Maximizing Supermarket Refrigeration System Energy Efficiency—Day 1

Moderator: Bob Zogg, Navigant Consulting, Inc.

Agenda

- Introductions/Session Overview (5 minutes)
- Speaker Presentation: *Lessons Learned on Commissioning* (30 minutes)
- Speaker Presentation: *The Future of Supermarket Refrigeration* (30 minutes)
- Status and Plans for Ongoing Team Activities (10 minutes)
- Break (15 minutes)
- Status and Plans for Ongoing Team Activities (Continued) (10 minutes)
- Discuss Possible New Team Activities (20 minutes)
- Set Team Goals (20 minutes)
- Measure Success (20 minutes)
- Wrap Up Day 1 (5 minutes)

Session Overview

This session will produce revised and expanded plans for Refrigeration Team activities that we will review on Day 2.

- Status update and speaker presentations will help inform planning
- Review status of ongoing activities and discuss plans
- Discuss and plan:
  - Discuss new Team activities
  - Set Team goals
  - How to measure success
- Tomorrow (Day 2), we will review/refine plans

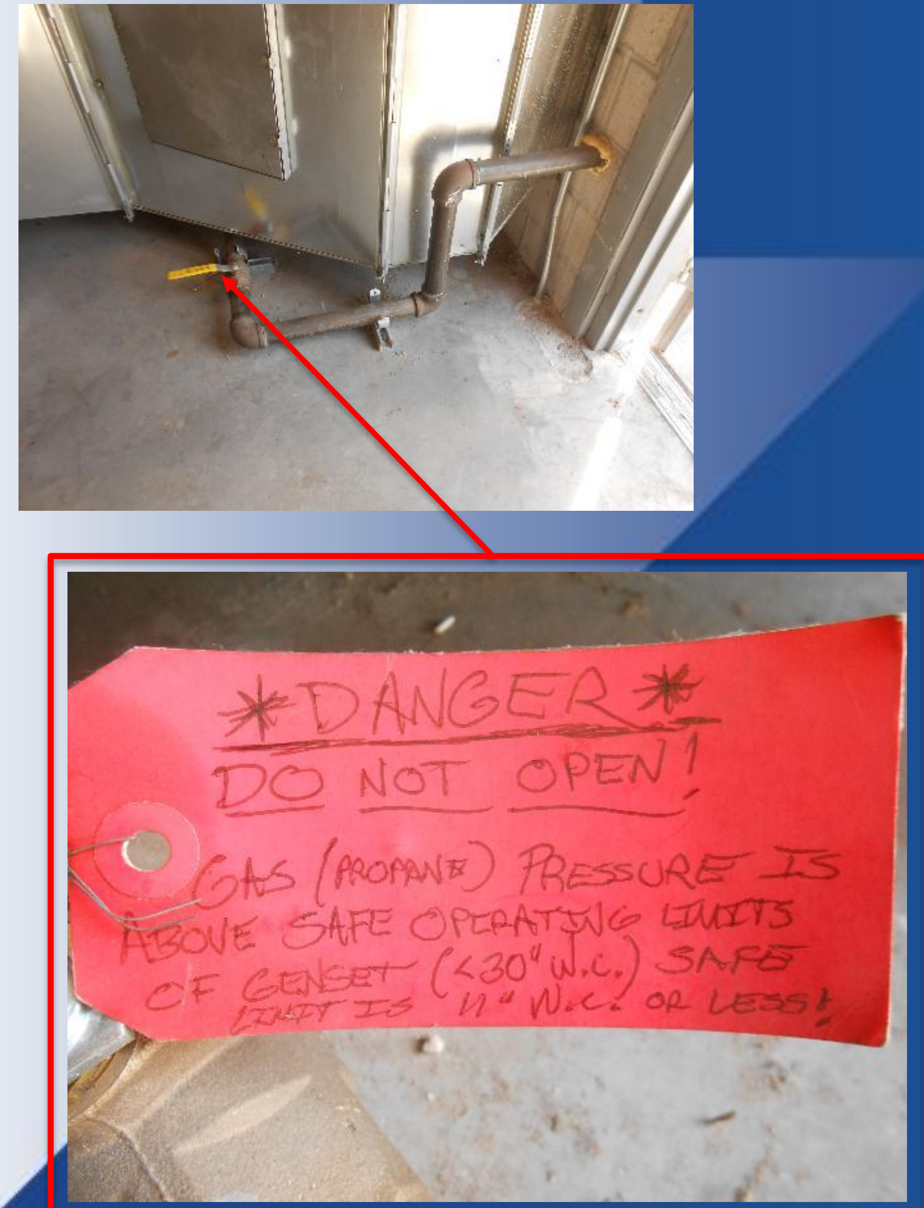
Speaker Presentation—*Lessons Learned on Commissioning*

Presentations by guest speakers will help inform our planning process.

- Presenter: Tom Wolgamot, Principal Engineer/Branch Manager, DC Engineering
- *Lessons Learned on Commissioning*

Lessons Learned on Commissioning

Tom Wolgamot, PE LEED AP BD+C



After one year of operation, still no secondary regulator installed. Unable to utilize additional fuel source to operate generator.

Agenda

- Commissioning Overview
- Commissioning – The WRONG Way
- Value of Commissioning
- Top 10 Supermarket Refrigeration System Deficiencies Found During Commissioning
- Hurdles / Barriers
- Main Take-aways & Suggestions
- Future Opportunities

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Commissioning Overview

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Commissioning Overview

Commissioning (Cx)

Collaborate and engage with the team to bring divergent parties together to have an optimally operating system based upon the Owner's Project Requirements (OPR) and the Contract Documents. The commissioning agent independently establishes and then completes functional performance testing to verify and document operational, energy, & maintenance aspects of system performance for today and into the future.

Commissioning Overview

The commissioning process can be tailored to meet the owner's and/or project specific requirements

- Commissioning (Cx)
  - A process for ensuring that a new facility or system is designed and operated as intended
    - Engage CxA early in the design process
    - Define expectations and hold kick-off meeting
- Retro-commissioning (RCx)
  - The process of ensuring that all the mechanical systems in an existing building perform optimally, based on the contract documents, design intent, and the owner's operational needs
    - Ability to structure work within facilities budgets to maximize initial allowed costs and provide additional facilities revenue as equipment ages
      - Less money on wasted energy and more money on the bottom line
- Fundamental / Enhanced Commissioning
  - Simple review to complex investigation
    - Energy Audits / Assessments

Commissioning Overview

What Type of Commissioning Should I Choose?

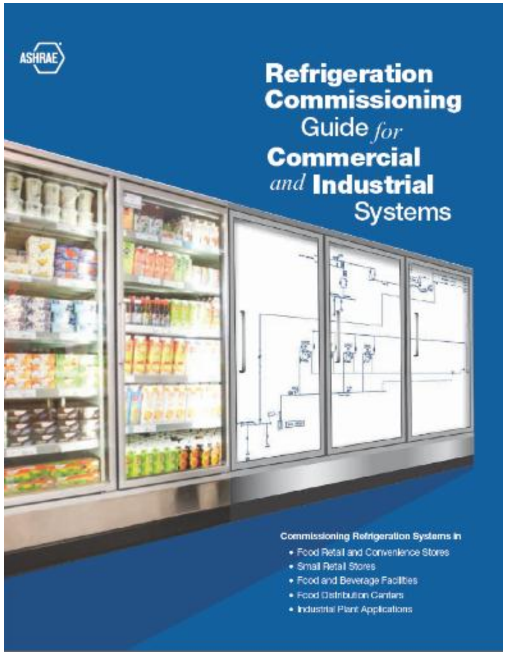
My Building is…	Consider…
…new or going to be undergoing major renovation.	**Commissioning (Cx)** – ideal for new construction or major renovation, and best implemented through all phases of the construction project.
…old and expensive to operate and experiencing a lot of equipment failures.	**Retro-commissioning (RCx)** – ideal for older facilities that have never been through a commissioning process.
…relatively new and was commissioned during the construction, but energy has been increasing.	**Re-commissioning** – ideal to "tune-up" buildings that have already been commissioned, bring them back to their original design intent and operational efficiency.
…large and complex, has a metering system and a preventative maintenance program, but still has high energy use and tenant complaints.	**Ongoing Commissioning** – ideal for facilities with building automation system (BAS), advanced metering systems, and well-run O&M organizations.

Source: https://www1.eer.energy.gov

Commissioning Overview

ASHRAE Refrigeration Commissioning Guide for Commercial and Industrial Systems

Provides guidance to owners and managers of commercial and industrial facilities that use refrigeration systems to help ensure that project requirements are met and owners' expectations are achieved



Commissioning - The WRONG Way

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Commissioning - The WRONG Way

Source: www.animalplanet.com

Do NOT review and establish CxA qualifications

Do NOT engage the CxA EARLY in the process

Do NOT develop and communicate the Owner's Project Requirements (OPR)

Do NOT account for commissioning activities in the project schedule

Do NOT provide the CxA with any authority (retainage)

Do NOT account for additional costs that could be incurred through RCx

Value of Commissioning

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Value of Commissioning

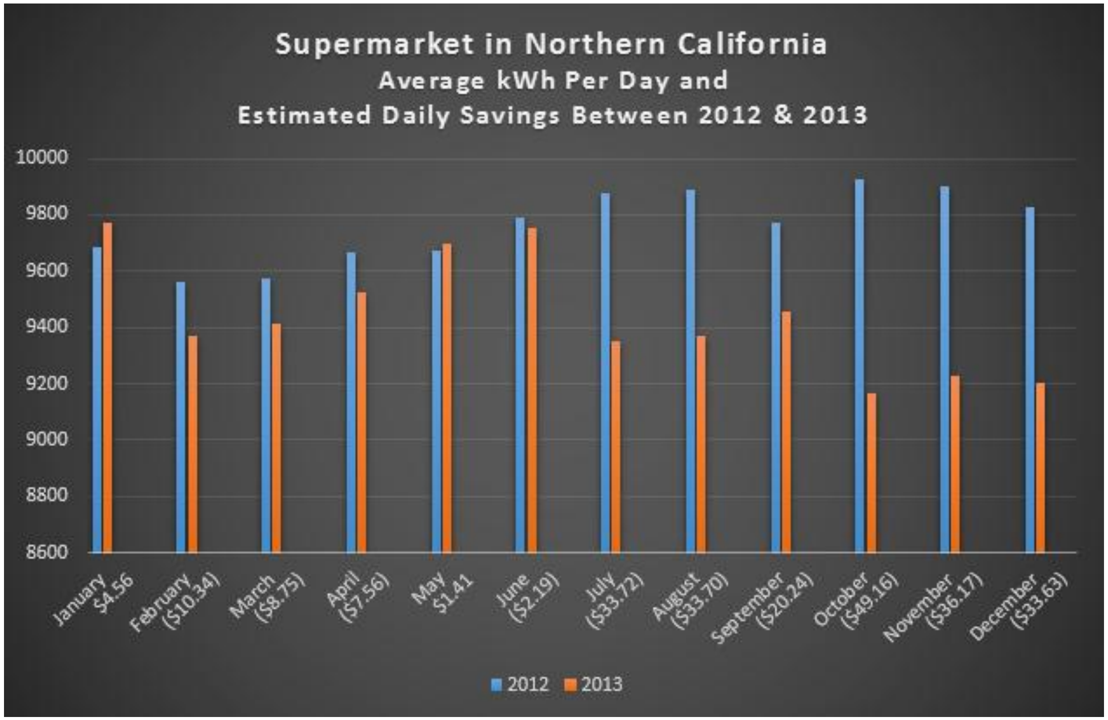
Lower Energy Costs

The *ASHRAE Refrigeration Commissioning Guide for Commercial and Industrial Systems* notes that 60% energy use in supermarkets can be attributed to refrigeration, and commissioning has the potential to result in energy savings of 7% to 25%

- Specific costs and values can be assessed prior to implementations through:
  - ✓ Review of utility bills
  - ✓ On-site audit
  - ✓ Energy modeling

Value of Commissioning

Lower Energy Costs



Estimated Average Annual Energy Savings: $12,566.95
Additional savings in Maintenance and Refrigerant

May 2013 – Onsite Review of Contractor Performance

- Overall, extremely poor performance and very high maintenance bills
- Systems undercharged / refrigerant leaks
- Cases needing to be defrosted
- Multiple compressor failures
- Scale building on evaporative condenser

July 2013 – Preventative Maintenance

- Proper operating charge
- Set point adjustments, including superheat

August 2013 – RCx

- Refrigerant leaks
- Open temperature probes
- Drain connections inside cases leaking water
- Outside Air Make-Up Unit not operational
- IRLDS not fully functional and setpoints incorrect
- Water running down cases due to saturated insulation on suction lines
- Cases overloaded
- Broken discharge valves on compressor valve plate

October 2013

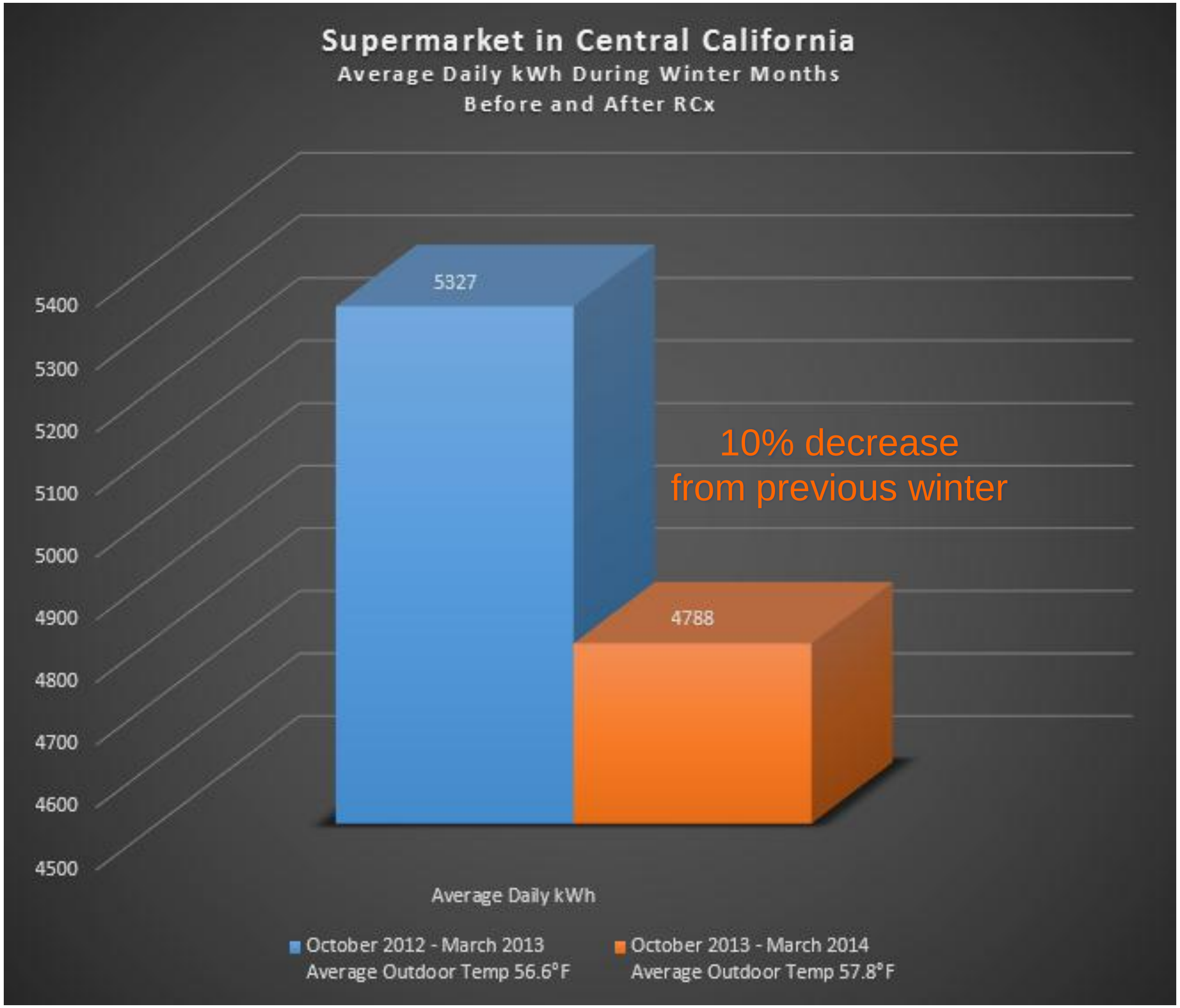
- New refrigeration servicing contractor
- Store replaced produce and service seafood cases

Value of Commissioning
Lower Energy Costs

May 2013 – RCx

- Modified heat pump loop heating injection pump sequence in controller
- Reset subcooler evaporator EPR valves
- Revised programming for condenser water setpoint so it would float with outdoor air ambient temperatures instead of being a fixed setpoint
- Re-balanced hydronic loop flows
- To achieve better staging performance the VFD for Rack C was moved from the largest compressor to the middle compressor

Estimated Average Daily Energy Savings During Winter Months: $64.68



Value of Commissioning

Lower Maintenance Costs

- Improves system performance
- Increases equipment life
- Minimized liabilities from refrigeration system leaks
- Reduces the frequency of repairs
  - ✓ Reduces amount of service calls

    New supermarket in pacific northwest
    - Approximately 42 alarms per day prior to Cx
    - Reduced to approximately 2 alarms per week after Cx

Walk-in Freezer not defrosting properly; frost buildup on ceiling

Value of Commissioning

Ensure Quality of Perishable Foods

- Properly trained operators and maintenance personnel
- Properly installed systems and controls
- Reliable system operation

