Pacific Northwest
NATIONAL LABORATORY
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Large Commercial Buildings: Re-tuning for Efficiency

Pre-Re-Tuning Phase: Trend Data Collection and Analysis

PNNL-SA-85063 1/11/2012 Version 1.1

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 set back during unoccupied modes, poor economizer operation

Steps for Trend Data Collection

- Develop a monitoring plan – plan includes the points to trend and for each point:
  - Planned trend start time
  - Planned trend end time
  - Length of measurement period
    - Minimum of 2 weeks is recommended, preferably 3 to 4 weeks
    - Allow characterization of both weekdays and weekends
  - Time interval between logged measurements
    - 5-minute frequency is preferable
    - Frequency over 30 minutes is not recommended
  - Measurement units (e.g., ^{o}F for temperature)
- Enable trend logging in building automation system

Suggested Units for Measurements

- Temperature - °F
- Relative humidity - % or dew point - °F
- Pressure – psig
- Damper and valve positions - % of fully open
- Fan speed – rpm
- Fan status – on/off
- Occupancy mode – occupied/unoccupied
- Chiller load – % loaded, amps, kW, or tons

Air handling Unit – Points to Monitor

- Outside-air temperature
- Mixed-air temperature
- Return-air temperature
- Discharge-air temperature
- Discharge-air temperature set point
- Discharge static pressure
- Discharge static pressure set point
- Mixed-air damper position
- Fan status
- Fan speed or vortex damper position
- Cooling coil valve position
- Heating coil valve position
- Occupancy mode of the AHU
- Building pressure
- Building pressure set point
- Any CFM that is part of the air handler control

Air handling Unit – Points to Monitor & Example Monitoring Plan

Air-Handling Unit Monitoring Plan

Building Name:	**ABC Bank Building**
Building Location:	**123 4th Ave., Seattle, WA 99111**
Date:	**April 3, 2007**

Planned Start Date/Time:	**5/1/07 TBD**
Planned End Date/Time:	**5/15/07 TBD**

Re-Tuning Technician Name:	**John Doe, McDonalds Control Services**
Contact Information:	**(509) 555-5555; john.doe@mcs.com**

Planned Measurement Period (hours, days or weeks)	**2 weeks**
Measurement Interval (seconds, minutes, or hours):	**30 minutes**

Floor:	1
Equipment Name:	AHU-1

Point Name	Measurement Description	Planned Start Date/Time	Planned End Date/Time	Planed Measurement Period (hours, days, or weeks)	Measurement Interval (seconds, minutes or hours)	Measurement Units
OAT1	**Outdoor air temperature**					**Degrees F**
MAT1	**Mixed air temperature**					**Degrees F**
RAT1	**Return air temperature**					**Degrees F**
DAT1	**Discharge air temperature**					**Degrees F**
DATSP1	**Discharge air-temperature set point**					**Degrees F**
PDIST1	**Discharge Static Press**					**in. w.c.**
MADamper1	**Mixed air damper position**					**% open**
Fan1	**Fan status**					**on/off**
Fan Speed1	**Fan speed**					**rpm**
CWV%1	**Chilled water valve position**					**% open**
HWV%1	**Hot water valve position**					**% open**
MODE1	**Occupancy mode**					**Occupied/ Unoccupied**

Zone/VAV Box – Points to Monitor

- Zone temperature
- Zone temperature set point
- VAV box damper position
- Reheat valve position (if supply-air is re-heated at the zone)
- Re-cool valve position (if supply-air is re-cooled at the zone)
- Occupancy mode (occupied/unoccupied)
- Zone CFM
- Zone CFM set point
- Zone discharge-air temperature
- Fan status, or fan command (for fan powered boxes only)

Zone/VAV Box – Points to Monitor & Example Monitoring Plan

Zone/VAV Box Monitoring Plan Template

Building Name:	**ABC Bank Building**
Building Location:	**123 4th Ave., Seattle, WA 99111**
Date:	**April 3, 2007**

Re-Tuning Technician Name:	**John Doe, McDonalds Control Services**
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Planned Start Date/Time:	**5/1/07 TBD**
Planned End Date/Time:	**5/15/07 TBD**

Planned Measurement Period (hours, days or weeks):	**2 weeks**
Measurement Interval (seconds, minutes, or hours):	**30 minutes**

Floor:	1
Equipment Name:	VAV1-1

Point Name	Measurement Description	Planned Start Date/Time	Planned End Date/Time	Planed Measurement Period (hours, days, or weeks)	Measurement Interval (seconds, minutes or hours)	Measurement Units
T1-1	Zone air temperature					Degrees F
VAV%1-1	VAV box damper position					% open
REHEAT%1-1	VAV box reheat valve position					% open
MODE1-1	Zone occupancy mode					Occupied/ Unoccupied

