



How Smart is your Refrigeration System?

Robert Zogg

Lead,
Refrigeration
Team

Agenda

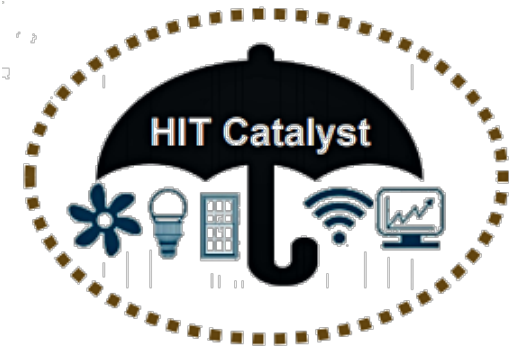
- **Introduction to Better Buildings and Refrigerated Display-Case Controllers: Benefits and Drawbacks**
 - *Bob Zogg, Navigant, BBA Technology Team Lead*
- **Manufacturer Perspective – Danfoss**
 - *Guest Speaker: Peter Dee, Danfoss*
- **Manufacturer Perspective – Emerson**
 - *Guest Speaker: John Wallace, 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:
 - <http://energy.gov/eere/buildings/high-impact-technology-catalyst>



Introduction: Refrigeration Team Resources

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://betterbuildingsolutioncenter.energy.gov/alliance/technology-solution/refrigeration>

The screenshot displays the DOE Better Buildings Solution Center website. The header includes the Better Buildings logo, social media icons, and a search bar. The navigation menu features links for Alliance Home, Sectors, Take Action, Partners, Resources, Newsroom, Get Involved, and Join. The main content area is titled "Technology Solution: Refrigeration" and includes a large image of a supermarket interior. A text box explains that commercial refrigeration uses roughly 1.3 quads per year of source energy, representing about 7% of total commercial building use in the U.S. Below this, there are three columns: "Take Action" (participate in expert-led technology teams), "Events Calendar" (browse upcoming events), and "Partner List" (over 200 public and private sector organizations). At the bottom, there are two related resources: "Refrigeration Commissioning Guide for Commercial and Industrial Systems" and "Guide for Retrofitting of Open Refrigerated Display Cases with Doors".

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

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

* 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



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?