Cases overloaded by store personnel

Value of Commissioning

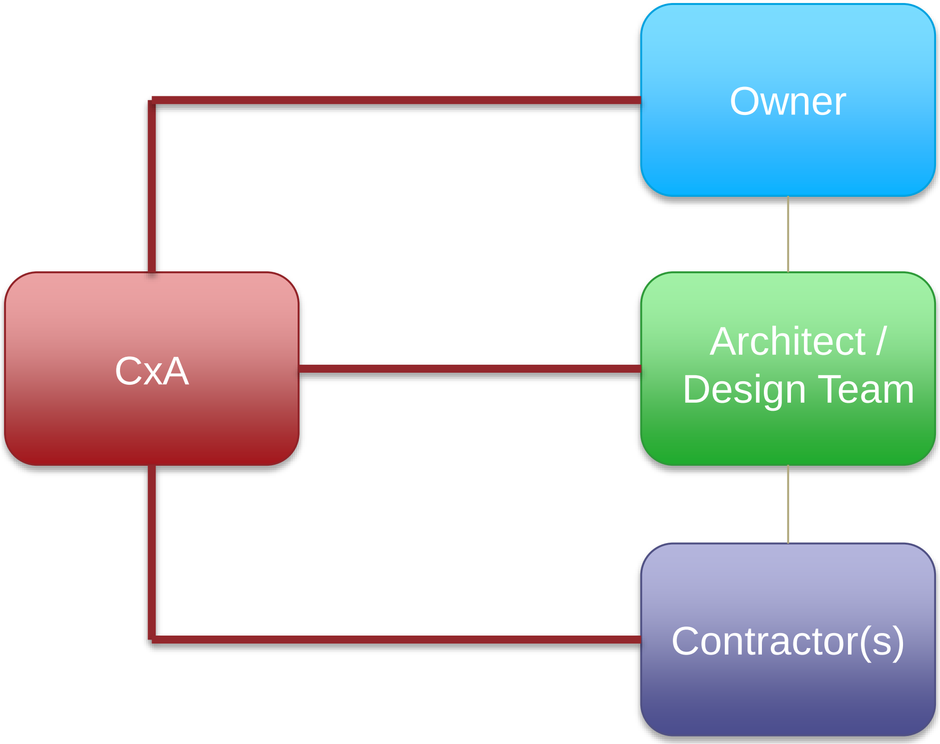
Peace of Mind

Managers are able to focus on the business of providing customer services, grocery and employee management rather than equipment failures and “nuisance” alarms

Value of Commissioning

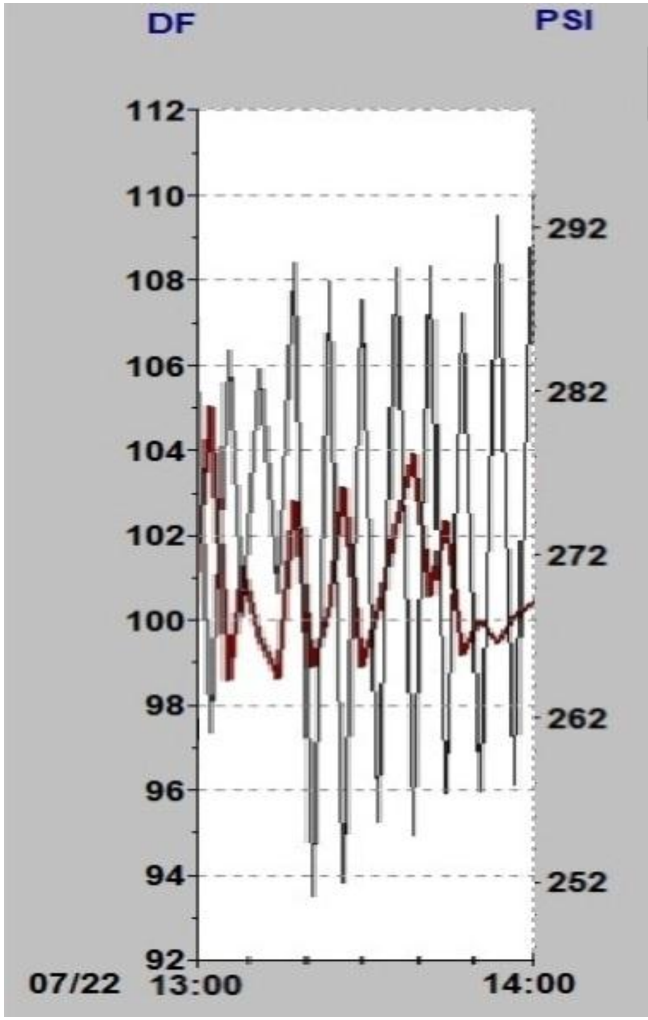
Ensure Performance Criteria is Met

Partnership with a qualified CxA will provide an independent advocate to the store, to ensure that the performance criteria is met



Value of Commissioning

Various Deficiencies Found During Supermarket Commissioning



Fluctuating ambient air temperature reading causing condensing pressure to fluctuate

Improperly mounted ambient air temperature sensor

Supermarket in Southern Idaho

Grand Opening – Early April
Commissioning – Late February
Outdoor ambient temps 20-30F

Seasonal Summer Check

- Head pressure on rack running high
- Only one or two fans running

Deficiency

- Ambient air temperature sensor mounted improperly
  - Supplying inaccurate readings

Result

- Increased compressor cycling
- Increased fan cycling
- Increased energy use
- Potential for future refrigerant leaks in condenser

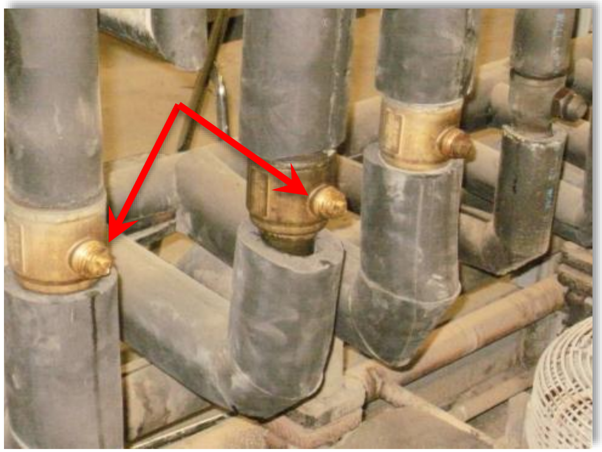
Corrective Action

- Ambient air temperature sensor relocated

Value of Commissioning

Various Deficiencies Found During Supermarket Commissioning

Coordination error between trades



Service caps missing

Glycol feeder is empty and valved-off

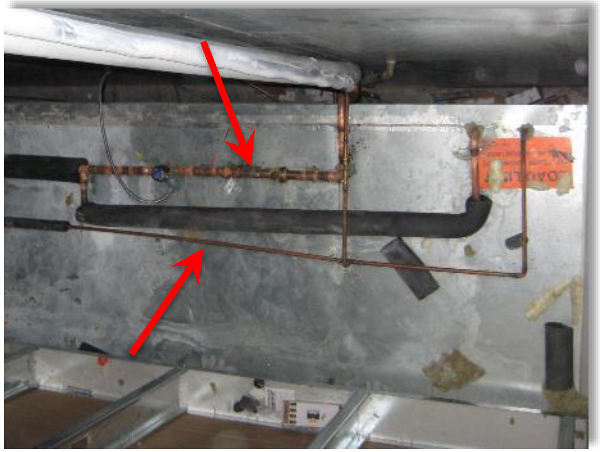
Water from drinking fountain running onto floor

Value of Commissioning

Various Deficiencies Found During Supermarket Commissioning

Thrown drive belt and worn bearing

Improperly supported refrigeration piping



Incomplete insulation of refrigeration piping

Interior of refrigerant leak detection alarm box
NOTE: No control conductors

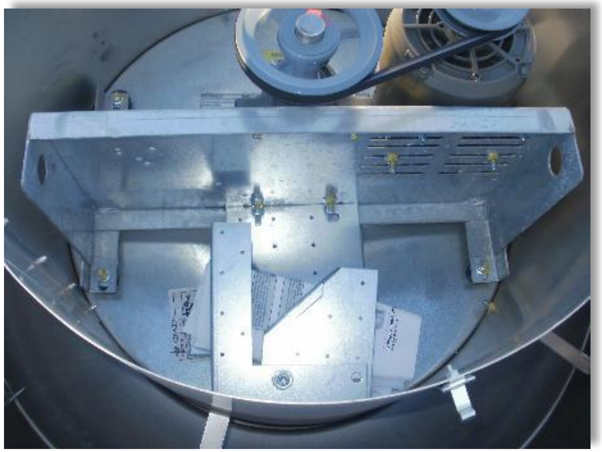
Value of Commissioning

Various Deficiencies Found During Supermarket Commissioning

Filters plugged and pulled into AHU

Outdoor weather station mounted in direct sunlight

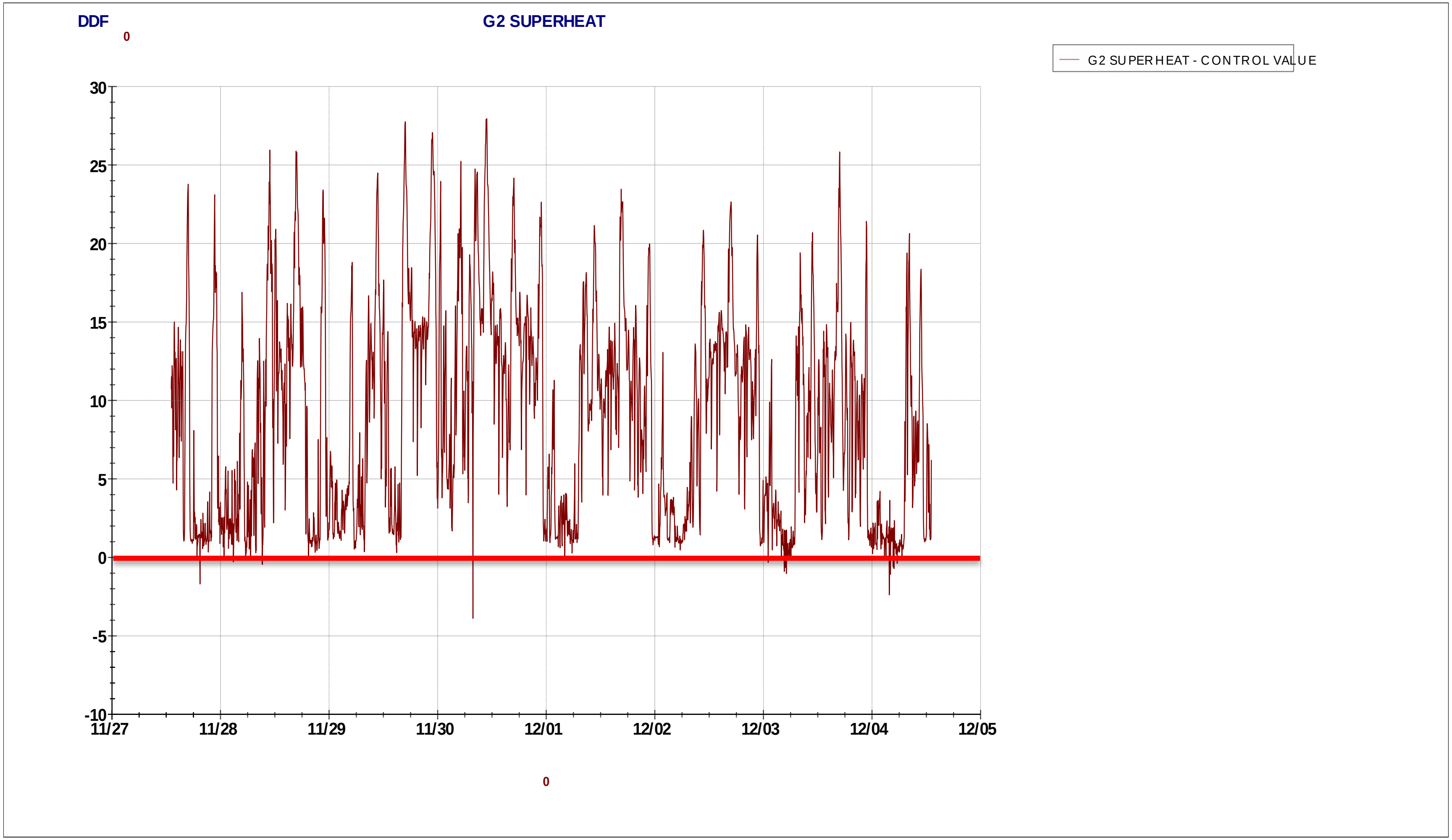
Belt out of alignment



Exhaust fan with hinged base – exhaust fan screwed down, hinged base still inside

Value of Commissioning

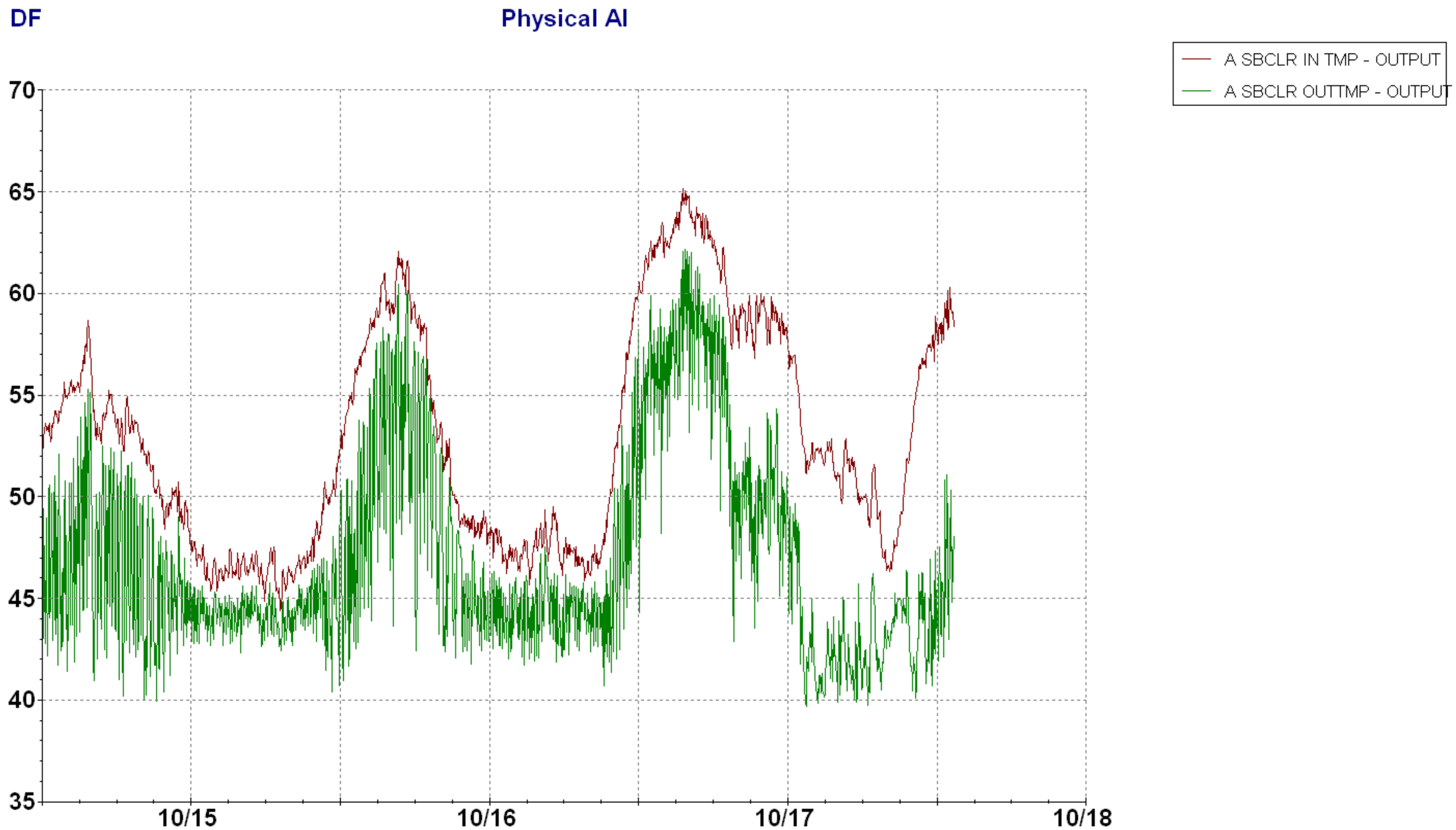
Various Deficiencies Found During Supermarket Commissioning



Rack has between 0°F and 20°F superheat at the suction header, and will run for hours at a time below 5°F superheat
This will eventually cause compressor damage or failure

Value of Commissioning

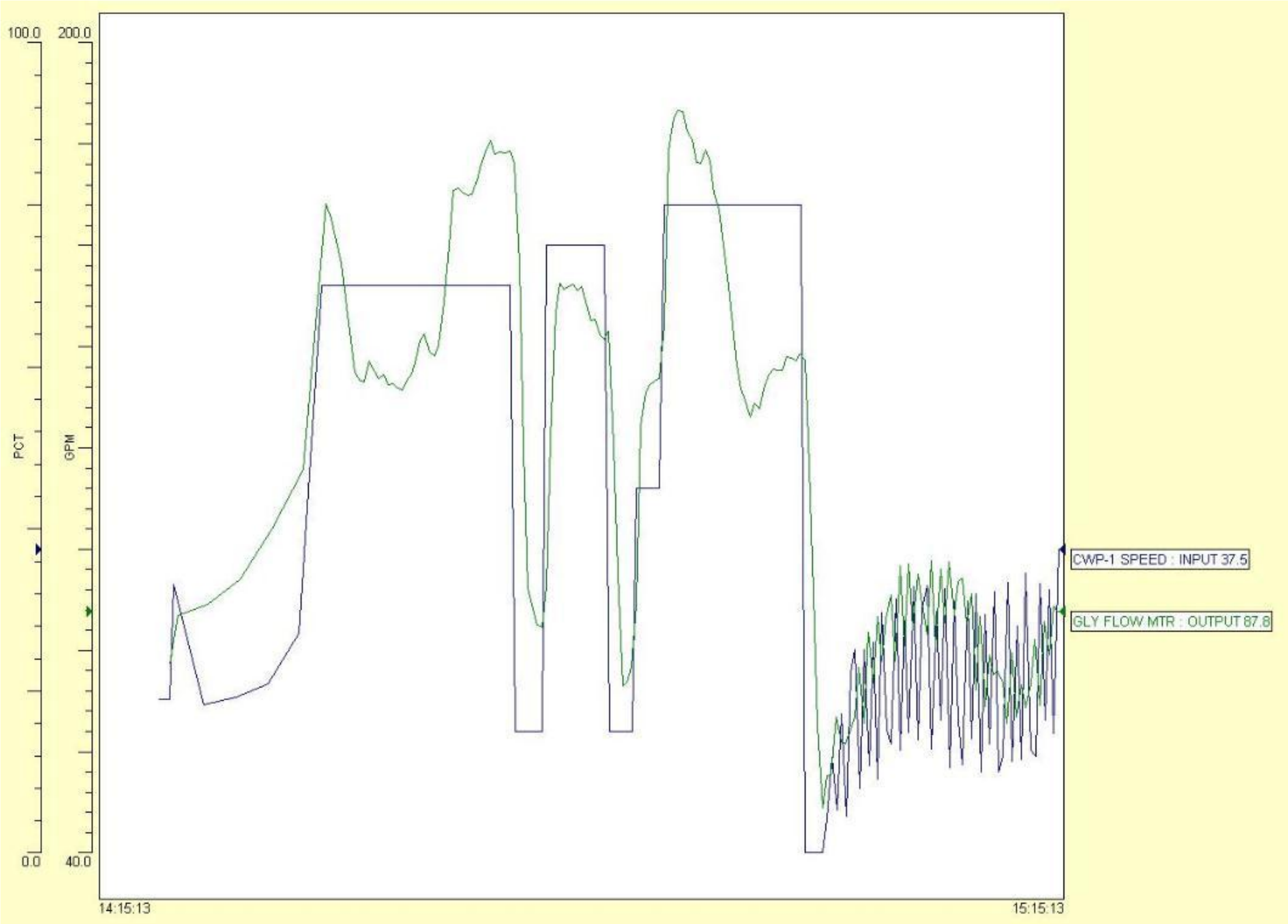
Various Deficiencies Found During Supermarket Commissioning



