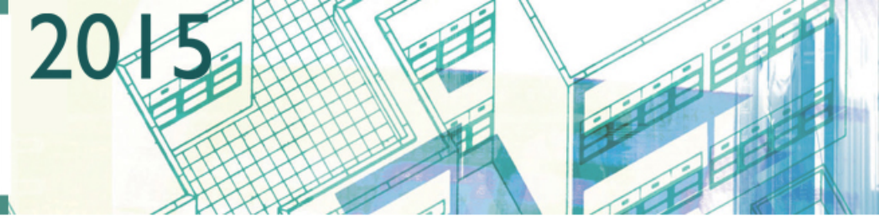
Energy & Store
Development Conference

E+SD 2015

A Provocative Look at the Future of Refrigeration and Store Design

Keilly Witman – KW Refrigerant Management Strategy

Paul Anderson - Target

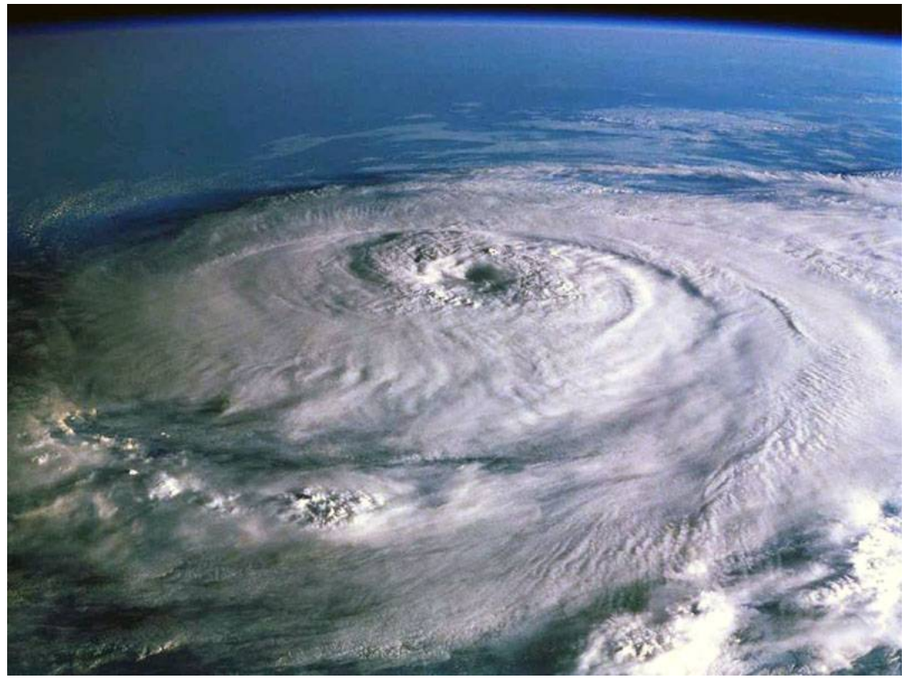


“Predicting rain doesn’t count. Building arks does.”

-Warren Buffet

Perfect Storm of Changes

- Urban population
- Increasing regulatory burden
- Creative merchandising focus
- Energy efficiency balance shift
- Better self-contained solutions
- New refrigerants
- Lack of (qualified) service technicians



Urban Population

- 71.2 % of U.S. lives in 486 urbanized areas*
- Millennials don't need (or want) to own a car
- More frequent smaller trips to walking-distance stores
- Urban stores: require shift in how retailers view property

*2010 US Census

Increasing Regulatory Burden

EPA is expanding Section 608:

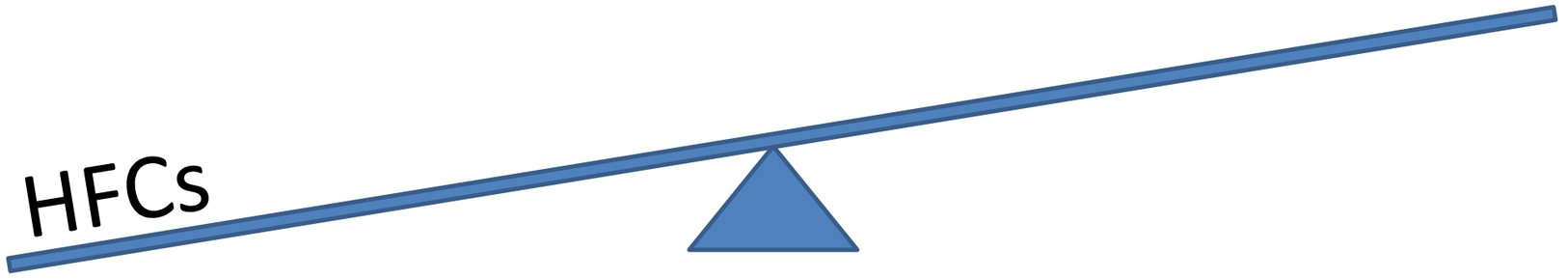
- Leak trigger rate reduction to 20%?
- Expansion to include HFCs?
- Additional leak repair verification procedures?
- Constant phase outs

Imagine stores exempt from Section 608 because every system has less than 50 lbs. of refrigerant!

Increased Focus on Creative Merchandising

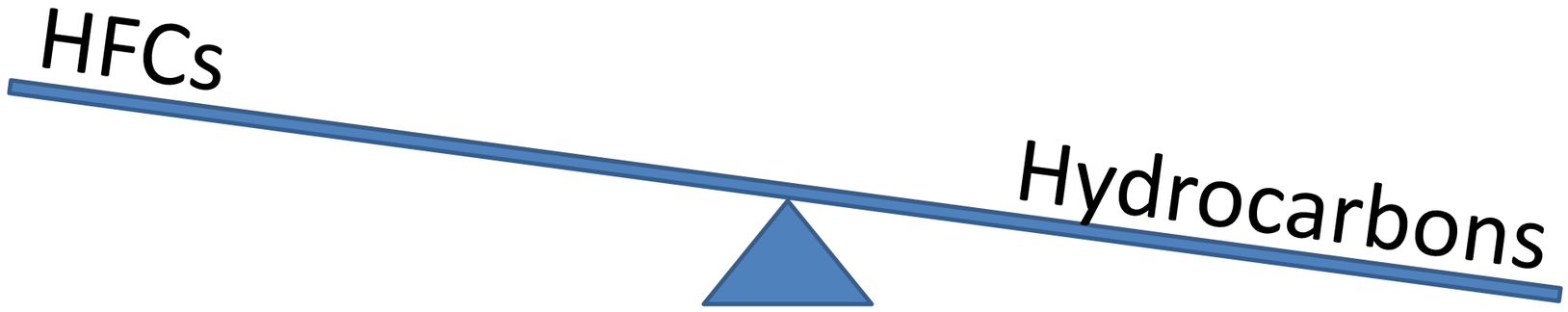
Shift in Energy Efficiency Balance

- Conventional Wisdom: Rack systems with remote cases are more energy efficient than self-contained cases



Shift in Energy Efficiency Balance

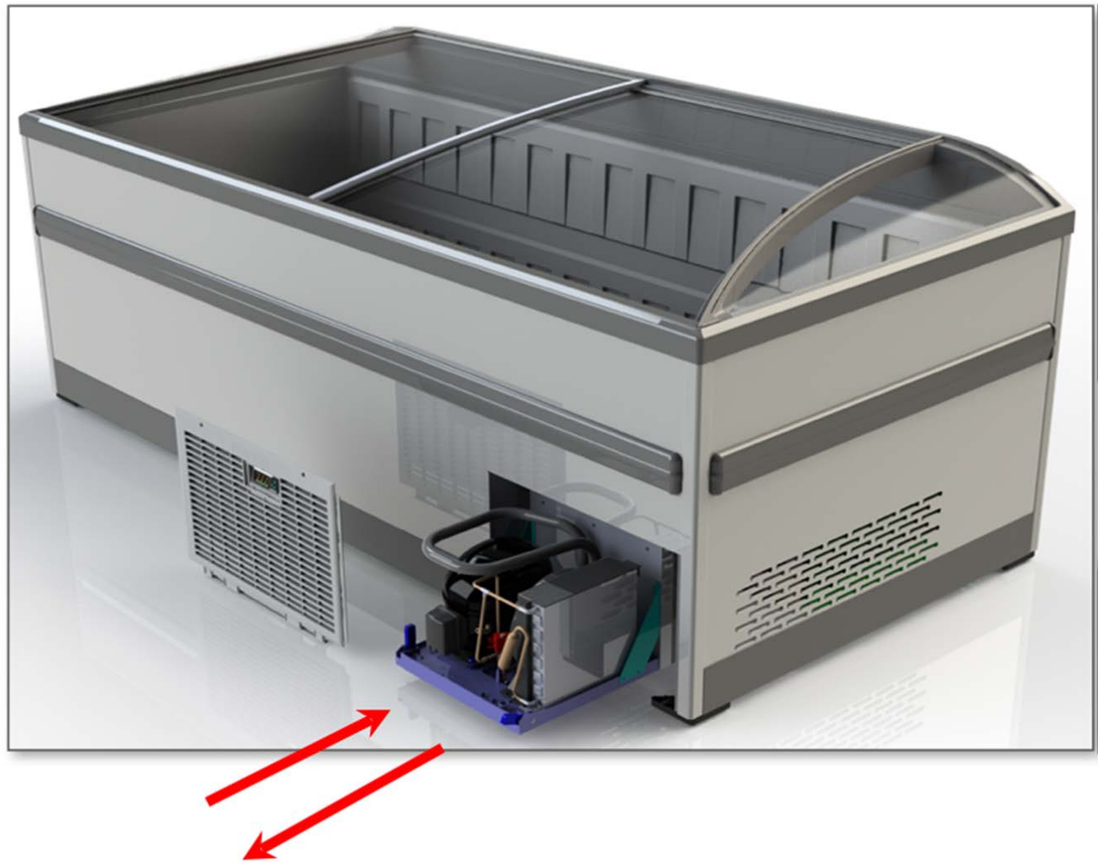
- Conventional Wisdom: Rack systems with remote cases are more energy efficient than self-contained cases
- Technology Disruption: Hydrocarbon-based self-contained units have shifted the energy balance



