Defense Commissary Agency's Experience with Transcritical Carbon Dioxide

October 27, 2020

Call-in Details 1-202-991-0477 ID: 357 196 678#

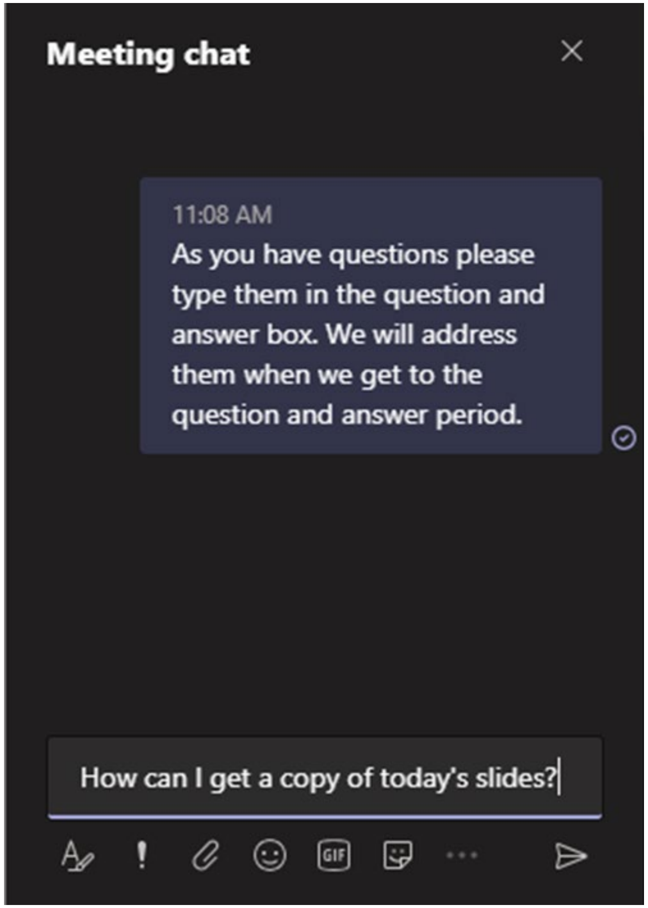
Questions and Webinar Feedback

Question and Answer Session

- Participants are muted
- Questions will be moderated at the end
- To ask a question, enter your comment into the chat box

Feedback Form

- We value your input!
- The link to a feedback form will appear in the chat window



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Webinar Materials

Recording and Slides

- Webinar is being recorded
- Materials will be posted on the GreenChill website under Events and Webinars: www.epa.gov/greenchill
- To receive notification when materials are posted email: EPA-GreenChill@abtassoc.com