Subcooling not working

Value of Commissioning

Various Deficiencies Found During Supermarket Commissioning



Finding air in a glycol system

Top 10 Supermarket Refrigeration System Deficiencies Found During Commissioning

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10. Water Treatment Not Installed / Operating Correctly

Scale forming on tubes in evaporative condenser

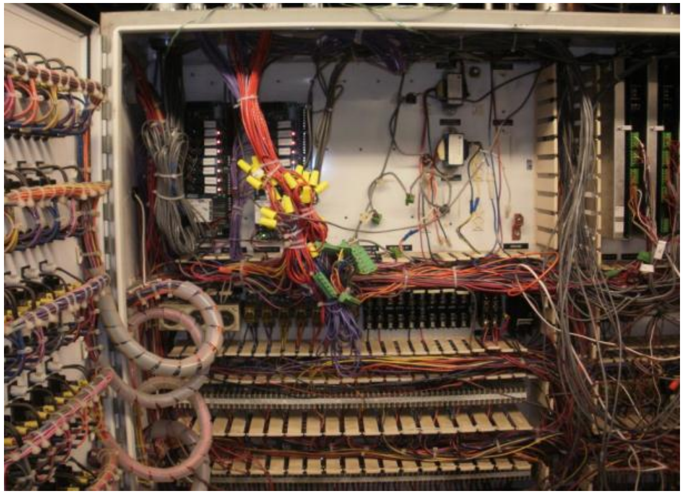
Scale forming on water tower inlet air splash screens

Result: Higher system operating pressure

Top 10 Supermarket Refrigeration System Deficiencies Found During Commissioning

9. Wiring Not Installed Correctly

- Control panel wiring improperly routed; unorganized
- Wiring not connected
- Unprotected control (low-voltage) wiring
  - ✓ No conduit
  - ✓ Going through unprotected drilled holes



Control wiring not complete or routed properly; routed in front of control components

Refrigeration control wires improperly mounted

Result: System not protected or operating correctly

Top 10 Supermarket Refrigeration System Deficiencies Found During Commissioning

8. Piping Insulation Not Installed Correctly

- Joints not sealed properly
- Incorrect insulation installed
- Insulation not installed

Incorrect insulation on fittings causing all fittings to drip condensation on floor

Missing insulation on top of glass door case; water is pooling and running towards the front of the case and down the door frame

Result: Efficiency / energy loss and safety concerns

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7. Walk-in Box Construction Incomplete

- Seams and penetrations not sealed

Walk-in Freezer door heater not working properly

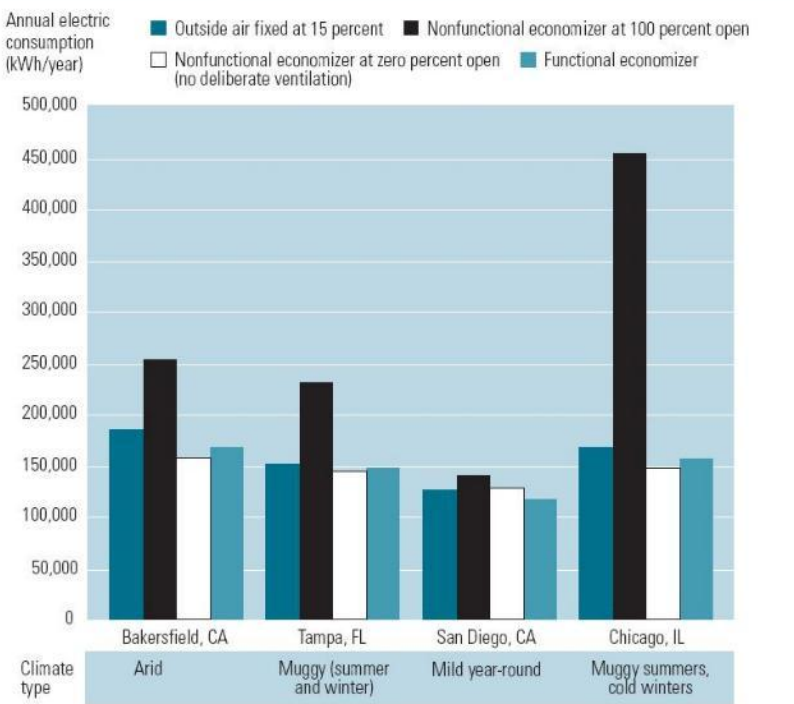
Ice building up on curb of walk-in freezer

Result: Higher energy consumption, equipment integrity and safety issues

6. Package Unit Economizers Not Working

- Estimates indicate that only about one in four economizers works properly

Figure 3: How much energy do economizers save?



Source: Financial Times Energy

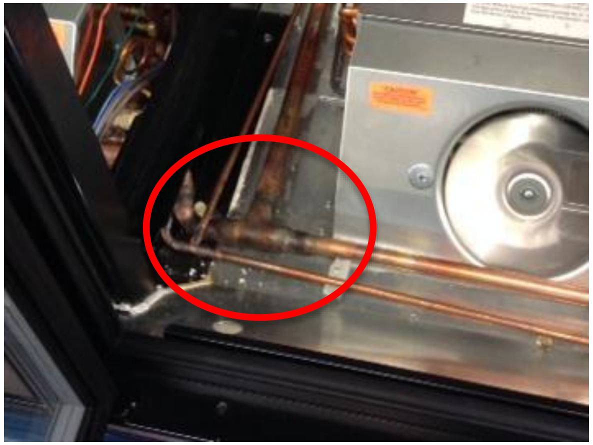
Source: http://energydesignresources.com

Economizer coiled up and in factory tie wraps; not hooked up

Result: Higher energy consumption, poor store pressurization, and OA infiltration

5. Improper Piping

- P-traps not installed
- Refrigeration lines not sloped back to machine room
- Nitrogen not used during installation
  - ✓ Plugged strainers and driers
  - ✓ Oil is much darker
- Bullhead tees used on suction lines

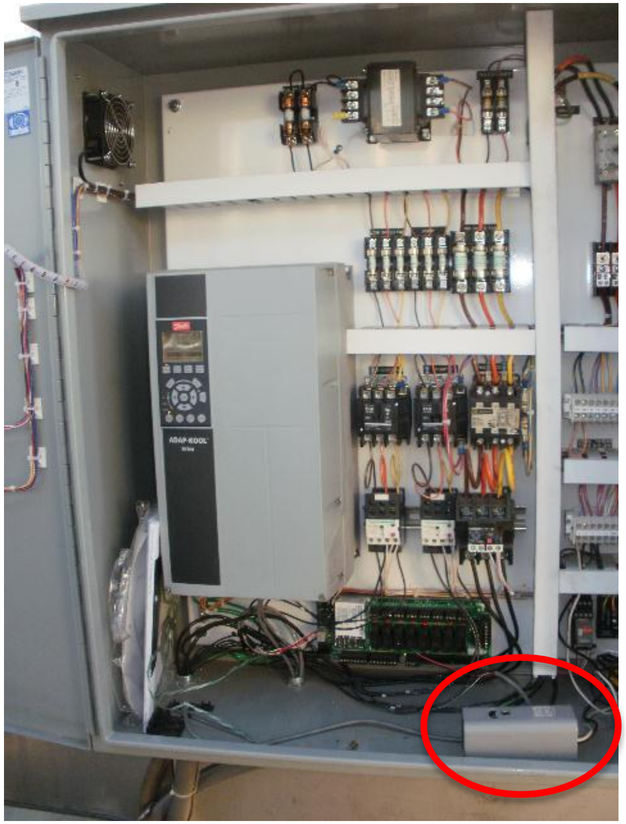


Bullhead tee piping configuration on the suction line within the case

Result: Higher pressure drops and more frequent equipment failures

Top 10 Supermarket Refrigeration System Deficiencies Found During Commissioning

4. VFDs Bypassed



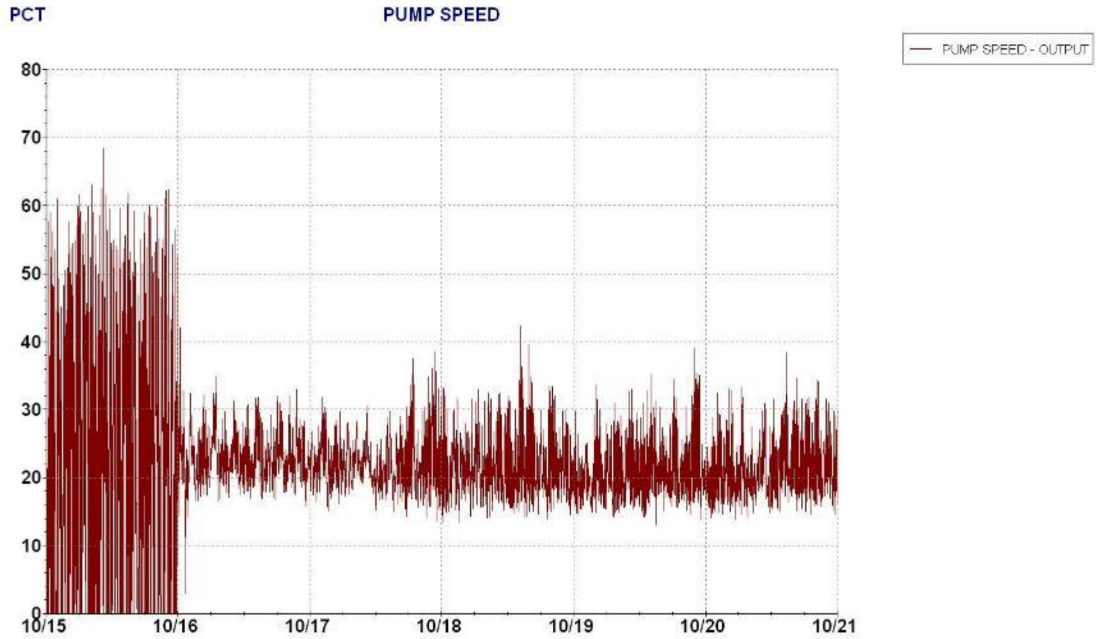
VFD inputs & outputs not wired; VFD is OFF and fan is controlled by thermostat that is in bottom of panel

Result: Loss of systems control and wasted energy

Top 10 Supermarket Refrigeration System Deficiencies Found During Commissioning

3. Untuned Control Loops

- Condensers
- Compressors
- Pumps



Tuning a glycol pump that was swinging from OFF to 60% power throughout the day to a more reasonable 16-32% fluctuation

Result: Higher energy consumption and more frequent equipment failure

2. Pressure Setpoints Not Set Correctly

- Condenser pressure setpoints set too high
- Suction pressure setpoints (racks and EPR) set too low

Commissioning Report stating suction setpoints are correct
NOTE: At 38psig the rack is running at an 11°F suction temp

Site Specific Narrative Notes

1. When we arrived on site, we reviewed the refrigeration system set points. The suction group set points for each rack were properly set up.

Rack ID: Rack C **Refrigerant:** R-407A

Operational Setpoints

	Group 1 Original	Group 1 Final
Target suction pressure setpoint	38	38

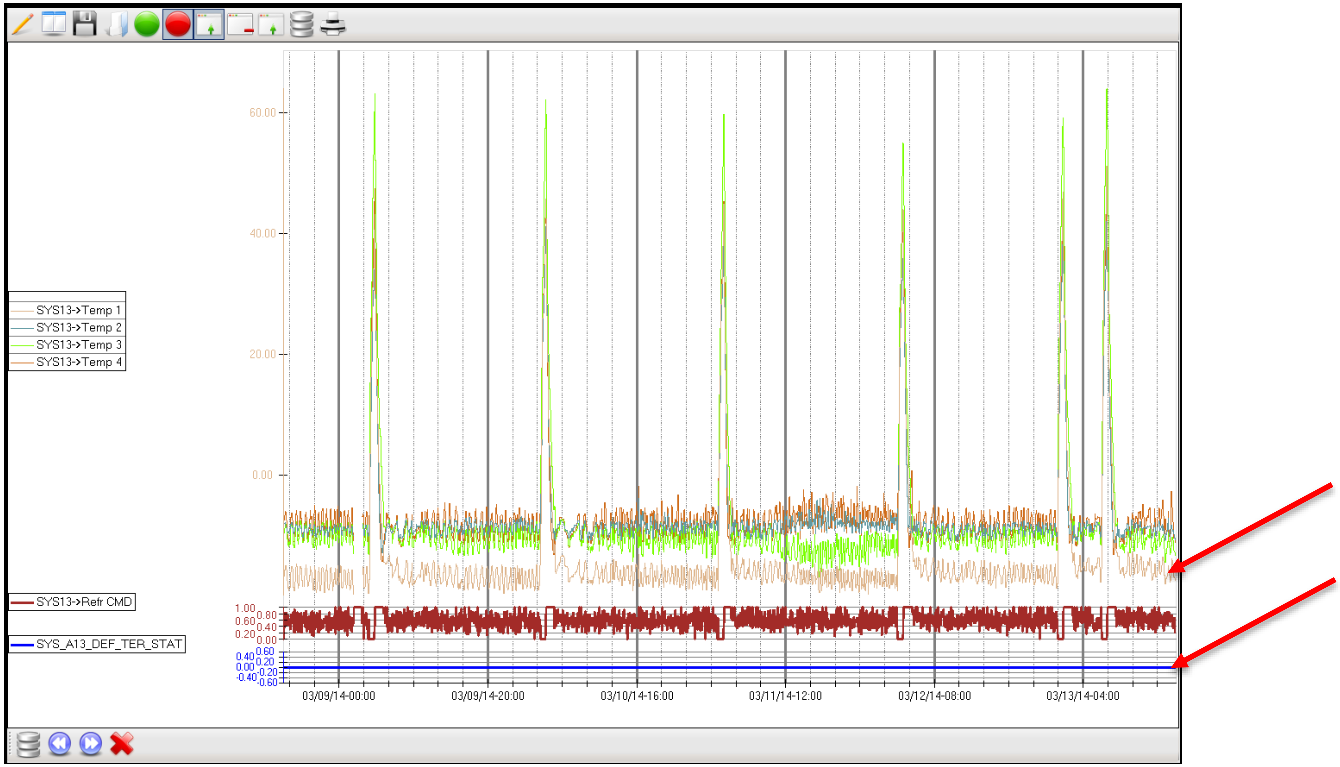
Suction temperature setpoint listed on Refrigeration Schedule

Refrigeration Schedule

DEFROST TERMINATION & DOOR SWITCH CONTROL CABLES	TEMPERATURE PROBES	208V SOLENOID VALVE CONTROL (See Note 12)	EEPR CABLE	TERMINATION PANEL	SYSTEM REFERENCE NUMBER	FIXTURE REFERENCE DESIGNATIONS	FIXTURE DESCRIPTION	CASE AND COOLER SIZE: NO. OTHER CASES (2 DOORS)	NO. 6' CASES (3 DOORS)	NO. 8' CASES (4 DOORS)	NO. 12' CASES (5 DOORS)	TOTAL LENGTH (# OF DOORS)	# OF COILS	MANUFACTURER AND MODEL NO. REFERENCE: MANUFACTURERS LEGEND (Note 8)	DESIGN EVAPORATOR TEMPERATURE °F	RACK SUCTION TEMPERATURE °F
							RACK C +24°F DX – R-407A									24

Result: Higher energy consumption

1. Superheats Not Set Correctly



- ✓ TEMP 1 is always lower than rest of temps. TEMP 3 is usually lower that TEMP 2 & TEMP 4 except during defrost
- ✓ Heater high limits are opening prior to the defrost klixon closing, causing systems to improperly defrost

Result: Possible product integrity and system efficiency issues

Bonus Item: Instability of high-glide refrigerants

- At saturation in receiver, bubble point is much closer to ambient than traditional refrigerants
- Small pressure drop or small gains in temperature tend to cause higher degree of flashing
- Low loads and low velocity cause liquid instability
- Subcooling may be beneficial for stable system operation where not typically applied

