



**natural refrigerants**

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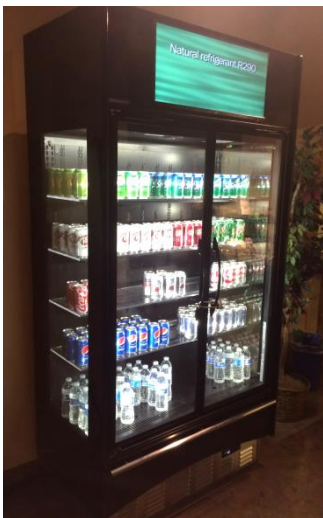
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# Advances in Refrigeration Utilizing Natural Refrigerants

*Scott Martin – Director of Sustainable Technologies  
Hillphoenix*

# Natural Refrigerant Applications

*Hydrocarbon – Point of Sale / Self-contained Display Cases*



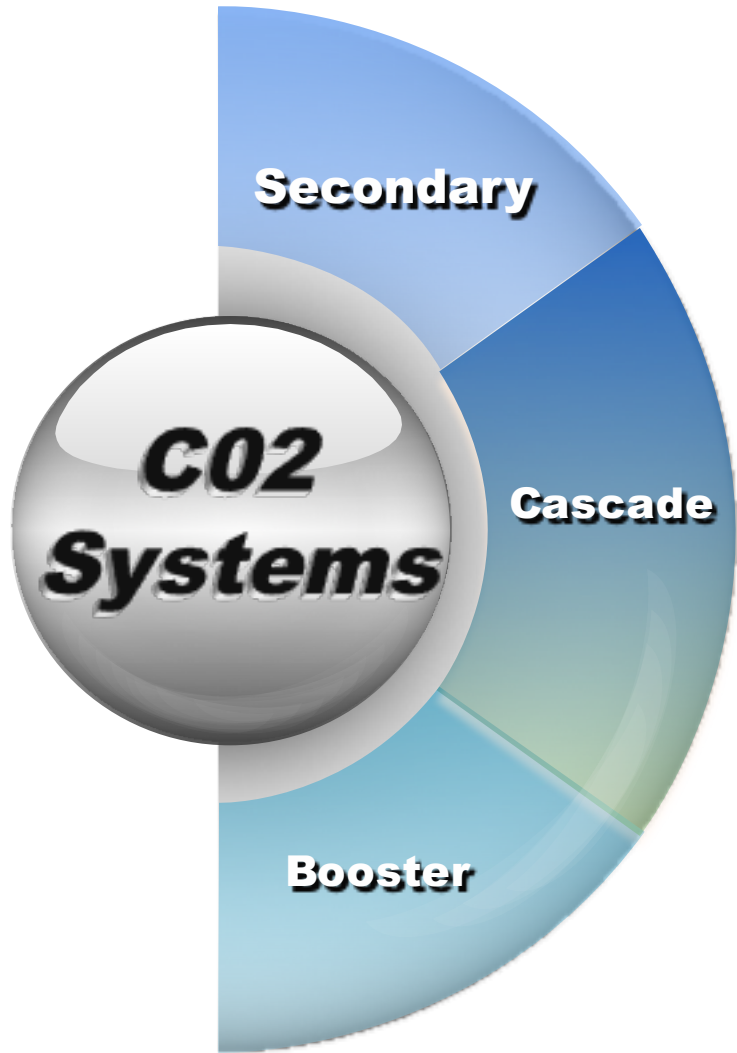
*Carbon Dioxide – Supermarket and Industrial Refrigeration applications*



*Ammonia – Supermarket and Industrial Refrigeration applications*



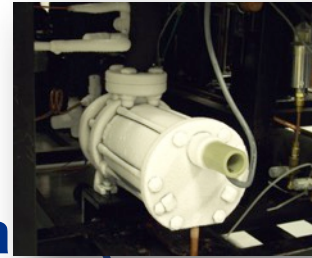
# CO<sub>2</sub> System Evolution for the North American Market