Better Self-Contained Cases

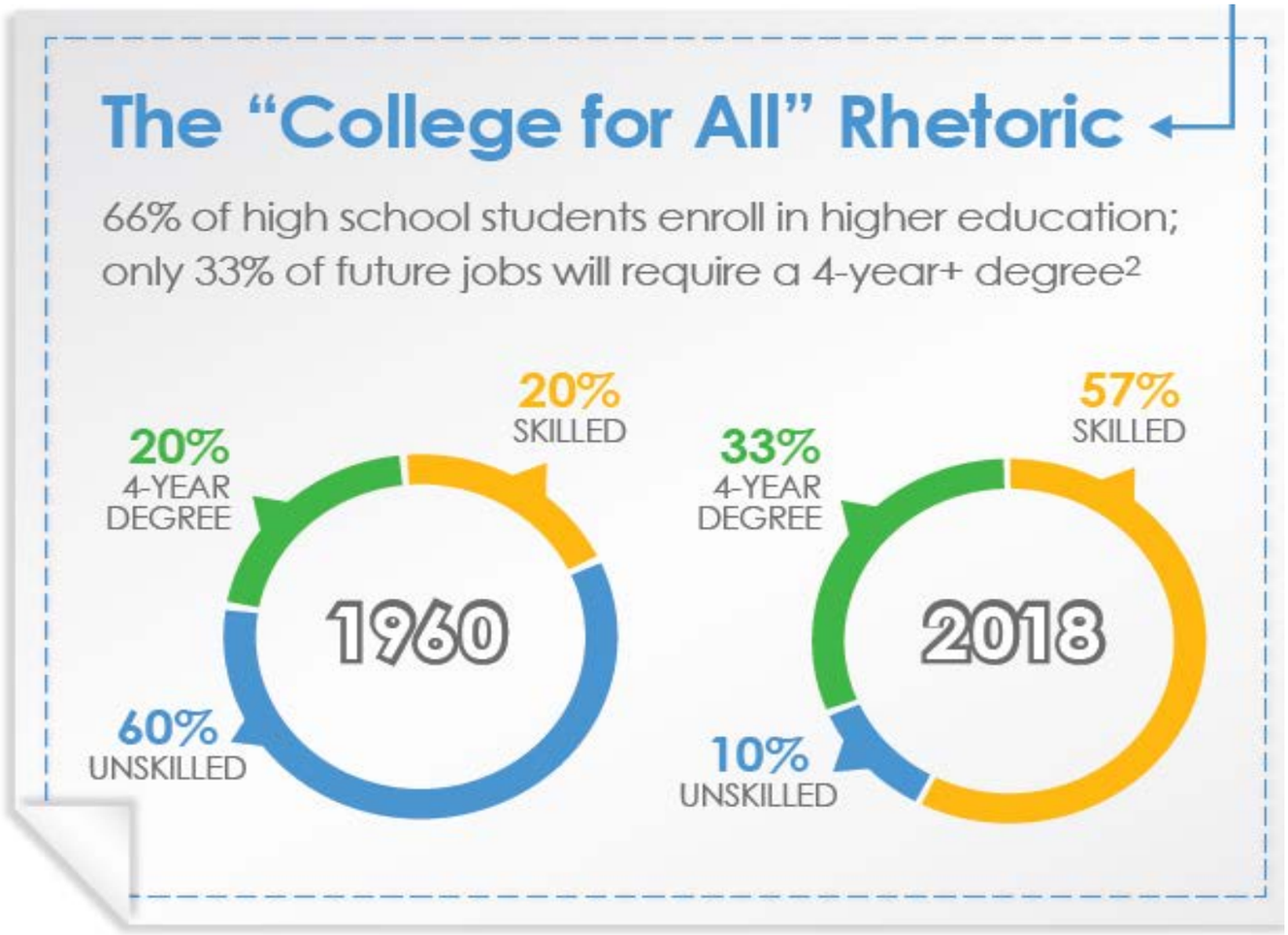
- Quiet - use scroll compressors and other low noise tech
  - Only 2 dB difference between remote and self-contained cases
- Rejected heat used to save energy
  - Reject heat into aisles
  - Reject heat into a water loop
  - Reclaim rejected heat to offset heating bills
- Safety concerns addressed

Solutions for Safety Concerns



Service Technicians

Only 6% of students consider a career in the trades!



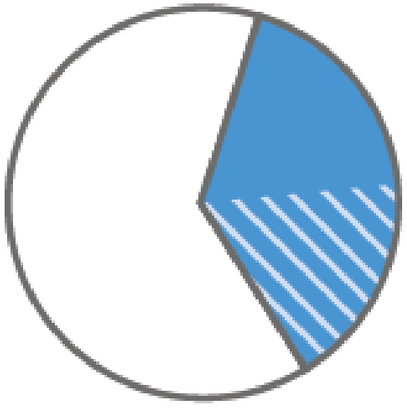
The Alarming Shortage Figures

In 2014, ManpowerGroup spoke to over 37,000 employers in 42 countries to look at the extent to which they are having difficulty finding the right talent and what jobs are most difficult to fill.[3]

Top 3 Jobs Employers Having Difficulty Filling

Skilled Trade Workers | Engineers | Technicians

Difficulty Filling Jobs



36% of all employers report difficulty filling jobs

54% of those experience a medium-to-high impact on their ability to meet the needs of clients

FMI
THE VOICE OF FOOD RETAIL

Energy & Store Development Conference E+SD 2015

Store of Today

Store of the Future

Store of Today

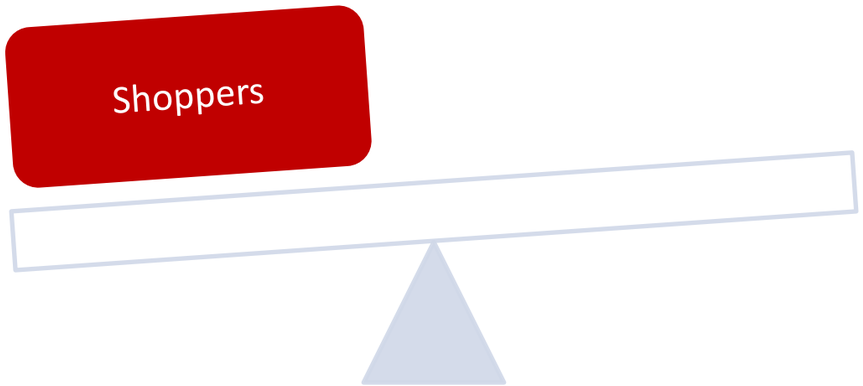
Store of the Future

What's important to:

What's important to:

Desires

Constraints



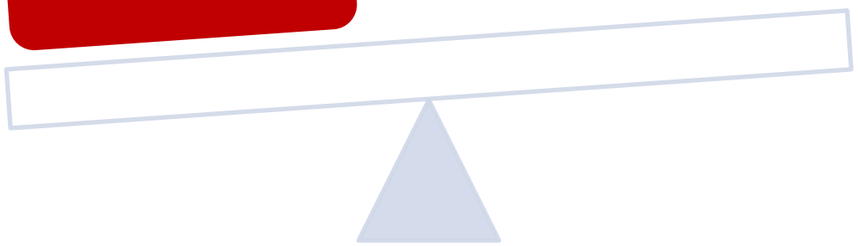
What's important to:

Desires

Constraints

Merchants

Shoppers



What's important to:

Desires

Constraints

- Store Planners
- Merchants
- Shoppers

What's important to:

Desires

Constraints

Store Planners

Merchants

Shoppers

Regulatory Agencies

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

U.S. DEPARTMENT OF ENERGY

What's important to:

Desires

Constraints

- Store Planners
- Merchants
- Shoppers
- Technology
- Regulatory Agencies

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

U.S. DEPARTMENT OF ENERGY

What's important to:

Desires	Constraints
Store Planners	Technicians
Merchants	Technology
Shoppers	Regulatory Agencies

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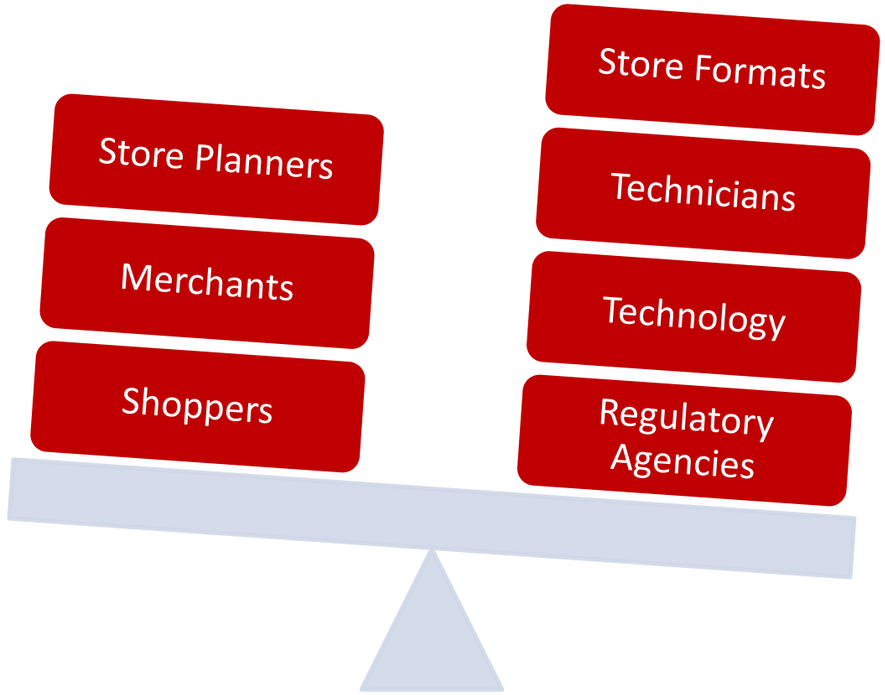
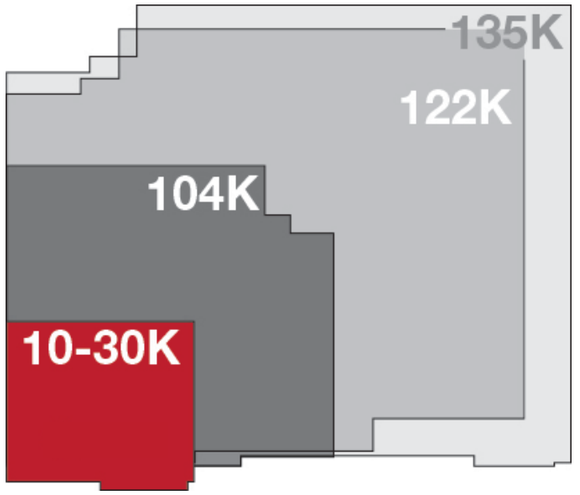
What's important to:

Desires

Constraints





UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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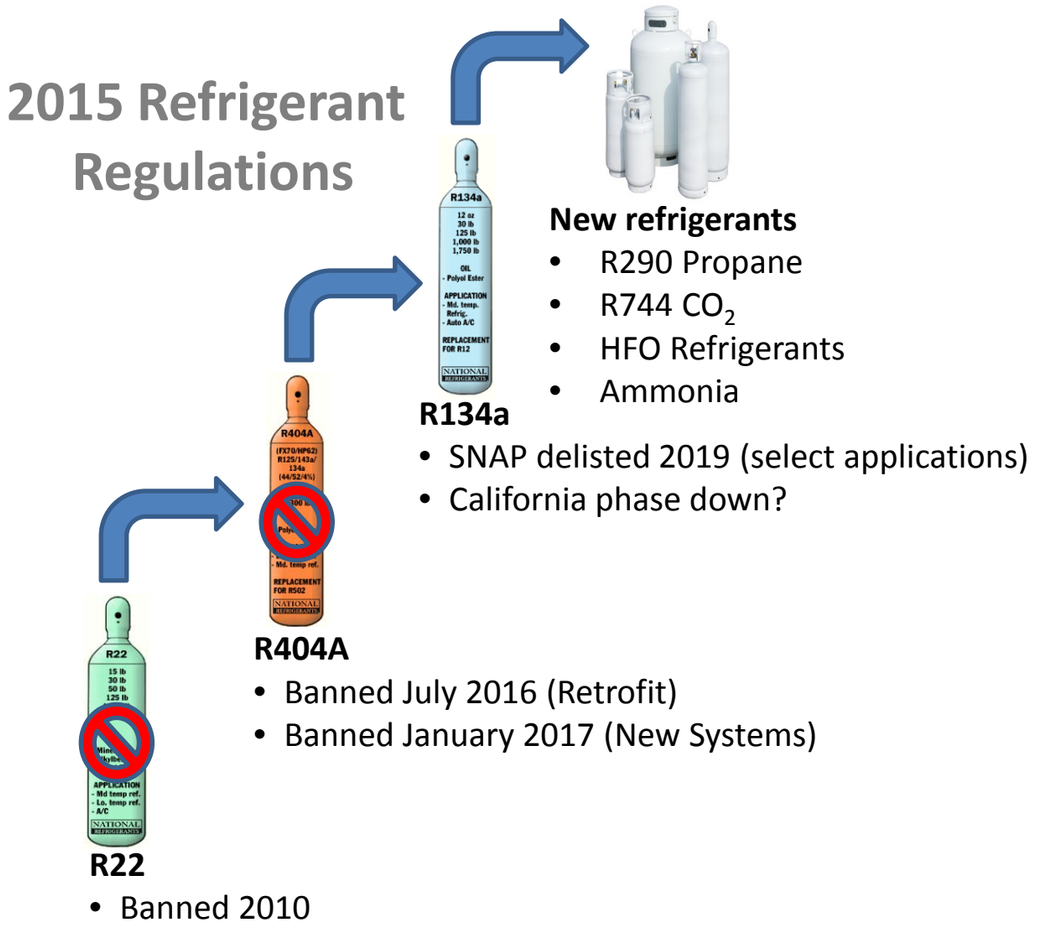
Challenges

- Regulatory requirements
- Confusion and uncertainty
- Definition of “Low GWP”
- Energy and Global Warming Potential
- Technical capabilities



Challenges

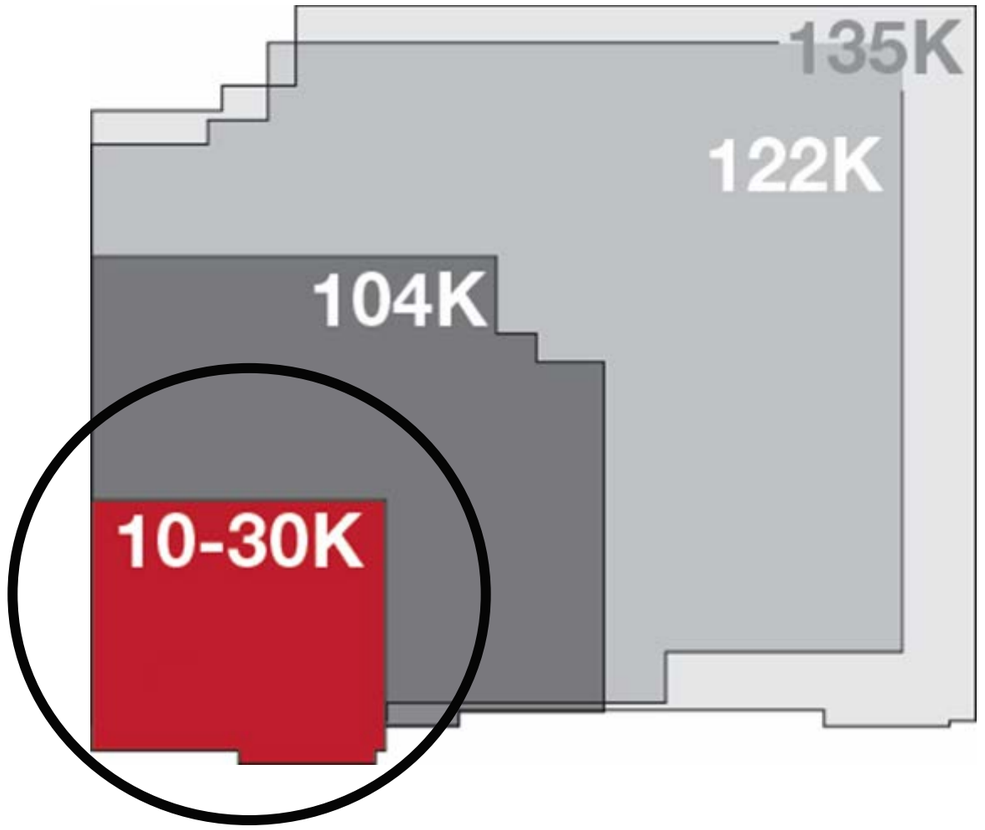
- Regulatory requirements
- Confusion and uncertainty
- Definition of “Low GWP”
- Energy and Global Warming Potential
- Technical capabilities

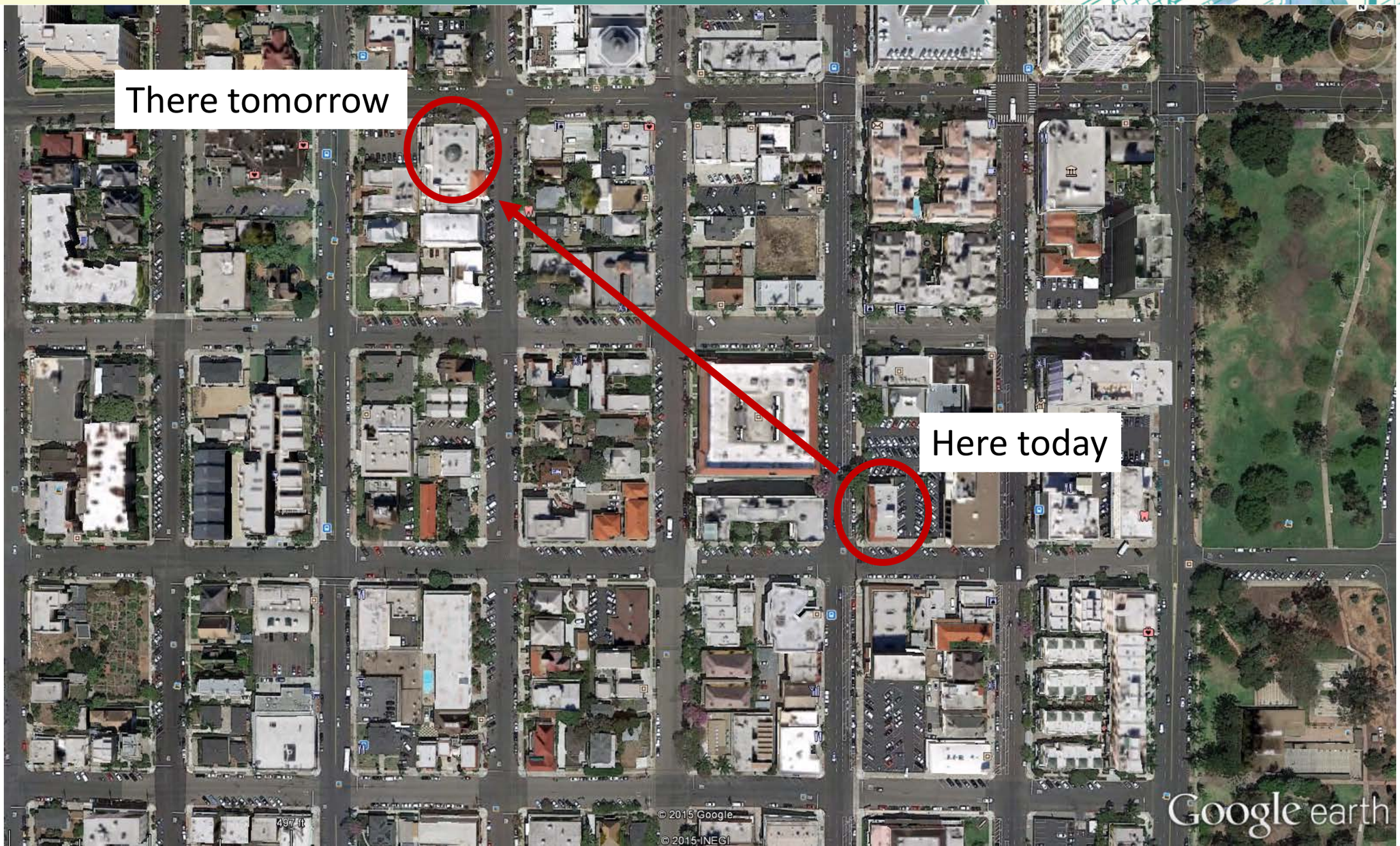
The Good News

- Options available
  - Lower GWP HFCs
  - Hydrocarbons
  - HFOs and HFO Blends
  - CO_2
  - Ammonia Cascade

There is no silver bullet!