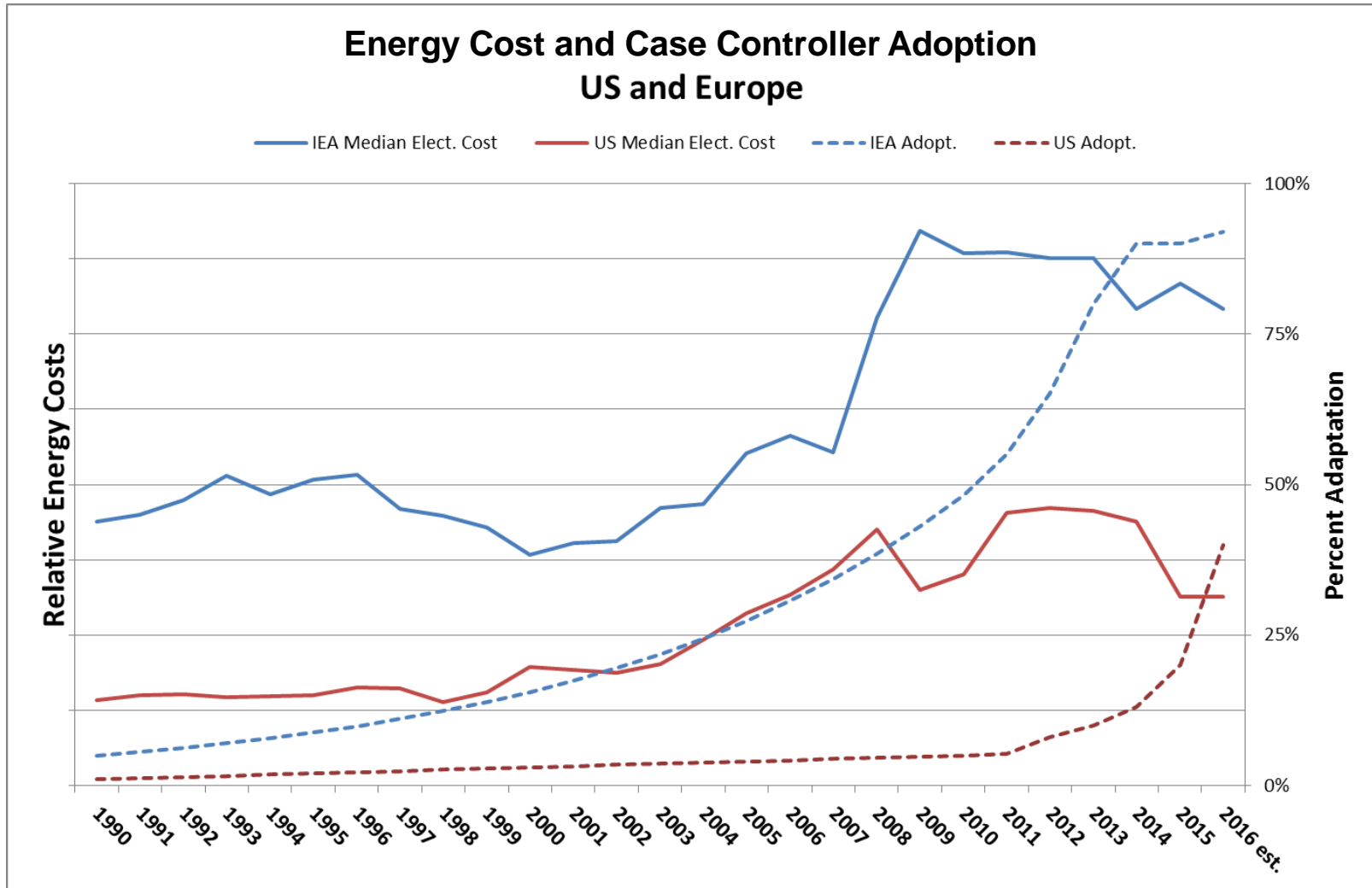
Case Controls

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**.