## CO<sub>2</sub> Secondary (pumped) Systems

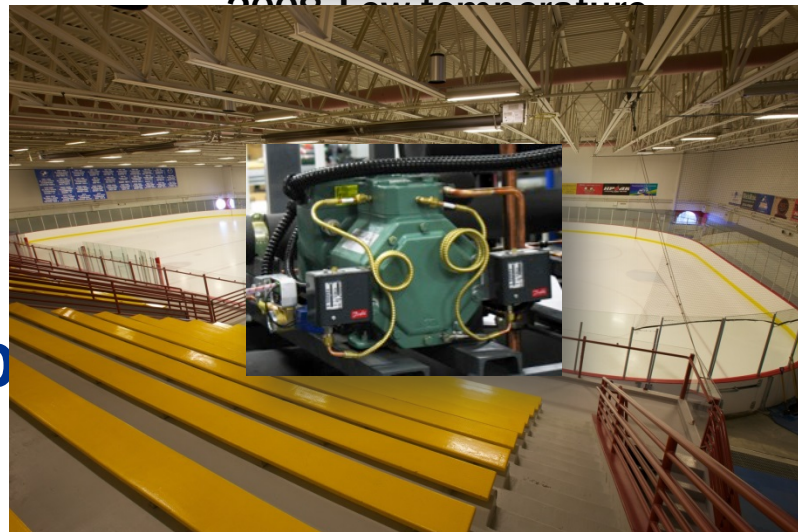
2006 Low temperature, 2010 medium Temperature

Close to 200 Installations in North America



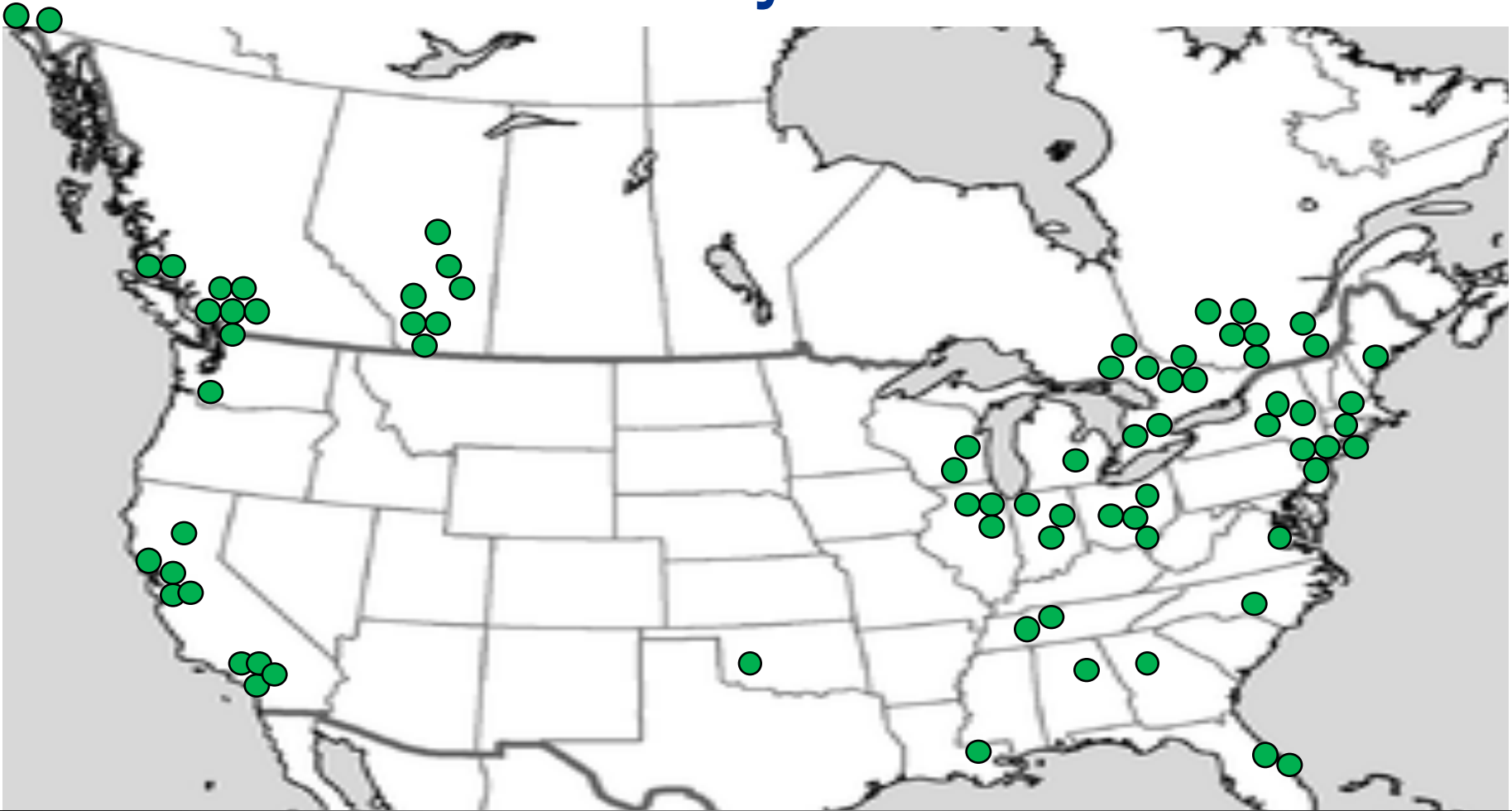
## CO<sub>2</sub> Cascade (and other) Systems