Hurdles / Barriers

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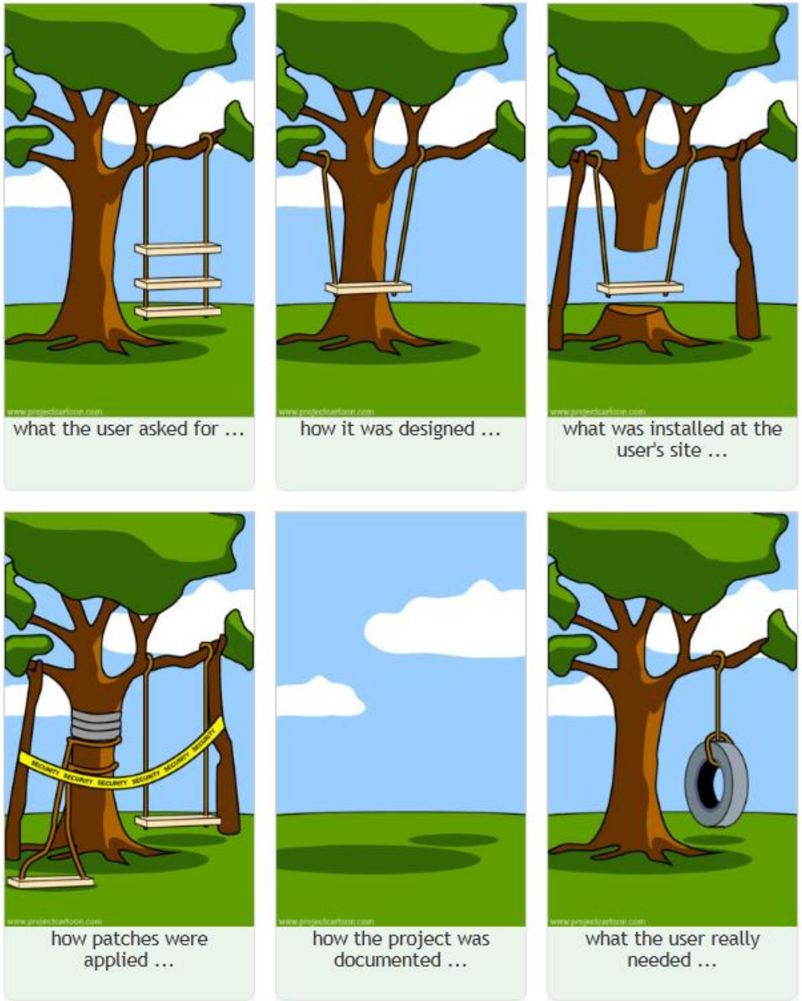
Hurdles / Barriers



- Understanding / Education
- Cost
  - Building Cx is usually between 2% and 5% of the HVAC construction cost
  - Refrigeration System Cx is usually between 1% and 4% of the refrigeration construction cost
  - Additional costs incurred through RCx
- Qualified CxAs
- Visible Energy Savings
  - Paybacks

Main Take-aways & Suggestions

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Main Take-aways & Suggestions

Take-aways

The commissioning process can be tailored to meet the owner's and/or project specific requirements

Commissioning can help improve profitability through lower operating and service costs as well as reduced product loss

- ✓ Most successful if the following occurred within the first year of operation:
  - ✓ A reliable controller with historical trending is used;
  - ✓ Thorough Cx was completed by a qualified CxA; and
  - ✓ Appropriate Warranty PMs performed at regular intervals.
- ✓ After the 2nd year of operation, and every year there after, without set point verification and PMs, you will find more and more opportunities

Value of commissioning typically outweighs hurdles of implementation and provides monetary and system benefits

The CxA is the Owner's Agent

Main Take-aways & Suggestions

Suggestions

- Refer to the *ASHRAE Refrigeration Commissioning Guide for Commercial and Industrial Systems*
- Have a detailed Owner's Project Requirement (OPR) document
- Ensure the CxA is qualified, committed to your long-term success, and engaged early in the process
- Provide the CxA with authority to enact change
- Account for CxA activities in the construction schedule
- Look for incentives offered by utility companies for Cx and RCx
- Account for additional costs that could be incurred through RCx

Future Opportunities

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Future Opportunities

- **More Education and Training**
  - ASHRAE Commissioning Guide
- **Accounting Methodologies**
  - Expensed vs. capitalized
- **Modern Controls with Ongoing Measurement and Verification (M&V)**
  - Remote trending and diagnostic methods
  - Continually assess utility bills to look for additional means of savings
  - Verify that implementations of Cx or RCx do not shift or glide
    - Tenants making changes to setpoints
    - Sensors / devices losing calibration
    - Failed components

Questions / Comments

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Contact Information

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Speaker Presentation—*Supermarket Refrigeration of the Future*

Presentations by guest speakers will help inform our planning process.

- Presenter: Rob Arthur, Director of Refrigeration Engineering, CTA Architects Engineers
- *Supermarket Refrigeration of the Future*

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Supermarket Refrigeration of the Future

Rob Arthur, P.E., PEng, LEED AP

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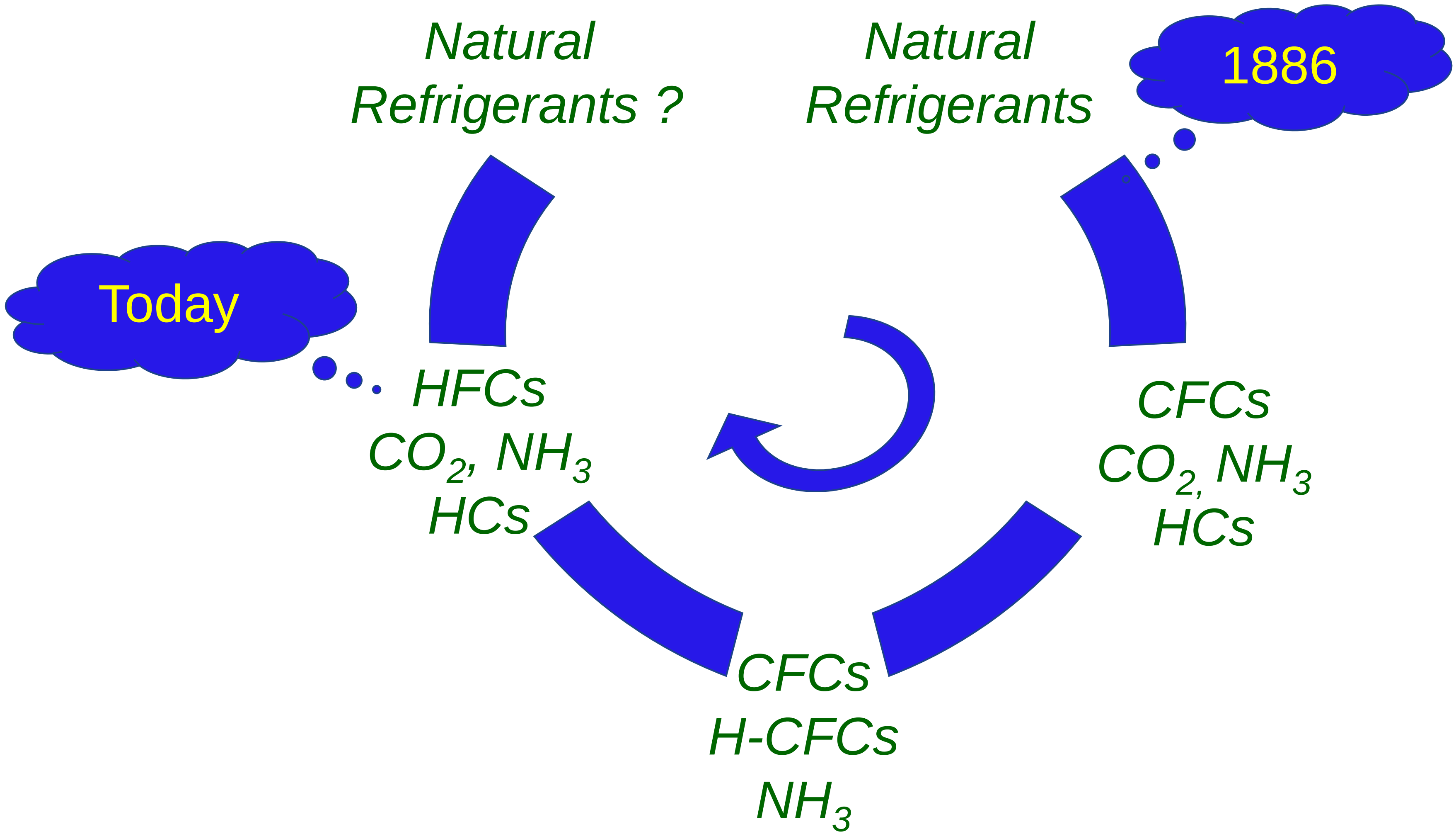
History of Refrigerants



Drivers for Change

- **Safety**
  - Toxicity, Flammability, High Pressure
- **Compliance**
  - Phase Outs, Leak Rates, Records
- **Sustainability**
  - Corporate Stewardship Goals, Awards, Marketing
- **Energy Conservation**
  - Corporate Goals, Awards, Energy Codes
- **Future Proofing**
  - Taxes, Charge Limits, Delisting, Fines
- **Business Case ???**

Refrigerant Options

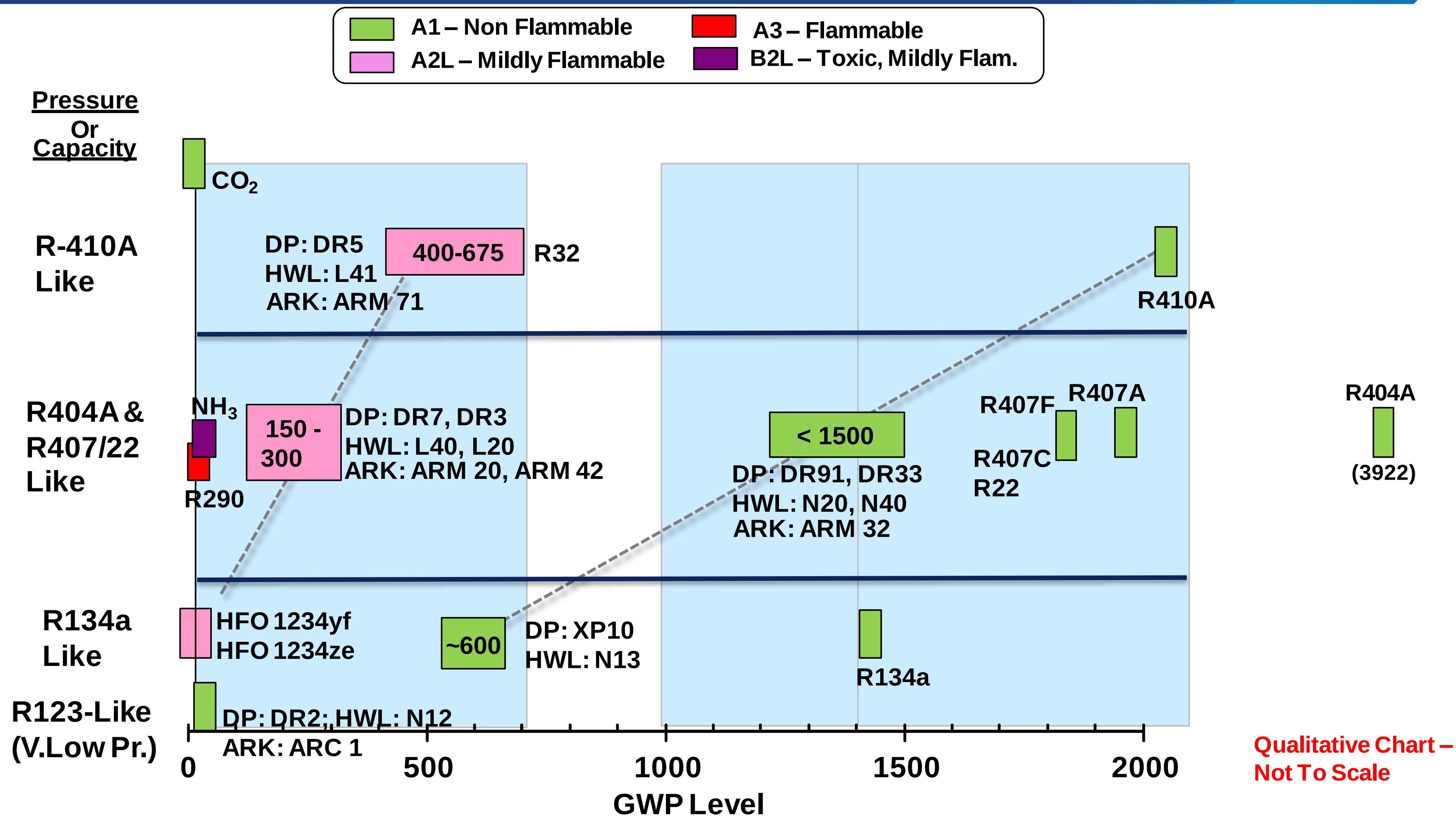
Current Refrigerants (Supermarket Systems)

R-404a/R-507
R-407a/R-407f
R-134a
CO2 (R-744)
Ammonia (R-717)
Hydrocarbons(limited charge)(R-290/R-600)

Possible Future Refrigerants

L40, L20, L41, N20, N40, N12
DR7, DR3, DR91, DR33
ARM20, ARM42, ARM32
R32, R290(larger charge), HFO-1234yf/ze

Refrigerant Options



Rajan Rajendran – FMI Energy Slide

Refrigerant System Options

- Industry Standard Parallel Compressor Racks
  - Utilizing R-404a, R-507, R-407a, R-407f, R-134a
- Distributed System (with conventional refrigerant)
- Medium Temperature Secondary Glycol System
- Medium Temperature Secondary CO2 System
- Low Temperature Secondary CO2 System
- Medium and Low Temperature Combined Secondary and Cascade CO2 System
- Transcritical CO2 Booster System

- Micro Distributed HC System
  - Not Analyzed due to newness to market

Life Cycle Analysis

Uniform Present Value Calculator

	R-407a Central System		R-407a Distributive System		R-407a Med Secondary Glycol Low Secondary CO2		R-407a Med Secondary CO2 Low Secondary CO2	
Initial Compressor Condenser Equipment Costs		$ 250,000.00		$ 250,000.00		$ 312,500.00		$ 350,000.00
Initial Case/Evaporator Equipment Costs		$ 800,000.00		$ 800,000.00		$ 920,000.00		$ 920,000.00
Initial Installation Costs		$ 300,000.00		$ 270,000.00		$ 330,000.00		$ 330,000.00
Intial Refrigerant Costs		$ 32,000.00		$ 25,600.00		$ 30,940.00		$ 9,800.00
Annual Refrigerant Costs	$ 8,000.00	$ 77,697.99	$ 5,120.00	$ 49,726.71	$ 3,094.00	$ 30,049.70	$ 980.00	$ 9,518.00
Annual Energy Costs	$ 240,000.00	$ 2,330,939.76	$ 240,000.00	$ 2,330,939.76	$ 276,000.00	$ 2,680,580.72	$ 240,000.00	$ 2,330,939.76
Annual Maitenance Costs	$ 7,500.00	$ 72,841.87	$ 7,500.00	$ 72,841.87	$ 5,250.00	$ 50,989.31	$ 5,250.00	$ 50,989.31
Uniform Present Value (based on yrs)		$ 3,863,479.62		$ 3,799,108.34		$ 4,355,059.73		$ 4,001,247.07
Percentage Higher then base line(100% equal)		100%		98%		113%		104%

Discount Rate	6%
Period(yrs)	15
Refrigerant Leak Rate (Central System)	25%
Refrigerant Leak Rate (Distributive System)	20%
Refrigerant Leak Rate (Secondary System)	10%
Refrigerant Leak Rate (Cascade)	15%
Refrigerant Leak Rate (Transcritial CO2)	15%
$/kW-h	$ 0.12
Annual kW-h	2,000,000.00
lb of R-407a	4,000.00
lb of CO2	1,800.00
lb of NH3	100.00
lb of Glycol	1,600.00
$/lb of R-407a	$ 8.00
$/lb of CO2	$ 1.00
$/lb of NH3	$ 5.00
$/lb glycol	$ 12.00

	R-407a High Side Med Seconday CO2 Low Cascade CO2		NH3 High Side Med Seconday CO2 Low Cascade CO2		Med/Low Transcritcal CO2 Booster	
		$ 350,000.00		$ 937,500.00		$ 350,000.00
		$ 920,000.00		$ 920,000.00		$ 920,000.00
		$ 345,000.00		$ 375,000.00		$ 360,000.00
		$ 9,800.00		$ 2,300.00		$ 2,400.00
	$ 1,470.00	$ 14,277.01	$ 280.00	$ 2,719.43	$ 360.00	$ 3,496.41
	$ 216,000.00	$ 2,097,845.78	$ 204,000.00	$ 1,981,298.79	$ 204,000.00	$ 1,981,298.79
	$ 6,750.00	$ 65,557.68	$ 18,750.00	$ 182,104.67	$ 8,250.00	$ 80,126.05
		$ 3,802,480.47		$ 4,400,922.89		$ 3,697,321.26
		98%		114%		96%

Life Cycle Analysis

- **Inputs**
  - Typical Compressor/Condensers costs
  - Typical Maintenance Costs
  - General agreed upon Energy (kW-h) differences between system types
  - Industry Average Refrigerant Costs
  - Industry Average Leak Rates
  - Typical Refrigerant Charge amounts

Life Cycle Analysis

Discount Rate	6%
Period(yrs)	15
Refrigerant Leak Rate (Central System)	25%
Refrigerant Leak Rate (Distributive System)	20%
Refrigerant Leak Rate (Secondary System)	10%
Refrigerant Leak Rate (Cascade)	15%
Refrigerant Leak Rate (Transcritial CO2)	15%
$/kW-h	$ 0.12
Annual kW-h	2,000,000.00
lb of R-407a	4,000.00
lb of CO2	1,800.00
lb of NH3	100.00
gal of Glycol	1,600.00
$/lb of R-407a	$ 8.00
$/lb of CO2	$ 1.00
$/lb of NH3	$ 5.00
$/gal glycol	$ 12.00

Life Cycle Analysis

Uniform Present Value Calculator

		R-407a Central System
Initial Compressor Condenser Equipment Costs		$ 250,000.00
Initial Case/Evaporator Equipment Costs		$ 800,000.00
Initial Installation Costs		$ 300,000.00
Intial Refrigerant Costs		$ 32,000.00
Annual Refrigerant Costs	$ 8,000.00	$ 77,697.99
Annual Energy Costs	$ 240,000.00	$ 2,330,939.76
Annual Maitenance Costs	$ 7,500.00	$ 72,841.87
Uniform Present Value (based on yrs) Percentage Higher then base line(100% equal)		$ 3,863,479.62 100%

