



Commissioning is NOT just testing!

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RCx: Planning Phase

- Define team and roles, responsibilities
- Define scope, schedule and budget
- Define goals
- Define the CFR for each use, system
- Preliminary benchmarking
- Interview O&M staff & stakeholders
- Create RCx Plan

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RCx: Investigation Phase

- Review existing documentation
- Site survey and review
- Building occupant interviews
- Benchmarking and baseline data analysis
- [Perform energy audit - LEED]
- Develop/review system control sequences
- System testing

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RCx: Investigation Phase (cont'd)

- Identify Facility Improvement Measures (FIM)
- Develop system diagnostic monitoring plan
- Develop Measurement & Verification Plan (M&V)

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RCx: Implementation Phase

- Prioritize & select FIMs to implement
- Prepare implementation plan
- Implement selected FIMs
- Verify and test new systems/changes
- Execute the M&V plan
- Create ongoing commissioning plan

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RCx: Turnover Phase

- Update O&M Manuals and as-built documents
- Compile or update systems manual
- Develop training plan
- Lessons learned & Final Report

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RCx: Persistence Phase

- Implement training plan
- Continue benchmarking
- Monitor & track energy use
- Monitor non-energy metrics
- Trend key parameters
- Document changes

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RCx: Persistence Phase (cont'd)

- Implement strategies for BAS
- Consider Automated Fault Detection & Diagnostic Tools (AFDD)
- Launch plan for on-going (continuous or periodic) re-commissioning

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LEED™ Certification Requirements
Energy and Atmosphere Prerequisite 1

Energy Efficiency Best Management Practices – Planning, Documentation and Opportunity Assessment

- **Document current sequence of operations for the building**
- **Develop a building operating plan**
- **Develop a systems narrative**
- **Create a preventative maintenance plan**
- **Conduct an ASHRAE Level I energy audit**

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Energy & Atmosphere Credit 2.1

EBCx – Investigation and Analysis

Requirements:

Option 1. Develop a commissioning plan and perform planning and investigation phases.

Option 2. Perform an ASHRAE Level II Energy Audit

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Energy & Atmosphere Credit 2.2

EBCx - Implementation

Requirements:

Implement no-cost and low-cost operational improvements

Create a capital plan for major retrofits or upgrades

Provide training for management staff

Update the building operating plan

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Cost

Retro-commissioning (RCx)