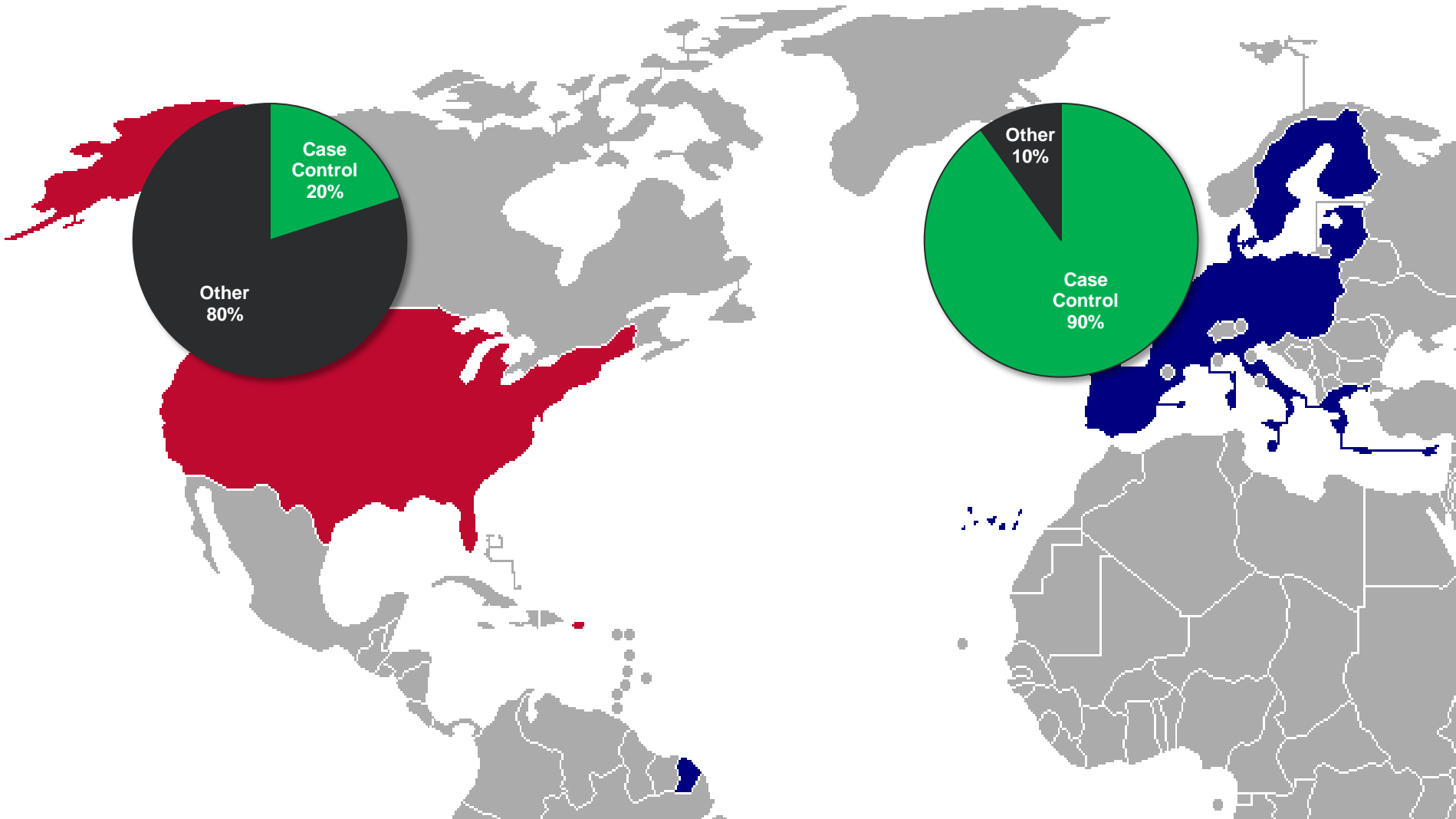
Historic Adoption of Case Controllers



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



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 CO₂

Installation Cost EPR Control vs. Case Control

65,000ft² Store 280-HP Refrigeration System

Case Controller vs Conventional Control Comparison

65,000 square ft, 280 HP Refrigeration Systems

Conventional-Circuit with EPR Control				Case Controller			
	Units	Cost/Unit	Extend		Units	Cost/Unit	Extend
Labor-Hours				Labor-Hours			
Cable-Rough	380	\$ 125.00	\$47,500.00	Cable-Rough	150	\$ 125.00	\$18,750.00
Cable-termination	500	\$ 50.00	\$25,000.00	Cable-termination	150	\$ 50.00	\$7,500.00
Hardware Install	80	\$ 125.00	\$10,000.00	Hardware Install	30	\$ 125.00	\$3,750.00
Power Wiring-Control	40	\$ 125.00	\$5,000.00	Power Wiring-Control	40	\$ 125.00	\$5,000.00
Power Wiring-Anti-Sweat	80	\$ 125.00	\$10,000.00	Power Wiring-Antisweat	40	\$ 125.00	\$5,000.00
Power Wiring-Lighting	80	\$ 125.00	\$10,000.00	Power Wiring-Lighting	40	\$ 125.00	\$5,000.00
Power Wiring-Defrost	80	\$ 125.00	\$10,000.00	Power Wiring-Defrost	80	\$ 125.00	\$10,000.00
Sub-Total			\$117,500.00	Sub-Total			\$55,000.00
Materials/Misc.			\$0.00	Materials/Misc.			\$0.00
Cable	40,000	\$ 0.50	\$20,000.00	Cable	10,000	\$ 0.50	\$5,000.00
Hardware	500	\$ 6.00	\$3,000.00	Hardware	200	\$ 6.00	\$1,200.00
Scissor Lifts	4	\$ 500.00	\$2,000.00	Scissor Lifts	2	\$ 500.00	\$1,000.00
Power Wiring	10,000	\$ 2.00	\$20,000.00	Power Wiring	8,000	\$ 2.00	\$16,000.00
Sub-Total			\$45,000.00	Sub-Total			\$23,200.00