2008 Low temperature



## CO<sub>2</sub> Boosted Systems

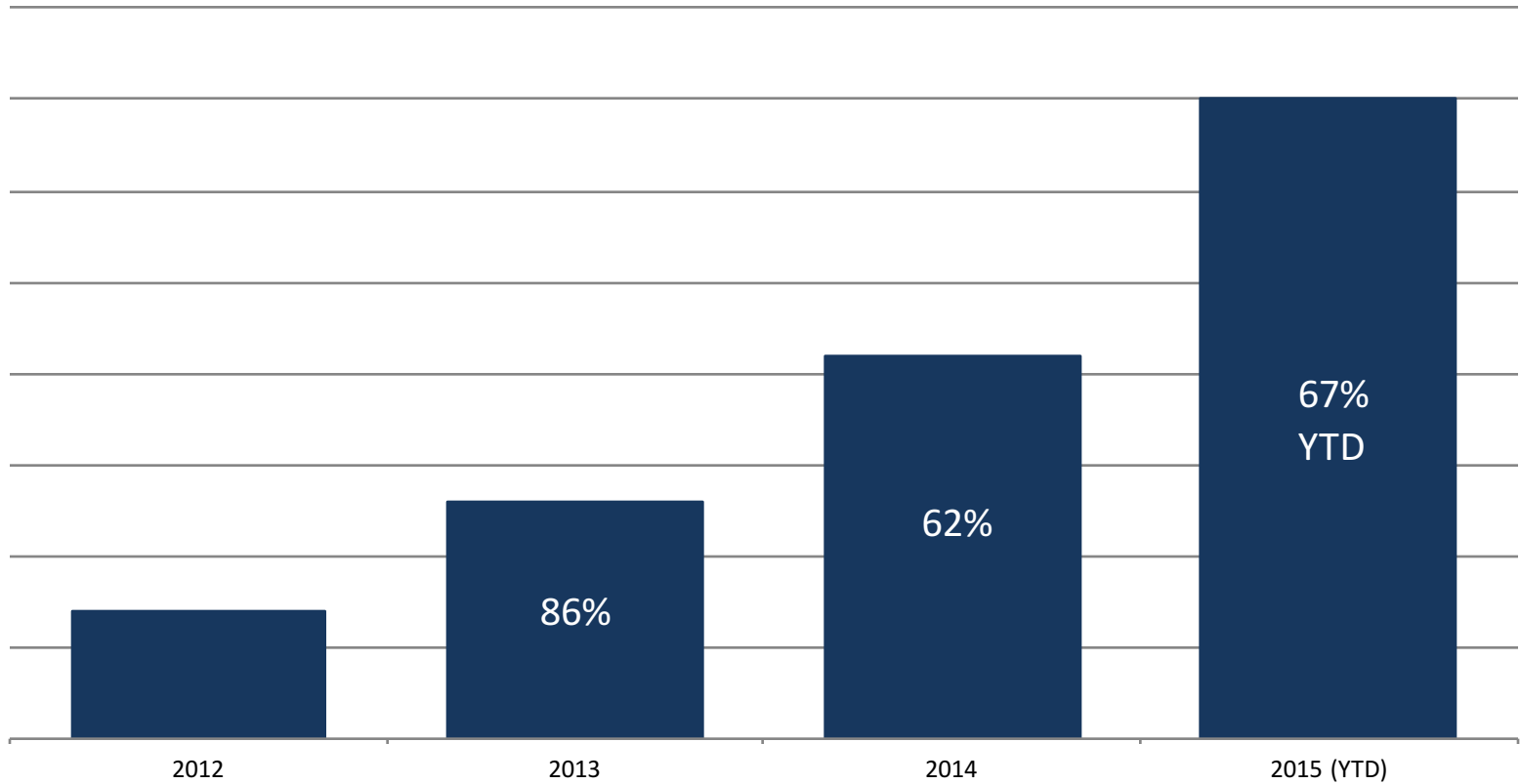
# Growth of CO2 Booster Systems in North America



