HVAC Real-time Remote Monitoring
4 year Case Study
Delivering Value

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Breakout Session Category
Technical
Session Objectives

- NYSERDA Residential Geothermal Monitoring Case Study Background (The why)
- Understanding the key metrics for monitoring and measuring system performance
- Interpreting the data
- New skills required for analyzing and diagnosing systems
- Recognizing value of remote monitoring to the Customer, Service contractor and HP Manufacturer
  - Critical to removing negative perceptions
  - Improving adoption of technology
- Remote monitoring - tool for delivery value added services
  - lower cost and higher value services
  - Doing more, doing it better, doing it cheaper
The Study

NY State Energy & Research Development Authority Supported Project

Deploy Real Time Telemetry to Validate Geothermal Technology Claims

- Investigate reliability issues?
- Cost effectiveness?
- Address the need for collecting statistical data to support the claimed benefits of adopting technology
- Generate data to support the continuation of state and federal incentives for residential Geothermal
  • Quantify the ROI
Agenda

- Building Automation vs Residential remote monitoring (What’s different?)
- Remote Data – Who needs it?
- What metrics are critical?
- Interpreting and analyzing the data
- Case studies
- Expert’s Perspective
- Conclusion
Contrasting Commercial Building Automation with Residential Monitoring

• Commercial Building Automation and Control (BAC) has been maturing for over 40 years...
  • Inhibitors to penetration into residential and small commercial market
    – Custom development
    – System software is proprietary
    – Recovery costs for software built into pricing

• Residential Monitoring is rapidly inserting itself into service industry
  – Combines custom and Open Source Software
  – High speed internet access is ubiquitous
  – Lower cost components
Remote Data – Who Needs It?

The Subscribers

• Home owner
  – Verification of operation (Current settings, system status, etc.)
  – Review energy consumption on demand
  – Distinguish system operational costs from other electricity usage*
  – Provides critical information empowering customer to make intelligent decisions related to system repair or replacement

• Service provider
  – Captures information to assure Customer that service provider is acting in Customers best interest*
  – Alerts: Provide visual, text, or email of potential system problem
  – Comparative analysis of system performance against baseline
  – Real-time and historical data for assessing performance
  – Problem Diagnosis
    • Root Cause Analysis
    • Collaboration with Subject Matter Experts, MFG Engineering

• Manufacturer
  – Provides real time field data to identify engineering, manufacturing, or installation defects and related problems
What metrics are critical?

Key Performance Indicators

– Temperature
  • Ground loop – Entering Water Temp (EWT), Leaving Water Temp (LWT)
  • Air In, Air Out
    • Load side W2W – EWT, LWT
  • Outside Air
    • Optional temperature sensing
      – Suction and Discharge

– System State (Digital I/O)
  • Demand – heating/cooling
  • System state (1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd}, E heat, cooling / heating)

Flow rate - Ground Loop
– Pressure - Ground Loop

Electrical Usage - Heat Pump, and dependent auxiliary systems
  • Kilowatt, Voltage, Amperage, Kilowatt Hours (Aggregate)
Interpreting and Analyzing Information

• Direct **visualization** of performance without complex calculations
  – Temperature differential (Delta t) of EWT and LWT
  – Delta T Load side Air in and Air Out or Load side EWT and LWT Water

• Flow and Pressure KPIs monitored as outlined in Critical Metrics above facilitate real time calculations for measuring System Efficiency at a glance
  – **Heat of Extraction/Rejection**
    • \((EWT - LWT) \times \text{GPM} \times 60 \times 8.35 = \text{Absorbed BTUH}\)
    • Kw (True Power) \times 3.412 (BTUH per watt) = \text{Electricity BTUH} (unit's HP electric usage)
  – **Coefficient of Performance (COP)**
    • \((\text{Absorbed BTUH} + \text{Electricity BTUH}) \div \text{Electricity BTUH} = \text{COP}\)
    – Graphs providing comparative costs for alternative Modalities of heating
Visualizing System Performance

Web Portal Tool Chest
System Stages – Daily/hourly

(Jan 1 – Jan 31) 2015

Daily

Jan 8, 2015

Hourly
Performance Graph

Jan 8, 2015
(12 Hour view)

Jan 8, 2015
(4 Hour view)
Status Dashboard – Snapshot

Jan 8, 2015 4:00:04 PM

Snap shot with additional information not provided on Performance timeline

- **Thermostat**
  - Room Temp (LCD Temp)
  - Heat Set-point
  - Cool Set-point
- **Thermostat Mode (state)**
- **System (state)**
- **Electrical**
  - Voltage
  - Current (Amps)
  - Instant (KW)
  - Aggregate (KWH)

System information description
Problem Determination and Remediation

Current Process

- Preliminary assessment. - Customer complaining not heating enough
- Send field engineer with appropriate skills to investigate Field site visit:
  - Set up instrumentation and perform visual inspection to verify
    - Flow rate (Pressure differential on heat exchanger)
    - Temperature
      - Air In, Air out, Ground loop WI, WO (ground loop), etc.
    - Thermostat Status (Mode*, Set point, room temp)
    - System Status (1st, 2nd, 3rd heating etc..)
  - Advise client based on assessment Either replace component at time of visit or schedule return for follow-up repair
  - Verify Repair was successful **