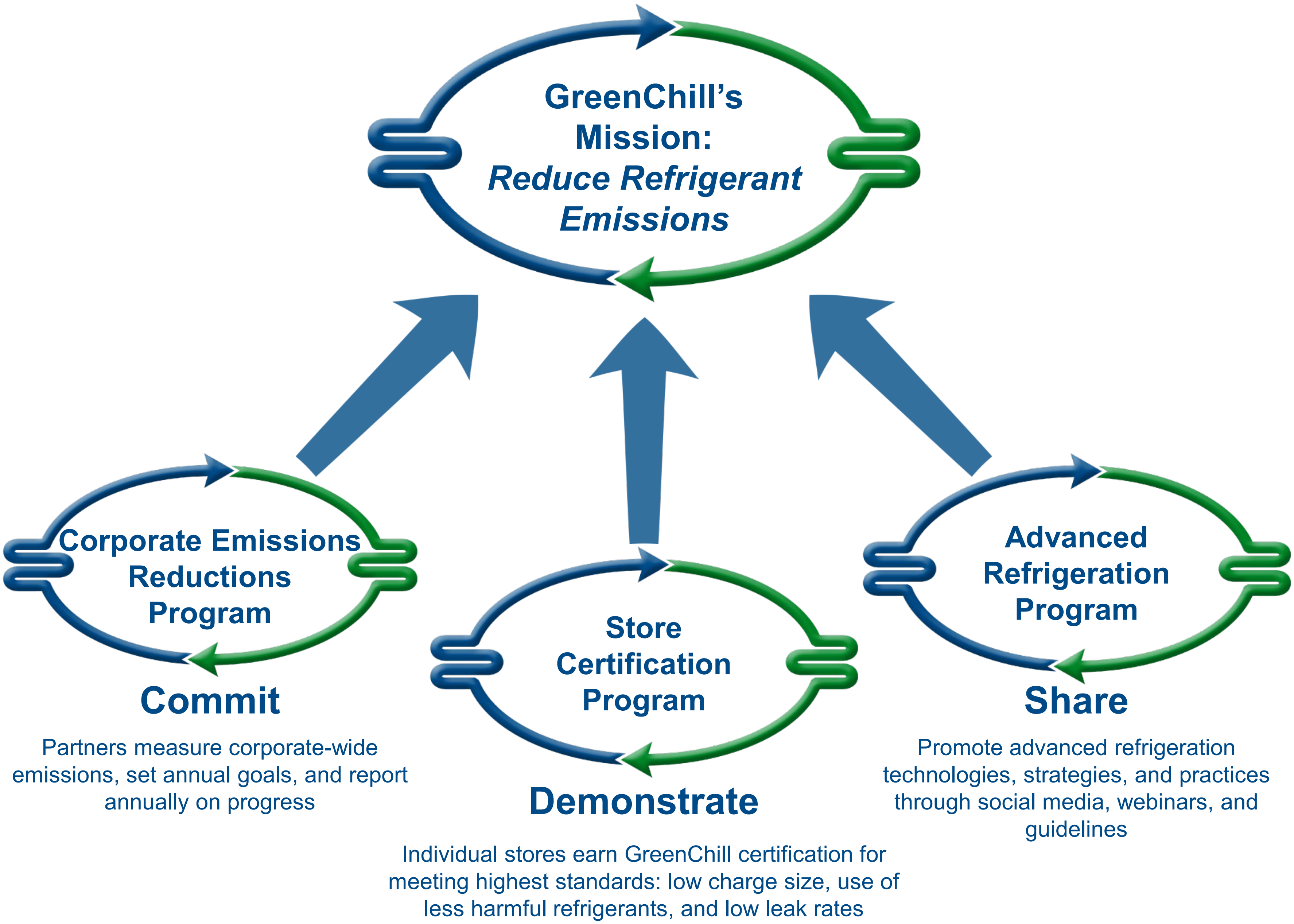
Program Overview

www.epa.gov/greenchill

GreenChill is a voluntary partnership program that works collaboratively with the food retail industry to reduce refrigerant emission and decrease stores' impact on the ozone layer and climate system

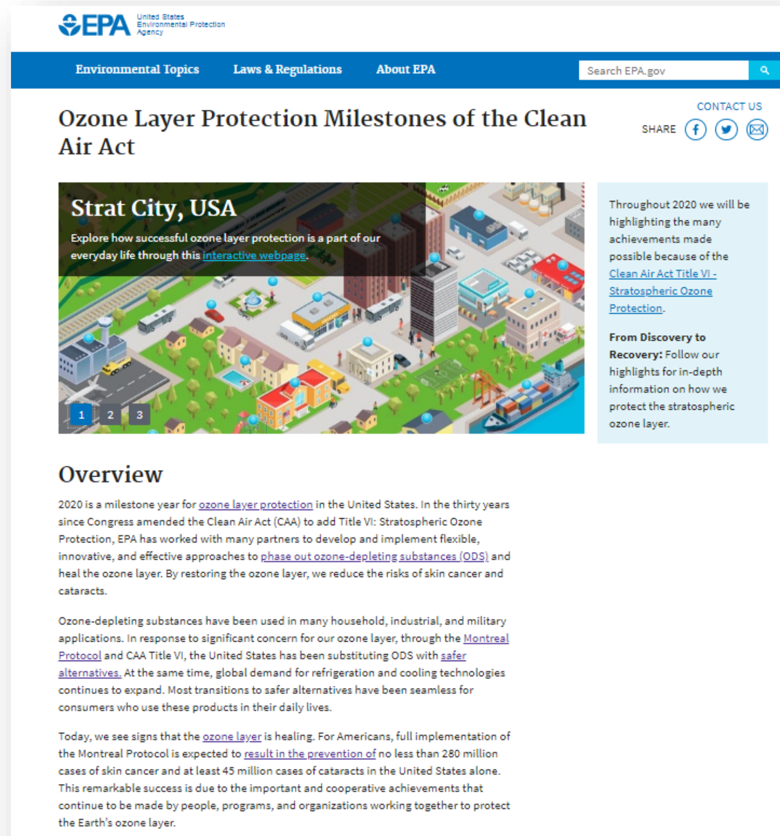
GreenChill works to help food retailers:

- Lower refrigerant charge sizes and eliminate leaks
- Transition to environmentally friendlier refrigerants
- Adopt green refrigeration technologies and best environmental practices