**Over 75 installations in North America**



# C02 Booster Projects



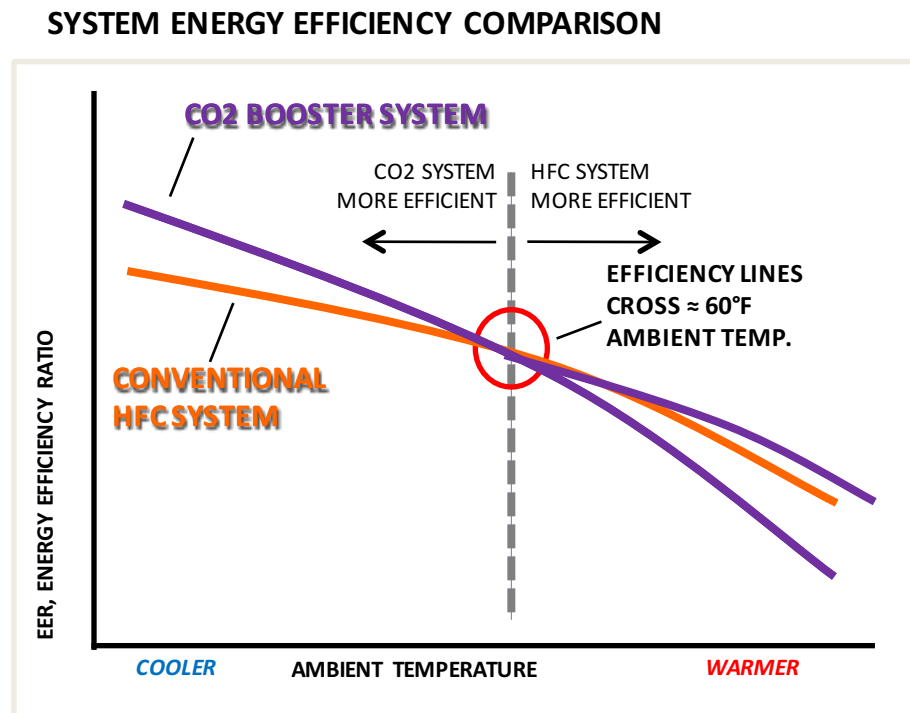
# Challenges / Lessons learned

- *What are the main challenges/opportunities/lessons learned from your projects and future projects*
- *What do you want to tell your partners, policy experts, academia/training – what is necessary to introduce NR on broader scale in North America*

