How Smart is your Refrigeration System?

Robert Zogg
Lead, Refrigeration Team
Agenda

- Introduction to Better Buildings and Refrigerated Display-Case Controllers: Benefits and Drawbacks
  - Bob Zogg, Navigant, BBA Technology Team Lead

- Manufacturer Perspective – Danfoss
  - Guest Speaker: Peter Dee, Danfoss

- Manufacturer Perspective – Emerson
  - Guest Speaker: John Wallace, Emerson Climate Technologies

- Discussion
Introduction to the Better Buildings Team and case controllers
Introduction: Current Focus of Refrigeration Team Activities

The Refrigeration Team is currently focused on case controllers and retrofit of open display cases.

- DOE’s 2015 analysis of High Impact Technologies (HIT) identifies two priorities for commercial refrigeration:
  - Retrofit of Open Display Cases
    - Currently have many valuable assets on our Webpage
    - Looking to document additional demonstrations/success stories
  - Refrigeration Controls
    - Focusing on case controllers
    - Looking to document additional demonstrations/success stories
    - Ongoing review of literature and documenting available data
    - Planning additional activities
  - See DOE webpage on High Impact Technology Catalyst:
DOE has revamped and moved the Refrigeration Team page—check it out!

- Reorganized content for faster access
- Updated content, including links to other sources
- See the Refrigeration Team page on the DOE Better Buildings Solution Center:
  http://betterbuildingssolutioncenter.energy.gov/alliance/technology-solution/refrigeration
Topics Covered in Today’s Session

- What are refrigerated display-case controllers?
- Types and levels of benefits possible
- History and market adoption
- What are some challenges and barriers to adoption?
- Example cost and performance data
- Retrofits – challenges and considerations
- Conclusions and next steps
What are Case Controllers?

- **Distributed control of display cases**
- **Includes an Electronic Expansion Valve ("EEV" or "EXV"),** which facilitates:
  - Improved superheat control
  - Floating head pressure
  - Floating suction

- **Enables point control of one or more of the following:**
  - Case lighting
  - Evaporator fans
  - Defrost (adaptive)
  - Anti-sweat heaters
## Estimated Energy Savings

<table>
<thead>
<tr>
<th>Control Type</th>
<th>Estimated Energy Savings*</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Floating Head-Pressure and Suction-Pressure</td>
<td>4 – 13%</td>
<td>Facilitated by EEV; benefits greater in colder climates</td>
</tr>
<tr>
<td>Anti-Sweat</td>
<td>7 – 11%</td>
<td></td>
</tr>
<tr>
<td>Adaptive Defrost (Low-Temp. Only)</td>
<td>7 – 9%</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>2 – 8%</td>
<td></td>
</tr>
<tr>
<td>Evaporator Fan</td>
<td>3 – 8%</td>
<td></td>
</tr>
<tr>
<td>Combined</td>
<td>15 – 30%</td>
<td>Savings are not additive</td>
</tr>
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</table>

* Compared to transparent-doored medium- and low-temperature cases that comply with current energy conservation standards.
Some Challenges and Barriers to Adoption

- Higher initial cost
  - Control equipment and EEVs add cost
  - But, there is savings in other costs (infrastructure, installation, commissioning, and start-up time)
- Few detailed/independent case studies or other publicly available test results that document benefits
- Economic attractiveness in retrofits varies

Source: [https://www.youtube.com/watch?v=Q-HREtwT6xA](https://www.youtube.com/watch?v=Q-HREtwT6xA)
Guest Speaker Presentation
Peter Dee
Danfoss
North America Sales & Services Director
Outline

- History of case controllers
  - When and where introduced
- Market penetration estimates
  - Europe
  - US
  - Other regions?
- Experiences with case controllers
  - Benefits and issues experienced with customers
  - How does one evaluate possible payback and ROI for retrofits?
- Most compelling types of applications
  - Which applications?
  - What makes them compelling?
Historically, supermarkets relied on a single central control device to monitor and manage multiple refrigerated units in a store.

The introduction of case controllers changed this approach, first in Europe and later — in the early 1990s — in the United States, as energy prices climbed and the food industry became better acquainted with the proven technology.
Historic Adoption of Case Controllers

Energy Cost and Case Controller Adoption
US and Europe

- IEA Median Elect. Cost
- US Median Elect. Cost
- IEA Adopt.
- US Adopt.

Relative Energy Costs

Percent Adaptation

Market Penetration Estimates

- Europe – Early adopters of case controls, with 90% of the market using case controls, and has benefited from **energy savings**, reduced **carbon emissions** and increased **food safety** and **quality**.