Solutions for New Format Stores <50k ft²




There tomorrow
Here today
© 2015 Google
© 2015 INEGI
Google earth

The store of the future will have refrigeration systems that are:

Self-contained

Plug and Play

Portable

Modular

2015 Refrigerant Regulations

R22

- Banned 2010

R404A

- Banned July 2016 (Retrofit)
- Banned January 2017 (New Systems)

R134a

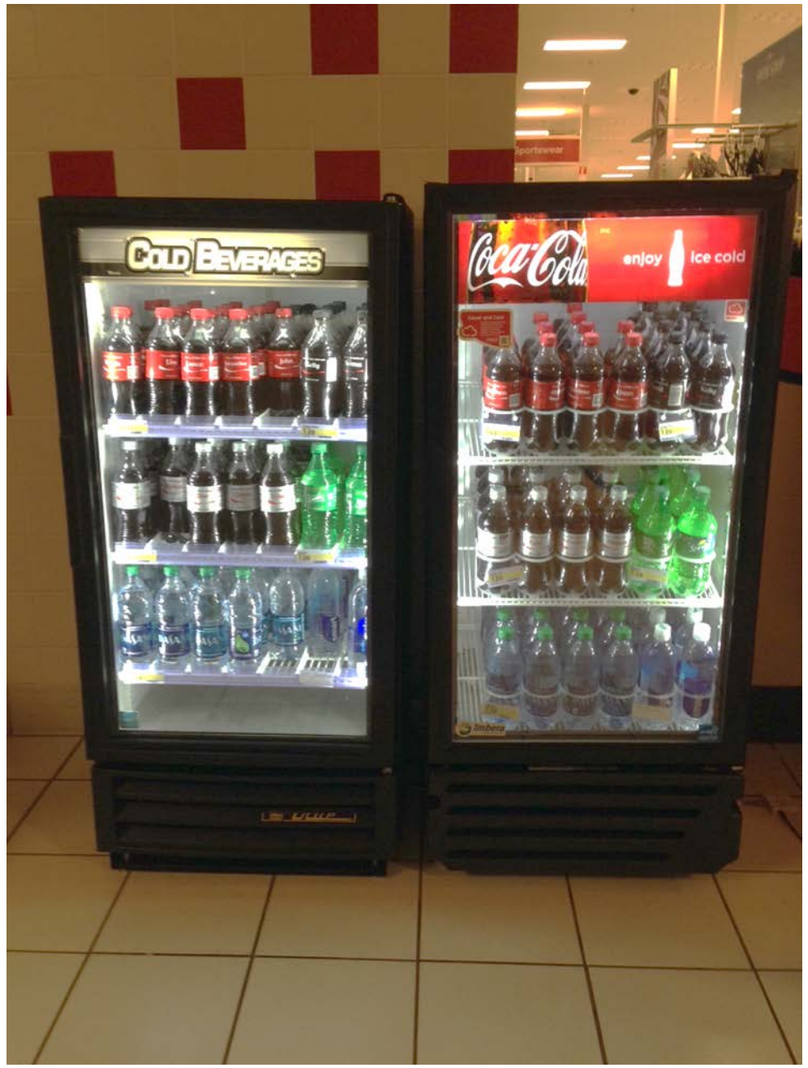
- SNAP delisted 2019 (select applications)
- California phase down?

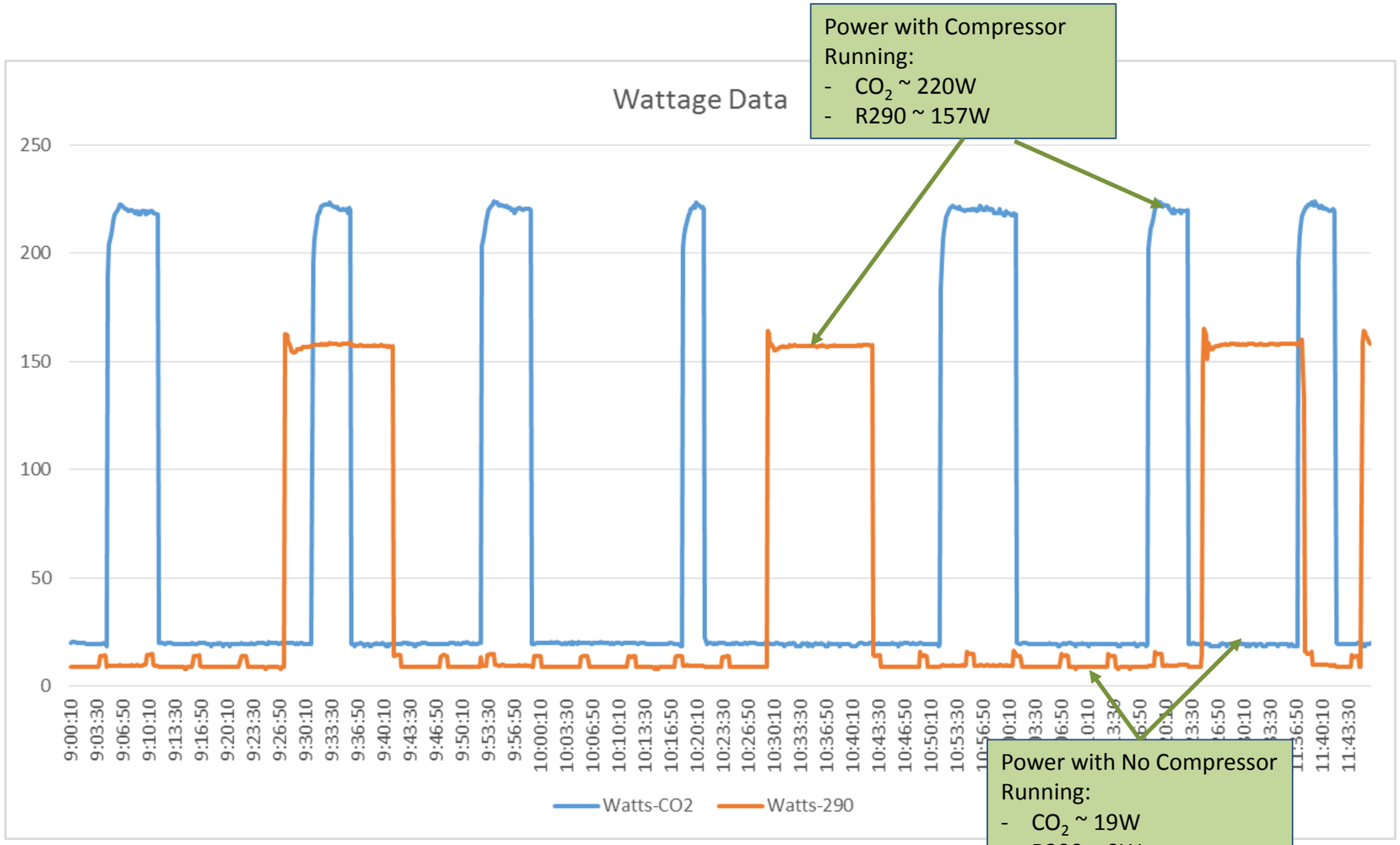
New refrigerants

- **R290 (Propane)**
- R744 (CO_2)
- HFO Refrigerants
- Ammonia

Self-Contained Solutions

- Side-by-side test:
  - R134a (baseline)
  - R290 (propane)
  - R744 (CO_2)
- Energy and Performance

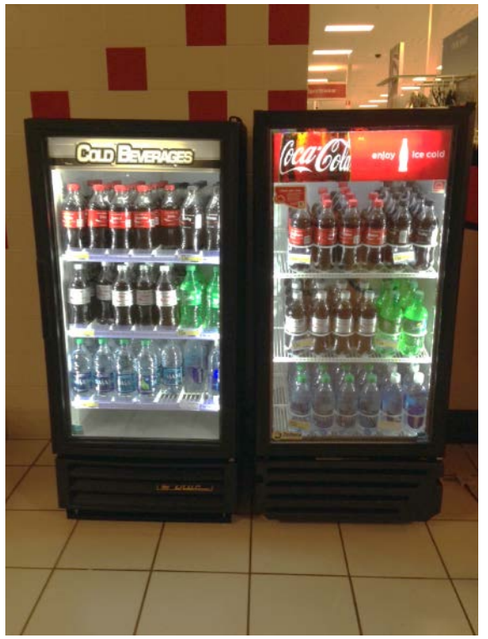




Observations:

1. Compressor Power with CO_2 system is definitely higher
2. The CO_2 Compressor cycles more frequently than the R290 compressor
3. CO_2 Unit without compressor running uses about 10W more power (electronics & lights)

Beverage Cooler Test	R134a	R744 (CO_2)	R290 (propane)
Power (kW)	0.092	0.069	0.043
Annual cost (@$.10/kW-Hr)	$ 80.59	$ 60.44	$ 37.67
Average Case Temp (°F)	40.4	39.9	39.7
Energy Savings	**Baseline**	**↓ 25%**	**↓ 53%**
Annual Chain Savings (100 stores with 10 cases)		**$ 20,150**	**$ 42,920**



R290 is the clear energy leader!