3.0 to 5.0 Percent of Total Operating Cost*

*Source: Building Commissioning Guide, DOE/GSA

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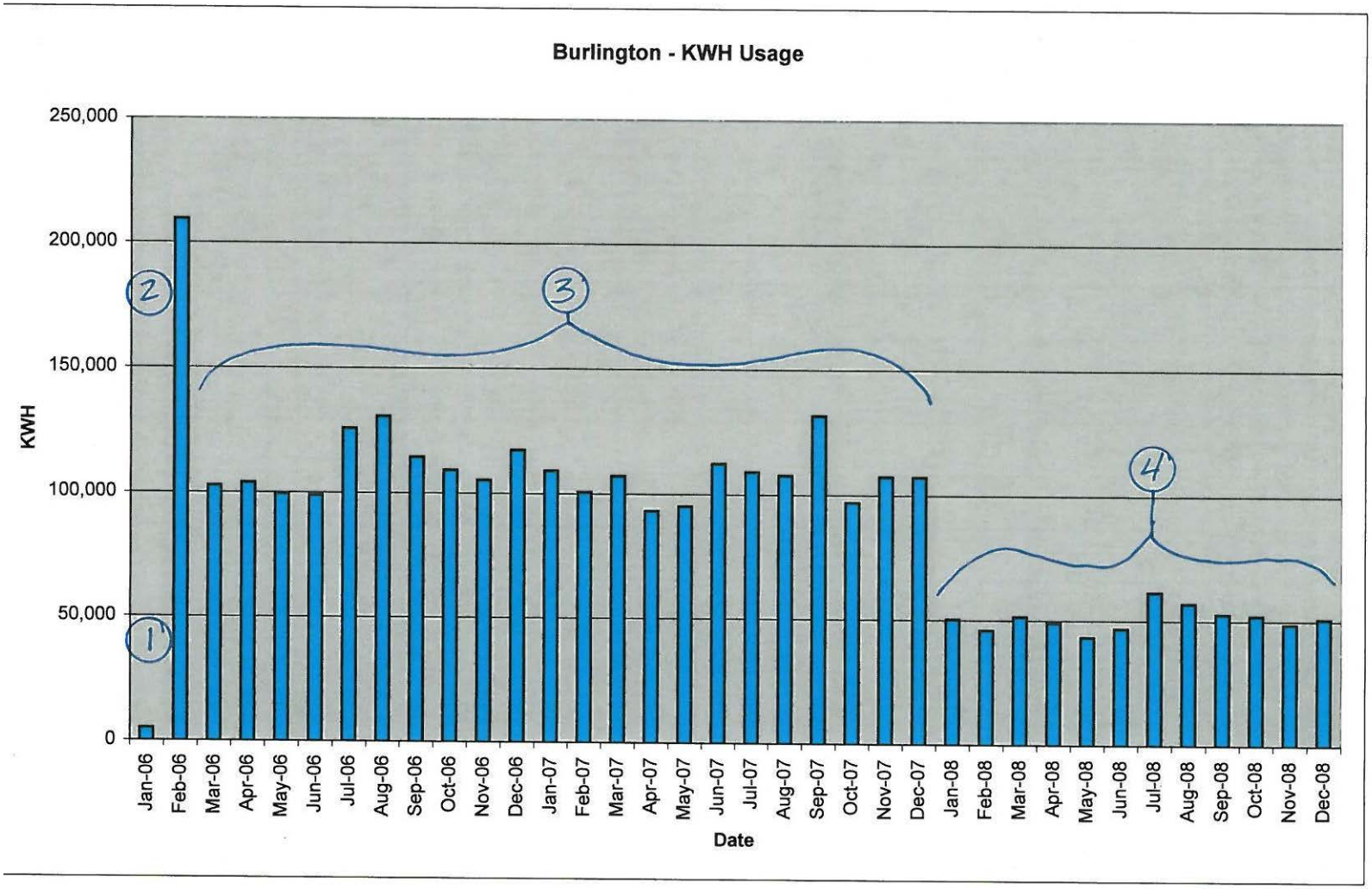
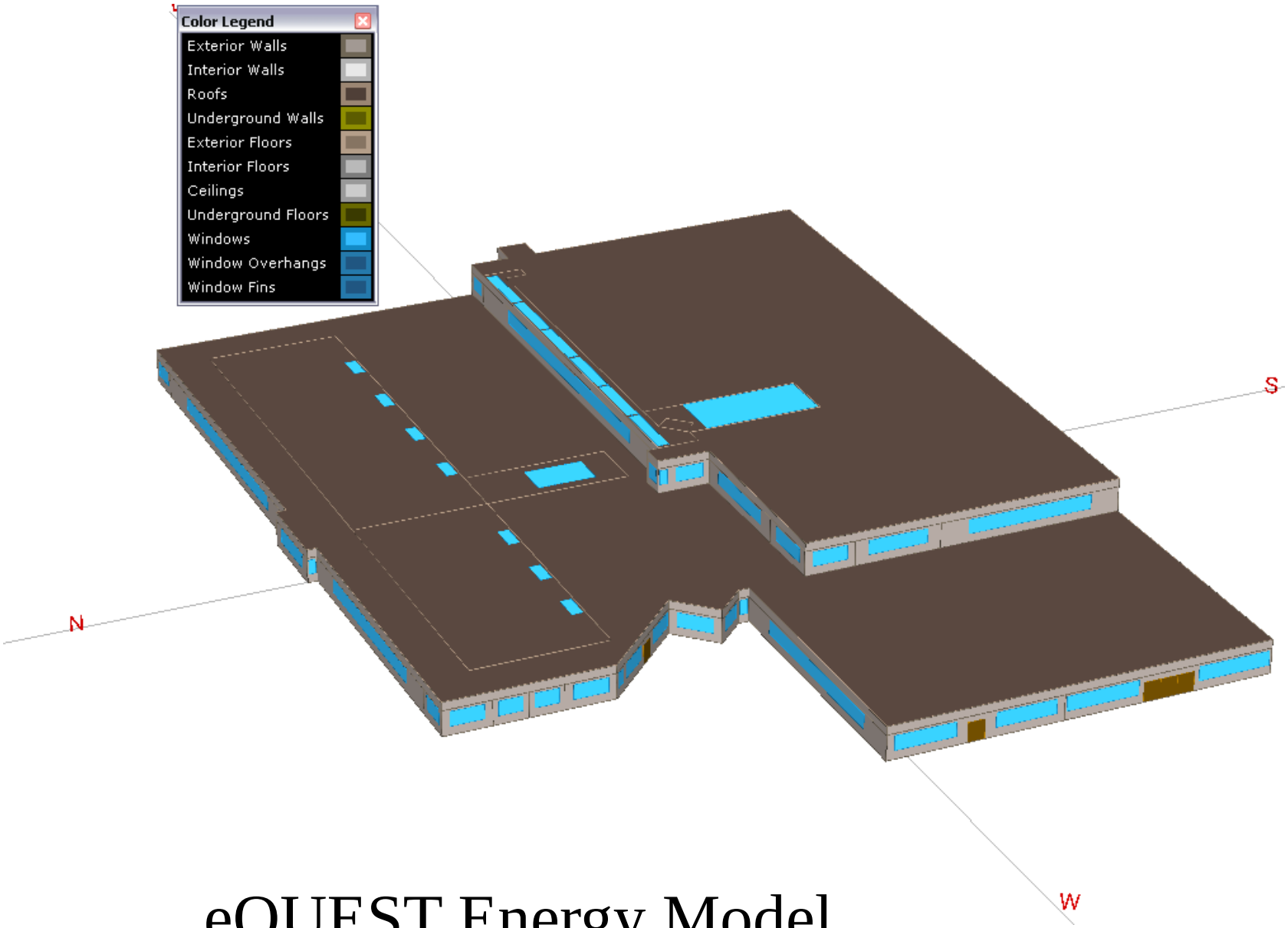
Energy Reduction



