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CASE STUDY

ULTRA-LOW CHARGE NH_3/CO_2 CASCADE SYSTEM IN A RETAIL ENVIRONMENT

KEITH MILLIGAN
JTM Corporation
Piggly Wiggly

MASOOD ALI
Alternative Systems Center of Excellence
Heatcraft Worldwide Refrigeration

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Piggly Wiggly : JTM Corporation

Piggly Wiggly Nationwide

- America's first self-service true grocery store founded in 1916
- Over 600 Piggly Wiggly stores serving communities in 17 states

Piggly Wiggly : JTM Corp

- JTM Corporation founded in 1966
- Third generation family business
- 19 stores and 9 neighborhood shopping centers

U.S. ENVIRONMENTAL PROTECTION AGENCY
GREENCHILL
ADVANCED REFRIGERATION PARTNERSHIP

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Drivers for Energy Efficiency Store Design

- Change in competitive landscape
  - Small format stores
- Razor thin margins for grocery business
  - Need to reduce operating cost
- Anticipating regulatory pressures
  - Ban of high GWP refrigerants by EPA SNAP and continuing actions
  - GWP limit of 150 proposed by California Air Resources Board
- Increasing cost of synthetic refrigerants
  - R-22 price increase from $50 to $300 per cylinder

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Collaboration

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THE NAME BEHIND THE BRANDS YOU TRUST ™

+

piggly wiggly®

Down Home, Down The Street

→ **New State-of-the-Art Refrigeration System** →

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Design Features of High Efficiency Store

Use of Natural Refrigerants

- NH_3 and CO_2 (GWP 1)

Reduced Refrigeration Energy

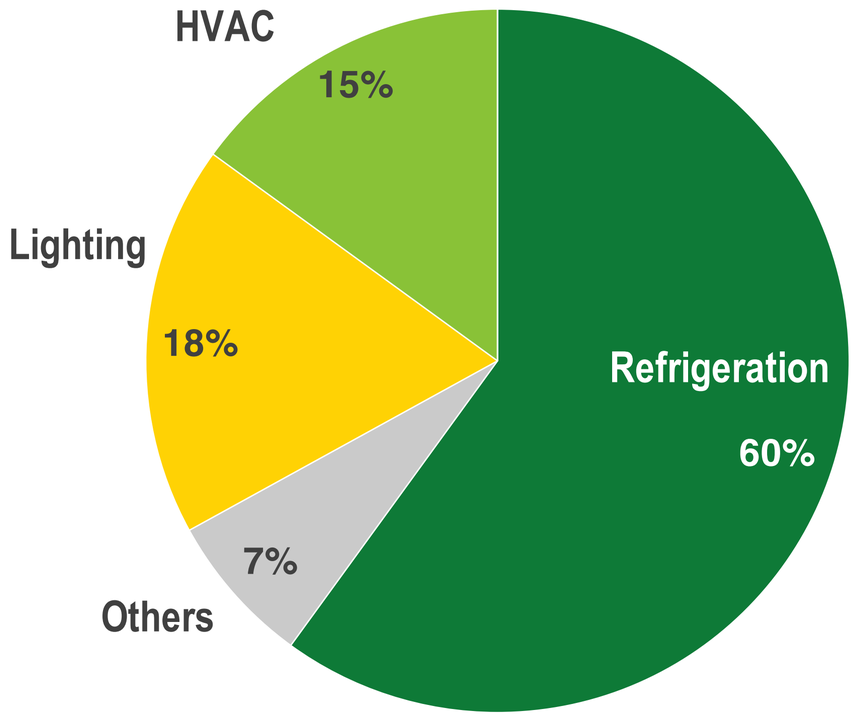
- High efficiency NH_3/CO_2 cascade refrigeration system
- Evaporative condenser, Heat Reclaim
- Advanced Integrated controls: VFDs, floating condensing etc.
- High efficiency STRATUS display cases
  - Electronic expansion valves (EEVs)
  - Doors on open display cases / Night curtains / EC motors/ Case LED lights