Beverage Cooler Test	R134a	R744 (CO_2)	R290 (propane)
Power (kW)	0.092	0.069	0.043
Annual cost (@$.10/kW-Hr)	$ 80.59	$ 60.44	$ 37.67
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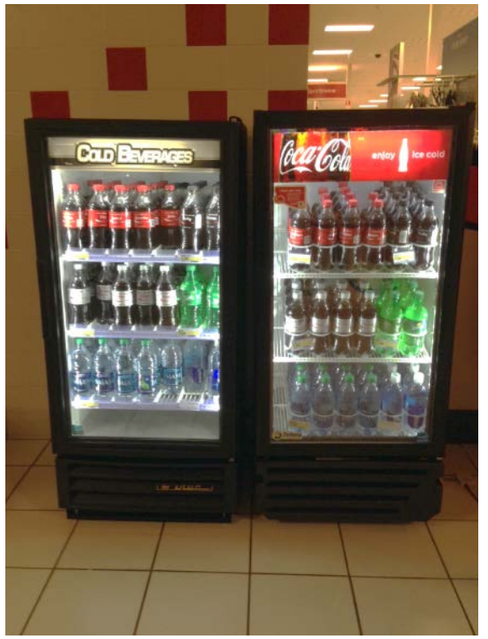
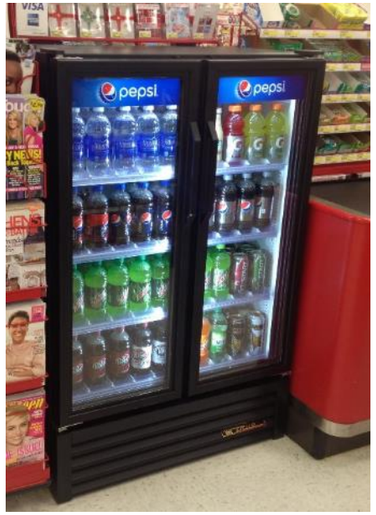


But R290 is a hydrocarbon, and aren't hydrocarbons FLAMMABLE?


BIC

=


pepsi
pepsi


Coleman
Propane Fuel

=


chill
quench
refresh

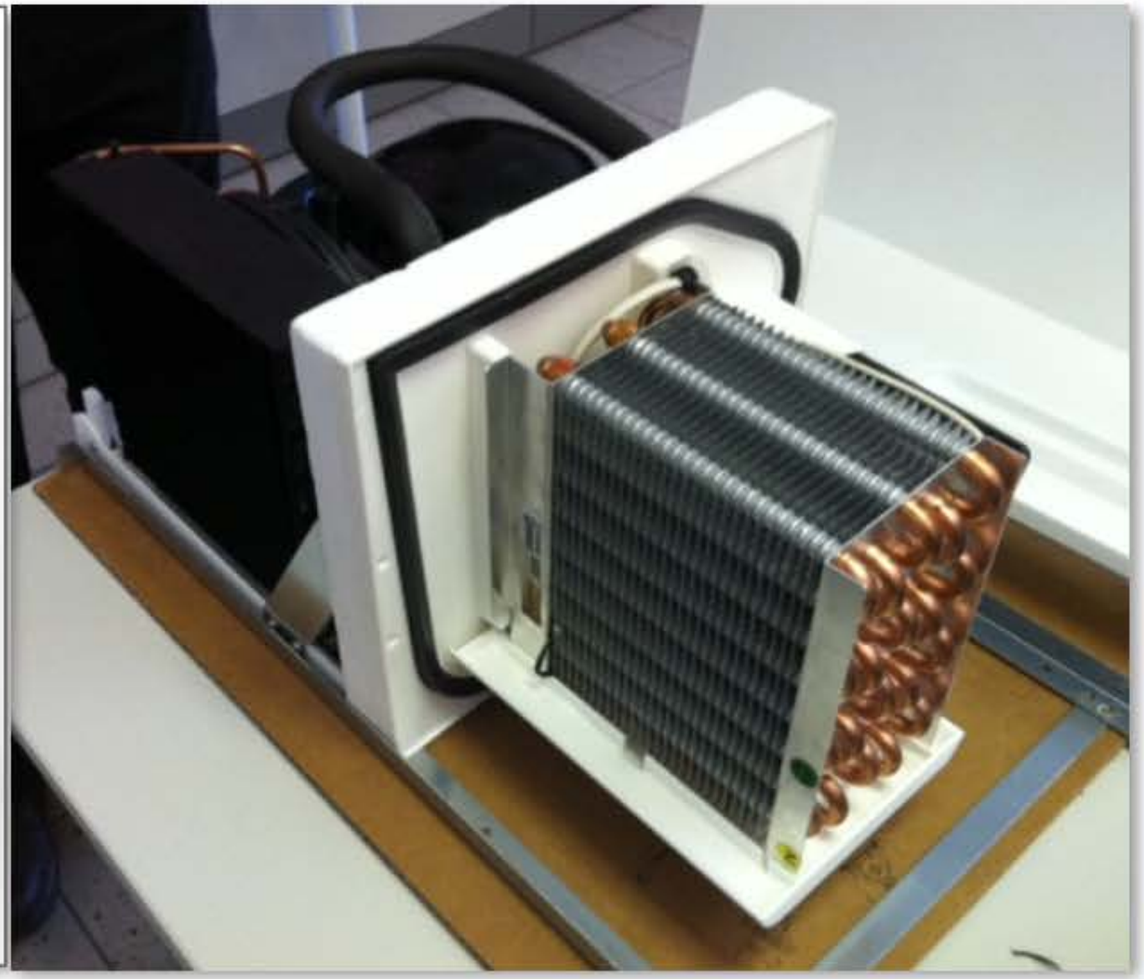

Coleman
PROPANE
BUTANE FUEL


market

Modeled Leak Rates

Table S4: Input Factors for Emission Calculations, Refrigeration and AC (stationary, transport refrigerated units, and refrigerated shipping containers), 2008

Equipment Type or Emissions sub-sector	Units in CA	Ave. Charge (amount) of F-gas in lbs.	Ave. Annual Leak (loss) Rate	Annual Loss in lbs. (units* charge* loss rate)	EOL units in CA	Ave. Charge (amount) in lbs. at EOL	Ave. EOL Loss Rate	EOL Loss in lbs. (units* charge* loss rate)	total loss in lbs. (annual + EOL)
Refrigerated stand-alone display cases [a]	577,457	7.1	0%	0	24,446	7	100%	173,566	173,566
Refrigerated vending machines [a]	452,086	0.66	0%	0	25,524	0.66	100%	16,846	16,846
Unitary A/C ≤ 22.7 kg (50-lbs. or less) (central) [b]	2,367,328	15.1	10%	3,574,665	133,608	12	56%	905,326	4,480,000
Unitary A/C ≤ 22.7 kg (50-lbs. or less) (window unit) [b]	639,511	1.54	2%	19,697	50,929	1.2	100%	59,587	79,000
Residential Appliance (refrigerator-freezer)	16,189,879	0.5	1%	80,949	946,725	0.4	77%	313,461	394,000
Residential A/C (central) [b]	5,994,796	7.5	10%	4,496,097	322,452	6	56%	1,083,440	5,580,000
Residential A/C (window unit) [b]	3,558,891	1.54	2%	109,614	283,422	1.2	100%	331,604	441,000
Transport Refrigerated Units (TRUs)	57,603	20.7	18.3%	218,208	4,580	17.4	15%	11,953	230,161
Refrigerated Shipping Containers	42,941	33.1	5%	71,068	12,853	33.1	19%	80,835	151,903



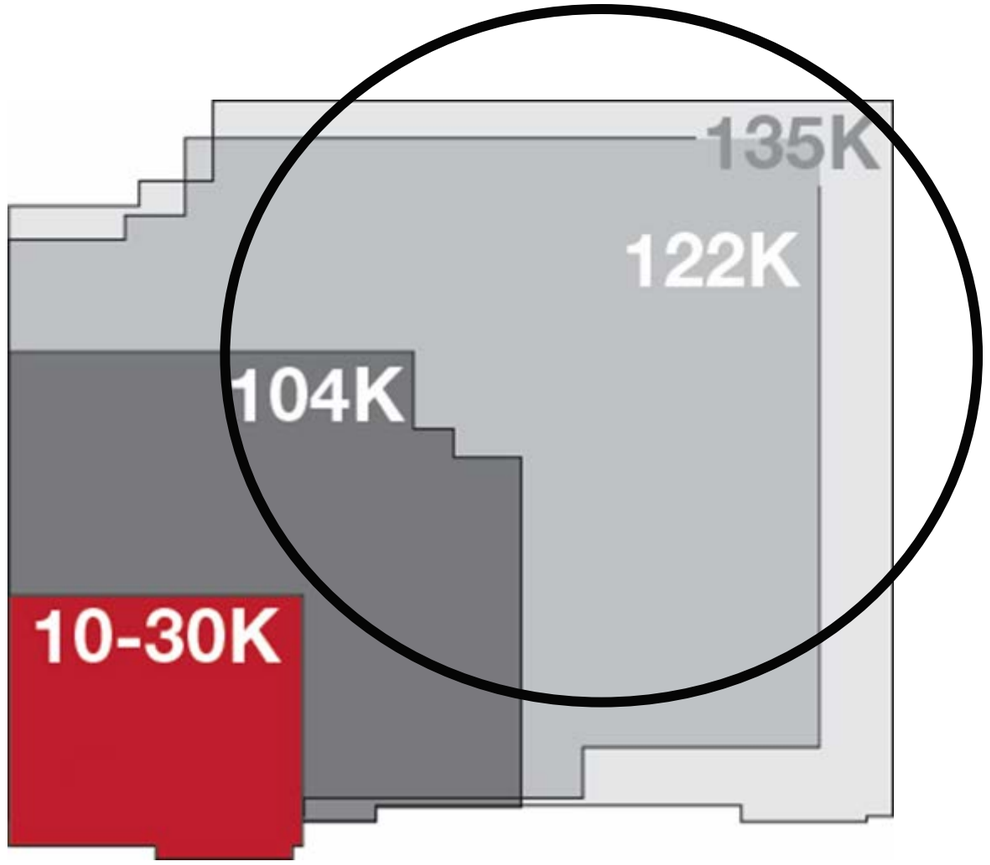
Can't You Get the Same Benefits with Rack Systems?