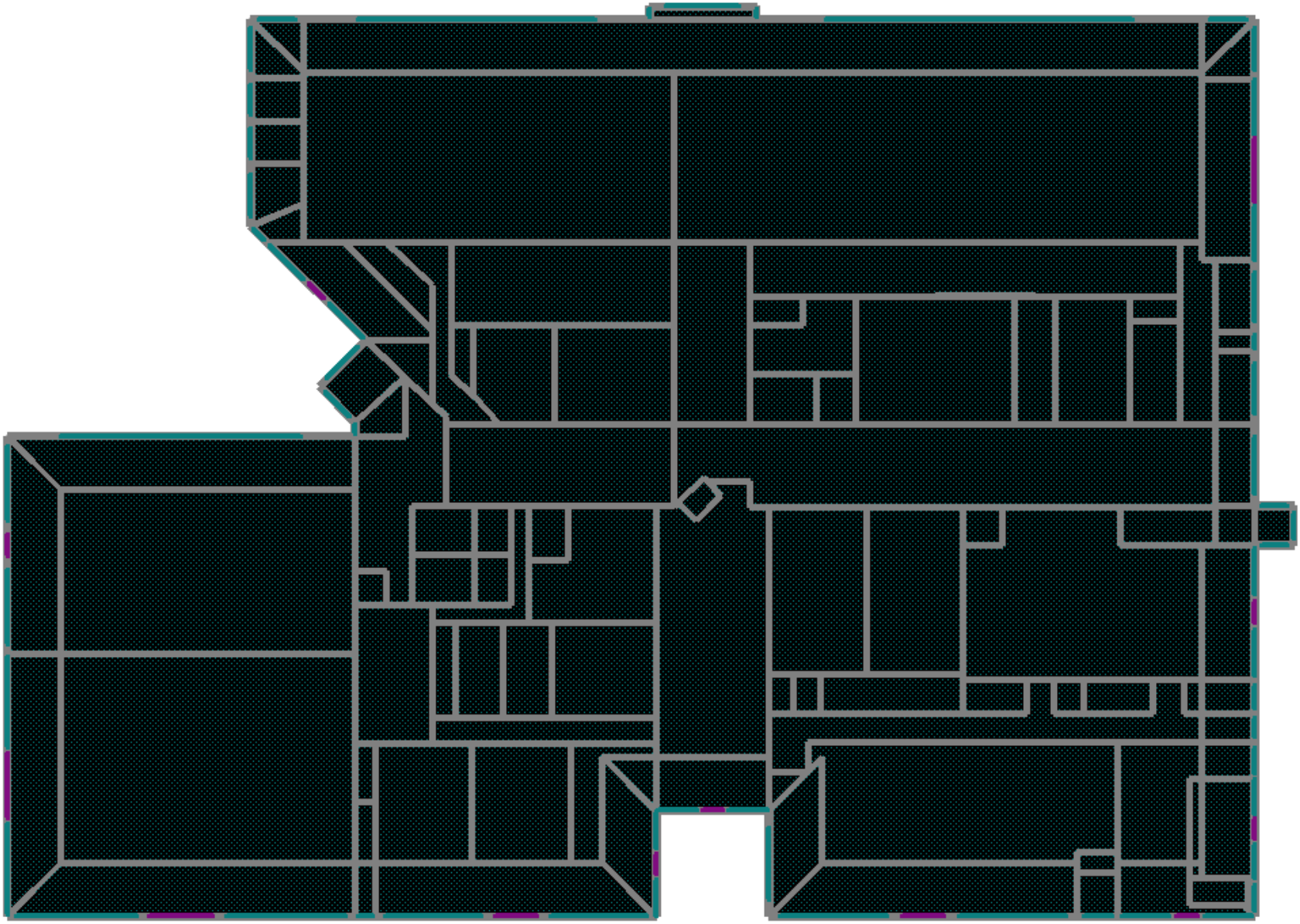
Practical Applications

1. Understanding compatible thermal and functional use zones
2. ATC/BAS Control sequences
3. Verifying and testing
4. Typical findings
5. Application to VAV Systems

ENERGY MODELING TOOLS



eQUEST Energy Model



Thermal and Occupancy/Use Zones – 1st Floor

Combining different Thermal and Use Zones on One HVAC System

- Entire system must operate as many hours as greatest zone. (Fan energy+)
- Entire system must cool for zone with greatest cooling requirement.
- All other zones reduce airflow (IAQ) and re-heat minimum air.
- Entire system must heat/cool outside air for zone with greatest code requirement.

Temperature Control Sequences

Fan Control:

Occupied – On or cycle

Unoccupied – Cycle or off

Fan Speed (VFD) – Static pressure, demand reset*

(*Requires terminal unit communication)

Functions:

Ventilate, Heat, Cool, Pressurize

Safeties:

Fire/Smoke, Freezestat

Interlock:

Return fan, relief fan, exhaust fans

Temperature Control Sequences

Cooling Control:

Occupied – Setpoint (Maximize deadband)

Unoccupied – Set-back or off?

Demand reset (Requires terminal unit communication)

Functions:

Temperature, humidity

Space temperature or system discharge

Economizer – enthalpy or dry bulb

Safeties:

Head pressure

Interlock:

Heating, fan, dampers, condensing units

Temperature Control Sequences

Heating Control:
Occupied – Setpoint (Maximize deadband)
Unoccupied – Set-back
Morning warm-up

Functions:
Temperature

Safeties:
Fail open

Interlock:
Cooling, boiler, pumps

Temperature Control Sequences

Damper Control:
Occupied – Minimum % or CO^2 (Flow measurement)
Unoccupied – Closed
Morning warm-up - closed

Functions:
Outside air, economizer (Free cooling)

Safeties:
Fail closed

Interlock:
Fan, cooling

Temperature Control Sequences

VAV Terminal Control:

Cooling – Setpoint (Maximize deadband)

Heating – Setpoint (Maximize deadband)

Functions:

Cooling, heating, (fan-powered), re-heating

Ventilation (minimum airflow ~ 30%)

Interlock:

Heat/cool changeover

Temperature Control Sequences

Testing Functions:

Normal Operation:

- Jumper device
- Reset variable
- Observe motor/drive/actuator action
- Calibration (Signal)
- Hysteresis (PID) and hunting/cycling

Failure Mode Tests:

- Disable device (disconnect)
- Observe motor/drive/actuator action

Temperature Control Sequences

Typical findings:

- Starters and VFDs in “Hand” position
- Systems run continuously
- Improper unoccupied setpoints
- Devices jumped out
- Variables over-ridden with fixed values
- Disconnected damper and valve actuators
- Broken equipment and devices
- Economizers that do not function
- Simultaneous heating and cooling