- US – Slow adopters of case controls; estimated 20% of the market using case controls; however, this is increasing as food retail end-users benefit from case controllers.
Market Penetration Estimates

- Case Control: 20%
- Other: 80%

- Case Control: 90%
- Other: 10%
Challenges of Case Controls (US)

- Application experience
  - Contractor
  - Designing Engineer

- Industry adoption of new technology

- First cost barriers
Advantages of Case Controls

- Stand-alone control function
- Seasonal TXV changes not required
- Reduced product loss
- Reduced installation costs
- Energy savings
- Reduced carbon emissions
- Gateway to CO$_2$
## Installation Cost EPR Control vs. Case Control

### 65,000ft² Store 280-HP Refrigeration System

<table>
<thead>
<tr>
<th></th>
<th>Conventional-Circuit with EPR Control</th>
<th>Case Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units</td>
<td>Cost/Unit</td>
</tr>
<tr>
<td>Labor-Hours</td>
<td>380</td>
<td>$125.00</td>
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<tr>
<td>Cable-Rough</td>
<td>500</td>
<td>$50.00</td>
</tr>
<tr>
<td>Cable-termination</td>
<td>80</td>
<td>$125.00</td>
</tr>
<tr>
<td>Hardware Install</td>
<td>40</td>
<td>$125.00</td>
</tr>
<tr>
<td>Power Wiring-Control</td>
<td>80</td>
<td>$125.00</td>
</tr>
<tr>
<td>Power Wiring-Anti-Sweat</td>
<td>80</td>
<td>$125.00</td>
</tr>
<tr>
<td>Power Wiring-Lighting</td>
<td>80</td>
<td>$125.00</td>
</tr>
<tr>
<td>Power Wiring-Defrost</td>
<td>80</td>
<td>$125.00</td>
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<tr>
<td><strong>Sub-Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials/Misc.</td>
<td>$0.00</td>
<td></td>
</tr>
<tr>
<td>Cable</td>
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<td>$0.50</td>
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<td>Hardware</td>
<td>500</td>
<td>$6.00</td>
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<td>Scissor Lifts</td>
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<tr>
<td>Power Wiring</td>
<td>10,000</td>
<td>$2.00</td>
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<tr>
<td><strong>Sub-Total</strong></td>
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**Estimated Savings = $21,800.00**
Retrofit Project

- No. of refrigerated cases/cold rooms:
  - 24 low temperature cases
  - 48 medium temperature cases
  - 9 cold rooms
- Removed existing controllers
- Installed new electronic expansion controllers
- Set up all controllers for energy savings
Retrofit Energy Results

**Project Tracking: Daily Data: Summary**

[06/01/2008 00:00 - 06/01/2009 00:00]

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**78,153 kwhrs Savings**

**Comments** | **kWh Reduction**
--- | ---
KWh savings in 5 months | 75,000
Estimated kWh savings in 1 month | 15,000
Estimated kWh savings annually | 180,000
January 2016 Commercial Average Price of Electricity (per kWh) | $0.098
Estimated Annual Electricity Expense Reduction | 17,640
The Case for Case Controllers

$10/day  Cost of energy of an average display case. (@ $0.098/kwh)

At least 7.5%  Energy saved with case controllers.

$18,000/yr.  Saved in an average store of 65 cases. ($50/day)

$900,000  Additional merchandise sales required annually to match the return.
Case Controls to be Successful.

Early collaboration with all stakeholders is critical to success.
Guest Speaker Presentation
John Wallace
Emerson Climate Technologies
Director, Innovation
Control Architectures

Centralized Control Architecture

- Control Elements At Refrigeration Rack Or Electrical Panel
- "Home Runs" For Sensors

Distributed Control Architecture

- Control Elements At Case
- Communication “Daisy Chain” To EMS
- Load Control At Refrigeration Case

Installation Costs Similar Across Architectures
Case Control Shifts Electronics From Electrical/Rack Rooms to Case

### Centralized Control

- **Electrical Room**
  - Elect. Panels
  - Lights
  - Antisweat
  - Sensors (2 per)

- **Refrigeration Room**
  - Rack House
  - Temp Solenoid
  - Fan
  - Defrost

<table>
<thead>
<tr>
<th></th>
<th>Rack</th>
<th>Case</th>
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<tbody>
<tr>
<td>Sensors</td>
<td>✓</td>
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</tr>
<tr>
<td>Input Boards</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Relay Boards</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Case Electronics</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>EEV</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Case Control

- **Electrical Room**
  - Elect. Panels
  - 120 VAC Feed

- **Refrigeration Room**
  - Rack House
  - Comm Loop

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<tr>
<td>EEV</td>
<td></td>
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</table>
## Flexibility in Case Control Functionality