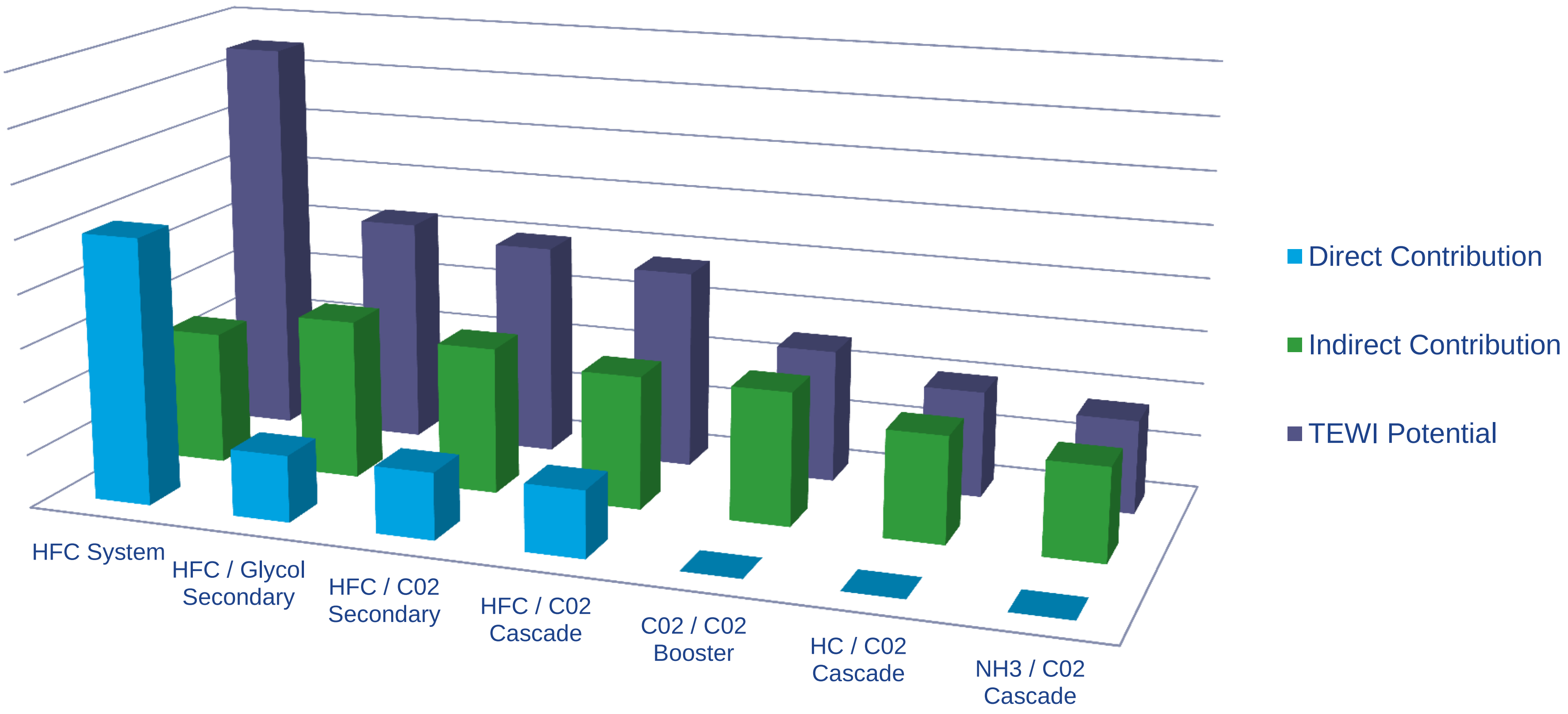
Life Cycle Analysis

15 Year Life Cycle Analysis	R-407a Central System	R-407a Distributed System	R-407a Med Secondary Glycol Low Secondary CO2	R-407a Med Secondary CO2 Low Secondary CO2
First Costs(Equip/Install)	100%	98%	116%	119%
Initial Refrig Costs	100%	80%	97%	31%
Annual Refrig Costs	100%	64%	39%	12%
Annual Energy Costs	100%	100%	115%	100%
Annual Maint. Costs	100%	100%	70%	70%
Life Cycle Cost	**100%**	**98%**	**113%**	**104%**

	R-407a High Side Med Seconday CO2 Low Cascade CO2	NH3 High Side Med Seconday CO2 Low Cascade CO2	Med/Low Transcritcal CO2 Booster
First Costs(Equip/Install)	120%	165%	120%
Initial Refrig Costs	31%	7%	8%
Annual Refrig Costs	18%	3%	5%
Annual Energy Costs	90%	85%	85%
Annual Maint. Costs	90%	250%	110%
Life Cycle Cost	**98%**	**114%**	**96%**

Environmental Impact

TEWI Potential

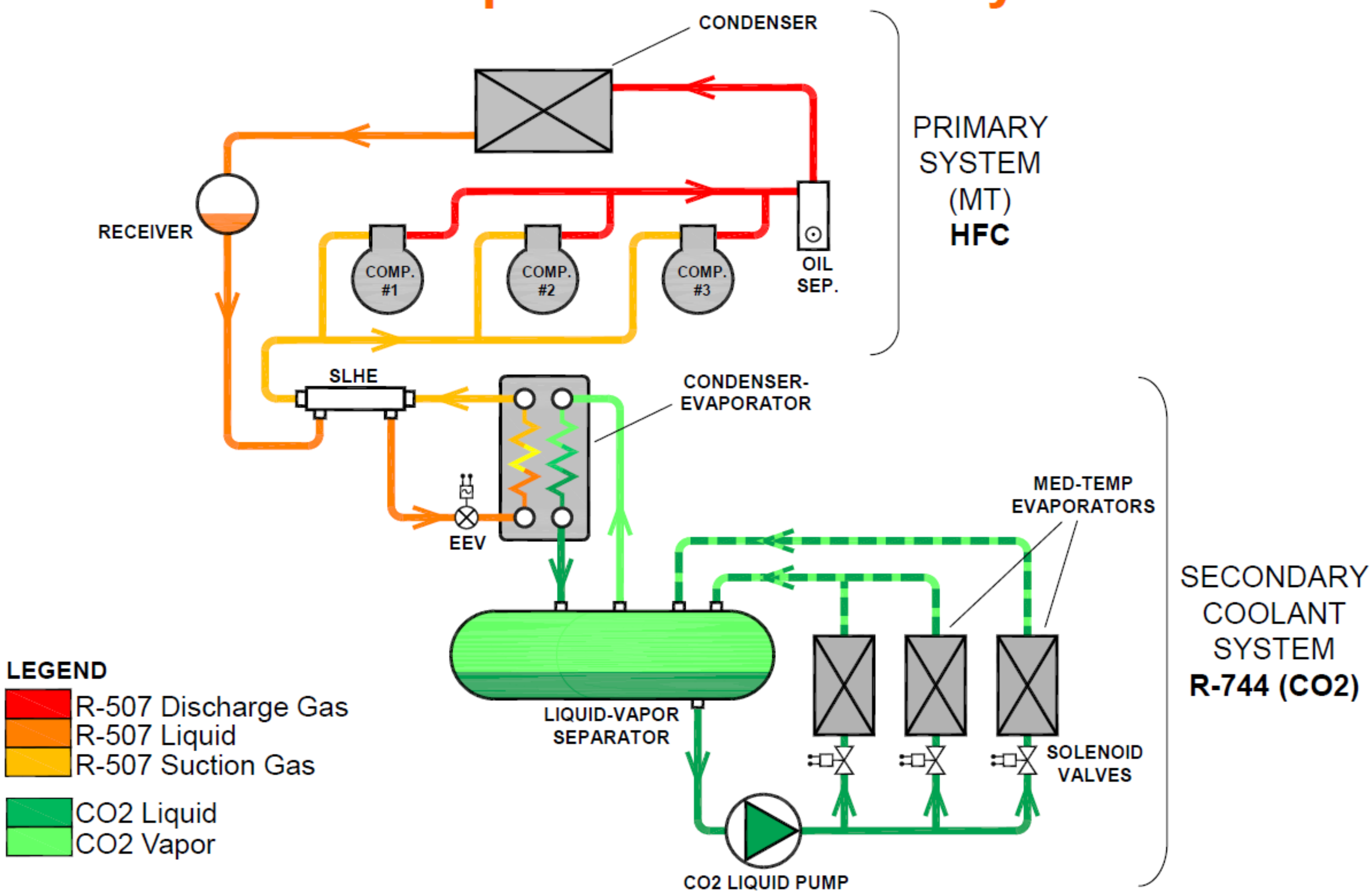


Possible Standard Refrigeration Systems in 5 to 10 Years

- Low Charge Synthetic/Medium Temp Secondary CO_2 System (90% Natural)
- Low Charge Synthetic/Low Temp Secondary CO_2 System (90% Natural)
- Medium and Low Temperature Combined Secondary and Cascade CO_2 System
  - Synthetic Refrigerant Option (90% Natural)
  - Ammonia Refrigerant Option (100% Natural)
- Transcritical CO_2 Booster System (100% Natural)

Possible Standard Refrigeration Systems in 5 to 10 Years

Medium-Temperature Secondary Coolant



Possible Standard Refrigeration Systems in 5 to 10 Years

- Low Charge Chemical/Medium Temp Secondary CO2 System (90% Natural)
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- Medium and Low Temperature Combined Secondary and Cascade CO2 System
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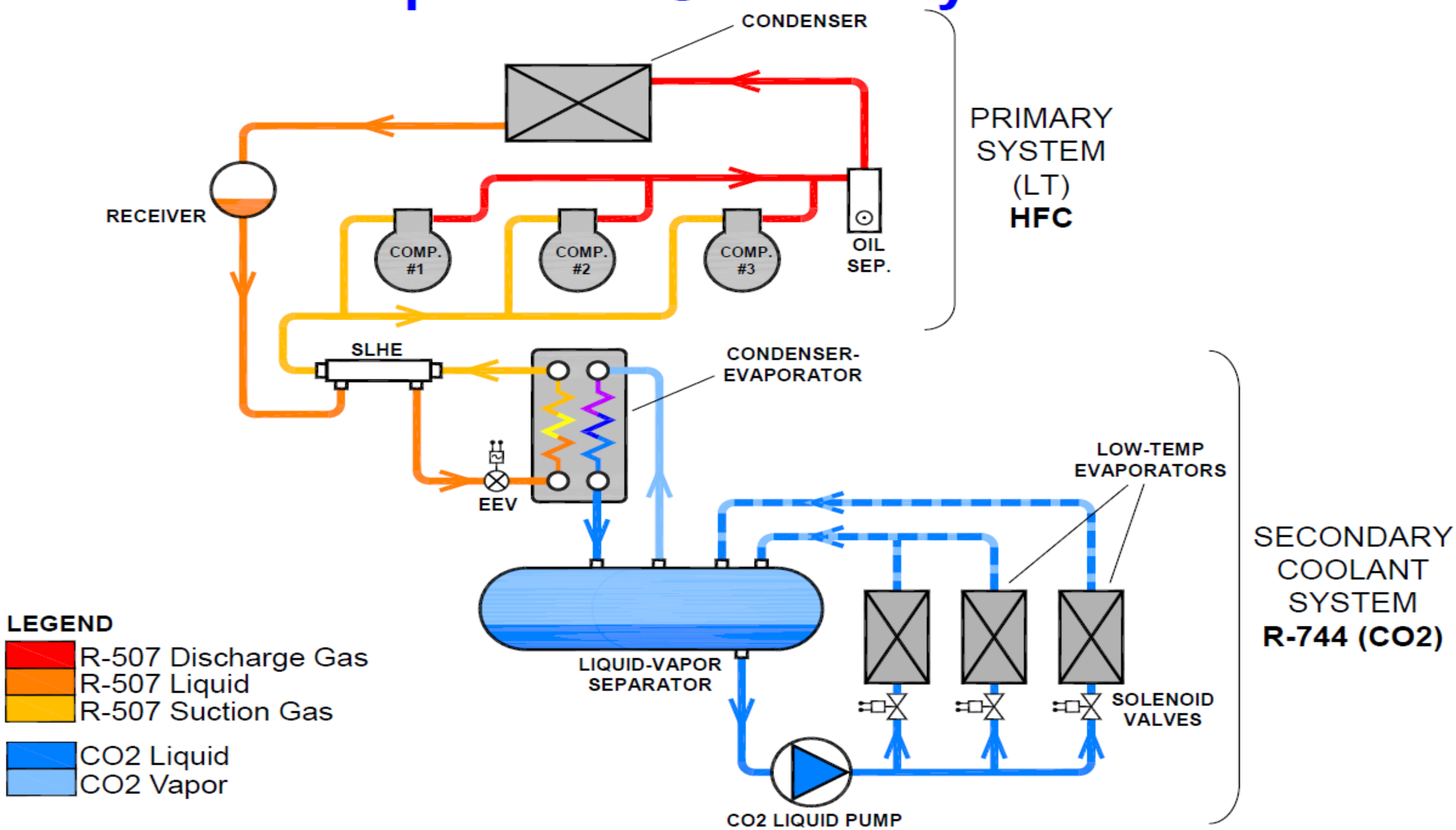
- Transcritical CO2 Booster System (100% Natural)

Possible Standard Refrigeration Systems in 5 to 10 Years

Low-Temperature Secondary Coolant



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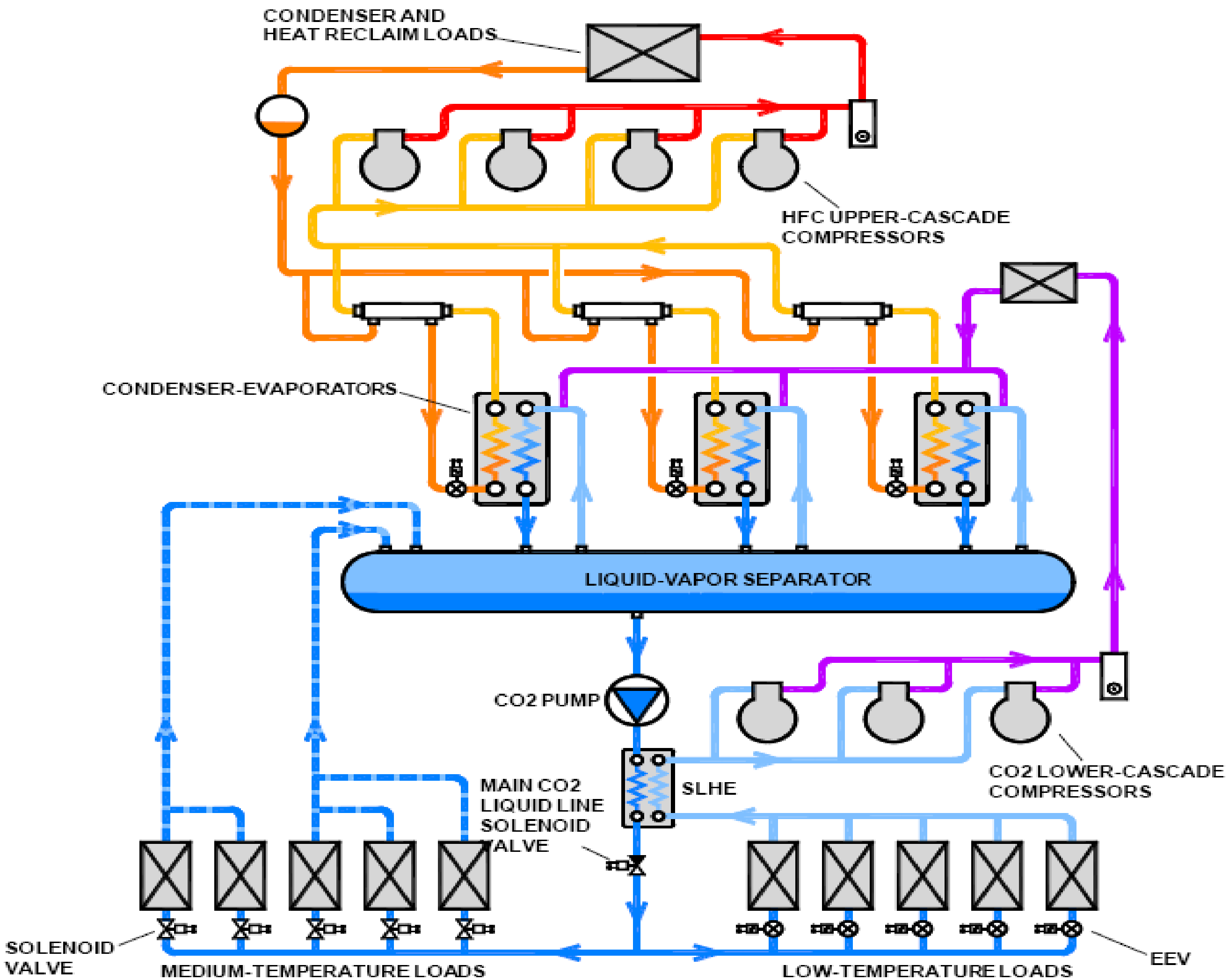
- Transcritical CO2 Booster System (100% Natural)