Equipment that should be Off is On

Temperature Control Sequences

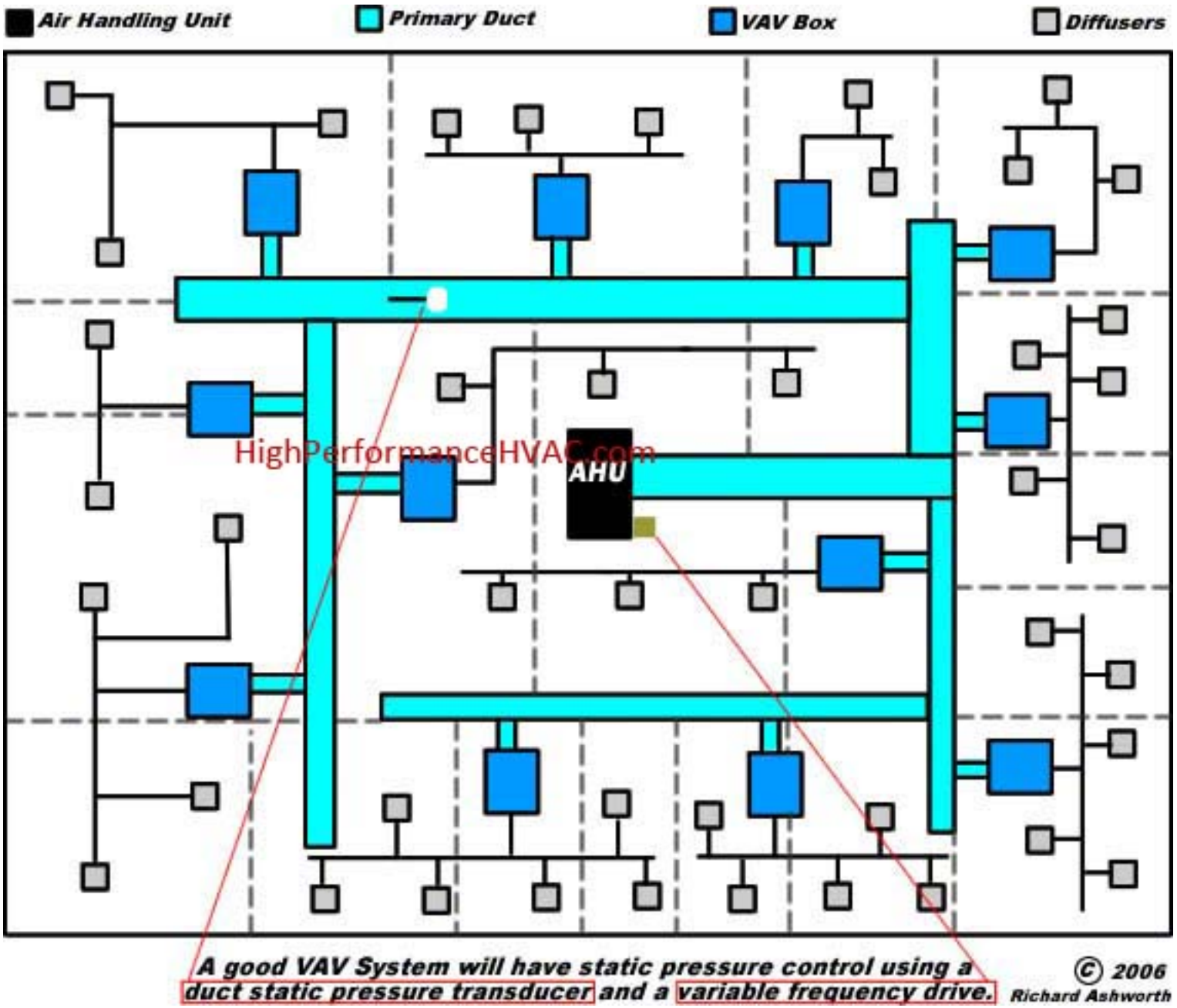
How? Why?

Mechanics generally operate systems as they were turned over, or as they were trained. Control sequence is rarely reviewed or questioned. This is how he/she thinks it is *supposed* to work.

Mechanics first goal is to make complaints go away.

BMS systems generally do not have self-diagnostic capability.

Inadequate Maintenance & Operating budgets, training, staff, motivation.