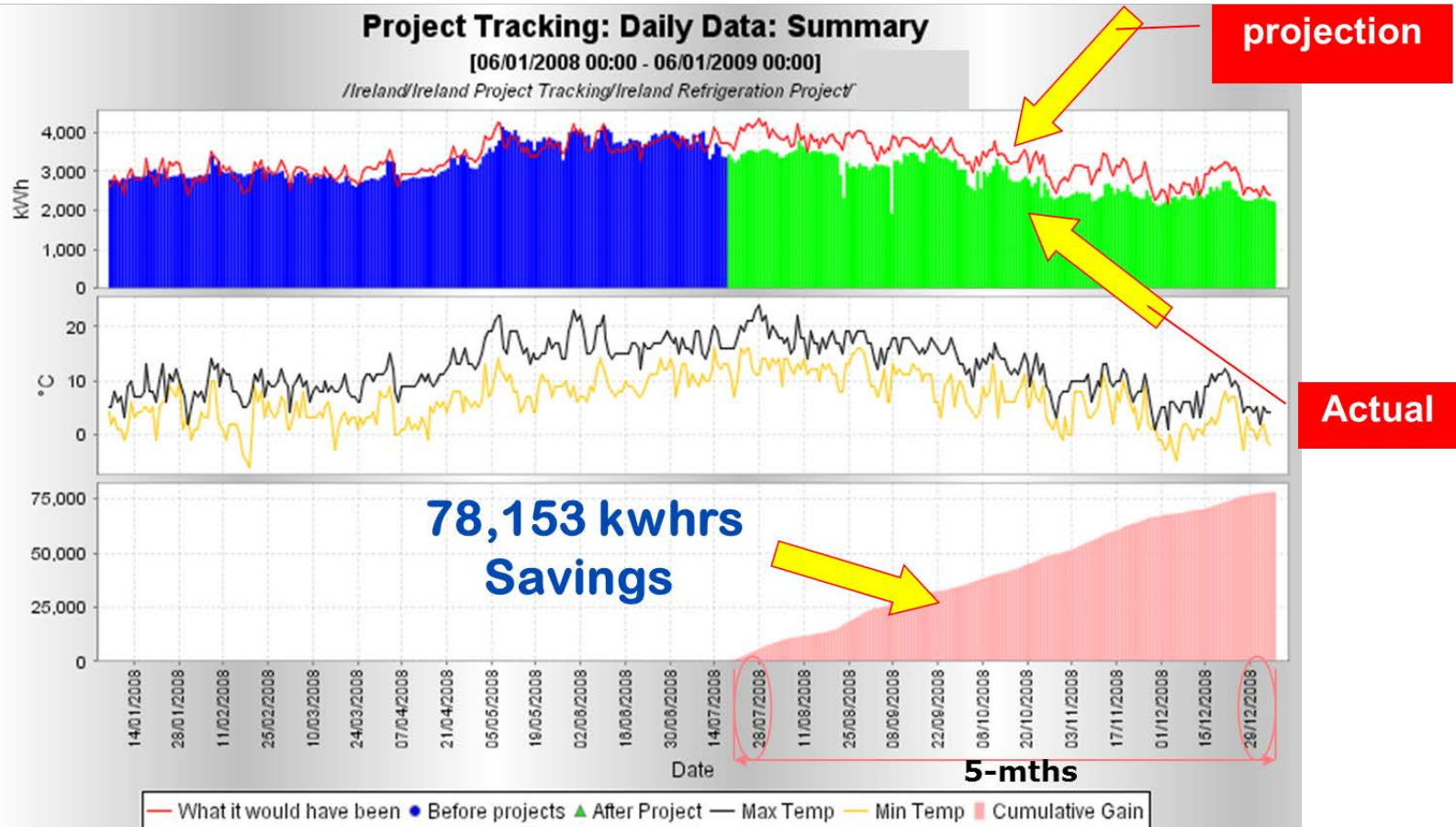
Estimated Savings = \$21,800.00

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



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.

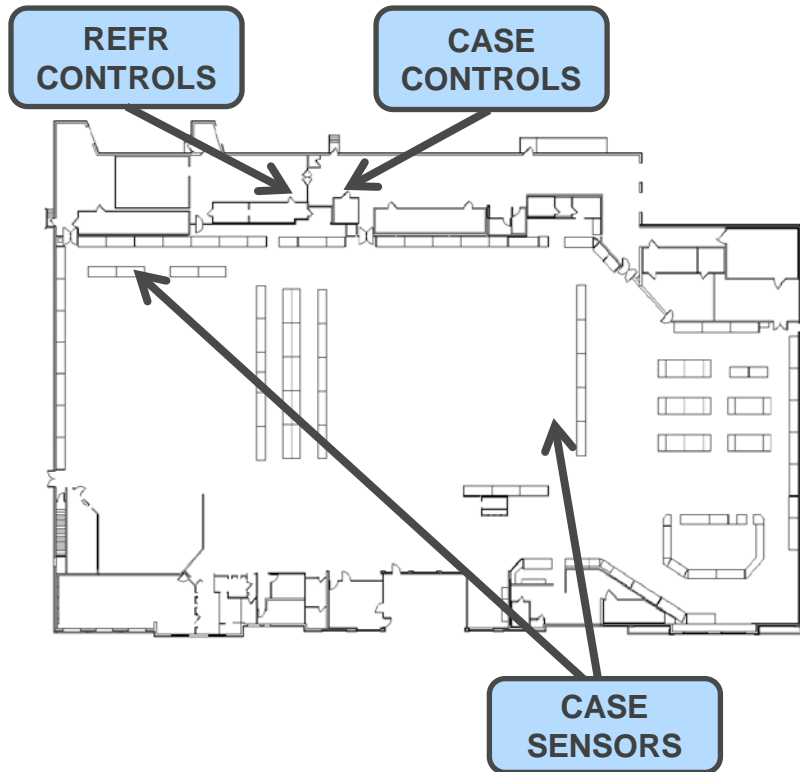
Early **collaboration** with all stakeholders is critical to success.



Guest Speaker Presentation
John Wallace
Emerson Climate Technologies
Director, Innovation