Reduced Lighting Energy

- LED lights
- Reduced lighting power density and skylights
- Occupancy and daylight controls

Reduced HVAC Energy

- High-efficiency Lennox rooftop units
- External Dryvit insulation and white roof (reduced gains)



Annual Electricity Consumption – Typical Supermarket

Reference: Energy Savings Potential and R&D Opportunities for Commercial Refrigeration by Navigant Consulting for U.S. Department of Energy

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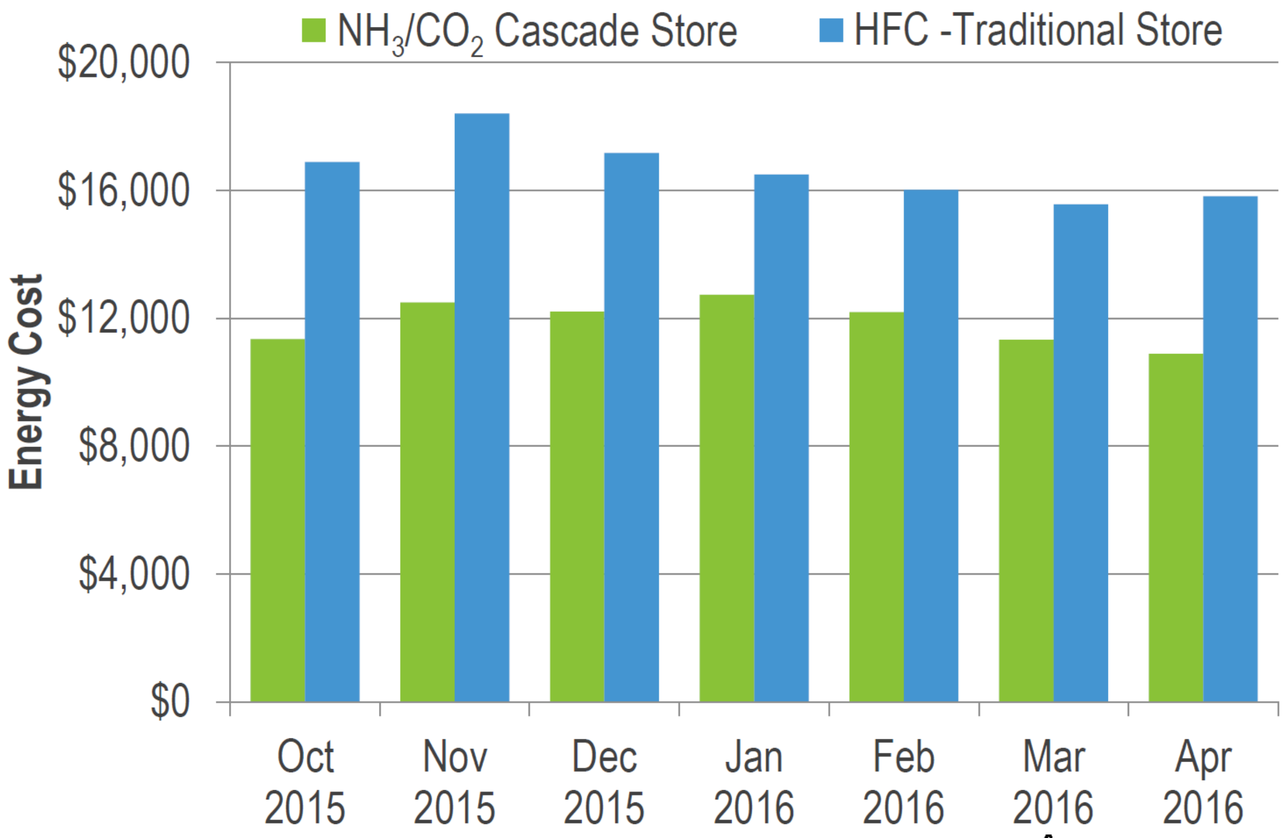
Energy Savings : High Efficiency vs Traditional