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Temp Control Only</th>
<th>Superheat Control</th>
<th>ESR Control</th>
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<tbody>
<tr>
<td>Temp Control</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Defrost Control</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Load Control</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Superheat Control (EXV or EEV)</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Electronic Suction Regulator (ESR or EEPR)</td>
<td></td>
<td></td>
<td>✓</td>
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</tbody>
</table>

*Load Control Includes Lights, Fans, Antisweats*
Case Evaporator Control Types

Conventional/Mechanical

TXV and Thermostat

Case Control With TXV

Case Control With EEV

Case Control With ESR
Electronic Expansion Valves (EXV)

- An Electronic Expansion Valve (EXV) Solution Measures and Controls System Superheat Electronically

- EXV Solution Components
  - Controller
  - Temperature Sensor(s)
  - Pressure Transducer/Sensor

- Provides Improved System Performance
  - Efficiency
  - Wide Operating Range

- Can Be Used With Multiple Refrigerants

- Faster Pull-Downs, Faster Recovery
Case Control Architecture Reduces Field Wiring and Provides Electrical Savings

• **Reduce Line Voltage Wiring**
  – Reduce Branch Feeder Wiring by 30% or More
  – Reduce or Eliminate Circuit Panels and Breakers
  – Eliminate Line Voltage Control Home Runs to Rack
  – Simplified Power Connections at Case

• **Reduce Low Voltage Wiring**
  – Eliminate Low Voltage Control Home Runs to Rack
  – Simplified Low Voltage Control Connections at Case

• **Reduce Case Field Wiring**
  – OEM Factory Wiring of Control and Sensors
  – Facilitates Factory Checkout Versus Field Troubleshooting
Case Control Enables Loop Piping, Which Reduces Piping and Leak Rates

Temperature and Defrost Control Shifts From Rack to Case

Loop Piping Reduces Pipes, Fittings, Insulation, Hangers, Labor

Piping Savings up to 50%; Refrigerant Charge Reduction 10+%
Case Controls Facilitate Faster Startups

• Reduced Startup Time Enabled By
  – Fewer Joints Mean Quicker Leak Checks
  – Reduced Refrigerant Charge
  – Superheat Set/Checked Automatically; No Manual Adjustment Needed

• Utilize Data Generated to Shorten Commissioning Cycle
  – Graphing and Data Analysis Reducing Commissioning/Measurement Time
Data Provided Can Be Used To Reduce Maintenance Costs

- **Reduce Labor Costs**
  - Additional Sensors Enable Remote Diagnostics and Facilitate Faster and More Reliable Troubleshooting
  - Remote Setpoint Adjustment Can Eliminate Service Calls
  - No Seasonal Expansion Valve/EPR/Temperature Adjustments

- **Reduce Material Costs**
  - Lower Refrigerant Leak Rate

- **Use Technology to Supplement Technicians**
  - Reduced Technician Knowledge Base Can Be Offset By Remote Diagnostics
Driving Operational Efficiencies By Leveraging Data From Case Controllers

- Sensors Used For Control Can Also Be Utilized For Analytics To Drive Better Operational Decisions
- Additional Data Points Typically Include Evaporator Coil Temperature & Pressure
- Data Can Be Collected & Analyzed To Provide Deep Insight Into Operation
- Aggregated Data Provides Insight Across An Estate
- Supports Informed Decision Making Regarding Capital Outlay, Efficiency Projects, etc.

Trend Analysis From Additional Sensors Provides Actionable Insights
Consider Life Cycle Savings In Addition To First Costs When Evaluating Case Control

Case Control Drives Life Cycle Savings
Conclusions and Next Steps
Conclusions and Next Steps

- **Conclusions:**
  - Promising, proven technology
  - U.S. adoption has been relatively slow
  - Cost-effective in new installations, but economics can vary for retrofits

- **Next steps:**
  - We are seeking chains that are willing to share their experiences with case controllers
  - *Have you looked at this technology?*
  - *Do you have any experiences to share?*
Next Steps: Gathering More Refrigeration Efficiency Information

- Although we are focusing on control-related activities, we remain interested in *documenting and sharing information about a broader range of energy-saving opportunities*:
  - *Have you had recent success improving refrigeration efficiency?*
  - *Do you have any documentation (case studies, fact sheets, white papers, etc.) that you can share?*
  - *If not, would you be willing to work with us to document your success?*
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sultan Latif</td>
<td>Grocery &amp; Food Service Sector Lead</td>
<td>202-287-1829, <a href="mailto:Sultan.Latif@ee.doe.gov">Sultan.Latif@ee.doe.gov</a></td>
</tr>
<tr>
<td>Robert Zogg</td>
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<td>781-270-8363, <a href="mailto:Robert.Zogg@Navigant.com">Robert.Zogg@Navigant.com</a></td>
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<tr>
<td>Andrew Mitchell</td>
<td>DOE Technology Teams Coordinator</td>
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