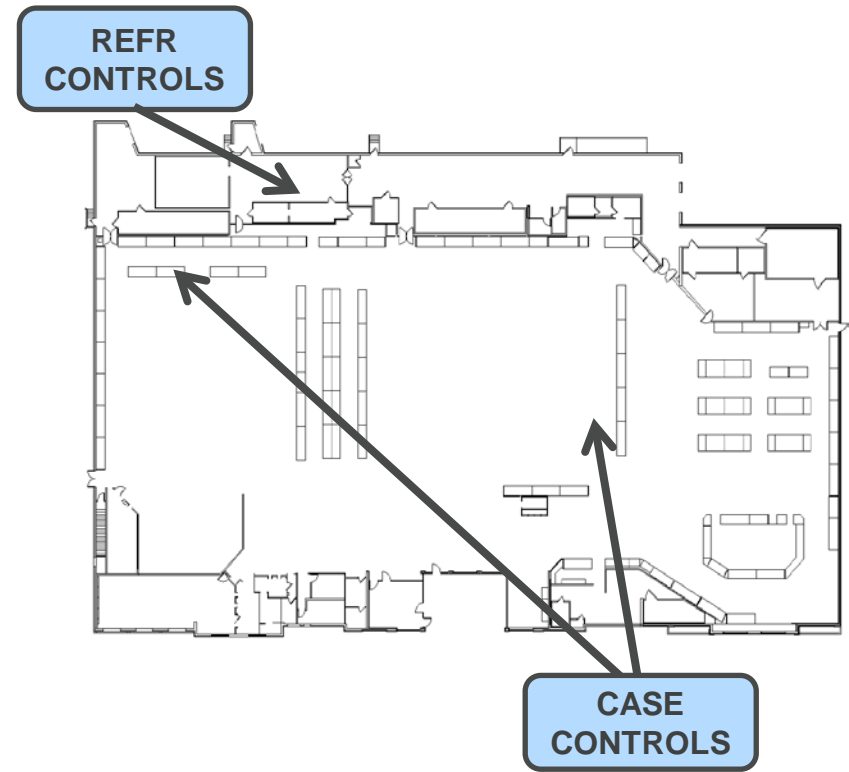
Control Architectures

Centralized Control Architecture



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

Distributed Control Architecture



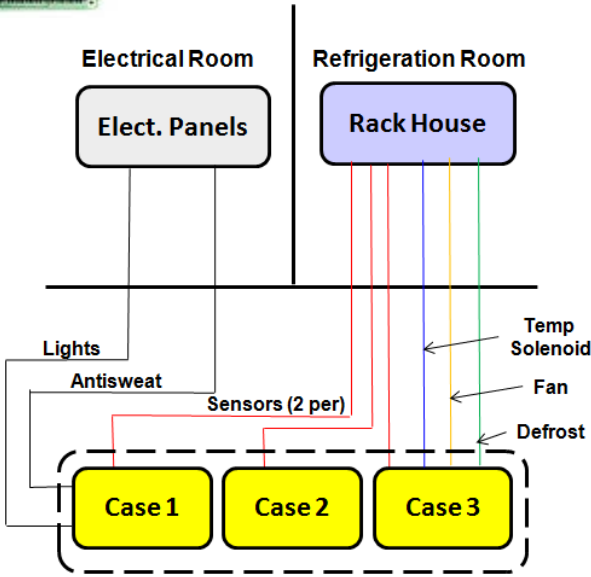
- Control Elements At Case
- Communication “Daisy Chain” To EMS
- Load Control At Refrigeration Case

Installation Costs Similar Across Architectures

Case Control Shifts Electronics From Electrical/Rack Rooms to Case



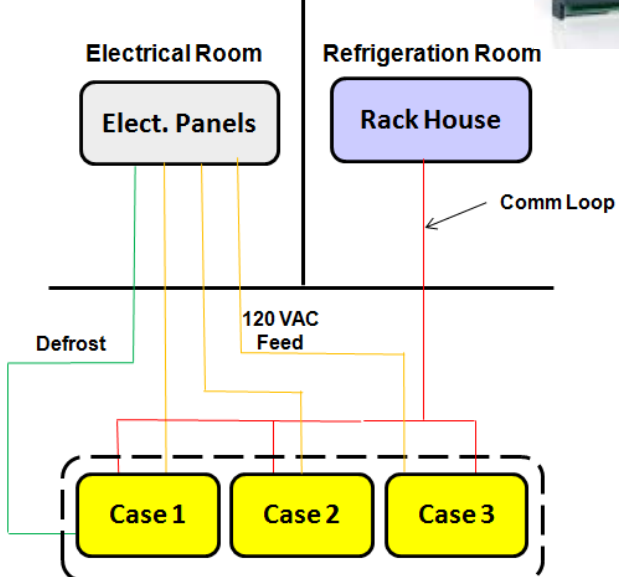
Centralized Control



	Rack	Case
Sensors		✓
Input Boards	✓	
Relay Boards	✓	
Case Electronics	N/A	N/A
EEV	N/A	N/A



Case Control



	Rack	Case
Sensors		✓
Input Boards	N/A	N/A
Relay Boards	N/A	N/A
Case Electronics		✓
EEV		✓



Flexibility in Case Control Functionality

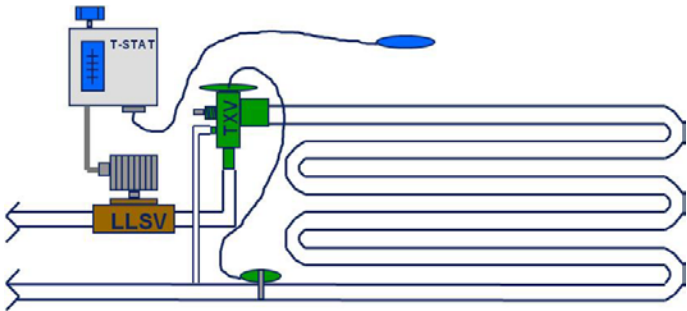
Functionality	Temp Control Only	Superheat Control	ESR Control
Temp Control	✓	✓	✓
Defrost Control	✓	✓	✓
Load Control	✓	✓	✓
Superheat Control (EXV or EEV)		✓	
Electronic Suction Regulator (ESR or EEPR)			✓

