


New Buildings Institute
Advances in HVAC Technology:
Fault Detection and Diagnostics

National Conference on Building Commissioning
 April 2006



New Buildings Institute
 White Salmon, WA
www.newbuildings.org & www.advancedbuildings.net

- Formed in December 1997 as a not-for-profit public benefits corporation
- Working with partners in: California, Northwest, Northeast & Midwest
- Funding:
 - Sponsors
 - Grants
 - Contracts
- Changing markets through research, guidelines, codes, and training
- Developed *Advanced Buildings™* and *Advanced Lighting Guide*



New Buildings Institute Projects

- ✓ **Advanced Automated HVAC Fault Detection and Diagnostics Commercialization Program**
- ✓ **Hot/Dry Air Conditioner Project**
- ✓ **Indirect Evaporative Cooler Monitoring Project**
- ✓ **Evaporative Cooler Market Assessment**
- ✓ **University of CA-CIEE Campus Project**
- ✓ **Building Performance Review**
- ✓ **Advanced Buildings / ALG Revision**
- ✓ **Getting to Fifty: www.advancedbuildings.net**
- ✓ **PNW and NEEP RTU-DTU Programs**

FDD: So Who's and What's at Fault?

- 2/3's HVAC systems large & small
- Everyone's holding on tightly



FDD or Controls?

- It's the controls, stupid...
- FDD is a natural control functionality
- Provides persistence & reliability of:
 - energy/demand savings
 - performance
 - efficiency
- Technology and training

Advanced, Automated HVAC Fault Detection and Diagnostics (FDD) Commercialization Program

DEVELOP & DEMONSTRATE:

- Advanced Fault Detection and Diagnostics Methods and Measurement Equipment for HVAC Systems Both Rooftop and Built Up
- More Advanced and More Fault Resistant HVAC Equipment



PIER FDD:Market Connections

- Identify/assess/implement activities/mechanisms to move successful FDD products into markets
- Influence codes/standards/regulators in California and nationally
- Strategic Partnerships

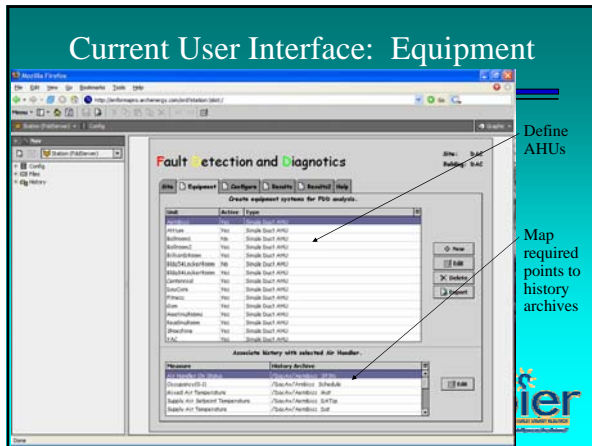
FDD Project 2: **Web-Enabled Diagnostics System**

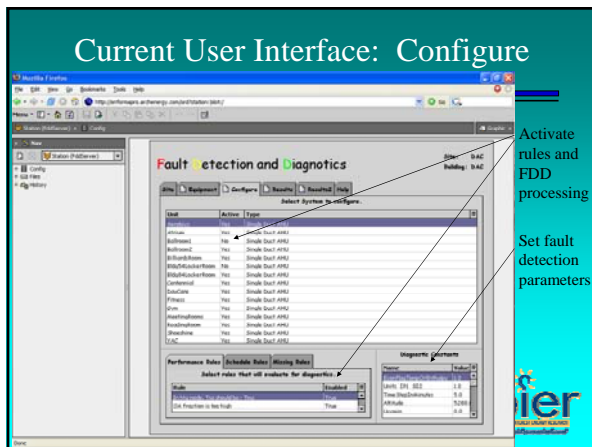
Project Lead: Architectural Energy Corporation

- Based on NIST AHU Performance Assessment Rules-APAR
- Dual duct AHU/chiller systems
- Chiller/cooling tower diagnostics
- Customer data transmission to web-based diagnostic engine with UI
- Tridium first development partner
- Ongoing commissioning functionality

Current User Interface: Site tab

Define and select sites and buildings





FDD Project 2: Field Test Status

- Alpha testing (Colorado)
 - Western Building Services has provided access to buildings in Denver area
 - > Denver Athletic Club
 - Multiple air handlers; district CHW and steam
 - > Regis University (library)
 - Large dual duct
 - Currently, air handler rules are being evaluated; chiller and cooling tower data is not yet available
- Beta testing (California)
 - Building has not yet been identified