Actual Data from Energy Bills*



GEORGIA POWER
A SOUTHERN COMPANY

Customer Name
J T M CORPORATION

Energy Savings
23 to 33%

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*Traditional HFC store data normalized for store size

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Energy Savings : High Efficiency vs Traditional Store

Cumulative Savings to Date

$33,170

Approx. 28.5 %

Projected Annual Energy Savings

$55,000-65,000

ACTUAL SAVINGS FOR FULL YEAR WILL BE PRESENTED IN 2017

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Ultra Low Charge NH_3/CO_2 Refrigeration System

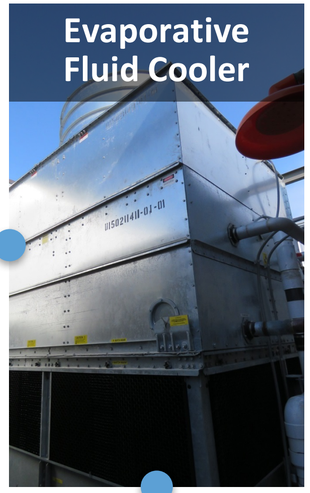
Rooftop

Store Backroom

Glycol Loop

Refrigeration Capacity : 70 Tons

Ammonia Charge @ 0.75lb/TR

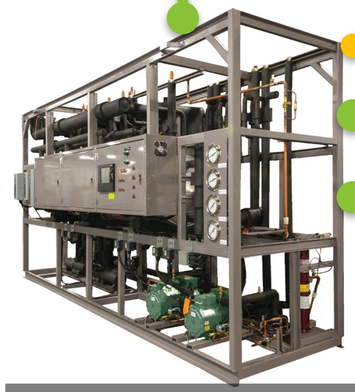


Design Conformance

- IIAR 2
- IBC
- IMC
- IFC
- EPA
- SNAP
- ASHRAE 15

Heat exchange (duplicate top sides)