# Challenge 1

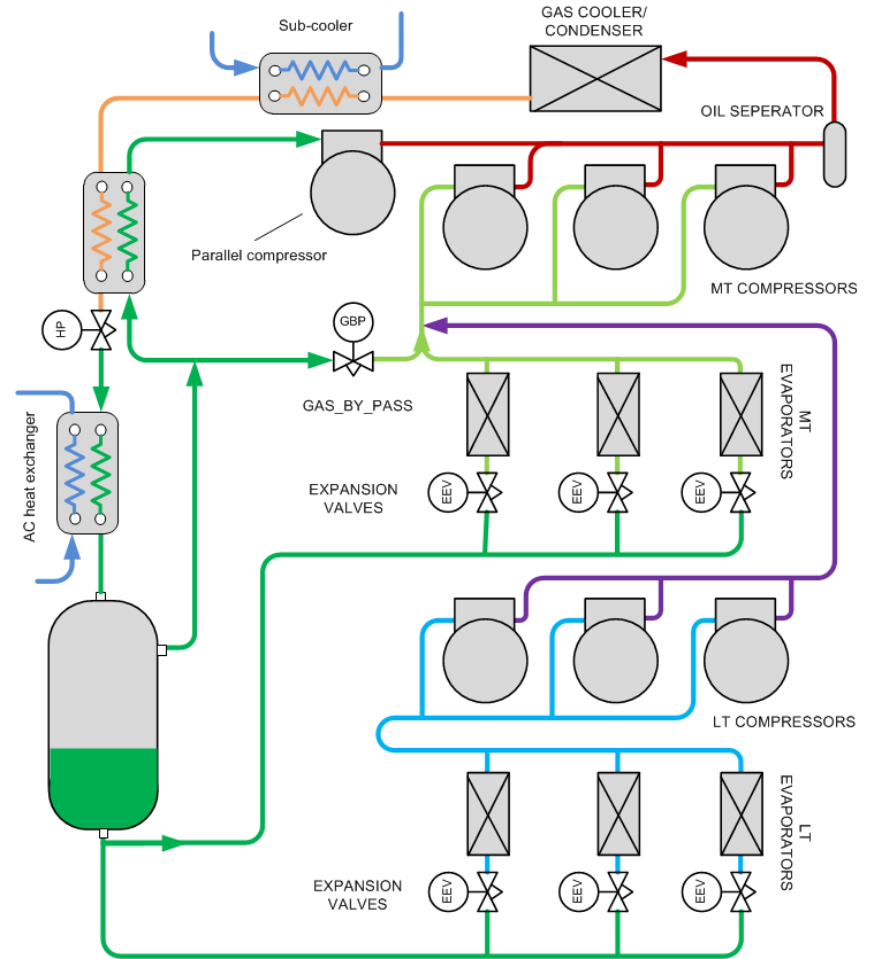
## System Energy Comparison

- CO2 Booster Systems are more efficient than conventional HFC systems in cooler climates, and less efficient in warmer climates
- Efficiency lines of the CO2 and conventional HFC system cross around 60°F

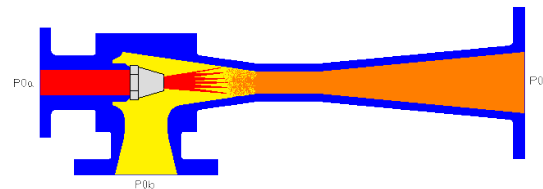


# Future Developments - 2014

- High pressure sub coolers
- Parallel Compression systems
  - Peak savings 12-20%, Annual savings 6-10%
  - Already introduced to the market
- Adiabatic gas coolers
  - Peak savings 20-30+%, Annual savings 10%