FDD Project 2: Requirements for CA Test Site

- Required HVAC equipment:
Central plant equipment:
Chiller
Cooling tower
One or more air handlers
- Currently installed Niagara system (AX or R2) is highly desired
- Site suggestions are requested immediately

FDD Project 3: AHU-VAV Diagnostics
Project Lead: National Institute of Standards and Technology (NIST)

- AHU Performance Assessment Rules + VAV box control charts
- Very low cost; embedded in controller logic
- BACnet enabled; works through existing BAS
- 28 AHU faults, 7 VAV box faults; rule-based trend logging
- Current development partners: Alerton, Automated Logic Corporation, Delta Controls, Tour Andover Controls
- Case Study of 450 Golden Gate Bldg: 2 AHUs + 1000 VAV
- Ongoing commissioning functionality
- Algorithms in public domain
- www.archenergy.com/pier-fdd/

FDD Algorithms Field Sites

Site	Location	Manufacturer	# AHUs	# VAVs
ALC corporate headquarters building	Atlanta, GA	ALC	2	53
Philip Burton Federal Building	San Francisco, CA	Alerton	2	1000
Alerton corporate headquarters building	Redmond, WA	Alerton	1	47
NIST campus	Gaithersburg, MD	Alerton + Andover	1	0
Foley Federal Building	Las Vegas, NV	Delta	2	2
Montgomery College Health Sciences Building	Takoma Park, MD	Alerton	2	101
Pennsylvania Military Museum	Boalsburg, PA	ALC	2	9
Shippensburg University	Shippensburg, PA	ALC	0	28
Iowa Energy Center ERS	Ankeny, IA	Invensys	1*	11*
			* in the works	

FDD Algorithms-What's Next?

- AHU: dual duct, multi-zone
- Unit ventilators, fan coil units, zone reheat, zone dampers, unit/cabinet heaters
- A/C, heat pumps, evap coolers
- Chillers and boilers
- Cooling towers

FDD Project 4: **Advanced Rooftop Unit**
Project Lead: Architectural Energy Corporation

- 5-ton rooftop unit prototype
- More robust operation
- Economizer enhancements
- FDD capabilities
- POC unit test about to begin

RTU Market

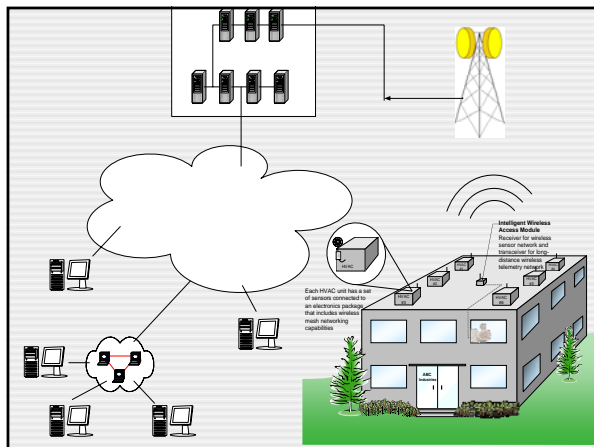
- In terms of number of systems installed, the most popular packaged DX system size is 5 tons, representing 24% of total units sold.
- Units up to 10 tons represent close to 90% of the total unit sales in new commercial buildings in California.
- 155 million square feet of new commercial building construction in CA each year
- Approximately 39 million square feet (25%) use packaged air conditioning units of 10 tons or less in capacity.

FDD Project 4: **ARTU**

- Economizer improvements
- Fan improvements
- Unit efficiency
- Refrigeration cycle improvements
- Fan controls
- Refrigerant control
- Thermostat capability
- Sensors
- Installation & check-out capability
- Advanced monitoring
- Embedded diagnostics

FDD Project 5: **Rooftop Unit Diagnostics Project**
Lead: Field Diagnostic Services, Inc.

- Automated data acquisition
- Wireless communications to website/email
- 25 alarm conditions; 5-50 tons; 1-2 stage
- Safety, energy, occupant comfort prioritized
- Trend log data graphed
- Utility costs/ROR on repair
- Ongoing commissioning functionality



Embedded Diagnostics Alarms

Refrigeration Cycle

- ✓ poor condenser heat transfer
- ✓ poor evaporator heat transfer
- ✓ refrigerant flow restriction
- ✓ low refrigerant charge
- ✓ high refrigerant charge
- ✓ low compressor pumping efficiency
- ✓ non-condensable gas in system
- ✓ sensor problem

Embedded Diagnostics Alarms

Air Handler

- ✓ no economizer cooling at low OAT
- ✓ high outdoor air fraction when high OAT
- ✓ low outdoor air fraction when occupied
- ✓ DCV signal and low OSA fraction
- ✓ low mixed air temperature
- ✓ low airside temp difference during heat or cool
- ✓ high airside temp difference during heat or cool
- ✓ sensor problem

