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Key Building Operational Faults and Their Correction

Srinivas Katipamula, Ph.D.

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Presentation Outline

- Definition of Re-tuning
- Identifying Low-cost/No-cost Operational Faults Using the Re-tuning Approach
- Common Operation Faults
- Example Operational Faults
- Early Results from Re-Tuning Buildings
- Conclusions

What is Re-Tuning?

- A systematic process to identify and correct building operational problems that lead to energy waste
- Implemented primarily through the building control system at no cost other than the labor required to perform the re-tuning process
- Includes small, low-cost repairs, such as replacing faulty sensors
- Includes identifying other opportunities for improving energy efficiency that require investment
- Might be thought of as a scaled-down retro-commissioning focused on identifying and correcting operational problems

Six primary steps of re-tuning

- Collecting initial building information: Basic building information
- **Pre-Re-Tuning Phase: Trend-data collection and analysis**
- Building Walk Down: Getting to know the building
- Re-Tuning: Identifying and correcting operations problems
- Post Re-Tuning: Reporting re-tuning findings
- Savings Analysis: Determining and reporting the impacts

Trend-Data Collection & Analysis: Purpose

- Detect potential operational problems even before visiting the building
- Identify problems that require time histories to detect – incorrect schedules, no use of setback during unoccupied modes, poor economizer operation

Major Focus Areas in Re-Tuning

- **Occupancy scheduling**
- Discharge-air temperature control
- Discharge-air static pressure control
- **Air-handling unit (AHU) heating & cooling**
- AHU outside/fresh air makeup
- **AHU economizer operation**
- Zone conditioning
- Meter profiles
- Central plant

Occupancy Scheduling

- Shut off systems whenever possible
  - Night unoccupied schedules
  - Weekend unoccupied schedules
  - Daytime no or low use unoccupied schedules
    - Auditorium, class rooms, conference rooms
  - Includes lighting
  - Includes specialized exhaust
  - Do not restart too early
    - Use a startup schedule based on building needs
  - Do not use fresh air during warm-up except last 30 minutes for flushing building

Occupancy Scheduling (continued)

- Shut off systems whenever possible
  - Refrain from starting up system for the occasional nighttime user or weekend user
  - Use bypass buttons
- Unoccupied mode is a major cost saver
  - Simple to implement
  - Simple to track
  - Simple to administer
- Sometimes the least paid employee is the most costly
  - Janitors working at night with all HVAC running, all fresh air open & lights on
  - Is this required?

Occupancy Scheduling (continued)

- When running at night for warm up, cool down, or maintaining temperatures, do not ventilate (no outside air)
- Run static pressure at ½ of normal set points, if it does not affect reheat controls
  - Check to make sure heated areas get full air in unoccupied modes
  - Push unoccupied mode air to where it is needed
    - Set VAV boxes in interior zones to unoccupied with 0 air flow
    - Set VAV boxes with reheat to a high air flow in unoccupied mode, so box will be 100% open during night cycling
      - Air gets to zones needing heat

Occupancy Scheduling (continued)

- Building electric consumption should show significant energy drop for nights/weekends
  - Signifying setbacks are active on all HVAC systems
  - Base load versus peak loads should be at least 30% difference and as much as 50% with aggressive setbacks
- Trended data for zone temps should show 5-10^{o}F deviations from set points when setbacks are active during non-shoulder months
  - Winter zone temps should drop down to 60-65^{o}F and summer zone temps should rise to 80-85^{o}F

Occupancy Schedule (continued)

- Trended data for discharge static pressures should show readings of 0” or at least 50% (half) of normal (occupied) static pressure readings
- Trended data for main supply/return fan status should indicate “OFF” during unoccupied periods
- Trended data for VAV boxes occupied status should indicate “Unoccupied” during unoccupied periods
- Trended data for support systems (reheat pumps, reheat converters, reheat hot water boilers, chillers, towers, pumps, etc) should indicate they are turning off at night, if all areas of the building are also shut down

Occupancy Schedule (continued)

- Unoccupied periods should include weekends, holidays and night hours during work week periods
  - If facility has sporadic use periods, this may require additional efforts to succeed at implementing setbacks
- Make sure the “tail” is not “wagging the dog” – janitors, special events, extreme weather events, overrides, etc
- How does your organization respond to trouble calls (occupant complaints)? How do you respond? Is the response a “band-aid” or a long-term solution? Overrides on schedules are not long-term solutions

Occupancy Schedule (continued)

- Empower occupants to control their ventilation when they need it
  - Most building designs provide occupants with local light switches for local lighting control
  - Does your DDC system provide similar capabilities for ventilation so occupants can obtain ventilation automatically when they need it (motion sensors, timed overrides, calendar scheduling of conference rooms or other “special” spaces)?
- Consider adding outdoor-air temperature interlocks that “override” the occupied schedule, anytime the outdoor-air temperature exceeds the design parameters
  - This will eliminate overrides that are left in place and should only be active 2-4 weeks/year
- Does your DDC system have “scheduling” capability?
  - Do you know how it works?
- Does your DDC system have “Optimal Start” scheduling capability?
  - Are you using it?