- Ejectors
  - Peak savings 15-20%, Annual savings 6-8%
  - Under development

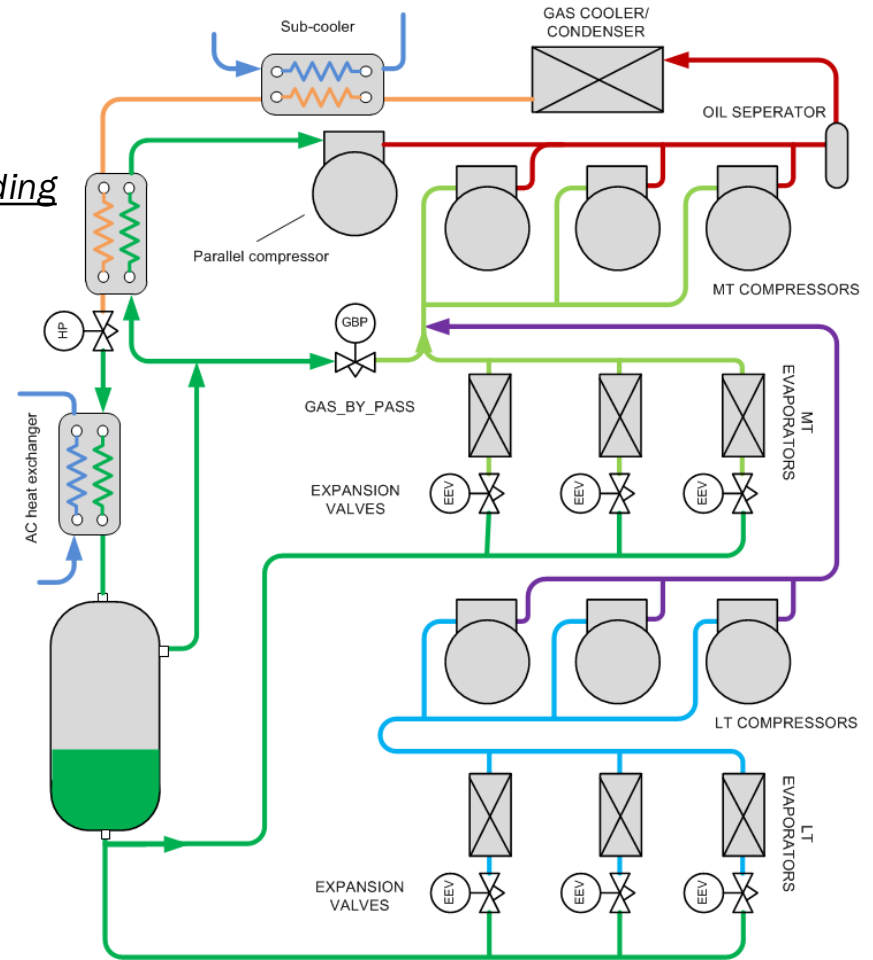




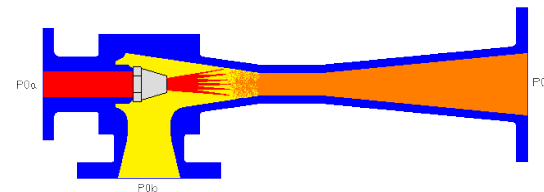
# 2015 Update

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- ✓ High pressure sub coolers
  - Using 45°F Facility Chilled Water – *Patents pending*
  - Peak Savings 20-30%; Annual Savings 6-15+%
- ✓ Parallel Compression systems
  - Peak savings 12-20%, Annual savings 6-10%
  - Already introduced to the market
- ✓ Adiabatic gas coolers
  - Peak savings 20-30+%, Annual savings 10%