GreenChill's Mission: Reduce Refrigerant Emissions
Corporate Emissions Reductions Program
Commit
Partners measure corporate-wide emissions, set annual goals, and report annually on progress
Store Certification Program
Demonstrate
Individual stores earn GreenChill certification for meeting highest standards: low charge size, use of less harmful refrigerants, and low leak rates
Advanced Refrigeration Program
Share
Promote advanced refrigeration technologies, strategies, and practices through social media, webinars, and guidelines

2020 Ozone Layer Protection Milestones

In March 2020, EPA published a new site to highlight achievements made possible because of the Clean Air Act Title VI - Stratospheric Ozone Protection


EPA United States Environmental Protection Agency

Environmental Topics Laws & Regulations About EPA Search EPA.gov

CONTACT US

Ozone Layer Protection Milestones of the Clean Air Act

SHARE

Strat City, USA

Explore how successful ozone layer protection is a part of our everyday life through this interactive webpage.

1 2 3

Throughout 2020 we will be highlighting the many achievements made possible because of the Clean Air Act Title VI - Stratospheric Ozone Protection.

From Discovery to Recovery: Follow our highlights for in-depth information on how we protect the stratospheric ozone layer.

Overview

2020 is a milestone year for ozone layer protection in the United States. In the thirty years since Congress amended the Clean Air Act (CAA) to add Title VI: Stratospheric Ozone Protection, EPA has worked with many partners to develop and implement flexible, innovative, and effective approaches to phase out ozone-depleting substances (ODS) and heal the ozone layer. By restoring the ozone layer, we reduce the risks of skin cancer and cataracts.

Ozone-depleting substances have been used in many household, industrial, and military applications. In response to significant concern for our ozone layer, through the Montreal Protocol and CAA Title VI, the United States has been substituting ODS with safer alternatives. At the same time, global demand for refrigeration and cooling technologies continues to expand. Most transitions to safer alternatives have been seamless for consumers who use these products in their daily lives.

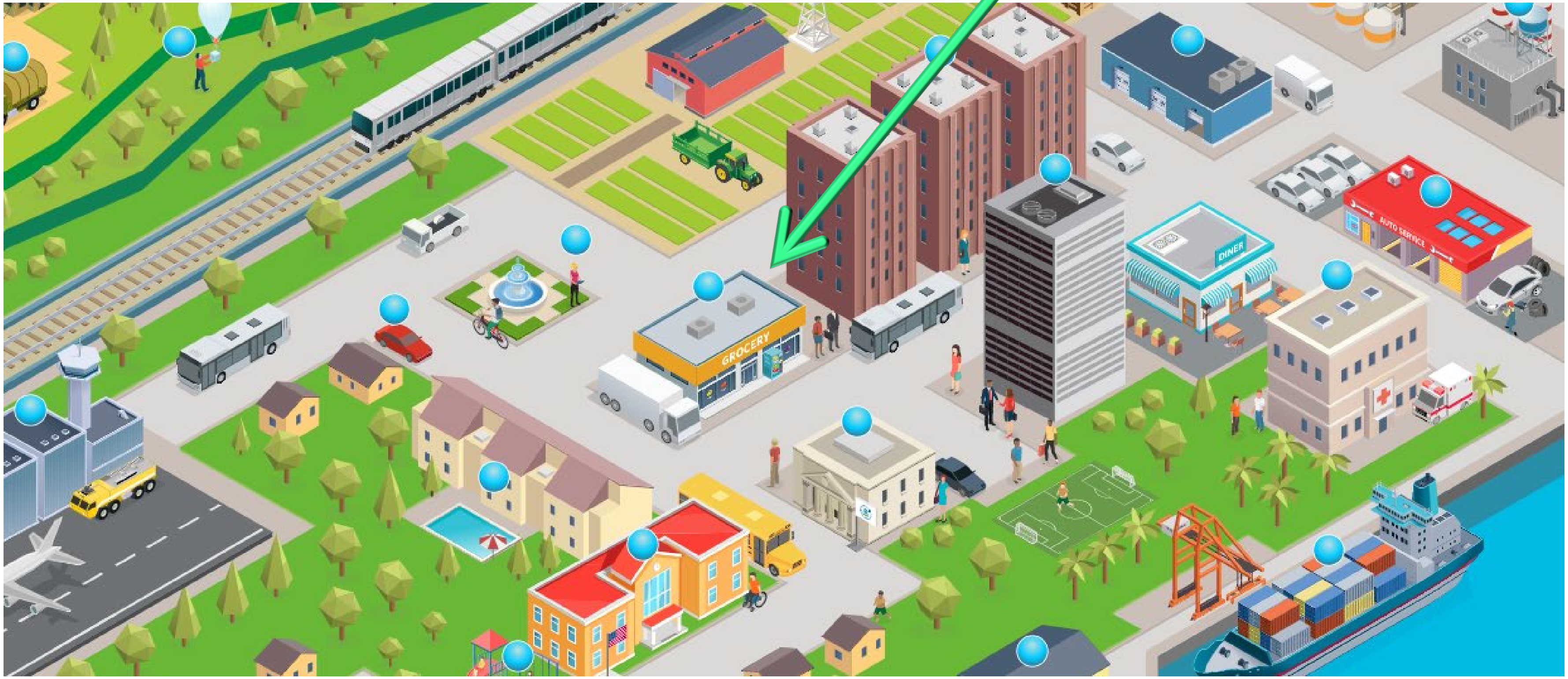
Today, we see signs that the ozone layer is healing. For Americans, full implementation of the Montreal Protocol is expected to result in the prevention of no less than 280 million cases of skin cancer and at least 45 million cases of cataracts in the United States alone. This remarkable success is due to the important and cooperative achievements that continue to be made by people, programs, and organizations working together to protect the Earth's ozone layer.