- Forever under the heel of EPA Section 608 - expanding to include HFCs
- Rack systems are leak prone!
- Restricted movement - lack of merchandising and store location flexibility
- Must have a service technician for each store, immediately available, at all times of the day/night, trained in all problems, trained in all refrigerants

What about Self-Contained Units with HFO blends?

Beverage Cooler Test	R134a	R744 (CO_2)	R290 (propane)
Power (kW)	0.092	0.069	0.043
Annual cost (@$.10/kW-Hr)	$ 80.59	$ 60.44	$ 37.67
Average Case Temp (°F)	40.4	39.9	39.7
Energy Savings	**Baseline**	**25%**	**53%**

Solutions for Traditional Stores >50k ft²



Refrigerant Properties

Refrigerant	Latent Heat of Vaporization (BTU/lb. @ -20F)	Global Warming Potential (GWP)	Ozone Depletion Potential (ODP)
R22	97	1810	0.055
R407A	101	2110	
R404A	82	3922	-
R448A	95	1273	-
R449A	95	1397	-
R134a	94	1430	-
R450A	90	547	-
R513A	84	631	-
R290 (Propane)	180	< 4	-
R744 (CO_2)	130	1	-
R717 (Ammonia)	584	0	-

2015 Refrigerant Regulations

R22

- Banned 2010

R404A

- Banned July 2016 (Retrofit)
- Banned January 2017 (New Systems)

R134a

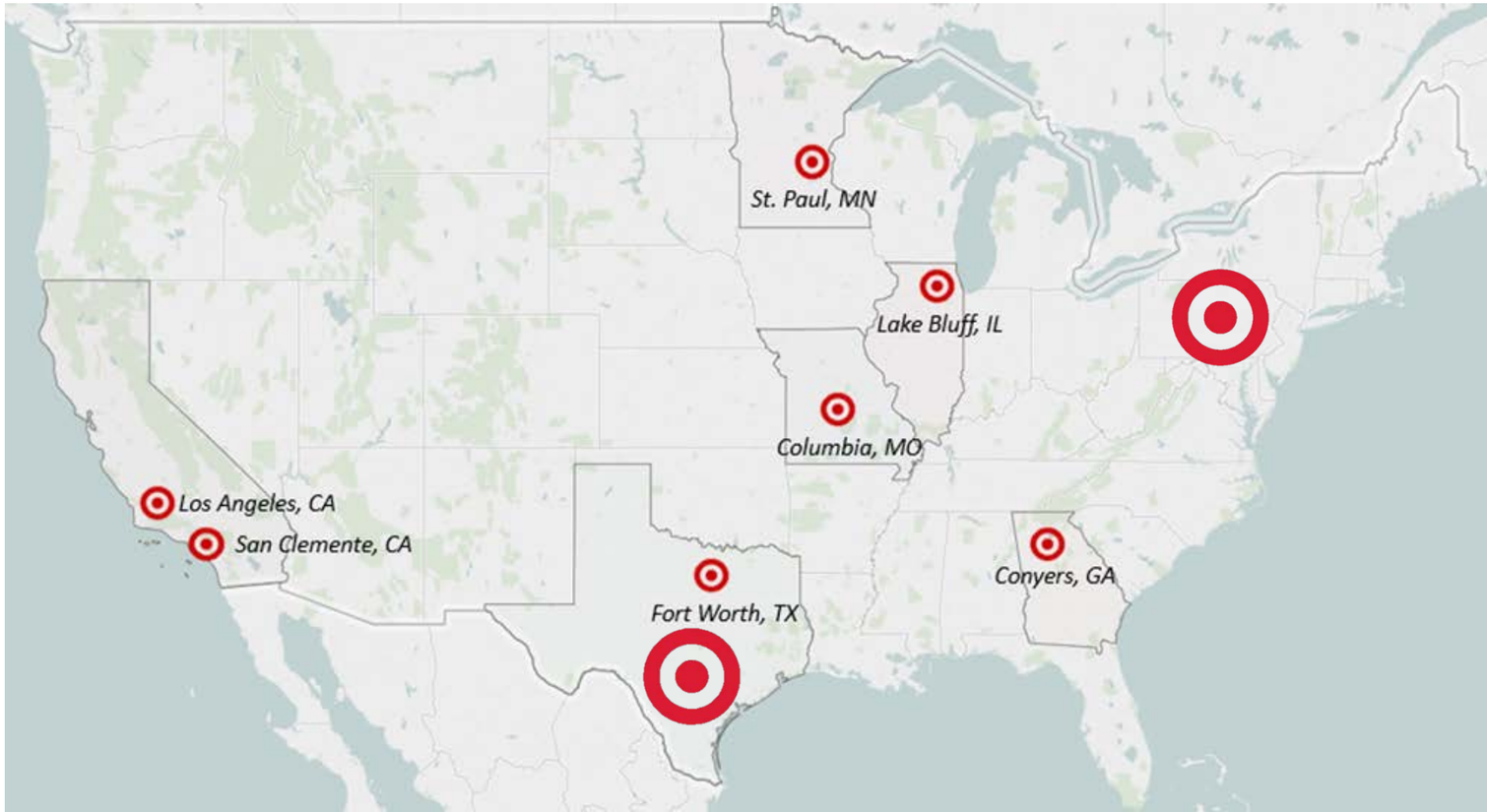
- SNAP delisted 2019 (select applications)
- California phase down?

New refrigerants

- R290 (Propane)
- **R744 (CO_2)**
- **HFO Refrigerants**
- Ammonia

Cascade CO_2 Systems

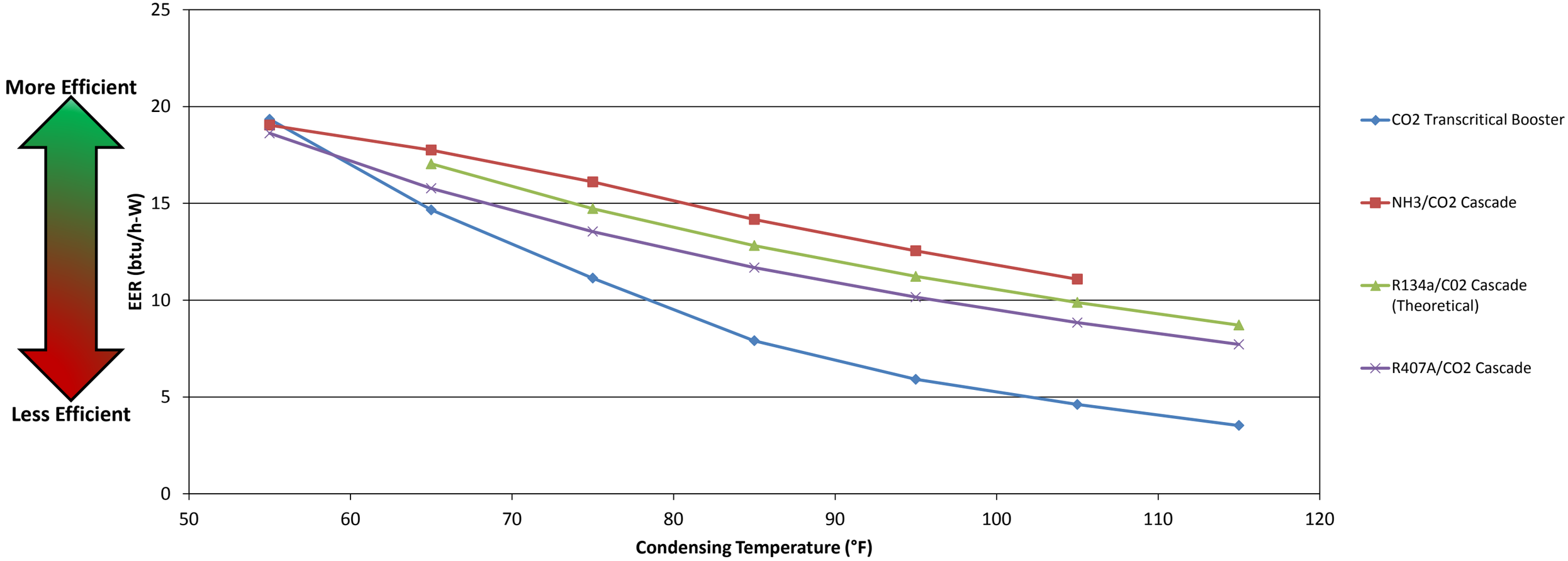
Total Cost of Ownership		
Energy	↓	$2,300/year
Cap-Ex: Equipment	↑	+25% - 30%
Cap-Ex: Installation	↑	+5%
Uptime (Guest impact)	=	No Impact
Maintenance Expense	↑	$2,300/year
Global Warming Potential	↓	-65%