Possible Standard Refrigeration Systems in 5 to 10 Years



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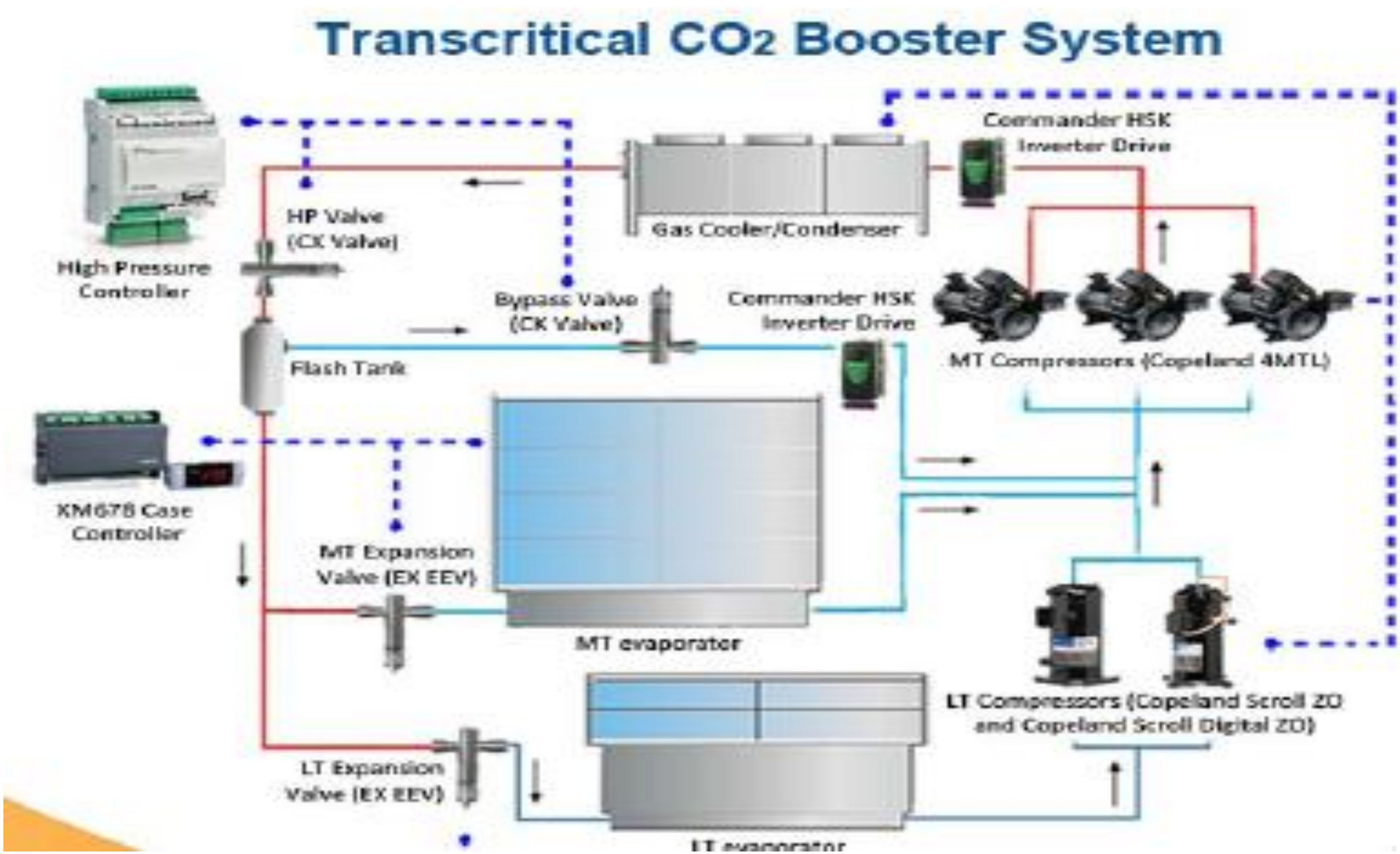
Possible Standard Refrigeration Systems in 5 to 10 Years



Possible Standard Refrigeration Systems in 5 to 10 Years

- **Don't believe Advanced systems of the future will look like current advanced refrigeration systems of today.**
  - **Standardized**
  - **Assembly Line**
  - **Modules**
  - **Off the shelf package units**

- 90% systems will use refrigerant with GWP under 500
  - Low GWP won't be 1500 to 2000 (R-134a/R-407a)
  - Possibly A2L, HFO or New Refrigerants

- CO_2 as a Refrigerant is inexpensive and has a Really Low GWP (GWP=1)
  - Better Heat transfer than Glycol or Brine
  - Lower pump energy requirements than Glycol or Brine
  - CO_2 Systems have Smaller Pipe size requirements than Glycol, Brine or DX systems
  - CO_2 Systems can be energy neutral or better then traditional DX systems

- For End Users Having an Aggressive Energy and Sustainability Goals
  - CO_2 Transcritical (where feasible)
  - Ammonia/CO_2 Cascade
  - HC/CO_2 Cascade (with SNAP and UL approvals)

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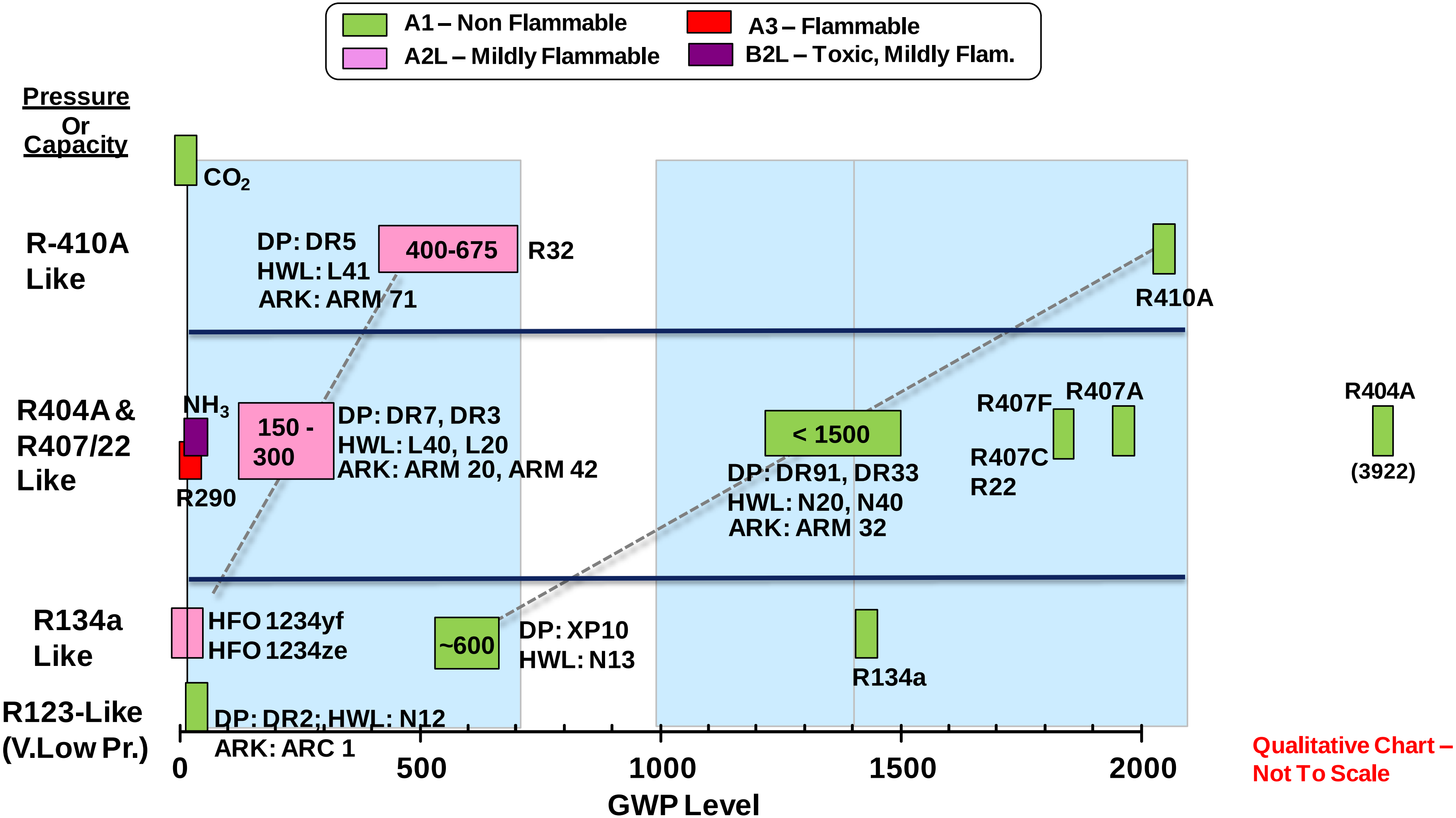
Refrigerant Options



Rajan Rajendran – FMI Energy Slide

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  - **Ammonia/CO_2 Cascade**
  - **HC/CO_2 Cascade (with SNAP and UL approvals)**

APPENDIX

- **Refrigeration System Schematics**

Refrigerant System Options

- Standard "DX" Central Parallel Racks

DX = "Direct Expansion" i.e. liquid refrigerant is piped directly to the expansion device at the product location and is fully evaporated.

Refrigerant System Options

- DX "Distributed" Racks

"Distributed" = Parallel Compression Racks fitted into a tighter package and "distributed" throughout the store in closer proximity to the load.

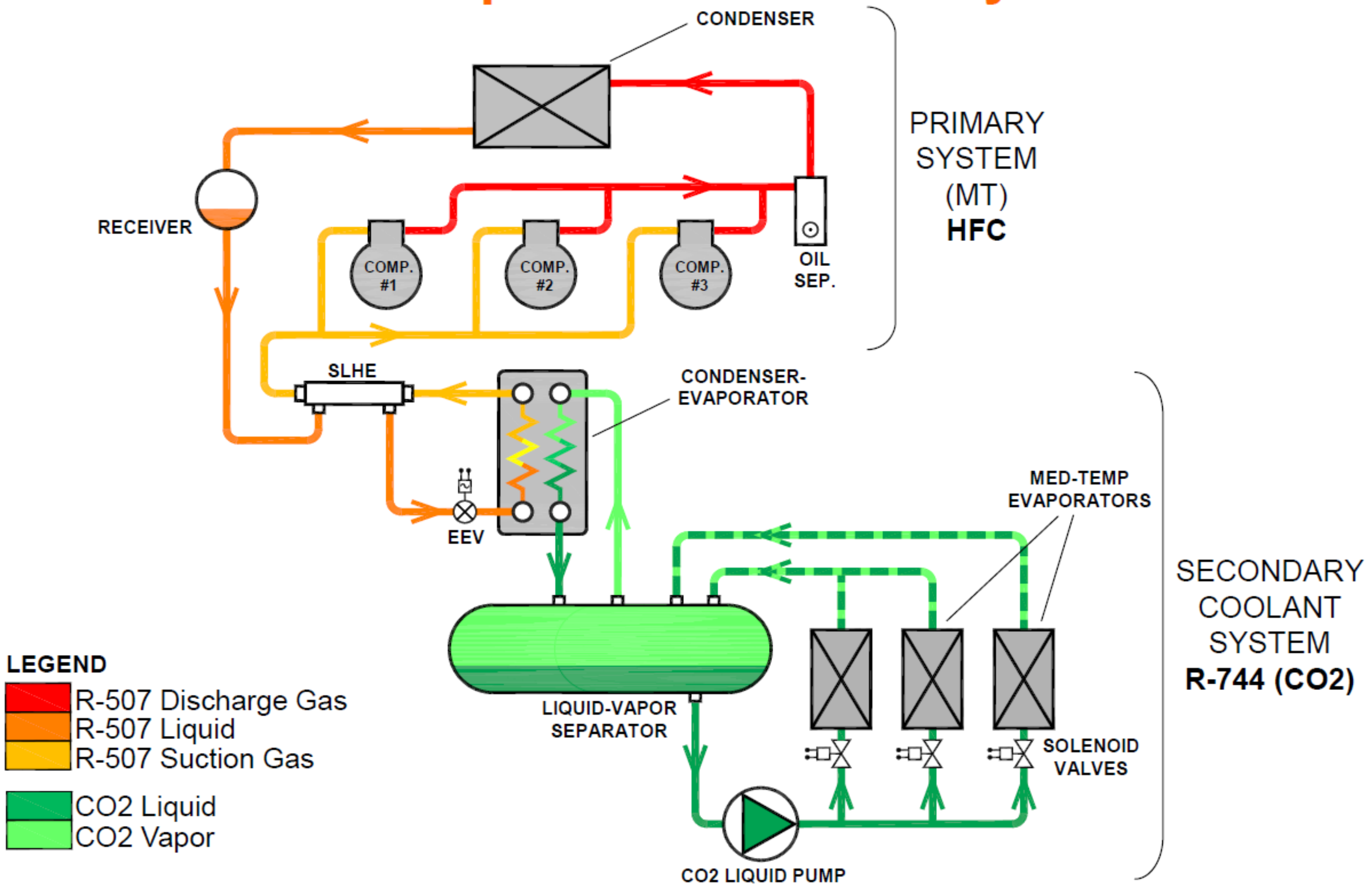
Refrigerant System Options

- "Secondary" Systems

"Secondary" = The refrigeration Rack (standard or distributed) chills a "secondary" fluid such as liquid C02, brine, or water/glycol mixture which is <u>pumped</u> out to the heat exchanger at the product location.