Glycol Loop



Low Temp CO_2 DX

Medium Temp CO_2 LOF

Duplicate Top Sides

- Allows for unparalleled comparison
- Eliminates ambient and store differences

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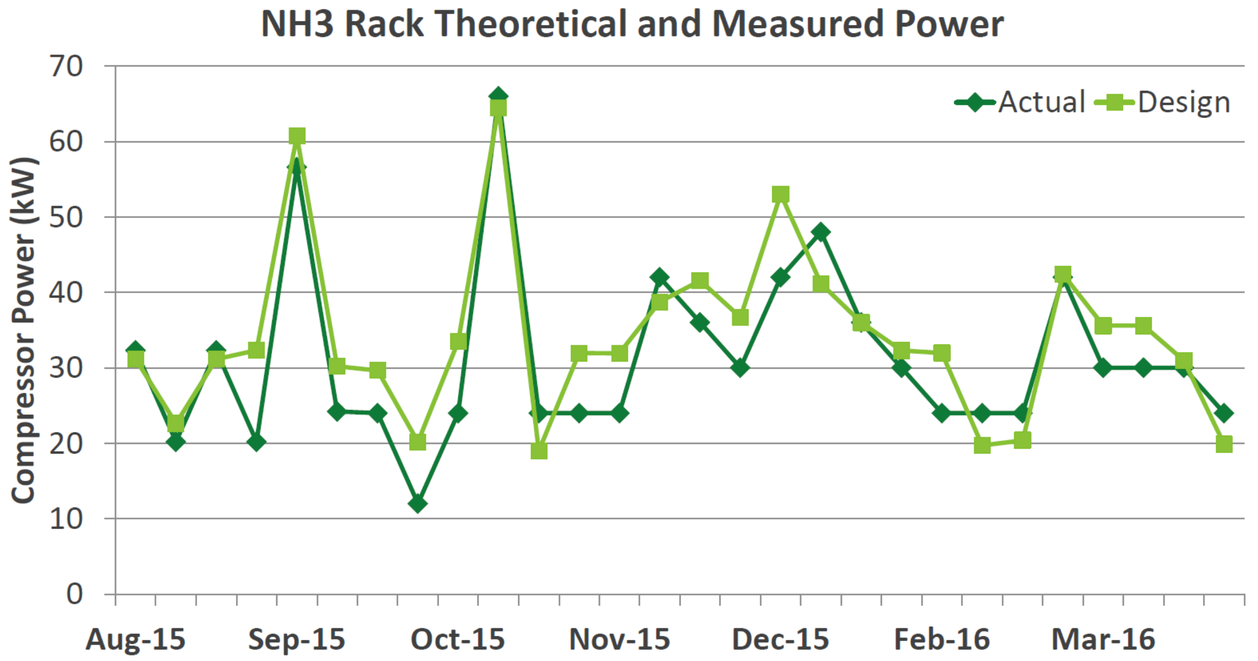
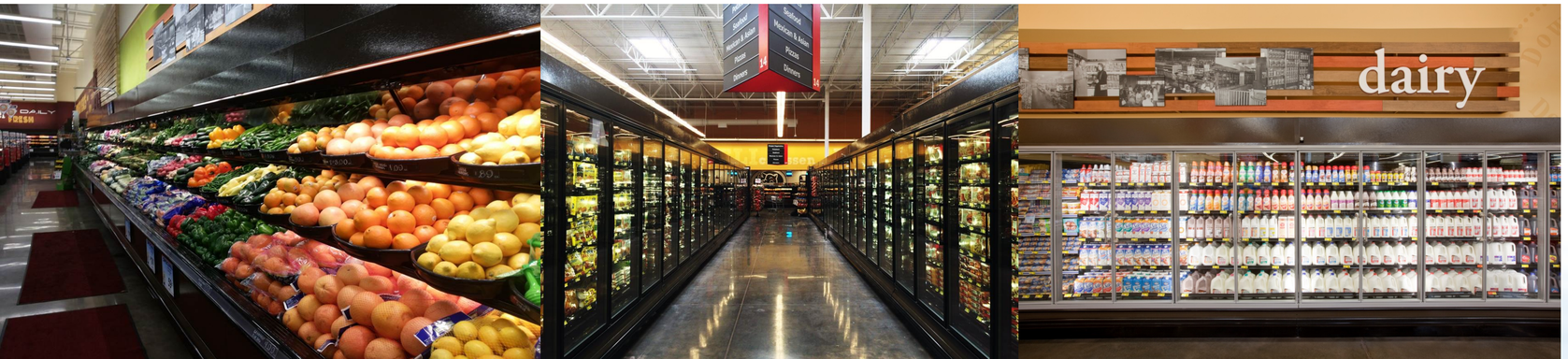
NH_3 Design Validation

- ✓ Critical safety testing
- ✓ Design criteria
- ✓ Functional performance
- ✓ Preliminary energy efficiency
- ✓ Initial serviceability