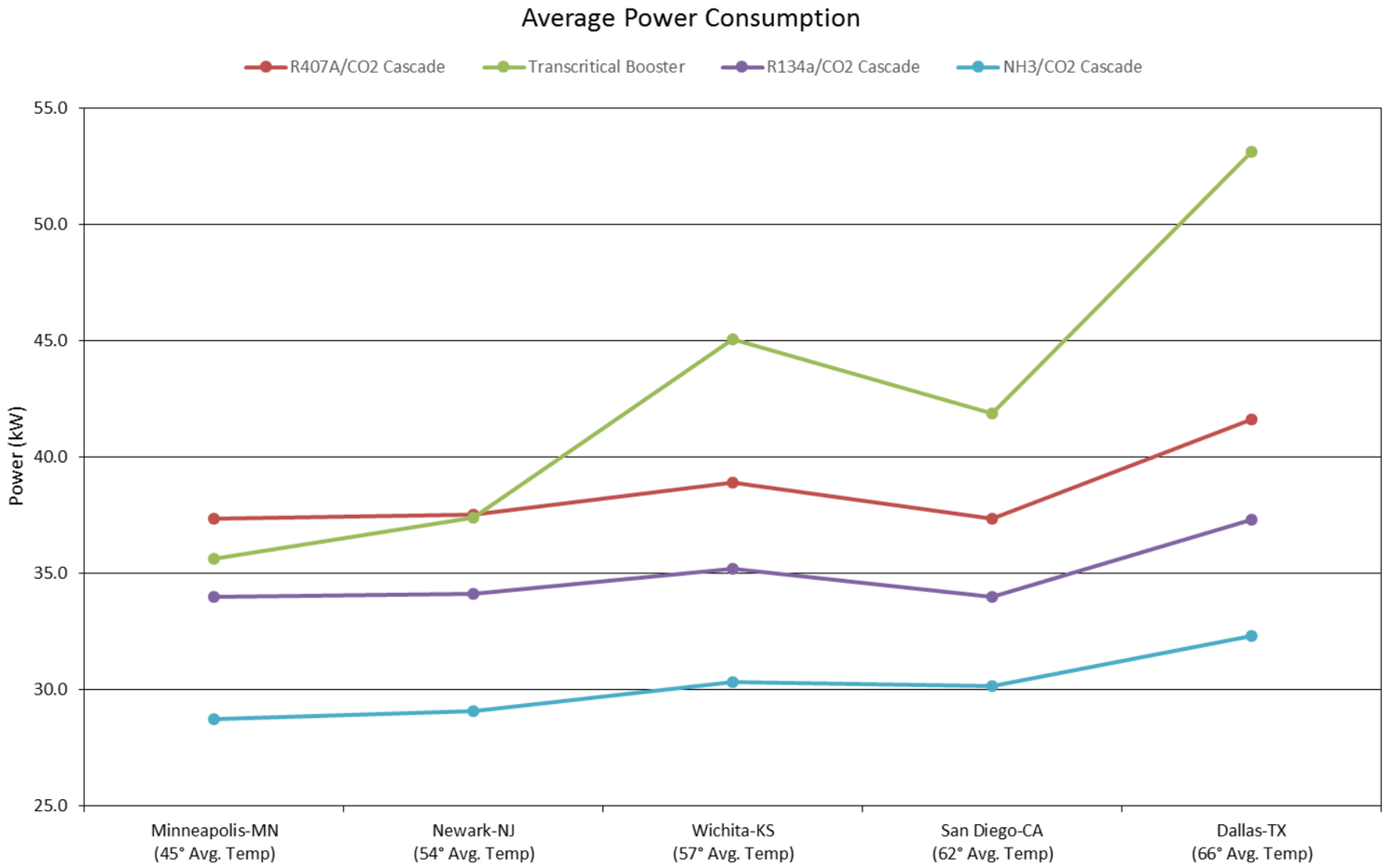
Aggregate Global Warming Potential (GWP)

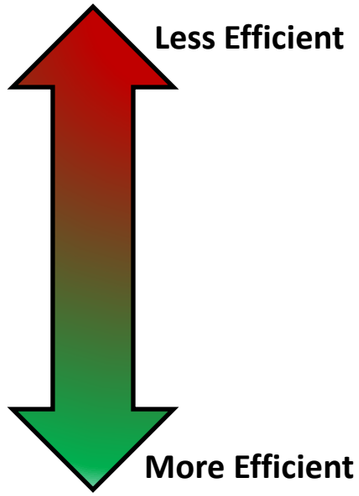
System Type	Refrigerant(s)	Global Warming Potential		Charge (lbs.)		Aggregate GWP
Standard DX	R404A	3922		1400		**3922**
Cascade DX	R134a/CO2	1430	1	700	300	**1001**
Cascade DX	HFO/CO2	600	1	700	300	**420**
Cascade DX (pumped CO2 MT)	HFO/CO2	600	1	300	600	**201**

Theoretical Efficiency of Various CO_2 Supermarket Refrigeration Systems



Theoretical CO_2 Supermarket Refrigeration Systems Analysis for Various Climates





Notes:

1. Analysis based on 500 mbh evaporator load
2. Analysis does not include condenser fan power or heat reclaim
3. Transcritical CO_2 system performance improves in colder climate but still not as good as R134a/CO_2 or NH_3/CO_2

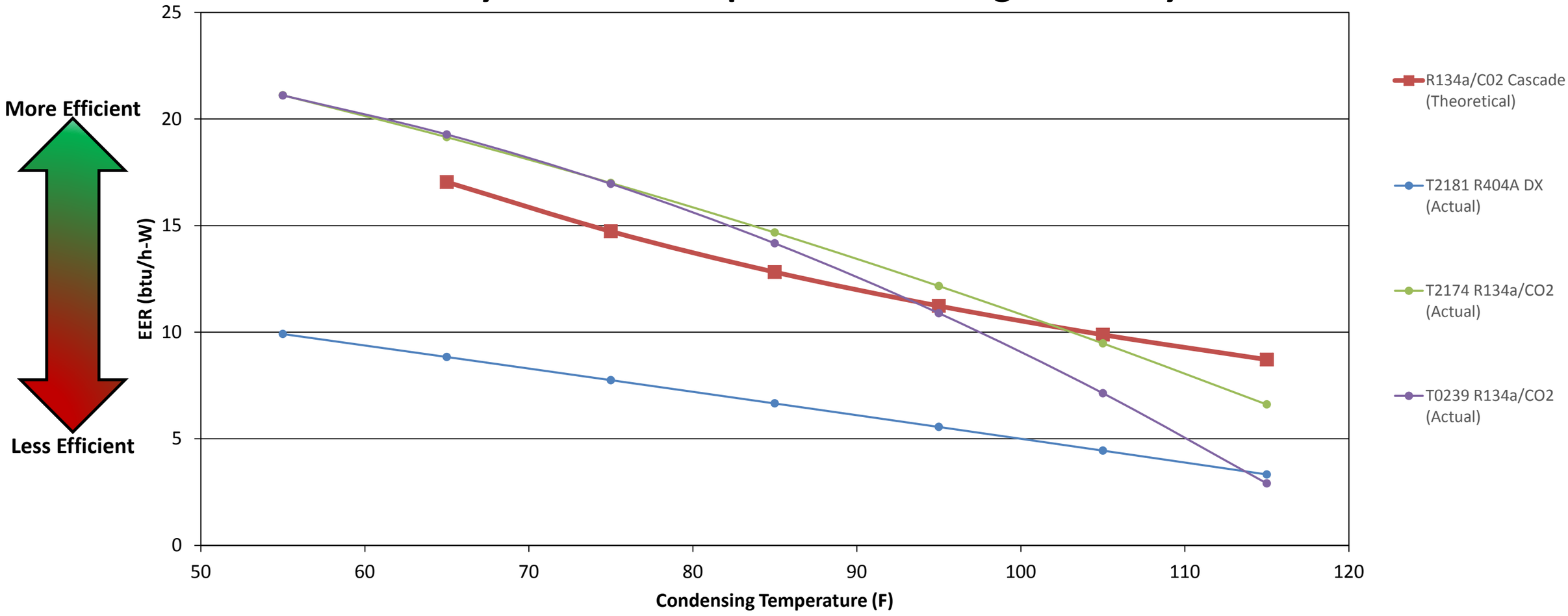
Better Buildings U.S. DEPARTMENT OF ENERGY

Target's Leading Rooftop Unit Replacement Program

ENERGY STAR

"We're moving closer to our goal of earning ENERGY STAR status in at least 75 percent of our U.S. buildings by the end of 2015."

Actual Efficiency of Various Supermarket Refrigeration Systems



Note:

1. EER for Store T2181 is much lower than EER of various CO_2 systems
2. EER data for theoretical R134a/CO_2 system does not include condenser fan power – all other systems do include fan power

So, if we look into our HFO Crystal Ball…

HFO Blends

Refrigerant	End Use Qualification	Retrofit (R) or New (N)	SNAP Approval Date
R450A (N-13)	LT self-contained, MT self-contained, remote condensing units, supermarket systems	R & N	10/21/14
R513A (XP-10)	LT self-contained, MT self-contained, remote condensing units, supermarket systems	R & N	7/2/15
R449A (XP-40)	LT self-contained, remote condensing units, supermarket systems	R & N	7/2/15
R448A (N-40)	LT self-contained, remote condensing units, supermarket systems	R & N	7/2/15

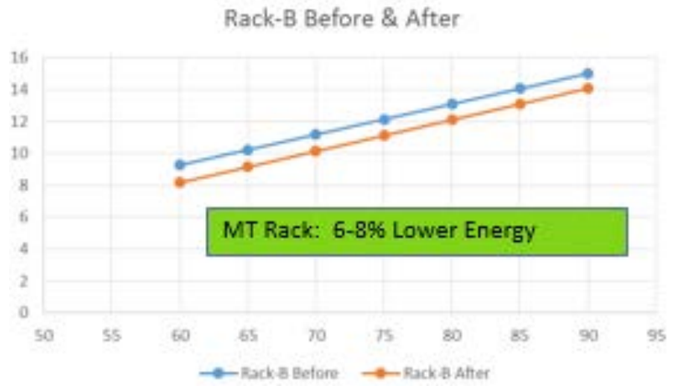
HFO Blends Performance Expectations

- Medium Temperature
  - 5% - 10% Energy Savings
- Low Temperature
  - 0% - 5% Energy Savings
  - Additional components for liquid injection

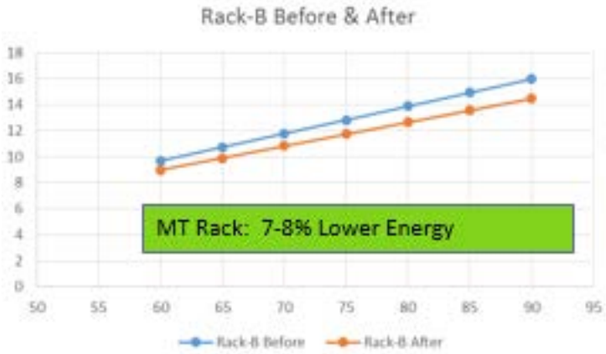
Medium Temperature HFO Blend Tests

Total Cost of Ownership	New Stores	Conversions
Energy	↓	↓
Cap-Ex: Equipment	=	=
Cap-Ex: Installation	↑	↑
Uptime (Guest impact)	=	=
Maintenance Expense	↑	↑
Global Warming Potential	↓	↓