Example of AHU Schedule Trend

Sample Time (Trend 1)	SF3_STATUS
11/17/2007 0:00	Off
11/19/2007 1:00	On
11/19/2007 17:00	Off
11/20/2007 2:00	On
11/20/2007 17:00	Off
11/21/2007 2:00	On
11/21/2007 17:00	Off
11/23/2007 2:00	On
11/23/2007 17:00	Off
11/26/2007 1:00	On
11/26/2007 17:00	Off
11/27/2007 2:38	On
11/27/2007 17:00	Off
11/28/2007 2:00	On
11/28/2007 5:24	Off
11/28/2007 5:26	On
11/28/2007 5:55	Off
11/28/2007 6:00	On
11/28/2007 17:00	Off
11/29/2007 2:00	On
11/29/2007 17:00	Off
11/30/2007 2:00	On
11/30/2007 10:48	On

Zone Heating and Cooling Demands

- Purpose
  - Get a feel for how many zones on each monitored air handler are heating and how many are cooling at the same time
  - Get a sense of which areas are heating and which are cooling at any given time
  - Determine if any individual zones are heating and cooling at the same time
  - Others?

Zone Heating and Cooling Demands (continued)

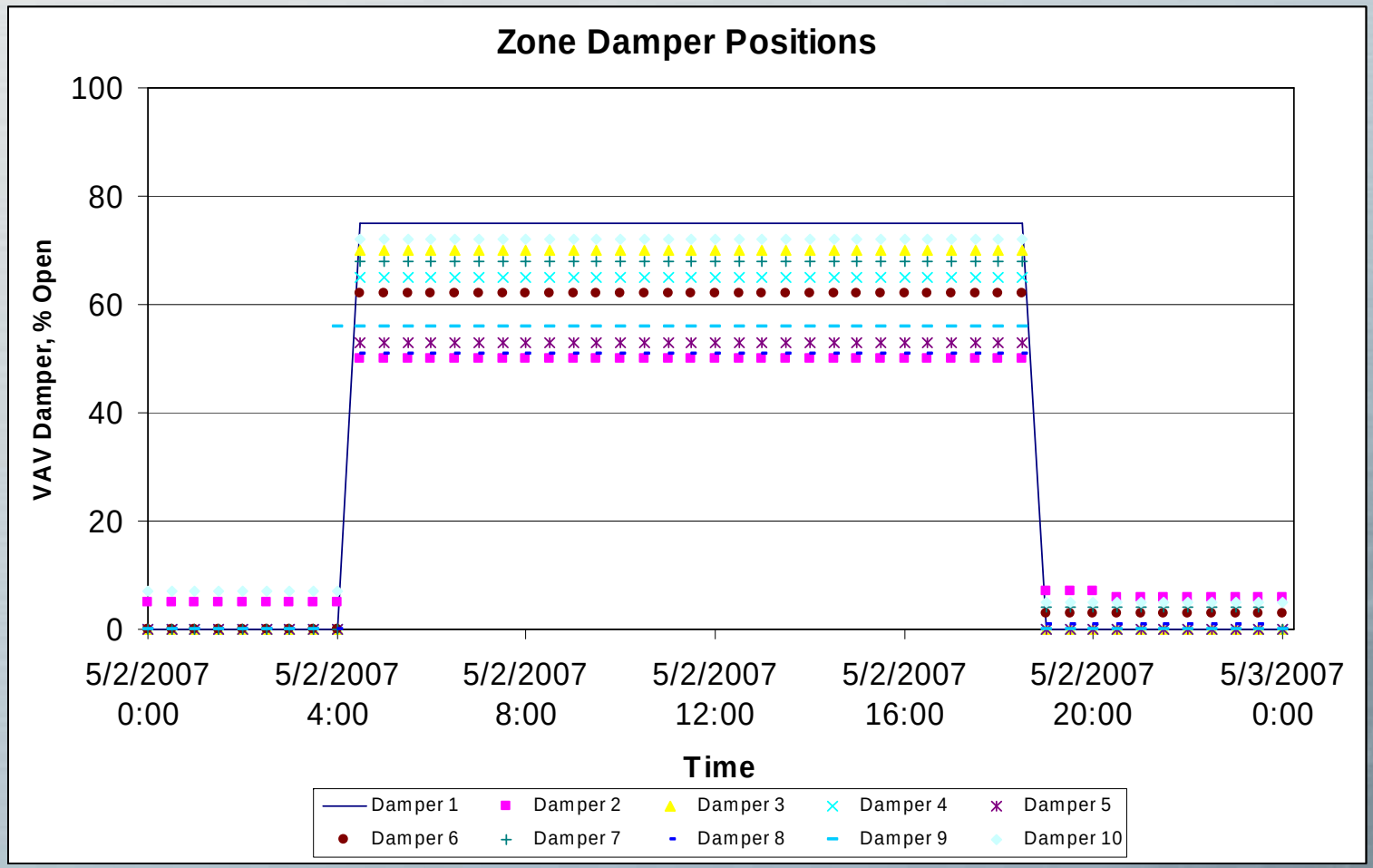
- Approach
  - For each air handler, count the number of zones served that are in heating mode and those in cooling mode under various conditions (e.g., time of day and approximate outdoor air temperature). Use a plot of number of zones in each mode and the outdoor temperature vs. time
  - Note which areas of the building (e.g., interior core vs. perimeter zones or zones facing certain directions) are in heating and cooling
  - Look for any monitored zones that are using both heating and cooling over relatively short time periods or cycling between heating and cooling

Zone Heating and Cooling Demands (continued)