Computed theoretical compressor power and measured compressor power in agreement



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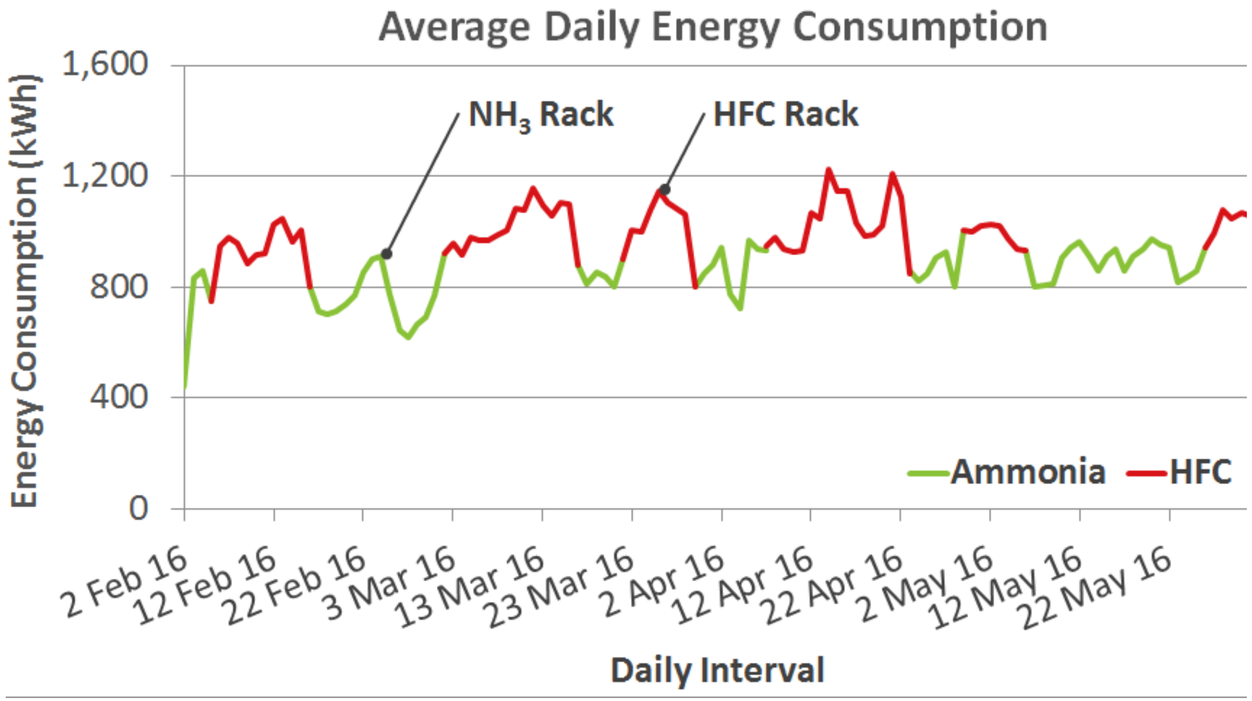
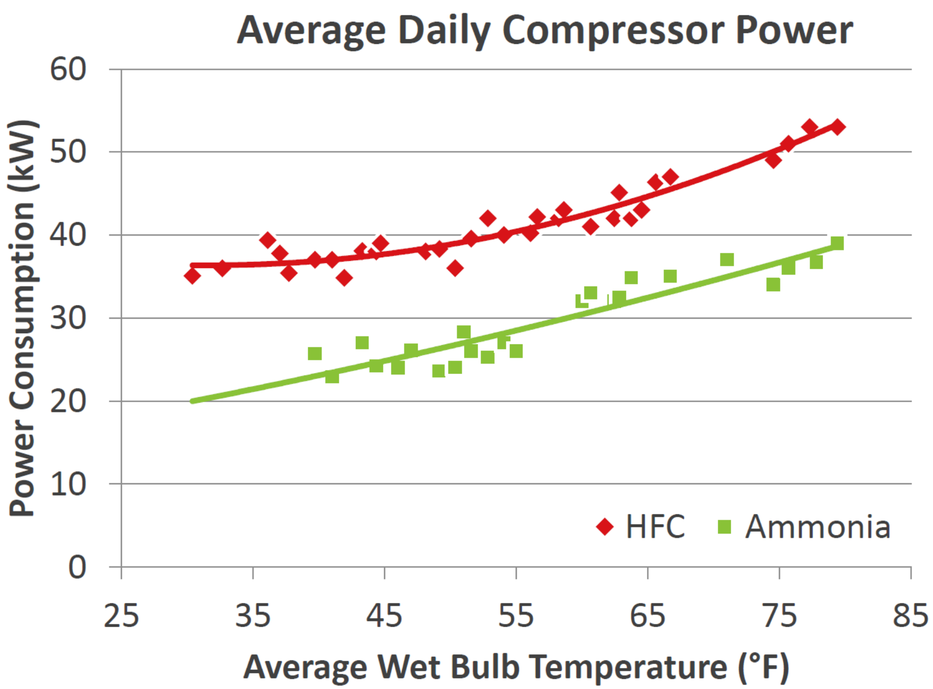
Same Store Comparison: NH_3 vs. HFC