Physical Plant – Points to Monitor

- Chilled-water supply temperature
- Chilled-water return temperature
- Chilled-water set point
- Hot-water supply temperature
- Hot-water return temperature
- Hot-water set point
- Condenser supply temperature
- Condenser return temperature
- Condenser- water set point
- Each chiller load (current)
- Each pump status (if there are multiple pumps record all of them)
- Each chiller status (if chiller load is recorded this point may not be needed)
- Chilled-water gpm
- Chilled-water differential pressure
- Chilled-water differential pressure set point
- Cooling-tower fan speed
- Cooling-tower fan speed set point
- Cooling-tower fan status
- Whole building electrical consumption (either average kW or kWh).

Physical Plant – Points to Monitor & Example Monitoring Plan

Physical Plant Monitoring Plan Template

Building Name:	**ABC Bank Building**
Building Location:	**123 4th Ave., Seattle, WA 99111**
Date:	**April 3, 2007**

Re-Tuning Technician Name:	**John Doe, McDonalds Control Services**
Contact Information:	**(509)555-5555; john.doe@mcs.com**

Planned Start Date/Time:	**5/1/07 TBD**
Planned End Date/Time:	**5/15/07 TBD**

Planned Measurement Period (hours, days or weeks):	**2 weeks**
Measurement Interval (seconds, minutes, or hours):	**30 minutes**

Mechanical Room Location:	Basement 1

Equipment Name	Point Name	Measurement Description	Planned Start Date/Time	Planned End Date/Time	Planed Measurement Period (hours, days, or weeks)	Measurement Interval (seconds, minutes or hours)	Measurement Units
Chiller Plant	CWST	Chilled water supply temperature					Degrees F
Chiller Plant	CWST-SP	Chilled water supply temperature set point					Degrees F
Chiller Plant	CWRT	Chilled water return temperature					Degrees F
Chiller Plant	CNDST	Condenser supply temperature (temperature of water returning from the cooling tower)					Degrees F
Hot Water Plant	HWST	Hot water supply temperature					Degrees F
Hot Water Plant	HWRT	Hot water return temperature					Degrees F

Physical Plant – Points to Monitor & Example Monitoring Plan – Continued

Physical Plant Monitoring Plan Template

Chillers: Create a table for each chiller in the physical plant.

Equipment Name	Point Name	Measurement Description	Planned Start Date/Time	Planned End Date/Time	Planed Measurement Period (hours, days, or weeks)	Measurement Interval (seconds, minutes or hours)	Measurement Units
Chiller 1	CHLOAD1	Chiller 1 load					Tons
Chiller 1	CHSTAT1	Chiller 1 status (only needed if load is not available)					On/off
Chiller 1	CNDRT1	Condenser return temperature (temperature of water leaving the condenser)					Degrees F
Chiller 2	CHLOAD2	Chiller 2 load					Tons
Chiller 2	CHSTAT2	Chiller 2 status (only needed if load is not available)					On/off
Chiller 2	CNDRT2	Condenser return temperature (temperature of water leaving the condenser)					Degrees F

Physical plant – Points to Monitor & Example Monitoring Plan – Continued

Physical Plant Monitoring Plan Template

Pumps: Create a row for each pump

Equipment Name	Point Name	Measurement Description	Planned Start Date/Time	Planned End Date/Time	Planed Measurement Period (hours, days, or weeks)	Measurement Interval (seconds, minutes or hours)	Measurement Units
Pump 1	P1-STATUS	Status of Pump 1					On/off
Pump 2	P2-STATUS	Status of Pump 2					On/off
Pump 3	P3-STATUS	Status of Pump 3					On/off

Monitoring Guidelines

- For the VAV system, the following data points must be trended at 30-minute maximum intervals for a minimum 2-week period for each air-handling unit (AHU)

Following are the guidelines for trending VAV systems:

- If there are fewer than 6 AHUs in the building, we recommend that all AHUs be trended.
- If the building is less than 4-stories tall, pick at least one AHU from each floor.
- If the building is 20-stories tall, trend all AHUs if there are fewer than 6. If there are more than 6 AHUs, trend 1 AHU on every other floor (maximum of 10 AHUs trended).
- Our recommendation is not to pick the AHU that is operating the "best." We recommended that the AHU be picked randomly for monitoring.

Following are the guidelines for trending zone VAV boxes:

- If there are fewer than 8 zones per floor, trend all zones on the floor.
- For each floor, trend at least one zone on each of the four directions (north, south, east and west) and at least four zones in core. So, we will need at least eight VAV boxes trended per floor.
- If the building is less than 4-stories tall, trend eight zones on every floor.
- If the building is 20-stories tall, trend all eight zones on every other floor (maximum of 80 VAV boxes to trend).