Load Control Includes Lights, Fans, Antisweats



Case Evaporator Control Types

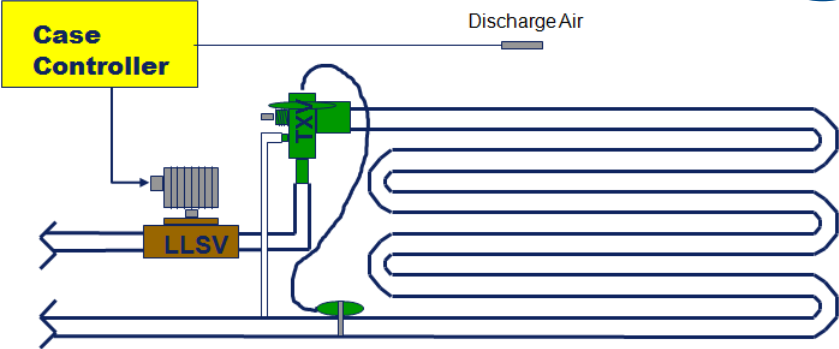
Conventional/Mechanical



TXV and Thermostat

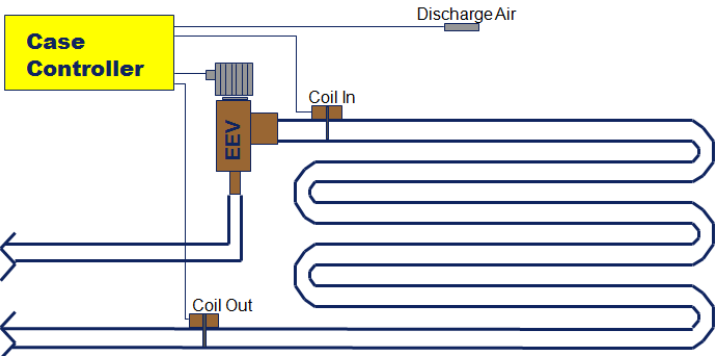
Case Control With TXV

A



Case Control With EEV

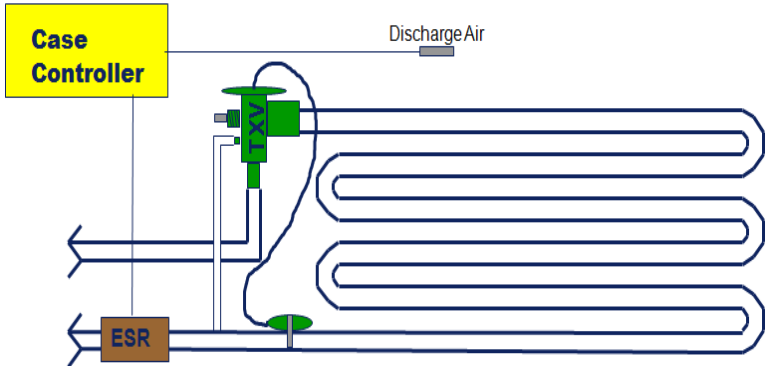
B



Pressure Transducer Can Also Be Used

Case Control With ESR

C



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

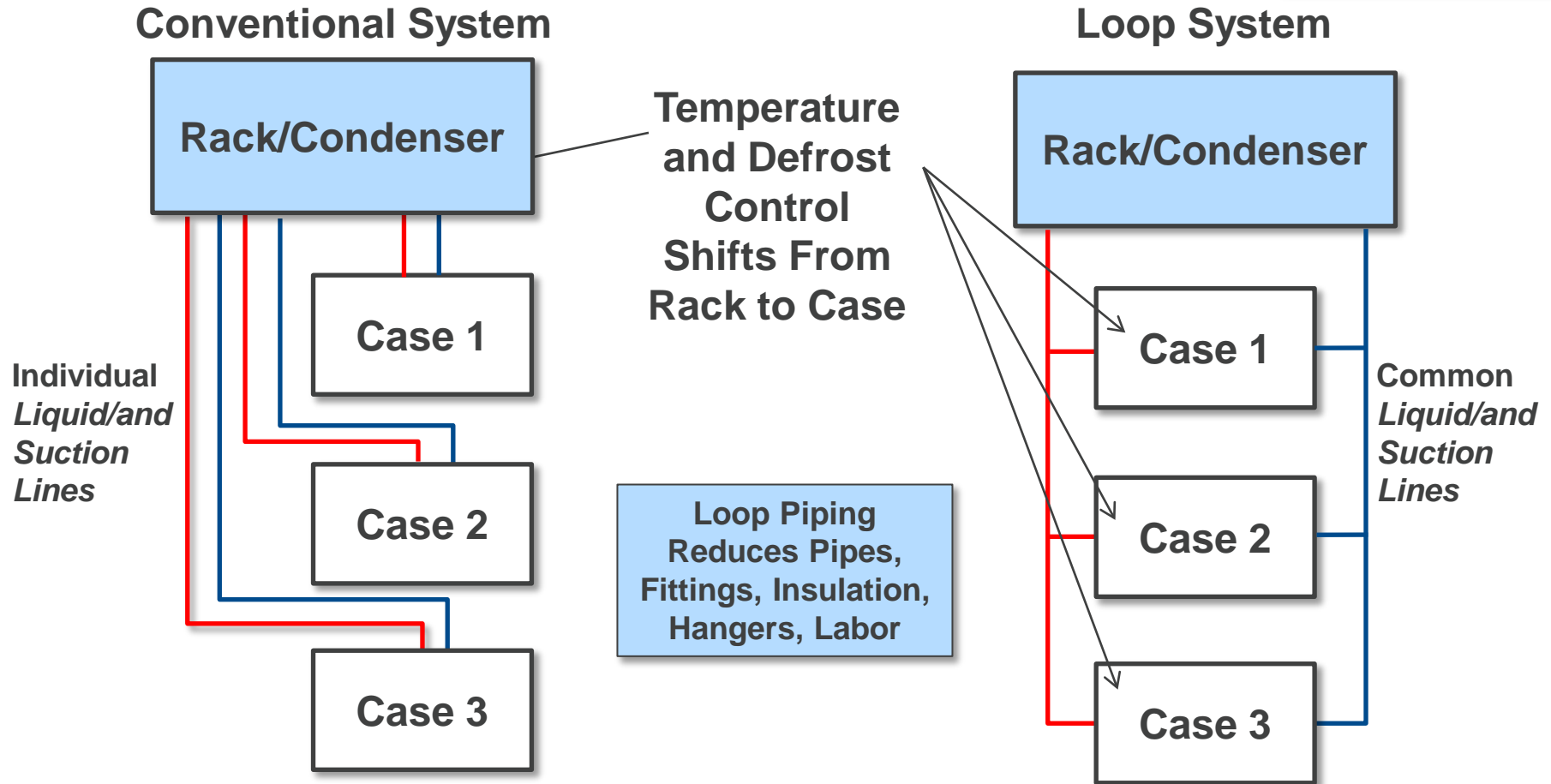
- **Reduce Low Voltage Wiring**