Top cycle alternated for one to two weeks between NH_3 and HFC racks for the past four months

AVERAGE RACK ENERGY SAVINGS: 22% *

*Ambient dependent : varies 18 to 25%

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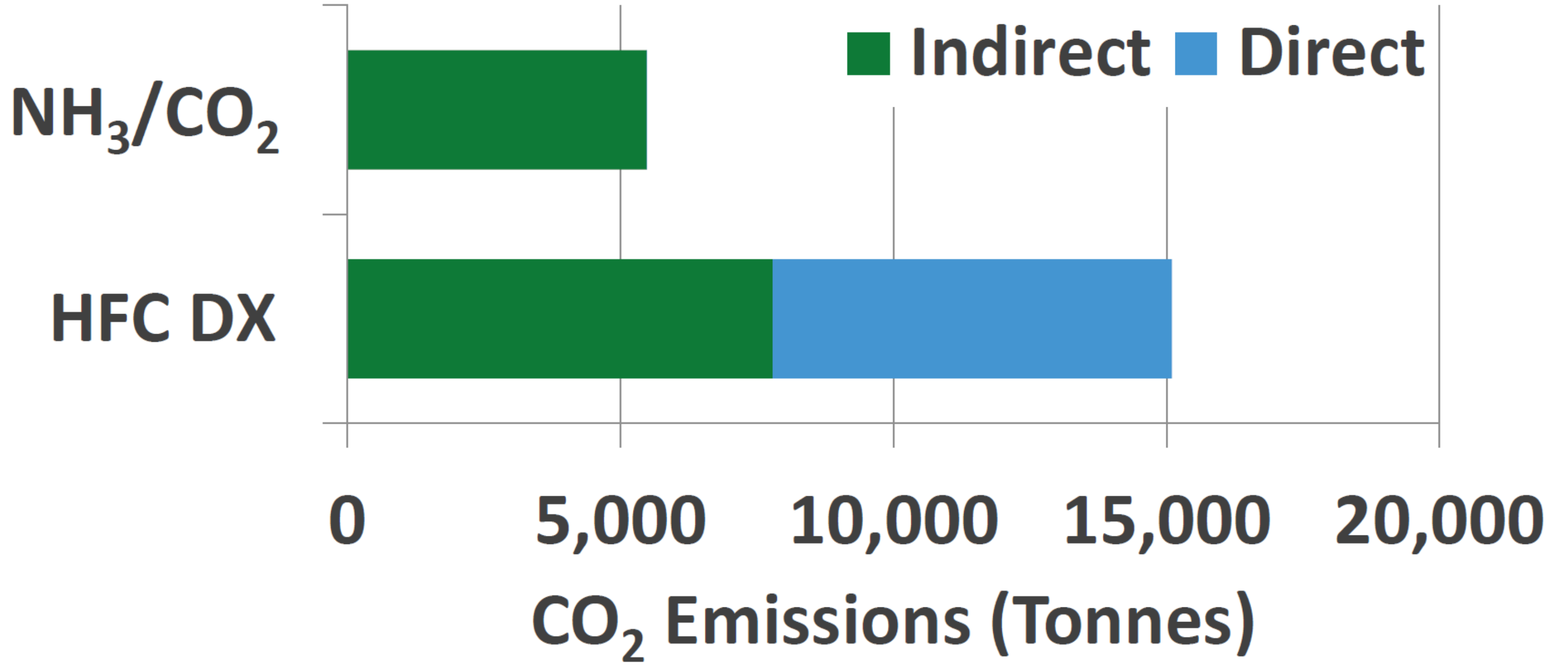
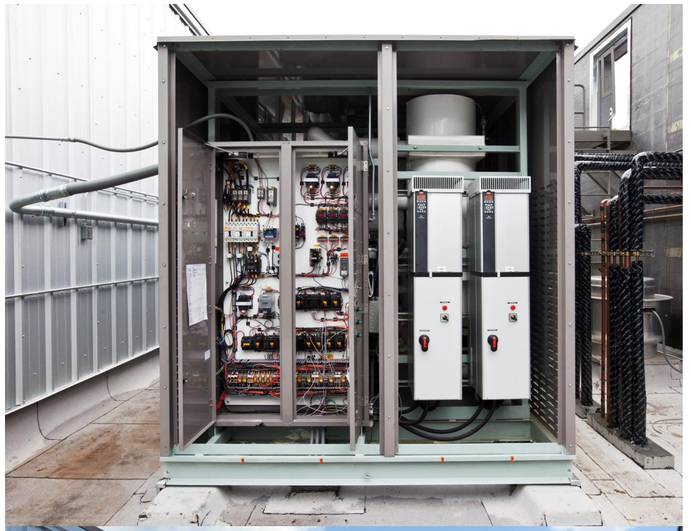
Life Cycle Climate Performance (LCCP)