Implementing Monitoring Plan: Setting up Trend Logs

- Trend logs are set up in the building automation system (BAS)
- Each BAS has its own procedures for setting up trend logs
- Use them to there fullest extent. The trends are your window into the past. How else do you really know what a system did during unoccupied periods or last weekend?

Analyze Trend Log Data with ECAM – Major Steps

- Download trend log data files from BAS
- Format data files for compatibility with the Energy Charting and Metrics (ECAM) spreadsheet analysis tool
- Open data files in the ECAM spreadsheet analysis tool and automatically generate graphs
- Review graphs to identify operational issues
- Record operational issues for reference during re-tuning

Convert Data Files to ECAM Format

- PNNL's ECAM spreadsheet tool works best if the data is in "CSV" (comma separated variable) format
- Two types of CSV data files
  - One point (or variable) per file – time stamp and value
  - Multiple points per file – time stamp followed by multiple point data (ECAM)
- ECAM only works with multiple point file
  - If the BAS outputs data one point per file, merge the data using Universal Translator tool – instructions can be found on PNNL website www.pnnl.gov/buildingretuning
- ECAM analysis tool can also be downloaded from the same website

Example of Single-Point Data File Format

Time,	Outdoor Temp.Trend (deg F)
4/20/07 2:45:00 PM PDT,	61.96875
4/20/07 2:50:00 PM PDT,	61.03125
4/20/07 2:55:00 PM PDT,	60.6875
4/20/07 3:00:00 PM PDT,	60.6875
4/20/07 3:05:00 PM PDT,	59.6875
4/20/07 3:10:00 PM PDT,	58.625
4/20/07 3:15:00 PM PDT,	61.65625
4/20/07 3:20:00 PM PDT,	59.5625
4/20/07 3:25:00 PM PDT,	59.5
4/20/07 3:30:00 PM PDT,	59.875
4/20/07 3:35:00 PM PDT,	61.3125
4/20/07 3:40:00 PM PDT,	61.3125
4/20/07 3:45:00 PM PDT,	59.5
4/20/07 3:50:00 PM PDT,	60.6875
4/20/07 3:55:00 PM PDT,	60.5

Example of Multi-Point Data File Format

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Date / Time,	Sf-1 Speed (%),			Sf-2 Speed (%),			Sf-3 Speed (%),			OA_TEMP),		OCCCMD,
5/2/2007 0:00,	0,	0,	0,	58.77789,	0,	62.06757,	0,	0,	0,	0.010427,		
5/2/2007 0:30,	61.7719,	0,	0,	52.62024,	0,	72.58334,	1,	100,	0,	1.1		
5/2/2007 1:00,	59.71371,	0,	0,	53.07013,	0,	72.41461,	1,	100,	0,	1.		
5/2/2007 1:30,	55.69472,	0,	0,	52.84518,	0,	72.3584,	1,	100,	0,	1.0		
5/2/2007 2:00,	55.59563,	0,	0,	52.84518,	0,	72.33029,	1,	100,	0,	1.		
5/2/2007 2:30,	55.88474,	0,	0,	52.98575,	0,	72.18973,	1,	100,	0,	1.		
5/2/2007 3:00,	55.88474,	0,	0,	52.31094,	0,	72.16162,	1,	100,	0,	1.		
5/2/2007 3:30,	55.88474,	30.16013,	0,	52.42343,	0,	72.021,	1,	100,	0,			
5/2/2007 4:00,	50.42294,	0,	0,	52.42343,	0,	72.16162,	1,	100,	0,	1.		
5/2/2007 4:30,	50.3317,	0,	53.9305,	52.42343,	0,	72.47089,	1,	100,	0,			
5/2/2007 5:00,	64.45383,	60.54897,	61.87724,	51.86108,	1,	72.47089,	1,					
5/2/2007 5:30,	75.39667,	60.54897,	59.67387,	51.77673,	1,	72.21783,	1,					
5/2/2007 6:00,	75.40579,	60.54897,	59.26752,	51.72049,	1,	72.18973,	1,					
5/2/2007 6:30,	75.40579,	60.54897,	58.20168,	51.86108,	1,	72.24594,	1,					

Review Graphs & Identify Operation Issues

- Issues to investigate with trend log data
- ECAM automatically generates graphs needed
- In the next section, we will look at some examples of what to look for
- Online reference document provides additional information and examples, which you can refer to any time you need to (see www.pnnl.gov/buildingretuning)

QUESTIONS?

www.pnnl.gov/buildngretuning