- Potential issues to identify
  - Supply-air temperature too cool or too warm
  - No use of supply-air reset
  - Certain zones (e.g., corner offices) driving air handler operation
  - Some zones out of control, oscillating between heating and cooling
  - Others

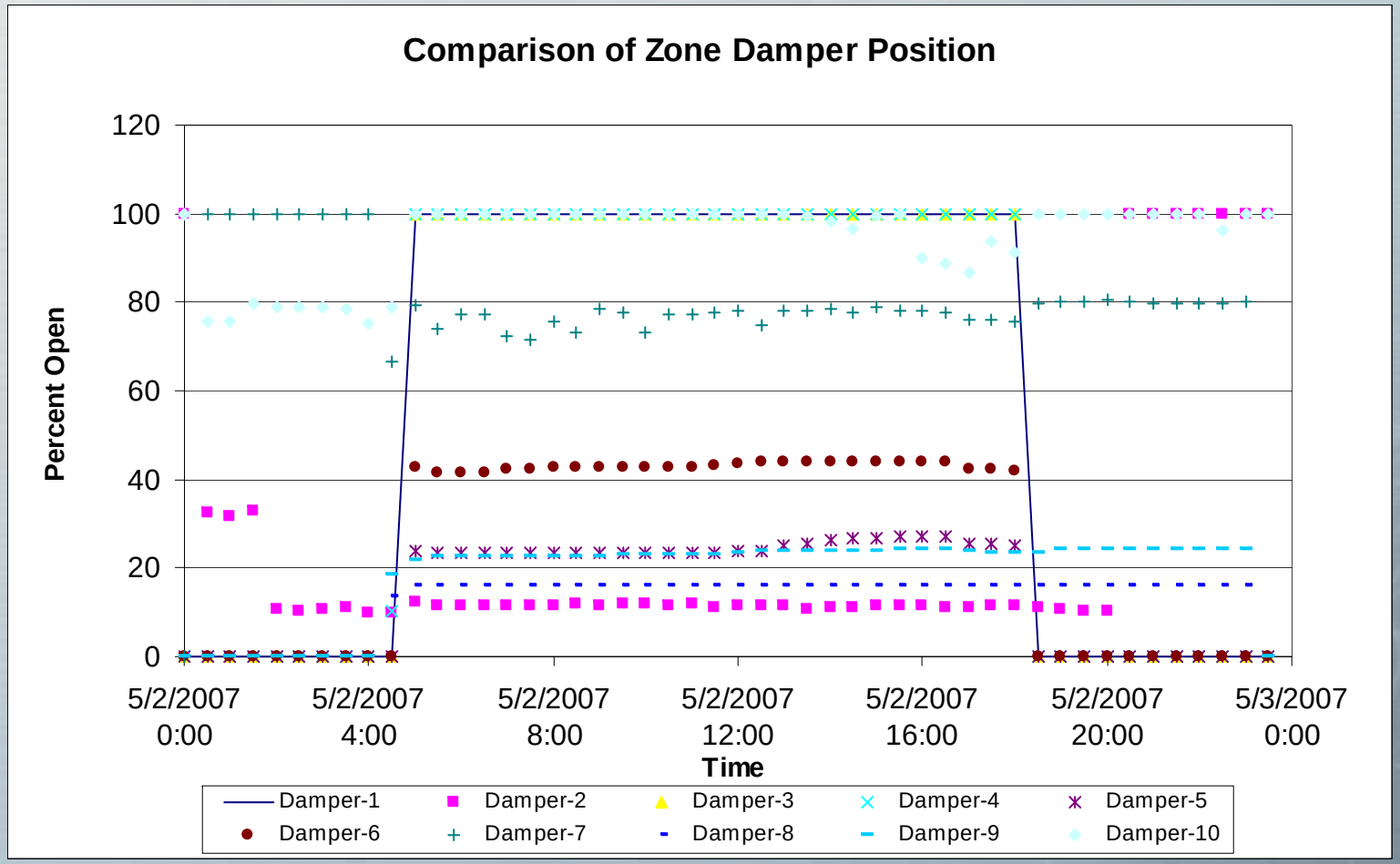
Zone Heating and Cooling Demands (continued): Example Use of Graphs

Plot of VAV unit dampers vs. time for all VAV units served by an air handler – **Very Good Distribution – Most 50% to 75% open**