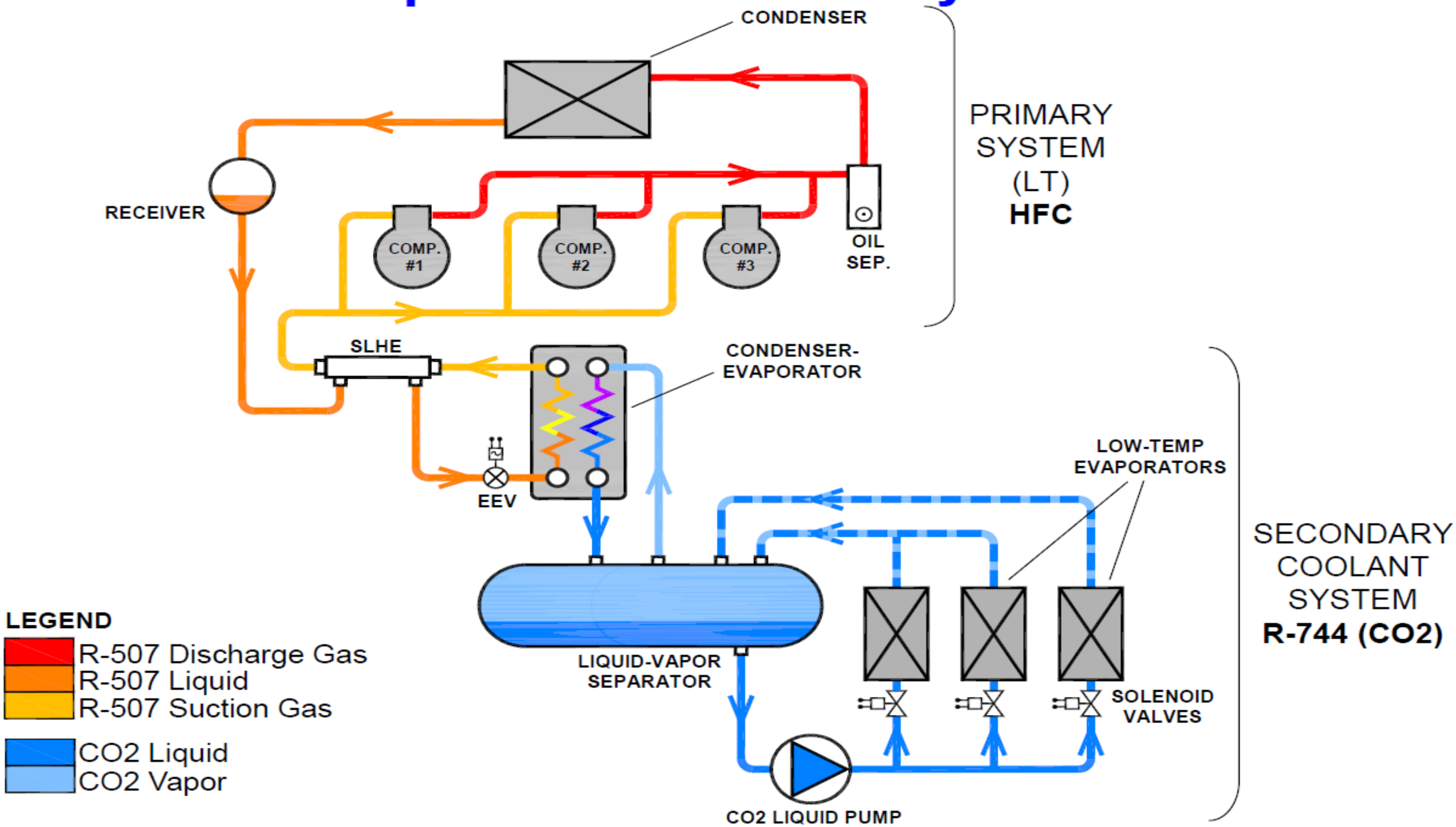
Refrigerant System Options

Medium-Temperature Secondary Coolant

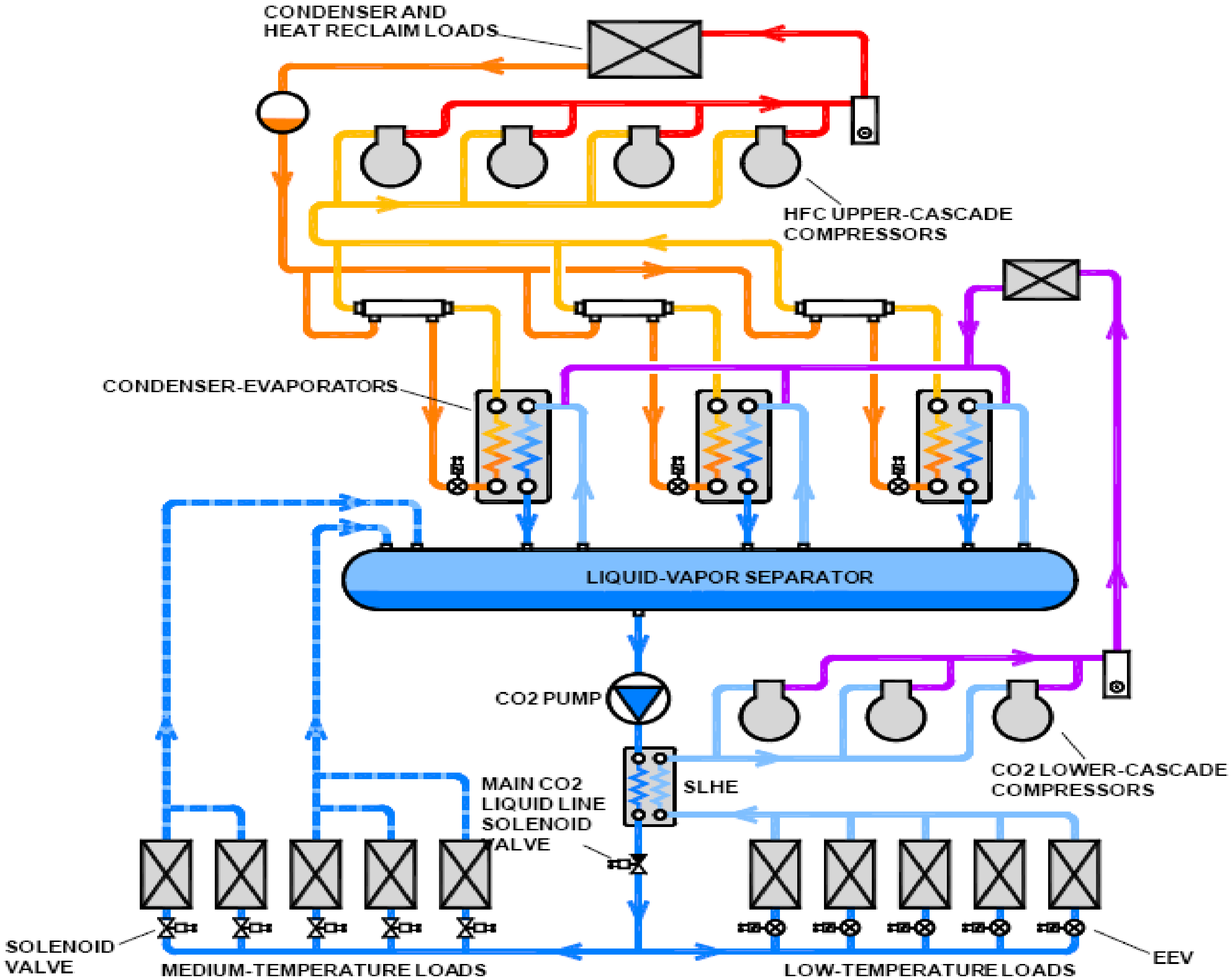


Refrigerant System Options

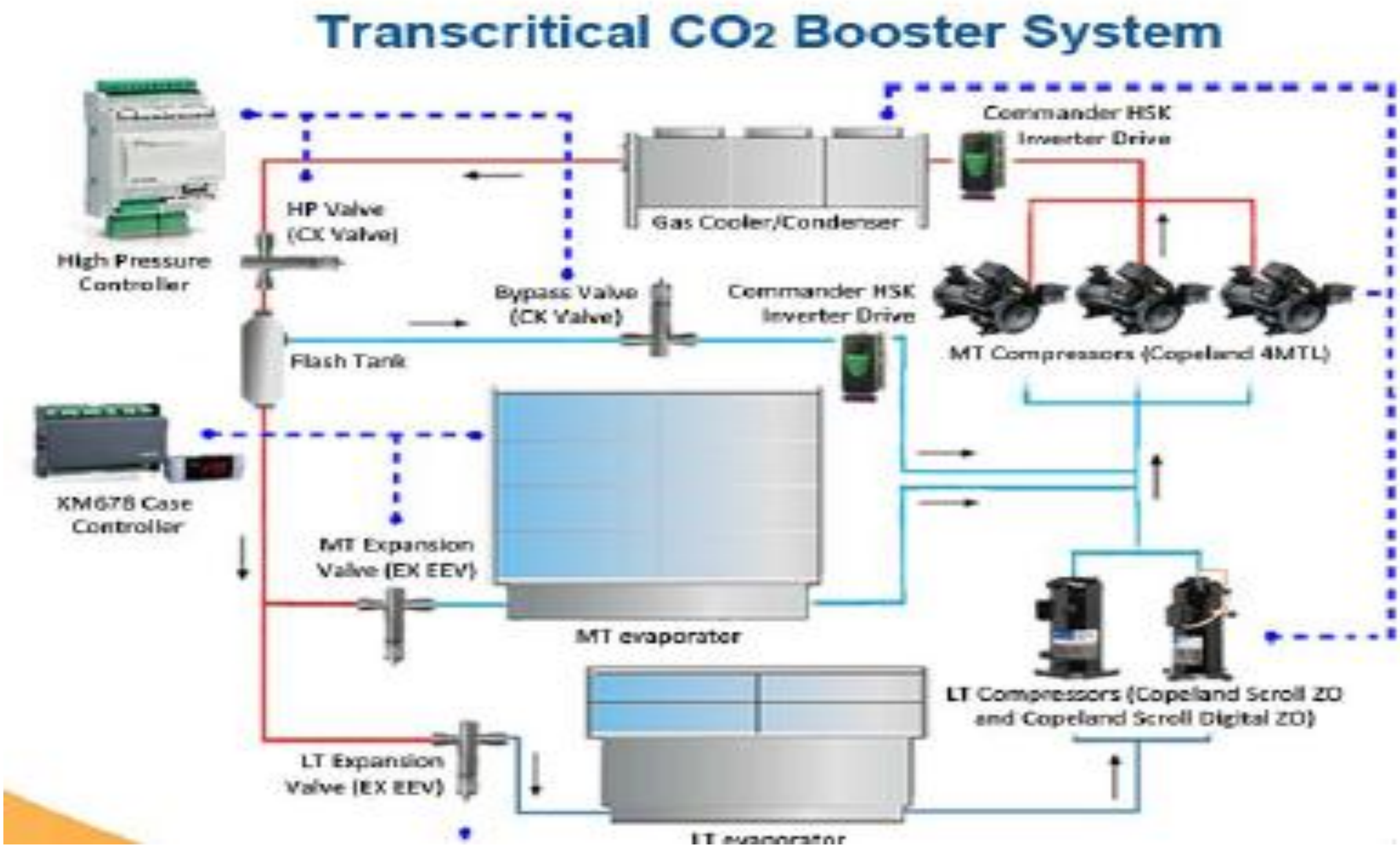
Low-Temperature Secondary Coolant



Refrigerant System Options



Refrigerant System Options



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Brief Update—Ongoing Team Activities >> ASHRAE Commissioning Guide

DOE and the Refrigeration Team supported development of ASHRAE's refrigeration commissioning guide.

- DOE/NREL and Refrigeration Team supported development of Guide (released January 2014)
- Guide is available at: Commissioning Guide
- NREL hosted Webinar on February 27, 2014 (Richard Royal/Wal-Mart, Caleb Nelson/CTA, Doug Scott/VaCom Technologies)
- Appliance Magazine published article (March 2014)

Brief Update—Ongoing Team Activities >> ASHRAE Commissioning Guide

Key activities are promoting the Guide and gathering feedback.

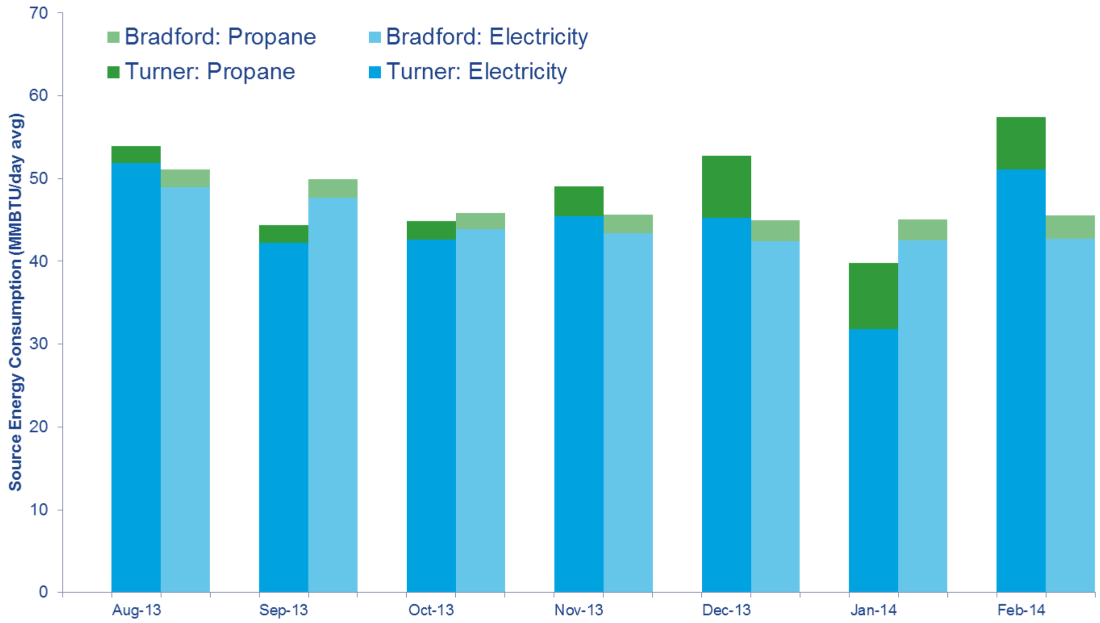
- Promotion Plan:
  - FMI Energy & Store Development Conference, September 7 – 9, 2014 (St. Louis): Energy Breakout Session will include Commissioning/Recommissioning (Paul Torcellini/NREL)
  - ASHRAE Annual Conference, Seattle, June 28 – July 2, 2014: *The Road to Success with the New Refrigeration Commissioning Guide* (Richard Royal/Wal-Mart, Jason Robbins/Walgreens, Bryan Beitler/Source Refrigeration & HVAC, Caleb Nelson/CTA)
  - ***Word of mouth—talk it up!***

- Gathering Feedback:
  - ***How can the Team help collect feedback?***
  - ***Do you plan to use the Guide for a specific project?***

Brief Update—Ongoing Team Activities >> Alternative Refrigerants Case Studies

Delhaize has provided seven months of data for their transcritical CO_2 supermarket in Turner, MA.

- ***Project Goal:*** Perform field case study of transcritical CO_2 refrigeration in a supermarket application
- ***Preliminary Results:*** Raw data suggest similar energy consumption compared to the Bradford, VT store using conventional refrigerants



Brief Update—Ongoing Team Activities >> Alternative Refrigerants Case Studies

Would additional case studies be helpful?

- Plan:
  - Complete Delhaize/Hannaford monitoring and case study
  - Complete two additional case studies—discussions continue, but no data collection yet
- Discussion:
  - ***How will you use these case studies?***
  - ***Would additional case studies be helpful? If so, what technologies and what host sites?***

Brief Update—Ongoing Team Activities >> Supermarket Refrigeration Initiative

We've conceptualized a short-term and long-term approach to rating refrigeration systems and engaged one industry association.

- Will encourage end users (owners and operators) to improve energy efficiency and recognize successful end users
- Developed initial refrigeration system "scorecard" in 2013 and vetted it with several members and suppliers
- Conceptualized a short-term approach (based on the "scorecard") and a long-term approach (based on developing a system rating metric)
- Held multiple discussions with AHRI in early 2014—ongoing

Brief Update—Ongoing Team Activities >> Supermarket Refrigeration Initiative

How will we engage Team members in developing and launching this initiative?

- Plan:
  - Regroup with AHRI in May 2014
  - Present to 90.1 committee at ASHRAE Annual Conference (June 28 – July 2, 2014 in Seattle)
- Discussion:
  - ***Are Team members willing to evaluate a sample of their stores to test the "scorecard"?***
  - ***How else can Team members engage in the process?***

Brief Update—Ongoing Team Activities >> Retrofit of Open Display Cases

The Team made great strides in promoting retrofit of open cases.

- Developed and published best practices guide: Case Retrofit Guide
- Developed a calculator to estimate economic benefits
- Published series of articles in *ACHR News* and the *RSES Journal* (Refrigeration Service Engineers Society)
- RSES adopted the guide as a Service Application Manual
- Hosted 2013 webinar
- Developed case study with Fresh & Easy
- Worked with Southern California Gas Company (SoCalGas) to develop a rebate package

Brief Update—Ongoing Team Activities >> Retrofit of Open Display Cases

What are our next steps to accelerate case retrofits?

- Current Activities:
  - Discussing additional case studies with end users
- Discussion:
  - ***How can we address specific data needs?***
    - Potential sales impact is a key driver, and data are lacking
    - Are members willing to work with the Team to develop sales impact case studies (using relative sales impacts, not actual sales data)?
  - ***Is a member progress tracking database of interest***?
    - Might include the number of retrofits conducted to date, retrofit project targets, equipment types used, etc.
    - Would allow for information sharing and learning through other adopters' experiences
  - ***What additional tools and resources can the Team develop?***

Brief Update—Ongoing Team Activities >> Webinars

The Team periodically conducts Webinars on topics of interest to Team members.

- DOE/NREL held February 2014 Webinar on ASHRAE Commissioning Guide

- Refrigeration Team held April 2014 Webinar on refrigeration system design (Presented by DC Engineering)

- Identified other Webinars of interest:
  - Improving Energy Performance in Distribution Warehouses
  - Distributed Generation, including Combined Heat and Power
  - Lowering Energy Costs (Benchmarking Energy Use; Utility Bill Audits; Tariff Options; Load Shifting to Lower Peak Demand)

- Discussion:
  - ***What Webinars would you attend (topics and presenters)?***
  - ***Can you help outline Webinar content?***

Discuss Possible New Team Activities—Alternative Refrigerants

What do you need to learn about alternative refrigerants?

- Current Team activities focus on documenting energy impacts of alternative refrigerants (CO_2 systems to date)

- Does the industry need multiple alternative refrigerant options?
  - What if R-404A is delisted?

- What do you need to learn about ammonia for supermarkets?
  - Are you open to considering this?
  - What would convince you that it can be sufficiently safe?
  - What do you need to know about energy performance, cost, operation, maintenance?

- What do you need to learn about distributed propane for supermarkets?
  - Is enough information available?
  - What can we learn from Europe?

Discuss Possible New Team Activities—Standardized Design / Service Specifications

Would the industry benefit from standardized refrigeration system design and service specifications?

- What industry benefits do you see?
  - Lower costs?
  - Higher reliability?
  - Improved energy efficiency?

- Do you have formal design specifications? Service specifications?

- Would you be willing to share them with the Team?

Discuss Possible New Team Activities—Distribution Warehouses

Should we investigate refrigeration efficiency improvements for Distribution Warehouses?

- Do you own and operate your distribution warehouses?
- What refrigeration issues/problems do you currently experience, and how do they impact energy efficiency?
- Can this Team address these issues/problems?

Discuss Possible New Team Activities— Energy Benchmarking

Do you know how your energy performance compares?

- Do you know how each of your stores compares to your typical store?
- Do you know how your stores compare to the industry average?
- What is your experience with EPA's Portfolio Manager?

Discuss Possible New Team Activities—Ongoing Commissioning

The ASHRAE Commissioning Guide covers planning through first year of operation—do we need more information on ongoing commissioning?

- Supplement to current Guide?
- Case studies?
- Other information?

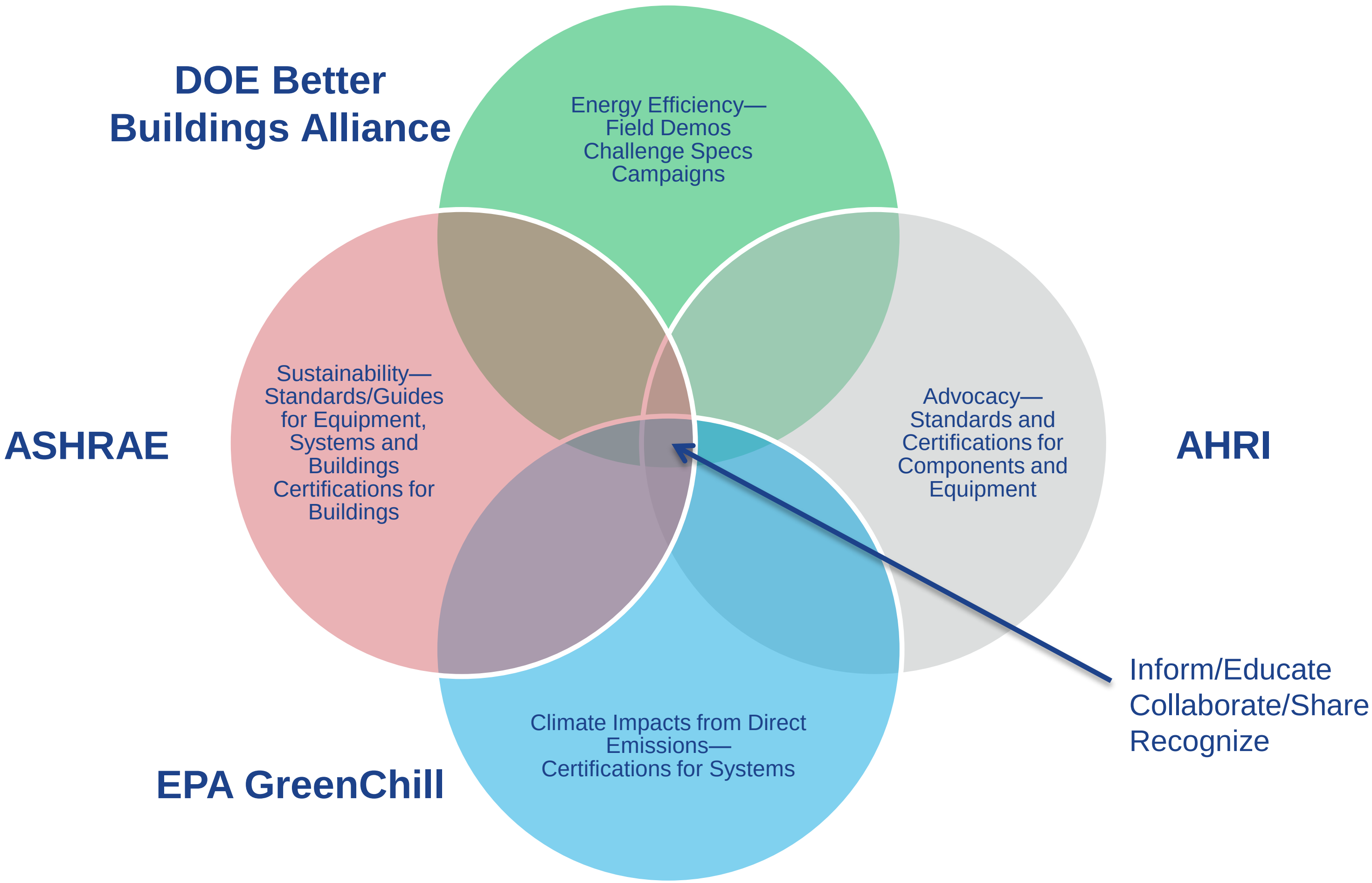
Discuss Possible New Team Activities—Other?