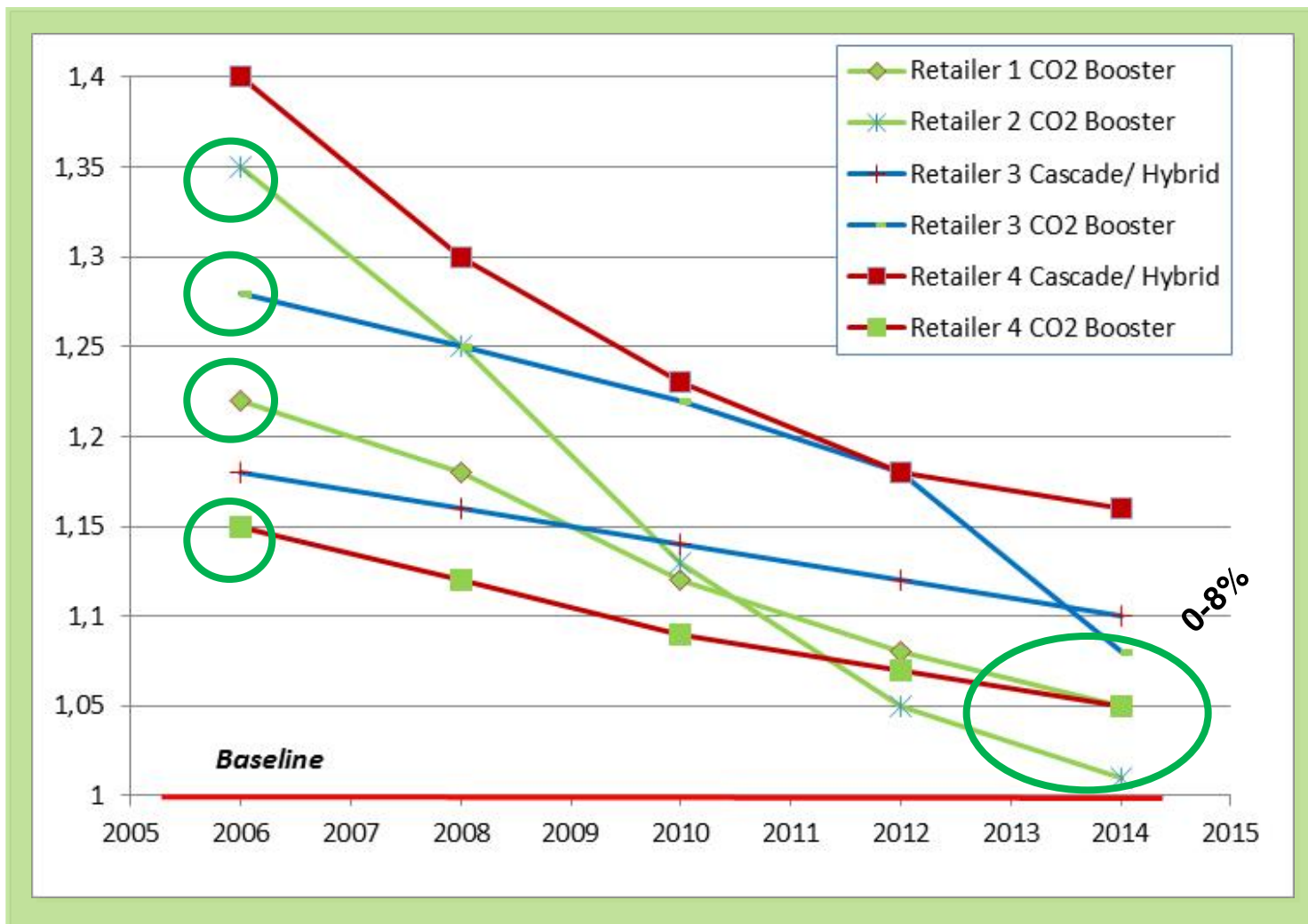


- ✓ Ejectors
  - Peak savings 15-20%, Annual savings 6-8%
  - Under test



# Challenge 2

## Focus on First Cost



# Focus on Total Cost of Ownership

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## New Technology Equipment ROI Summary

Based on a project size of LT 250 BTUH & MT 750 BTUH

ROI Summary	MT HFC DX LT HFC DX	Advansor CO2 Booster	Difference	
Refrigeration Systems cost	xxx,xxx	xxx,xxx	xxx,xxx	
Refrigerated Cases cost	xxx,xxx	xxx,xxx	xxx,xxx	
<b>Capital Cost</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ 198,060</b>	
Initial refrigerant cost	\$ 20,800	\$ 2,250	\$ (18,550)	-89.2%
Refrigeration install cost	\$ 398,486	\$ 298,000	\$ (100,486)	-25.2%
Electrical install cost	\$ 277,388	\$ 248,000	\$ (29,388)	-10.6%
<b>Installation Cost</b>	<b>\$ 696,674</b>	<b>\$ 548,250</b>	<b>\$ (148,424)</b>	<b>-21.3%</b>
Annual Refrigerant cost	\$ 3,188	\$ 275	\$ (2,913)	-91.4%
Annual operating cost	\$ 110,332	\$ 93,477	\$ (16,855)	-15.3%
<b>Annual Totals</b>	<b>\$ 113,520</b>	<b>\$ 93,752</b>	<b>\$ (19,768)</b>	<b>-17.4%</b>

Capital Cost Difference	\$ 198,060
Installation Cost Savings	\$ (148,424)
<b>Balance</b>	<b>\$ 49,636</b>
Annual Maintenance & Operating cost savings	\$ (19,768)
<b>ROI in years</b>	<b>2.5 years</b>

ROI's vary based on what type of benchmarked the design is being compared too.

# **Additional Challenges**

- Regulatory Approvals
- Contractor Training - Engagement



business case

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