www.epa.gov/ozone-layer-protection-milestones-clean-air-act

Strat City, USA

An interactive webpage where users can explore how ozone layer protection affects many aspects of everyday life.

GreenChill is highlighted



Learn More

www.linkedin.com/groups/1426947/

www.epa.gov/greenchill

GreenChill@epa.gov

Today's speakers…

John Stuit

John Stuit
Chief, Defense Commissary Agency
Design & Construction
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John Stuit brings 34 years of experience to the supermarket industry. As Chief of Design and Construction, he executes the global design and construction program for DeCA. He is also a certified Construction Manager and has a strong interest in emerging technologies for refrigeration systems. He has a Bachelor's of Science in Mechanical Engineering.

Abtar Singh

Abtar Singh
President, Singh360, Inc.
Phone: 651-605-1093
Email: abtar@singh360.com

Abtar Singh is the President of Singh360, Inc. He specializes in facility management systems, performance monitoring, predictive analytics, and optimization of energy and maintenance systems. He previously served as the Vice President of Product Management and Engineering at Emerson Climate Technologies and was the Vice President of Business Development for Verisae. He holds a Bachelor's of Science in Energy Engineering from the Indian Institute of Technology in Kharagpur, India and a Master's Degree and Doctorate in Mechanical Engineering from the University of Maryland in College Park.

What Is DeCA?

The Defense Commissary Agency (DeCA) is the supermarket to the military.

- 236 stores world wide on military bases
- Cold storage and distribution facilities overseas
- $5 billion in grocery sales
- Retail organization looking at what the future holds and planning for it

Locations of CO_2 Systems

Location	Climate
Spangdahlem, Germany	Cool
Lakenheath, England	Cool
Vicenza, Italy	Warm & Dry
Lackland Air Force Base (AFB) (San Antonio, TX)	Hot & Humid
Newport, RI	Marine
Vandenburg AFB, California	Marine
Edwards AFB, CA (Mojave, CA)	Hot & Dry
Mountain Home, ID	Mountain

Low Charge Micro-distributed

- Installed at El Centro, CA, Yuma, AZ and White Sands, NM
- Very low charge compressors at each case/unit cooler
- Two pound charge at each compressor
- Water loop for cooling with an exterior fluid cooler
- Potential for R-290/R-600 in future

Challenges of CO_2 Installation

- For remodels, a large load is required for start up – at least 50%
- Coleman grade carbon dioxide (CO_2)refrigerant is not expensive. But, it may not be easily available. Recommend a 2nd full charge be available on site
- Extreme high pressure (XHP) rated pipe is hard to source

Adiabatic Gas Cooler/Condenser

- Standard coils with adiabatic pre-cooling media
- Runs dry during cold weather
- Objective: minimize time the system operates in transcritical mode