Direct LCCP Reduction: 99%
Total LCCP Reduction: 64%
EPA GreenChill Platinum Certification

Assumptions: refrigeration load 535 KW, 15 year life, emission factor 0.75 lb CO_2/kWh, end-of-life recovery 0.75, leak rate 15%, location San Diego, CA

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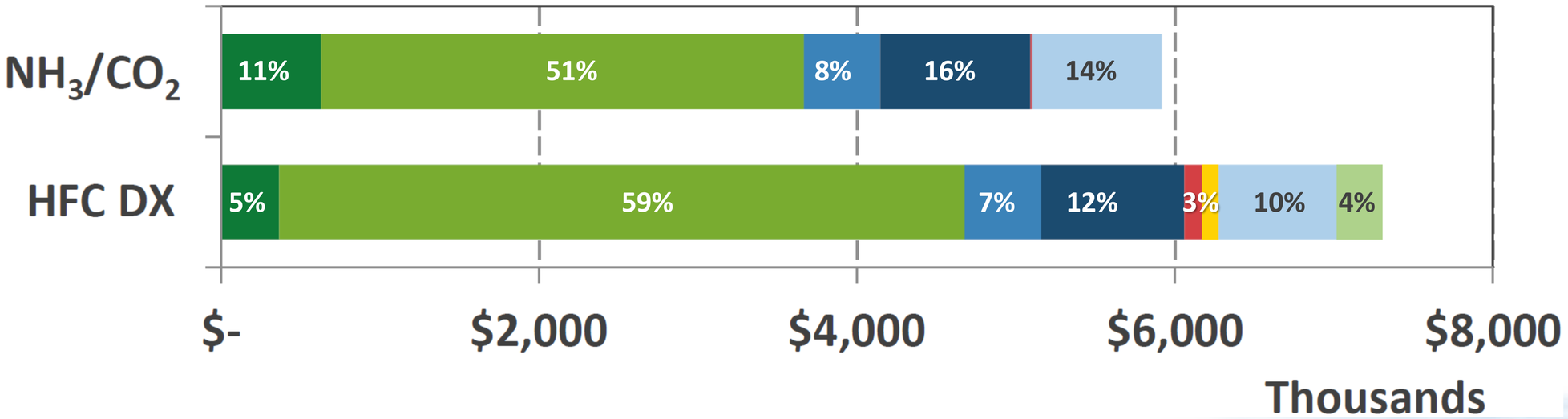
Total Cost of Ownership – San Diego, CA

	Global Warming Impact	Energy Cost	First Cost	Maintenance Cost	Total Cost of Ownership
Traditional HFC	-	- BASELINE		-	-
NH_3/CO_2 Cascade	↓ 99%	↓ 15-23%	↑ 50-70 %	↑ 0-5%	↓ 15-20%