R404A Conversions



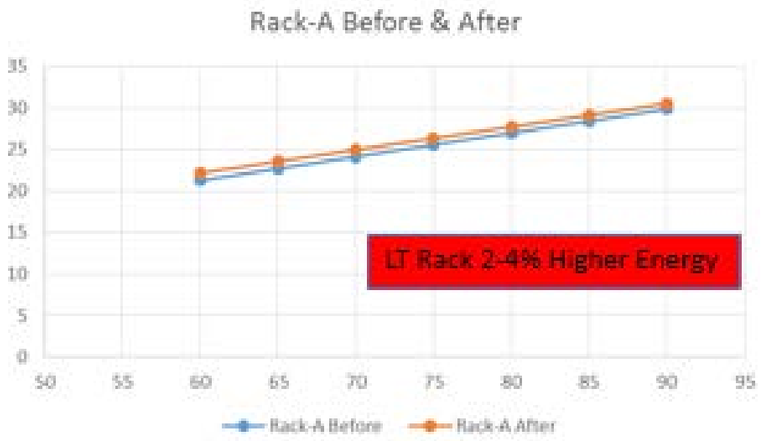
R134a Conversions

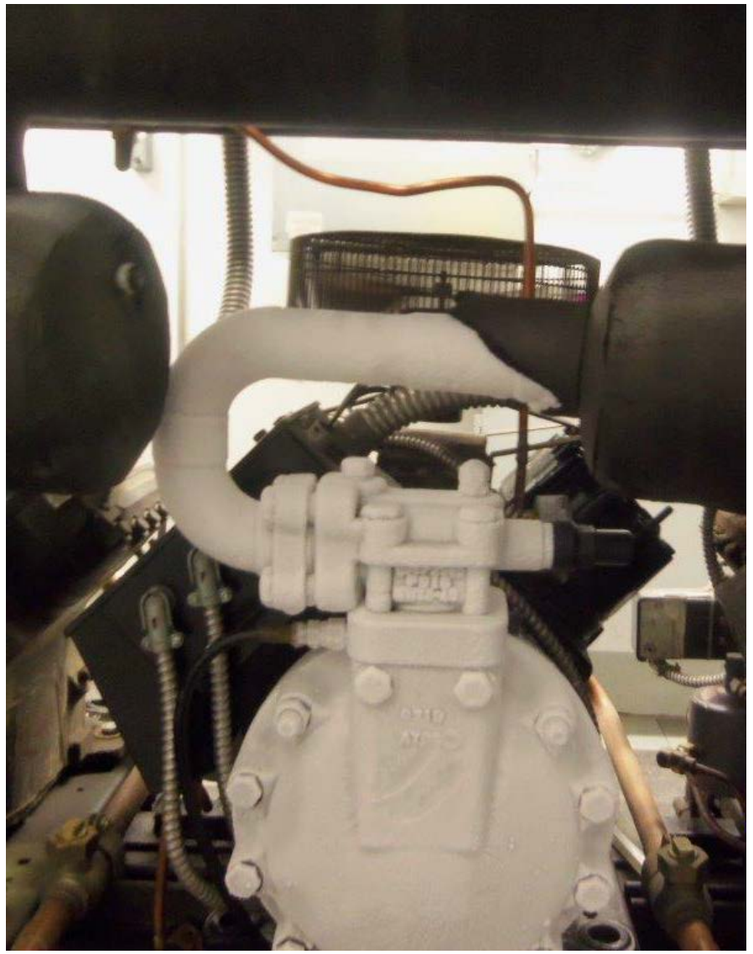


Low Temperature HFO Blend Tests – Initial Results

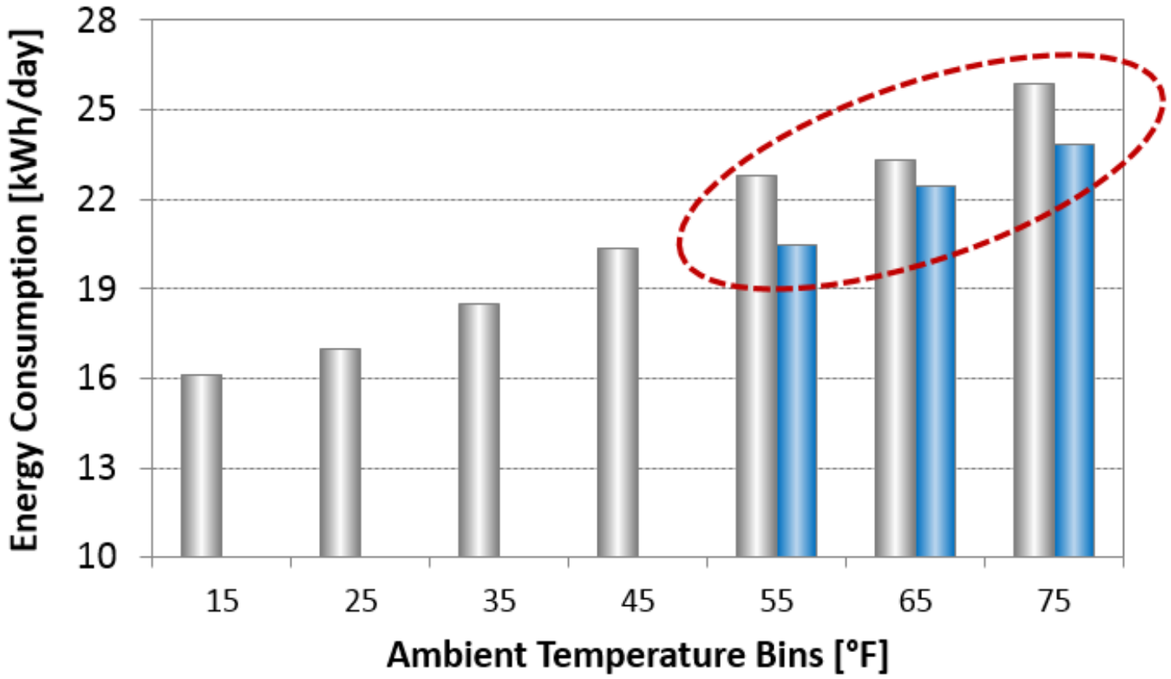
Total Cost of Ownership	New Stores	Conversions
Energy	=	↑
Cap-Ex: Equipment	↑	↑
Cap-Ex: Installation	↑	↑
Uptime (Guest impact)	=	=
Maintenance Expense	↑	↑
Global Warming Potential	↓	↓

R404A Conversions

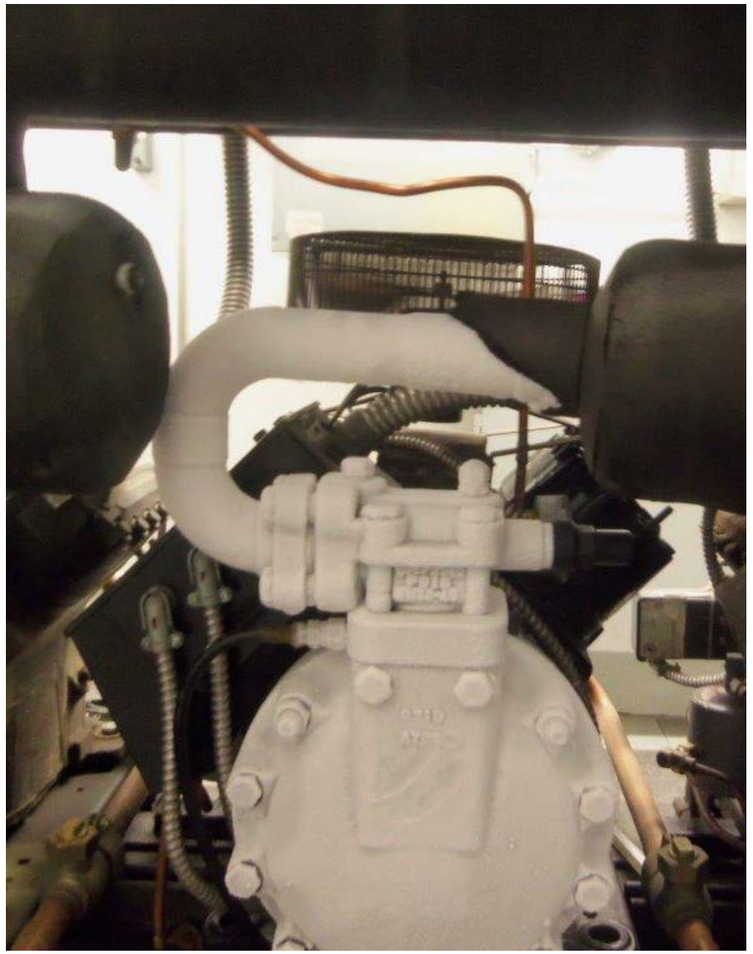




Energy Optimization



Getting the right superheat at the cases is key to energy performance!



Low Temp Final Results

Total Cost of Ownership	New Stores	Conversions
Energy	↓	↓
Cap-Ex: Equipment	↑	↑
Cap-Ex: Installation	↑	↑
Uptime (Guest impact)	=	=
Maintenance Expense	↑	↑
Global Warming Potential	↓	↓

Getting the right superheat at the cases is key to energy performance!

HFO Compressor Tear-Down

WHAT'S NEXT?

Conversions, Remodels, etc., etc.

- Didn't we just do this?
- How much is this going to cost?
- We can't throw all this equipment away!
- Can't we be done with this already?!

- **Low GWP HFC's**
- **R290 (Propane)**
- **R744 CO_2**
- **HFO Refrigerants**
- **Ammonia**

Service Challenges:

25 years experience

or

1 year experience 25 times

In Summary:

1. R290: great candidate for small format systems & self-contained cases
2. CO_2 Cascade: good for new larger systems
3. HFO Blends: show promise for retrofit and new larger systems
4. Understand your business drivers when investing in new systems
5. Know that system size matters
6. Trust but verify
7. Continue to innovate, share your experiences, and help each other