Remote Monitoring

- Review system critical performance indicators leading up to the event
  - Review Alerts if any
  - Examine Timeline graph for period when event occurred
  - Launch detailed status dashboard (select instance in time just before event)
  - Step forward on status dashboard
  - Review metrics monitored as they change to determine what has failed or may be responsible for interruption in service
  - Review system history with subject matter expert/system engineer* if necessary
- take further action based on evaluation of real time and historical data
- Resume system monitoring after system restored
Case Studies

Demonstrating Value in the Wild
First Case Study

Hard Failure – No Heat
System - Failure
Customer Complaint - No Heat

- Home Owner wakes up to discover room temperature at 60° F
  • Calls for service
- Service tech logs onto web portal
  • Checks last 24 hours system performance graph
  • **Observe anomaly** at about 3:30 AM
    ✓ Dramatic drop in Air Out temperature and increase in Water Out temperature (No heat exchange)
    ✓ Flow rate, pressure and current system state seem normal.
    ✓ System goes into second stage heat after time delay.
  • Needs additional detail of events leading up to failure
    - Checks system status dashboard
Status Just Prior to Failure

- EWT and LWT
- Air in and Air out
- Thermostat
- Flow rate
- System state
- Electrical Energy

All parameters prior to failure appear within acceptable tolerances *
Status Just After Failure

- Technician goes to status view from Time-Line graph. During review of parameters observes:
  - Dramatic drop in Air Out temp and rise in temp of LWT
  - Flow rate, pressure and current state seem normal.
  - Power consumption indicates compressor off line
  - **Thermostat** status indicates calling for heat stage 1
  - **System** status indicates stage 1 heating enabled*
Problem determination

• Analysis of time line and failure was indicative of unexpected Compressor lock out

• *Review of the captured monitoring system data leading up to the fault incident* + *Experienced Service Tech, indicates bad system sensor*

• Service technician brings a replacement to site

• Verifies sensor is defective using approved method

• Replaces defective sensor

• Follow up with monitoring that system is restored
Case Study 2

Normal monitoring of System Reveals System in Emergency Heat mode?
System in Emergency Heat Mode

Routine monitoring revealed system inadvertently set to E Heat instead of Heat

- Anomaly noticed during routine scan (E Heat mode sometime during day Oct 21, 2014)
- Hourly detail shows that first occurred at around 8:00 PM
System in Emergency Heat Mode
Performance Chart

No fault indication prior to switching to E Heat mode
Case Study 3
Expert’s Perspective

Lloyd Hamilton – Verdae LLC

Intermittent System Lockout
Low Pressure/Temperature
System – Intermittent Failure Customer Complaint – Manual Resetting

- Service tech was uncertain what was going on – **Intermittent lock out of compressor** – Several months and many trips attempting to diagnose problem.

- The System under observation is a Water Furnace Synergy 3-D 5 zone heating and cooling heat pump that is a 5 zone water-to-air and water-to-water Heat Pump

- The following snap shot illustrates performance of the system over a two-hour period.
System – Intermittent Failure
Analyzing the data

It was clear that temperature of the air out was dangerously close to freezing

Flow ≈ 15 GPM

Water Out = 63° F
Water In = 58° F
Air In = 67° F
Air Out = 34.8 ° F

Water Delta t ≈ 5°
Air Delta t ≈ 32.2° F
Navigating Complex System Behavior

Some systems exhibit behaviors impossible to analyze without viewing history.

Cooling
Fan Only
Heating

Flow Rate 15 GPM
Electrical 5.14 Kw 22.20 A
Case Study 4

Identifying Areas for System Design / Improvement
System – Short Cycling

- Historical Data provides knowledge that drives design optimization

Historical trending indicates sub-optimal positioning of thermostat with respect to air supply register
Beyond Geothermal

New Projects
Complementing Zero Net Energy Initiatives

Zero Energy housing development

“I take great comfort in knowing that my geothermal system is precisely monitored from end to end... I also know that I can take advantage of its energy consumption numbers to better understand how my zero-energy home is performing across the board, by comparing my total home consumption against the HVAC consumption numbers.”

David Shepler – Homeowner (Green Acres)
Real-time Monitoring
Installer Benefits

Reduce Costs / Increase Profitability

• Fix it first time – Fix it Quick
• Minimize unnecessary site visits
• Increase efficiency of Service Engineer
• Increase customer satisfaction (Customer Retention / Referral)
• Commissioning Systems quicker (Increase Profits)
Real-time Monitoring
Customer Benefits

• Reduced mean-time to restore service
• 24 x 7 365 days a year monitoring and alerting
• Lower Service Costs
• Avoid false service calls
• Reduced inconvenience to customer
• Increased confidence in service company
• Directly view and assess their system performance
Conclusion

Implications of remote monitoring residential systems on the future of the Service Industry

- First tool to reach for in the tool chest!
- Service providers offering 24 x 7 remote monitoring will be able to contain costs by
  - Fewer Site Visits
  - Reducing time to respond and restore service
  - Removing the guesswork
  - Eliminating call backs

The value of the Visualization of data cannot be overstated

Remote Monitoring is to Geothermal as OBD is to Auto Industry
Do we really want to go back to a blinking fault light indicator for first level diagnosing a system fault ??
Questions?

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