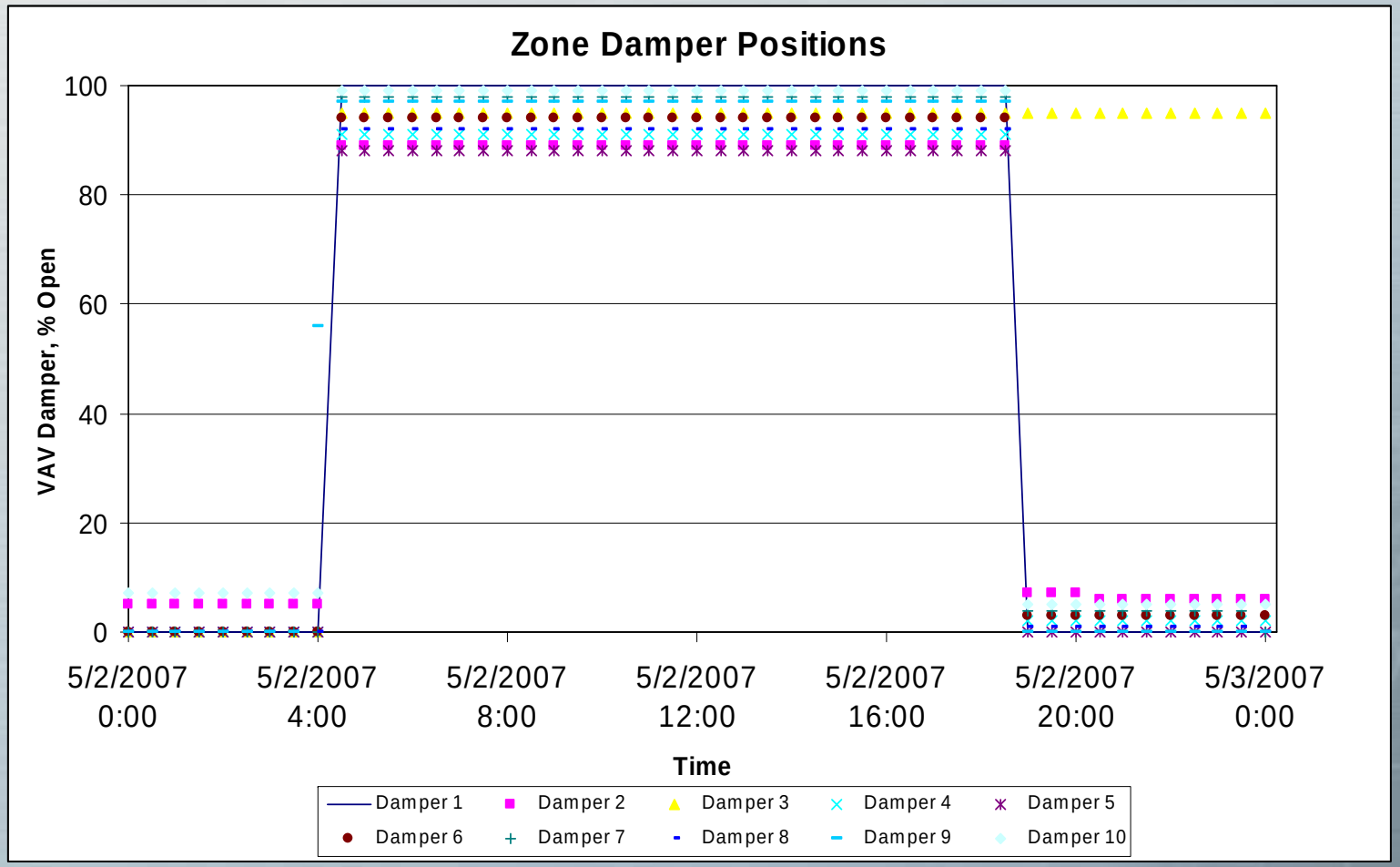
Zone Heating and Cooling Demands (continued): Example Use of Graphs

Plot of VAV unit dampers vs. time for all VAV units served by an air handler – **Distribution Marginally OK**



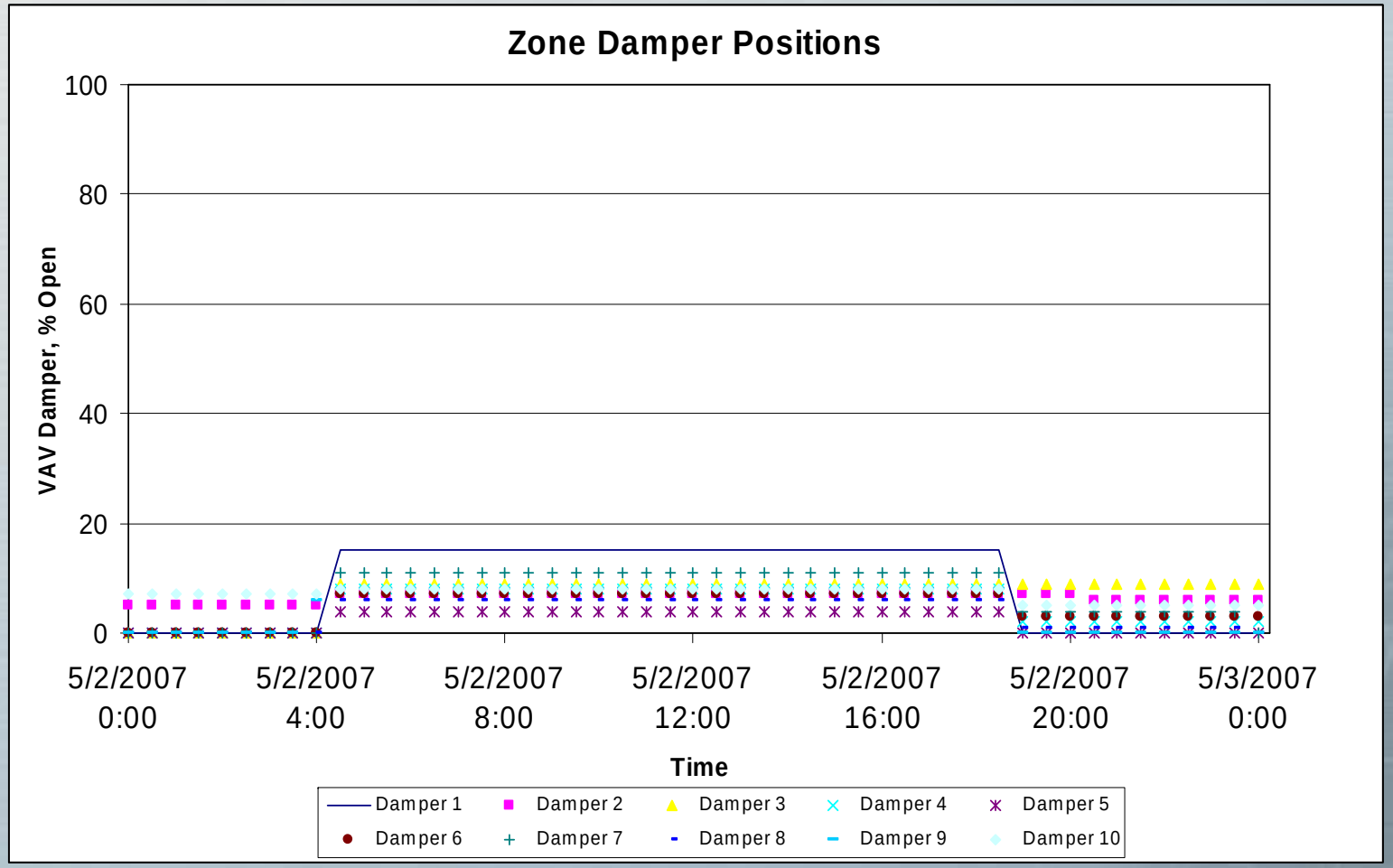
Zone Heating and Cooling Demands (continued): Example Use of Graphs