- 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

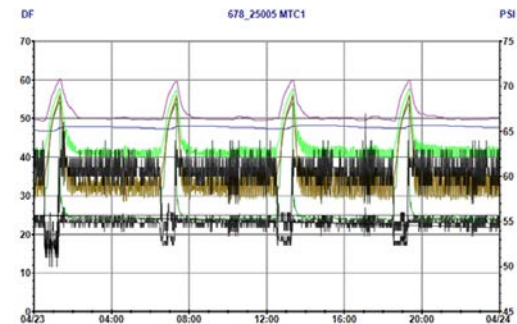
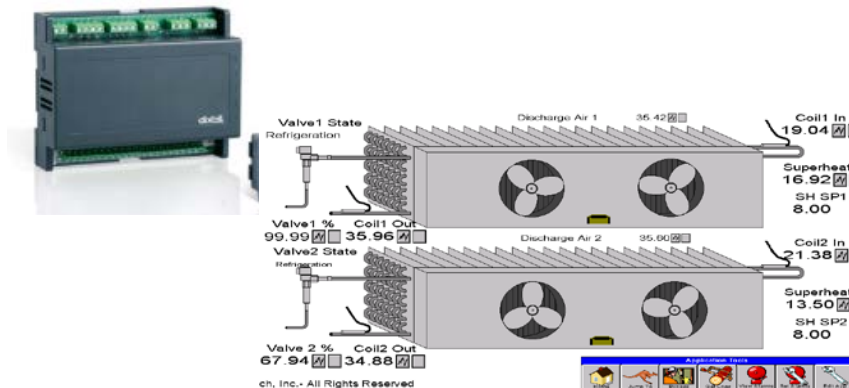
Case Control Enables Loop Piping, Which Reduces Piping and Leak Rates



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



Reduced Commissioning and Startup Time Results in Faster Store Openings

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

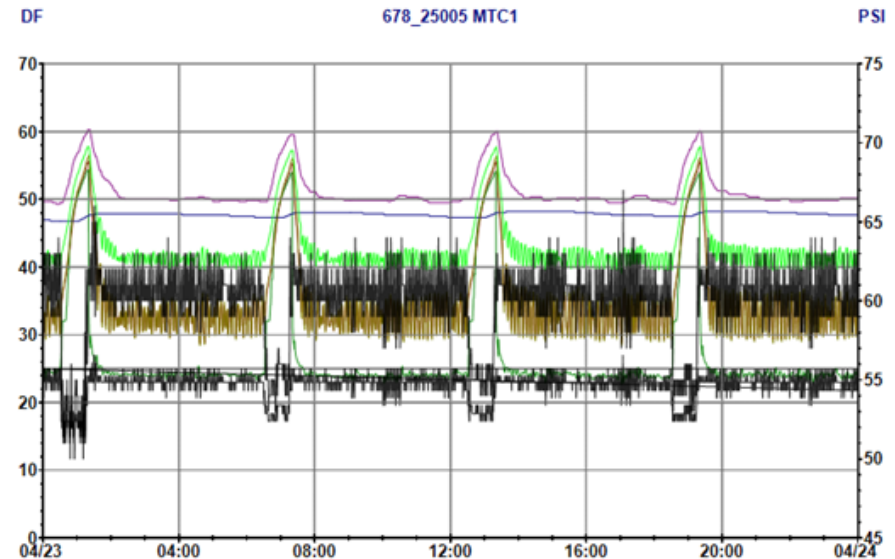
- **Use Technology to Supplement Technicians**