What other activities can this Team tackle to help lower energy use?

- What additional ideas do you have?
- Can this Team effectively address those ideas?

Set Team Goals >> New Approach

Several organizations serve overlapping roles, but none serve all roles.



Set Team Goals >> New Approach

Should our goals address supporting activities only, or actual energy savings?

- ***Past/Current Approach:***
  - We perform activities to support Team members as they pursue the goals set by their respective organizations
  - Each member organization tracks its own progress—no report back to the Team
  - Team sets goals based on completing supporting activities—no direct linkage to actual energy savings
- ***Potential New Approach for Discussion:***
  - Set goals as a Team
  - Report progress to the Team
  - Team sets goals directly linked to actual energy savings
- What advantages/disadvantages do you see?
- Would your company support this potential new approach?

Measure Success

DOE encourages us to focus on measuring success.

- Possible Metrics based on our Current Approach:
  - Testimonials
  - Added energy-efficient features, measured reductions in energy consumption

- Possible Metrics based on a New Approach:
  - Measure, collect, and report results (by Team member and/or collectively for the entire Team)
  - Metered field energy consumption (energy consumption per unit of refrigeration capacity, energy consumption per unit volume of display case; energy consumption per unit display area, other?)
  - Feet (or fraction) of display cases retrofitted
  - Store consumption per unit floor area

Wrap Up Day 1

We will review today's decisions and action items at tomorrow's meeting.

- Recap decisions, including new Team activities
- Recap action Items

R290 (Propane)
In Micro-Distributed Systems

Presentation By:

Tobey Fowler, CEM
Energy Engineer

Presentation For:

The DoE Energy Efficiency Forum,
Event Hosted by BBA,
Session Facilitated by Navigant

Outline

- Safety & Risk Analysis
- Why R290 [is allowed]
- Field Test [with HEB]
- Compliance [with Gov’t]
- Applications
- Summary: What this all means to the Customer

Safety & Risk Analysis

- **Need for proper labeling**
- **Awareness of flammability**
  - leak AND oxygen present AND within LFL/UFL AND ignition source
- **Qualified technicians**
  - experienced with flammable/compressed gases
  - familiar with equipment specific to the architecture
- **Follow manufacturers safety guidelines**
- **Abide by Federal, State, & Local regulations**

Why R290?

- **Natural refrigerant**
  - Ozone Depletion Potential (ODP) = 0
  - Global Warming Potential (GWP) = 3 (R404A = 3,922 … R407A = 2,107)
- **Reduced energy consumption** (Appendix I)
  - regulations force smaller circuits
  - more efficient working fluid
- **Non-toxic**
- **Lower operating pressures** (Appendix III)

Field Test

- **Hussmann partnered with HEB**
- **HEB is not sharing monitored data at the moment**
- **Hussmann cases:**
  - 52 MT cases – multi-deck cases
  - 47 LT cases – islands & reach-ins
  - 17 specialty cases
- **< 150 lbs of refrigerant**
- **~330 compressors**
- **HEB has published Information…**

Compliance

- **EPA's SNAP** [Significant New Alternatives Policy]
- **DoE** [energy consumption (kWh/day) by equipment classification]
- **UL 471** [standard for commercial refrigerators & freezers]

Applications

- **Medium Temp**
  - dairy, deli, bakery, meat, & seafood
- **Low Temp**
  - reach-ins, & coffins

- **All major applications typically seen in retail**

Summary

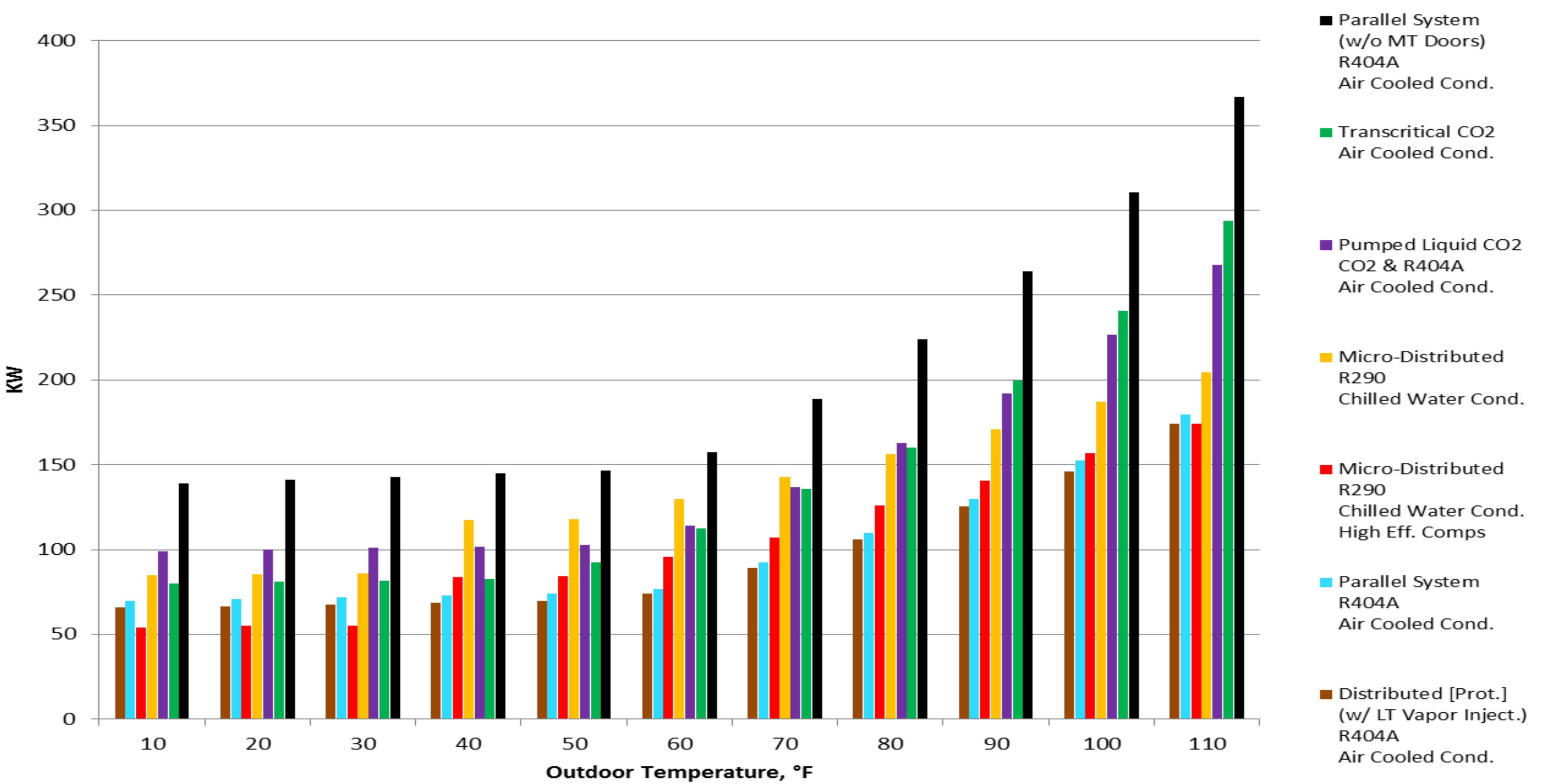
- **Peace-of-Mind for Owners & Managers**
  - reduced operating costs
  - focus on core competency
- **Peace-of-Mind for Facility Directors & Maintenance Staff**
  - hermetically sealed for reduced maintenance & minimal leaks
- **Ease-of-use**
  - quick-connect condensing units
  - shorter setup times
  - local controls
- **Lower energy consumption compared to other ‘Low GWP’ alternatives**

Tobey Fowler, CEM
Energy Engineer
314.298.6218

Last Updated
4/29/2012

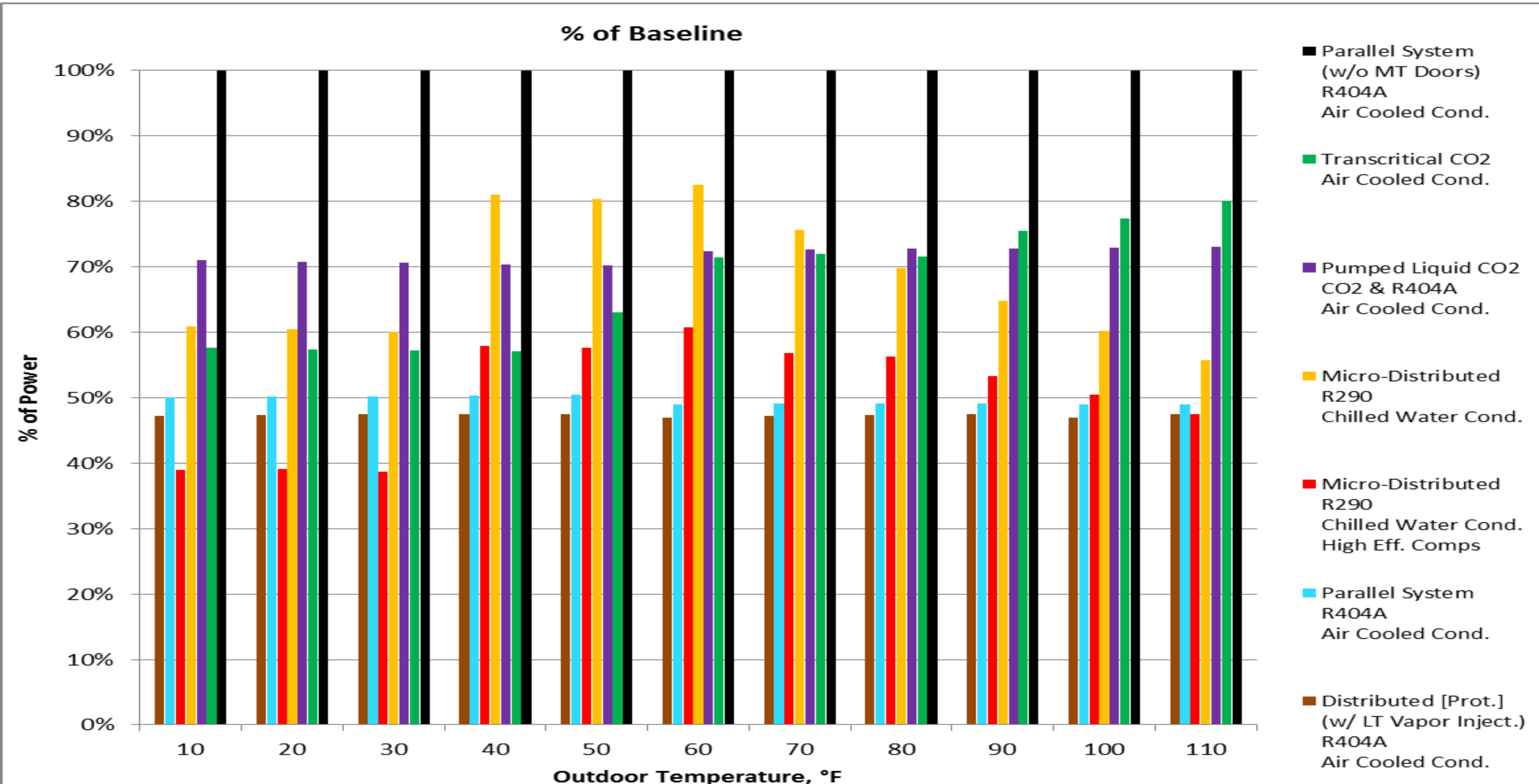
Appendix I.a

Energy Modeling



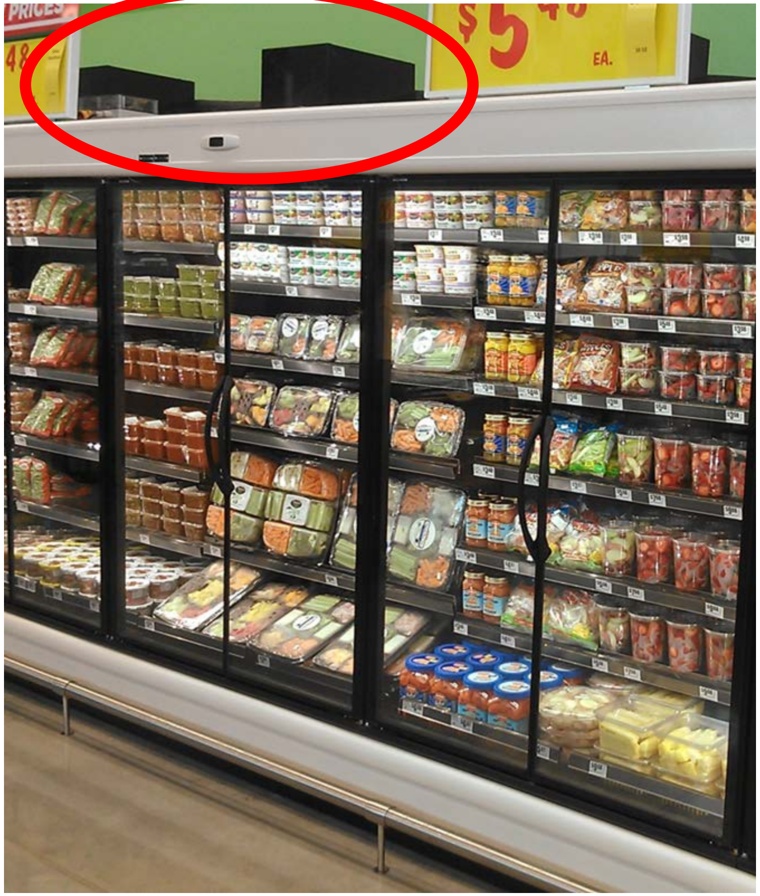
Appendix I.b

Energy Modeling



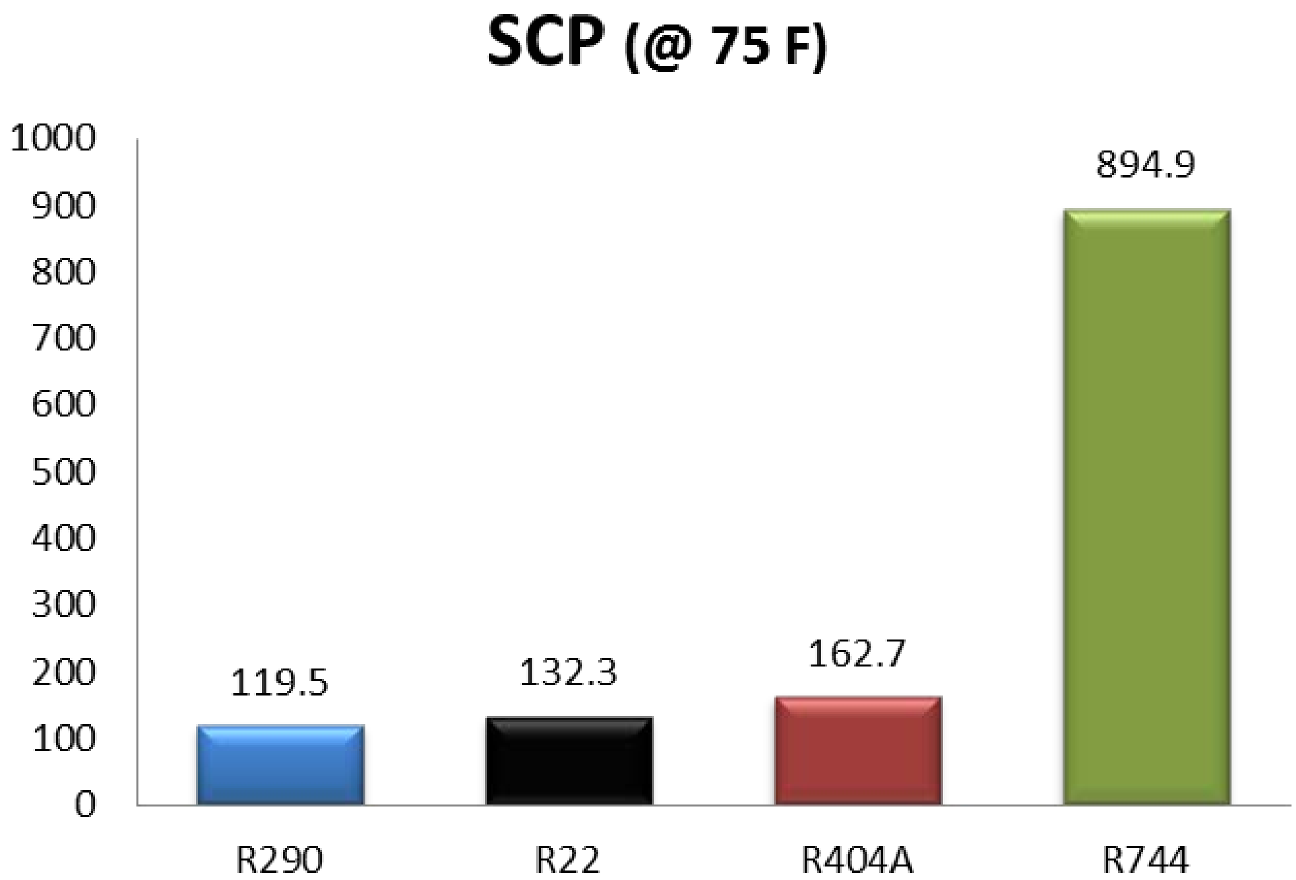
Appendix II

Condensing Unit Location



Appendix III

Operating Pressures



Appendix IV

References

http://www.epa.gov/greenchill/downloads/Refrigerant%20Updates.pdf

http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf

http://ulstandardsinfonet.ul.com/scopes/0471.html

Appendix V

Relative References

< 4 Grams

> 400 Grams