Plot of VAV unit dampers vs. time for all VAV units served by an air handler – **Bad Distribution – Too many near fully open**



Zone Heating and Cooling Demands (continued): Example Use of Graphs

Plot of VAV unit dampers vs. time for all VAV units served by an air handler – **Bad Distribution – Too many near fully closed**



Economizer Operation

- Purpose
  - To determine whether air-side economizers are operating properly
    - Do economizers open, close, and/or modulate under appropriate conditions?
    - At what temperature compared to the discharge temperature?
    - At what apparent control signal values do the economizers open?
    - Does the cooling coil operate (chilled water flow) during economizing?

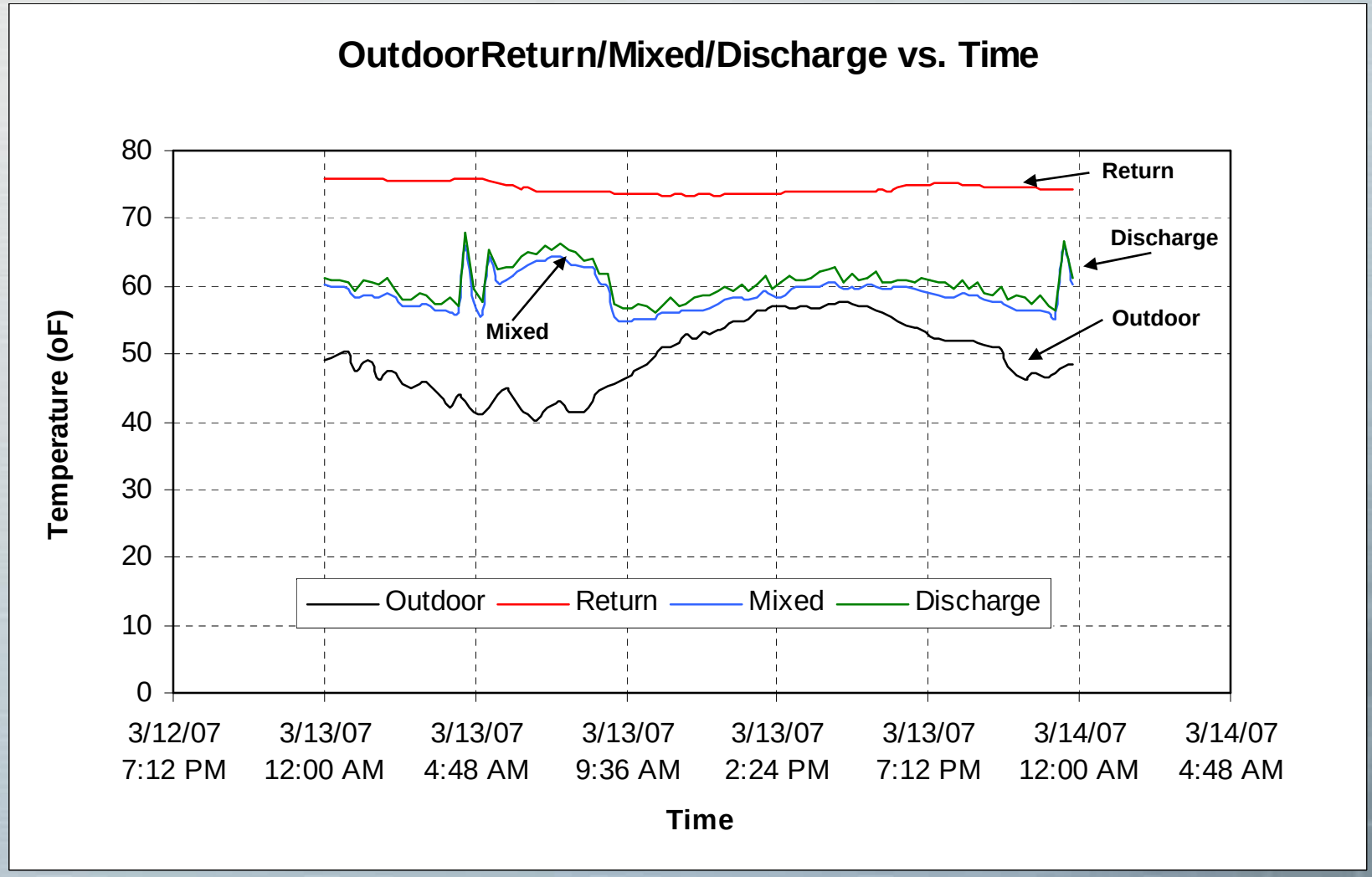
Economizer Operation (continued)