- Reduced Technician Knowledge Base Can Be Offset By Remote Diagnostics



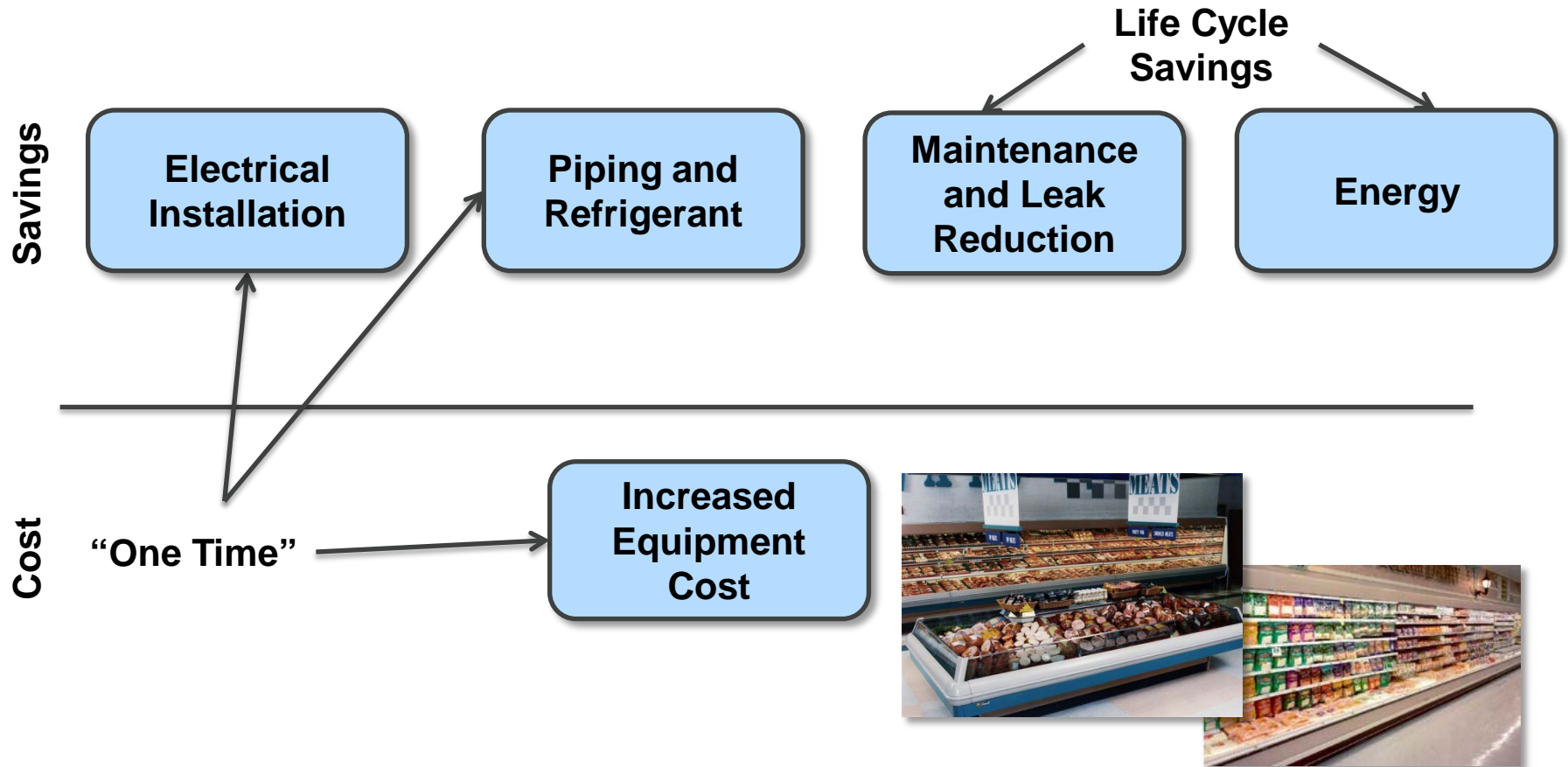
Driving Operational Efficiencies By Leveraging Data From Case Controllers

- 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?*

Thank You

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