Assumptions: refrigeration load 535 KW; 15 year life; energy costs ($/kWh) - 0.15 (0-5y), 0.18 (6-10y), 0.26 (11-15y); refrigerant cost $10/lb; leak rate 15%

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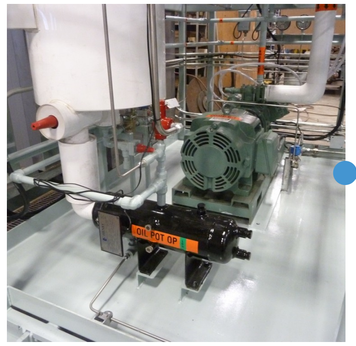
NH_3 Design Highlights



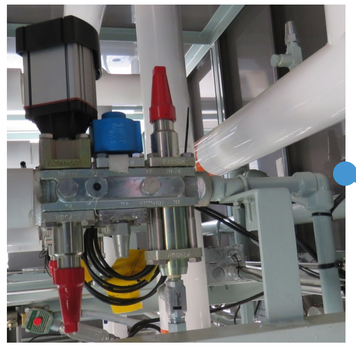
Diffusion Tank
No NH_3 discharge to ambient

Automatic
Oil Recovery

Conventional
Supermarket Controls

Open Drive
Reciprocal Compressors

Variable
Frequency Drive



Seal Cap on All Valves
Minimize NH_3 leakage

Electronic Stepper
Motor Control

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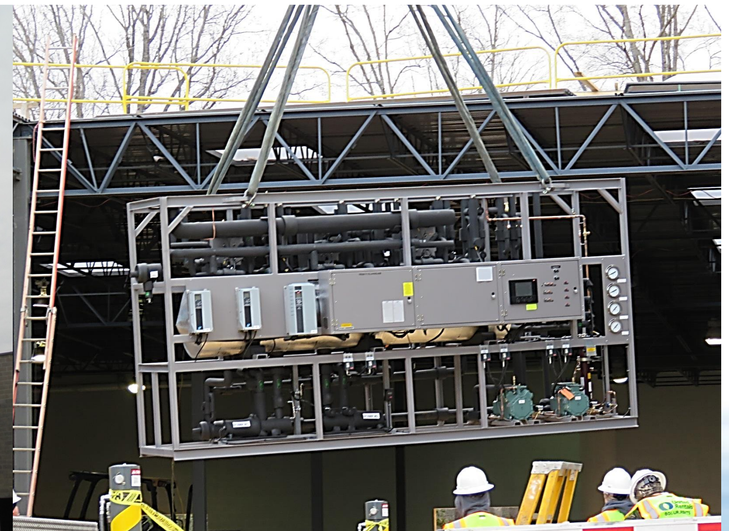
Commissioning and Serviceability

Training of Installation Contractor / Local Service Technicians

- Ammonia rack charging & startup
- Ammonia pump down & charge recovery
- Replacement of coalescing filter element in oil separator, other strainers
- Oil charging & system oil balancing and monitoring
- Replacement of oil regulator float, check valves , liquid level sensors etc.

Firsts for Installing Contractor
- New store installation
- NH_3/CO_2 cascade system



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Lessons Learned and Key Takeaways

- Proper piping design techniques for flow balancing to cascade evaporators and thermosyphon carrying CO_2 vapor
- Downsized specifications of oil filter element to prevent clogging
- Oil Management: Refined design criteria for separator efficiency vs. OCR
  - Replaced with high capacity coalescing filter media
- Lack of synchronized defrost termination from case controller in case lineup
- Excessive pressure drop in heat reclaim control valve

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Heatcraft Kysor/Warren

ASCOE: Alternative Systems Center of Excellence
R&D: Research and Development
LITC: Lennox India Technology Centre
WWR: Worldwide Refrigeration

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