- Approach
  - For each air-side economizer, review plots of:
    - Outdoor-air temperature, mixed-air temperature, return-air temperature and discharge-air temperature vs. time
    - Outdoor-air damper position (% open), outdoor-air temperature, and return-air temperature vs. time
    - Outdoor-air damper position and chilled-water valve position (% open) vs. time
  - Look for outdoor-air dampers (economizer) open at unusual times of day or under unusual outdoor temperature conditions
  - Look for outdoor-air dampers not open to economizer under favorable conditions (outdoor-air temperature between 40°F and 60°F)
  - Look for outdoor-air damper not closing to minimum position for freeze prevention when outdoor temperature is less than about 40°F

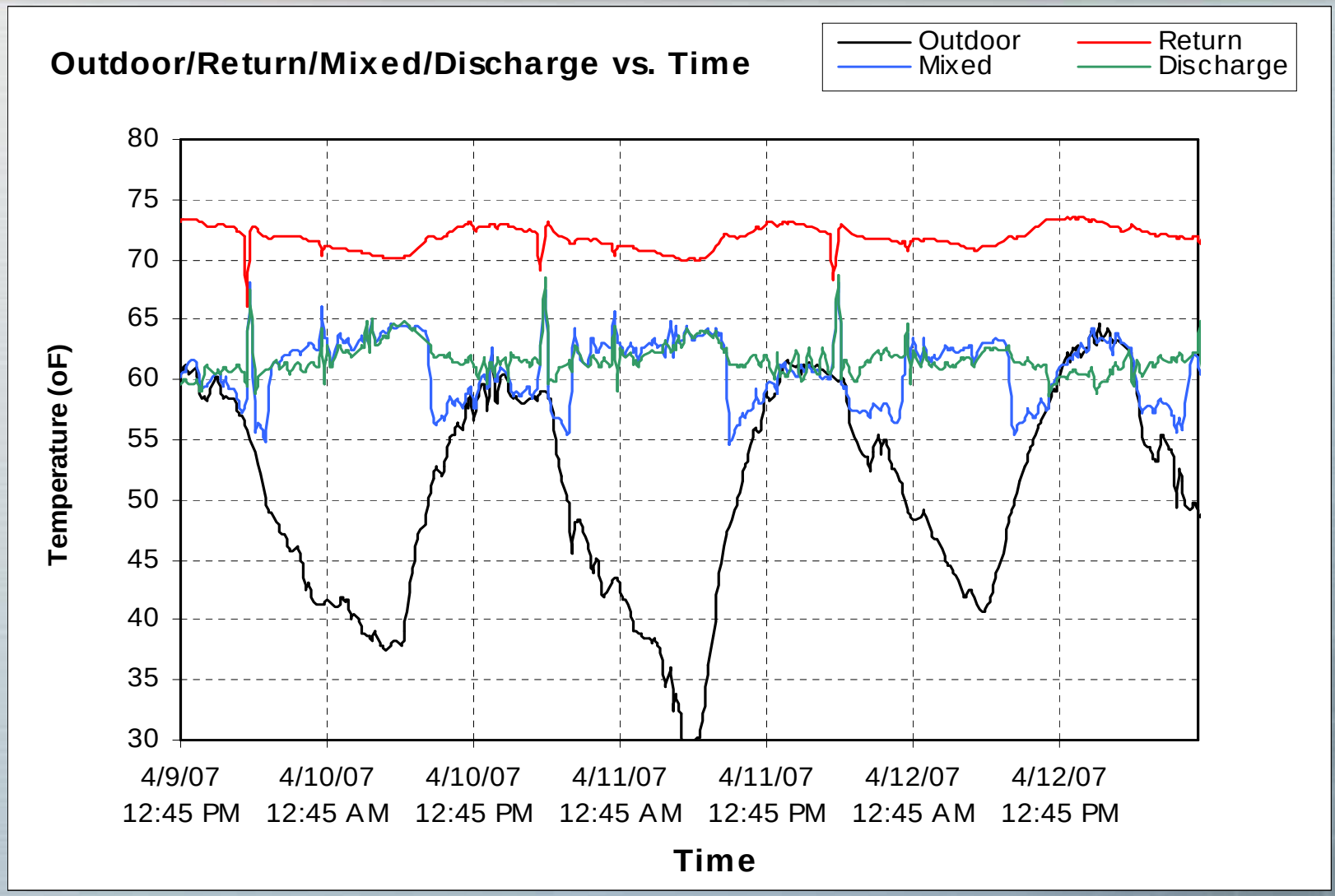
Economizer Operation (continued)

- Potential issues to identify
  - Incorrect economizer operation – numerous causes (identified later during on-site work)
    - Incorrect control strategy
    - Stuck dampers
    - Disconnected or damaged linkages
    - Failed actuator
    - Disconnected wires
    - Failed, uncalibrated or miscalibrated sensors
    - 2 X 4 in damper
    - Others?