Air Handling Unit
Primary Duct
VAV Box
Diffusers
HighPerformanceHVAC.com
AHU
A good VAV System will have static pressure control using a duct static pressure transducer and a variable frequency drive.
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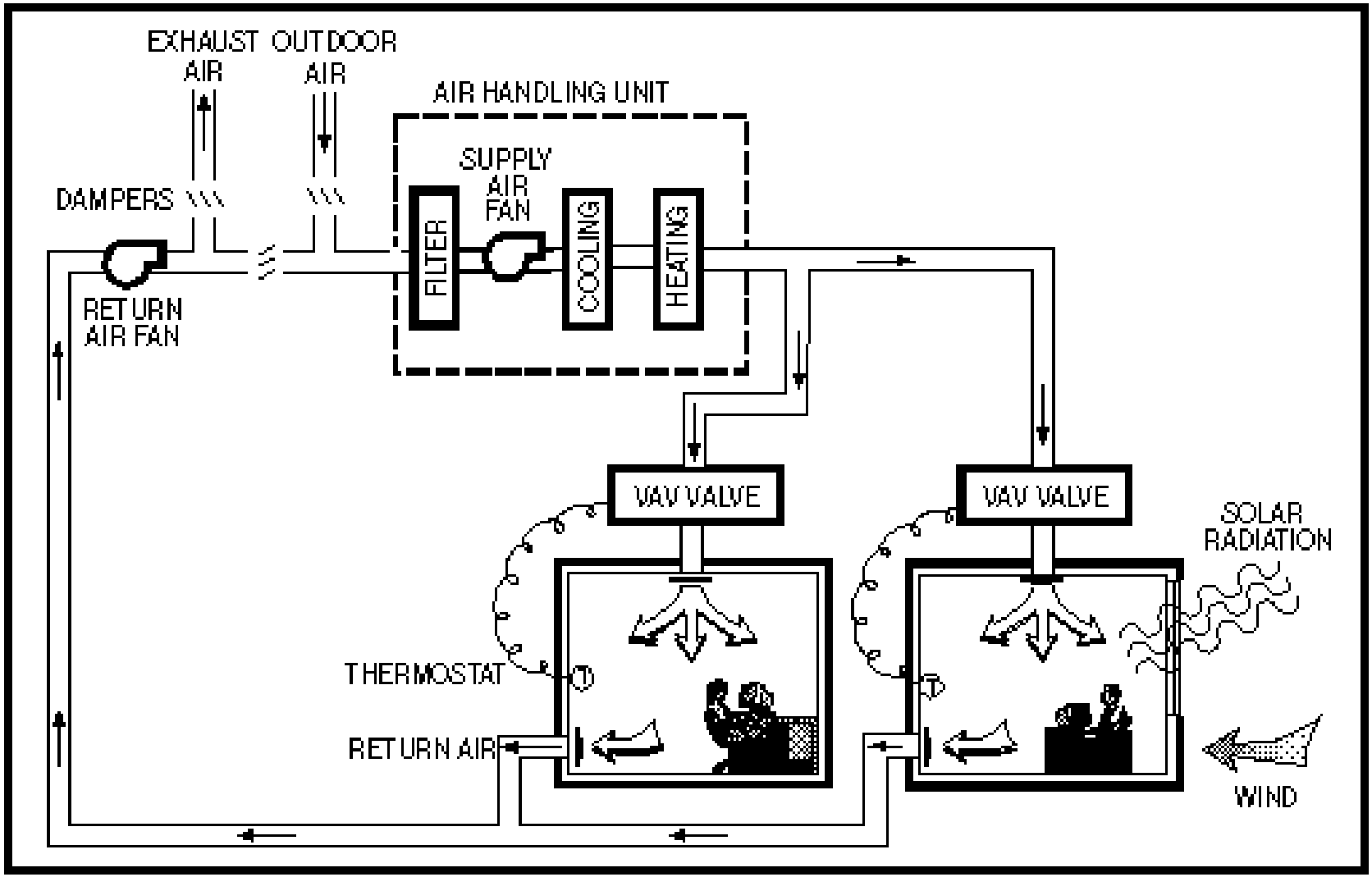
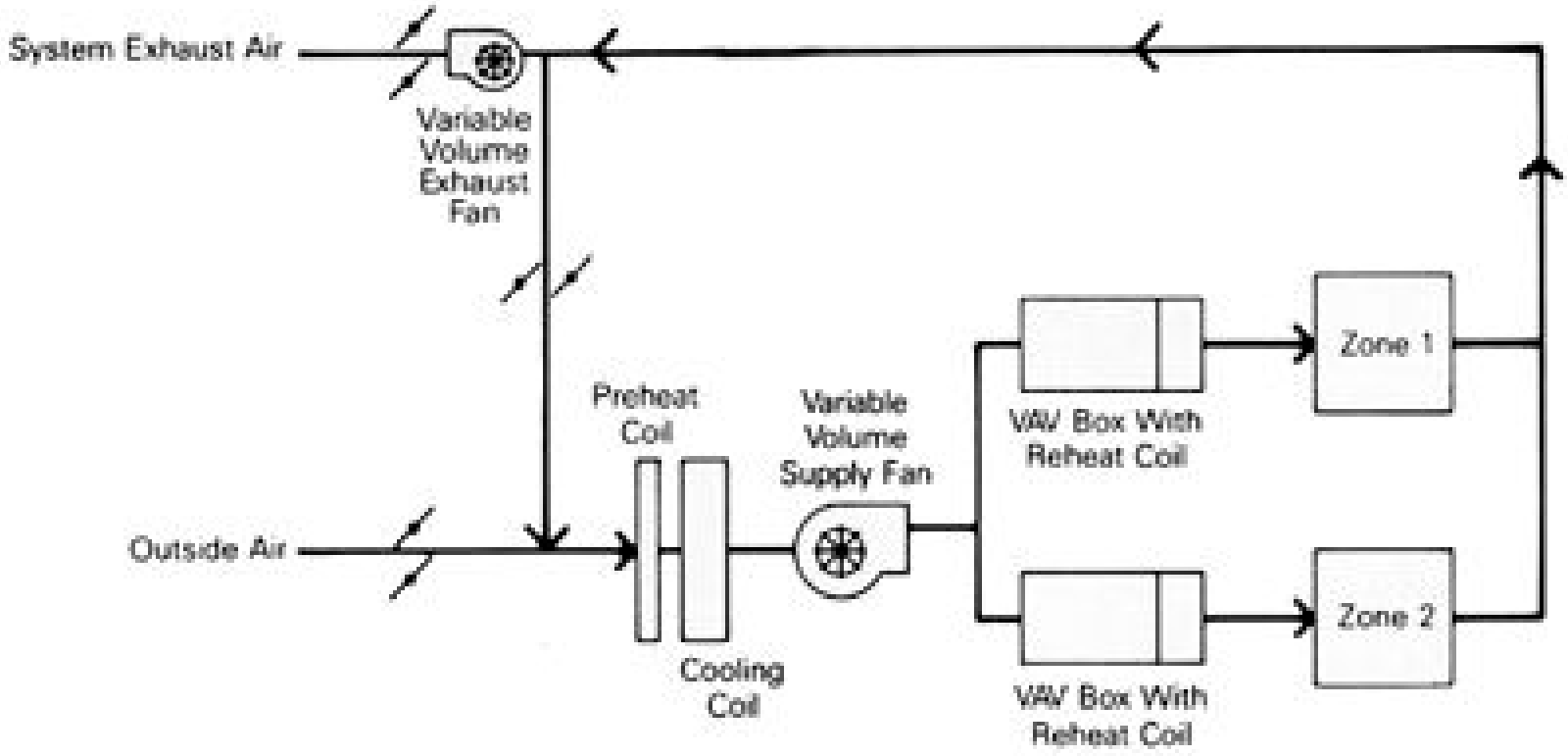

EXHAUST AIR
OUTDOOR AIR
AIR HANDLING UNIT
SUPPLY AIR FAN
DAMPERS
FILTER
COOLING
HEATING
RETURN AIR FAN
VAV VALVE
VAV VALVE
SOLAR RADIATION
THERMOSTAT
RETURN AIR
WIND


System Exhaust Air
Variable Volume Exhaust Fan
Outside Air
Preheat Coil
Cooling Coil
Variable Volume Supply Fan
VAV Box With Reheat Coil
VAV Box With Reheat Coil
Zone 1
Zone 2

Energy Reduction Strategies

Variable Air Volume (VAV)

- VAV is a less-bad form of reheat
- Reheat is as stupid as it sounds

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