Embedded Diagnostics Alarms

Controls

- ✓ continuous call for cooling or heating
- ✓ simultaneous heating and cooling
- ✓ fan cycling, not continuous during occupied period
- ✓ fan running continuous when unoccupied
- ✓ mechanical cooling at low OAT-no economizer
- ✓ t-stat cooling/heating demand, but no cooling/heating
- ✓ compressor short cycling sensor problem
- ✓ extended run time
- ✓ sensor problem

Embedded Diagnostic UI

Unit Status

Company: GSRC
 Site: GSRC Atlanta
 Unit: RTU-1
 Expansion Device: TxV
 Stg 1 Capacity: 15 tons
 Model:
 Number of Stages: 2
 Refrigerant: R22
 Stg 2 Capacity: 15 tons
 Make: Trane
 SEER: 10

Embedded Diagnostic UI

Unit	Comfort Alarm	Equipment Safety Alarm	Energy Savings Opportunity	Monitoring System Alarm	Efficiency Index	Potential Annual Savings	Expected Cost	Return on Investment
RTU-1	OK	2 alarms	1 alarms	OK	63	\$940	N/A	N/A
RTU-2	OK	2 alarms	1 alarms	OK	88	\$535	N/A	N/A
RTU-3	OK	1 alarms	1 alarms	OK	94	\$97	N/A	N/A
RTU-4	OK	OK	1 alarms	OK	NA	NA	N/A	N/A
RTU-5	OK	2 alarms	1 alarms	OK	79	\$301	N/A	N/A

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Embedded Diagnostic UI

Top of Form

All Alarms for Unit: RTU-1 List of Alarms

Alarm Name	Duration	Status	Priority
Low Evaporating Temperature	348 days 16 hours	New	Equipment Safety Alarm
No Economizer Cooling at Low OAT	351 days 16 hours	New	Energy Savings Opportunity
Short Compressor Off Time	28 days 17 hours	New	Equipment Safety Alarm

Top of Form
Top of Form

Embedded Diagnostic UI

Alarm Category	Status
Equipment Safety Alarm:	2 Alarms
Energy Savings Opportunity:	1 Alarms
Comfort Alarm:	OK
Monitoring System Alarm:	OK
Alarm Details Alarm History	

Embedded Diagnostics UI Alarm Details

- Description: Evaporating temperature is lower than expected
- Fault Condition: Steady-state cooling operation and evaporating temperature less than 28 F
- Occurrence Condition: 10 minutes accumulated during a day
- Possible Cause: Low indoor airflow, refrigerant flow restriction
- Possible Impact: Frozen indoor coil, energy use
- Alarm Trigger Date: Jan 29, 2006
- Alarm Last Observed Date: Feb 03, 2006


Embedded Diagnostic UI

Alarm History

Unit: RTU-1

Alarm	Trigger Date	Event	Event Date	Event Time	UserName	Description
No Economizer Cooling at Low OAT	Dec 02, 2004					No Records Found
Low Evaporating Temperature	Dec 05, 2004					No Records Found
Short Compressor Off Time	Oct 21, 2005					No Records Found

Embedded Diagnostic UI

 Cooling Performance

Parameter	Value
Last Cooling Date:	Nov 20, 2005
Mechanical Cooling Efficiency Ind.	No Steady State Data Avail
Mechanical Cooling Runtime Frac	0.188
Economizer Cooling Runtime Frac	0
Cooling Cycles:	N/A
Occupied Period Outdoor Air Frac	N/A

Embedded Diagnostics-Results

- 5 buildings, 15 RTUs (HP/package), 5-15 tons
- monitored 4-10 months
- 60% with short compressor on cycles (<5")
- reduced equipment life; part load perform
- 80% with short compressor off cycles (<5")
- reduced equipment life

Transformative Technology

- Zero distance between building owner and service provider with what's on the roof
- Installation and service quality are transparent
- Equipment flaws also transparent

FDD Project 6: **SpeciFlow™ Technology**
Project Lead: Federspiel Controls

- On the market: Greenheck Fan Corp IAQ-42
- High accuracy damper monitoring & control
- Peak savings from OA control
- LEED credit for OA control
- CA Title 24 Nonresidential compliant
- Integral controller-standalone or DDC

The Future Home of FDD
& Remote Commissioning
Services?



Midnight phone call
from home?

No. It's RTU #34 at the
Commerce Mall reporting
low refrigerant
pressure. I'll finish
the recommissioning on
Monday if the bears
don't get us.

(with apologies to the Notifact
website)

Interested in More Information?

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