Economizer Operation (continued): Example use of Graphs – 1 Day

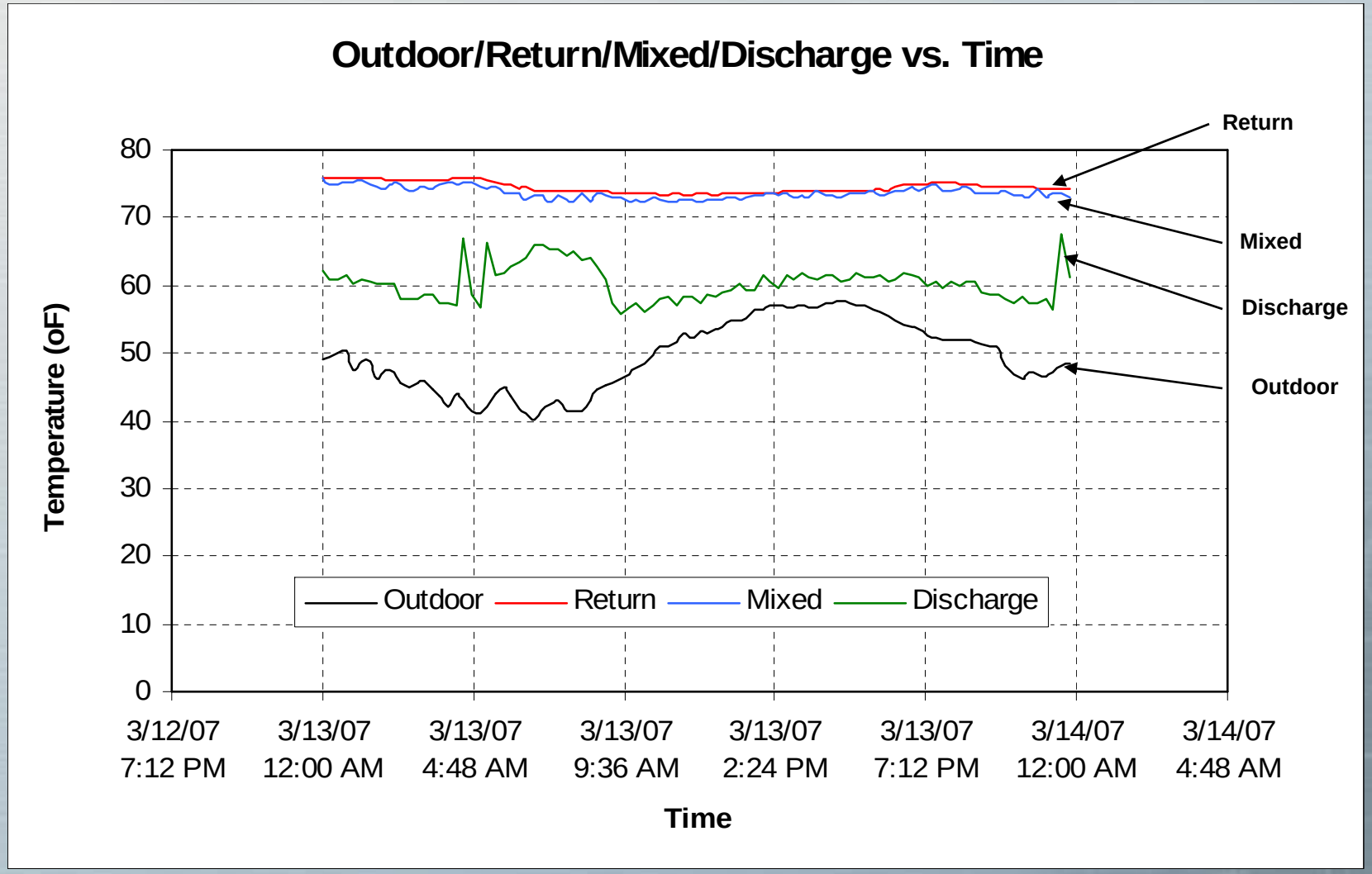


Economizer Operation (continued): Example use of Graphs – 3 Days



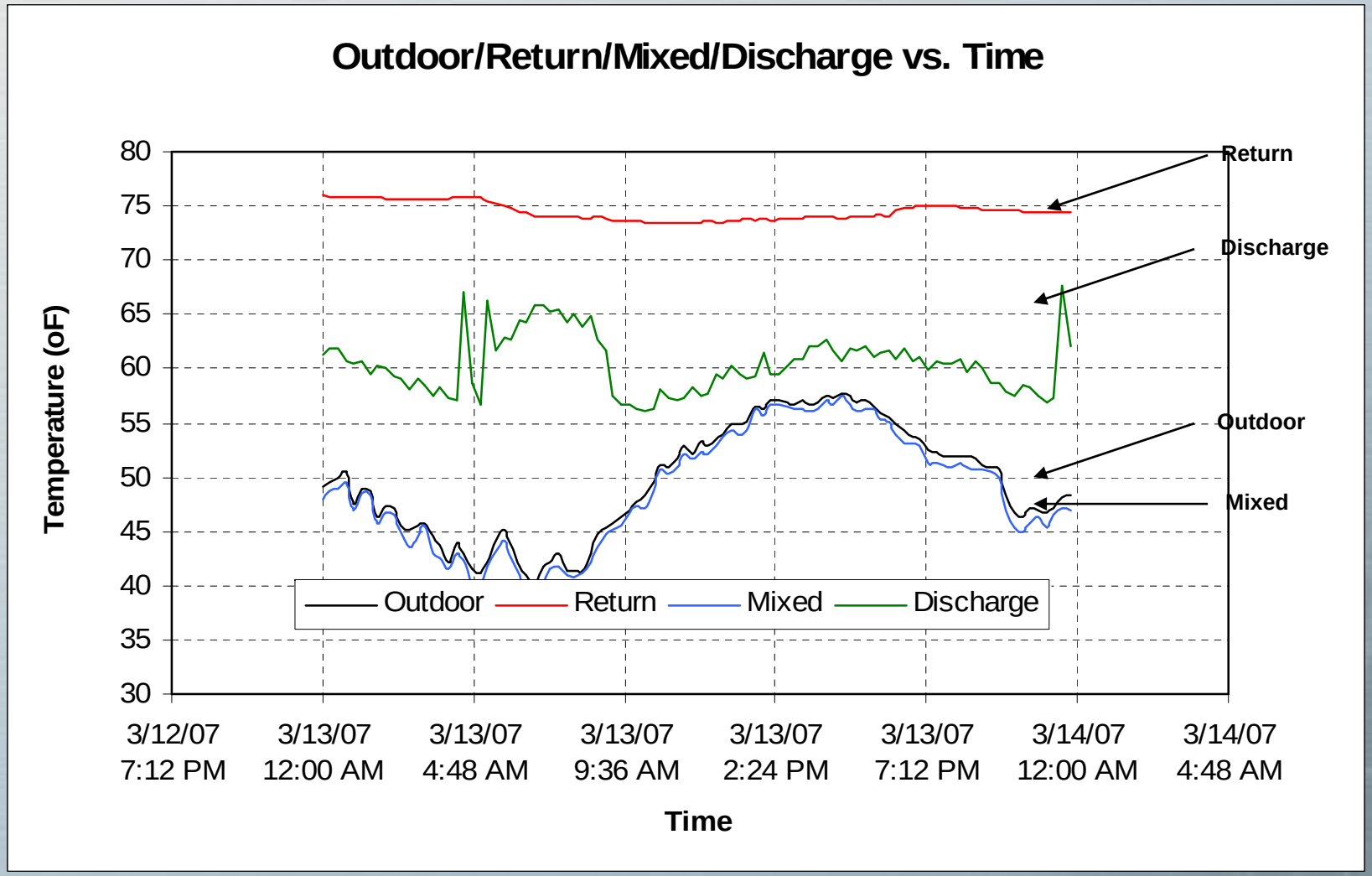
Economizer Operation (continued): Example use of Graphs – 1 Day - Faulty

- Outdoor-Air Damper Stuck Fully Closed



Economizer Operation (continued): Example use of Graphs – 1 Day - Faulty

- Outdoor-Air Damper Stuck Fully Open



Highlights of Re-Tuning

- Every set point adjustment made will have an impact of some sort on the utility meter
- Can save energy and keep occupants comfortable
- It takes time to tune a building
- There are no magic set points that work all the time
- Always monitor the utility meters (gas & electric) to see what affect you have had
- Look at the big picture when making adjustments
- Watch the meter profiles weekly
- Learn and know the building's personality

Example Problems

- Re-tuning approach has found a number of “no-cost” and “low-cost” operational changes that could result in significant savings (>5% of the total consumption) in almost all buildings used for field training

List of Common Problems Based on Re-Tuning 20 Building

Type	Problem	Number of Buildings
Controls	Systems running longer hours than needed	6
	Improper economizer operations	6
	Outdoor-air is not reset to zero during morning warm-up or cooling	5
	Optimal start/stop not working or not present	4
	Tight Dead-band ($1^{o}F$), causing excessive cycling between heating and cooling modes	3
	Building unoccupied during summer months, but all systems running during that period	3

List of Common Problems (cont.)

HVAC Systems	No chilled water or hot water reset	6
	Leaky valves	3
	Static pressure too high	2
	Exhaust fans on 24 x 7	2
	No static pressure reset	2
Building	Un-insulated chilled/hot water pipes or missing attic insulation	4
	Missing door/window seals	3
	Faulty sensors	2
Lighting	Some areas over lit	4
	Lack of occupancy sensors in common areas	3

Issues – Re-Tuning Results from a Pilot Project

- One of the objectives of the large commercial buildings task is to document savings
  - Re-tuning approach has identified a number of “no-cost” and “low-cost” savings opportunities
- Many of the changes are taking a long time to implement
- Stumbling block appears to be the perception by building operations staff that they lack clear authority to implement minor operational changes
- In many cases, the building operator takes directions from someone who is not present in the building on a day-to-day basis
- There is some reluctance by building operational staff to make changes because of a perception that changes can lead to complaints

Questions?