Experienced Partners Required

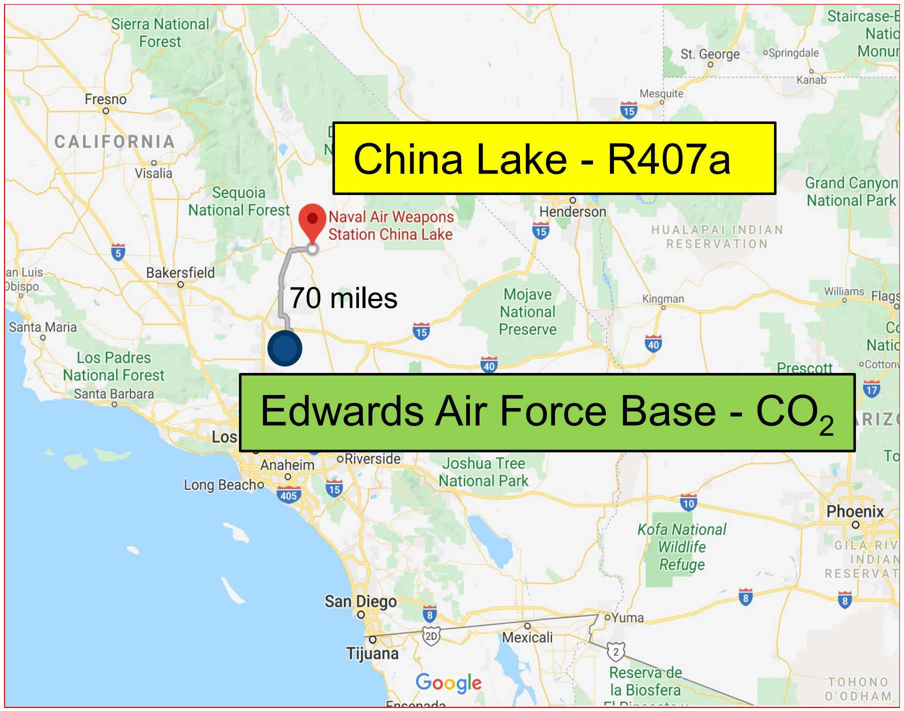
- Refrigeration manufactures are providing excellent support to installation crews
- Training is available from refrigeration and controls manufactures
- When you are the first installation in a geographic area, trained technicians may not be available for service

Opportunities

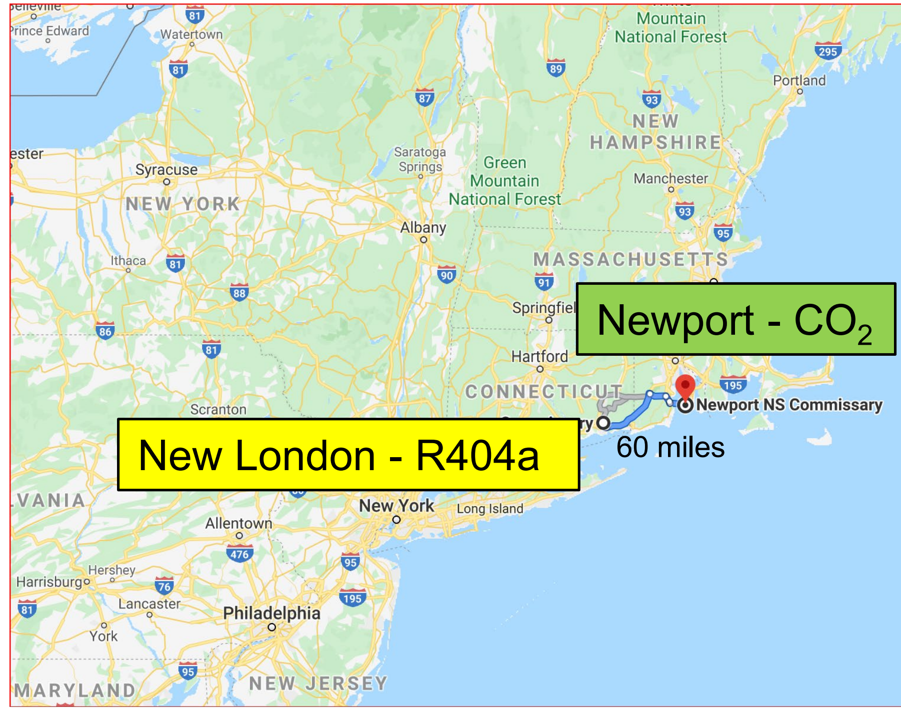
- Good public relations with customers – environmentally responsible
- Heat reclaim opportunities are excellent
- Refrigerant cost for service is low
- Future proof
- No reporting requirements for refrigerant usage

Comparison Study
CO_2 Vs. Hydrofluorocarbon Refrigeration at DeCA Commissaries in Two Distinct Climate Regions

Four Locations



CA COMMISSARIES



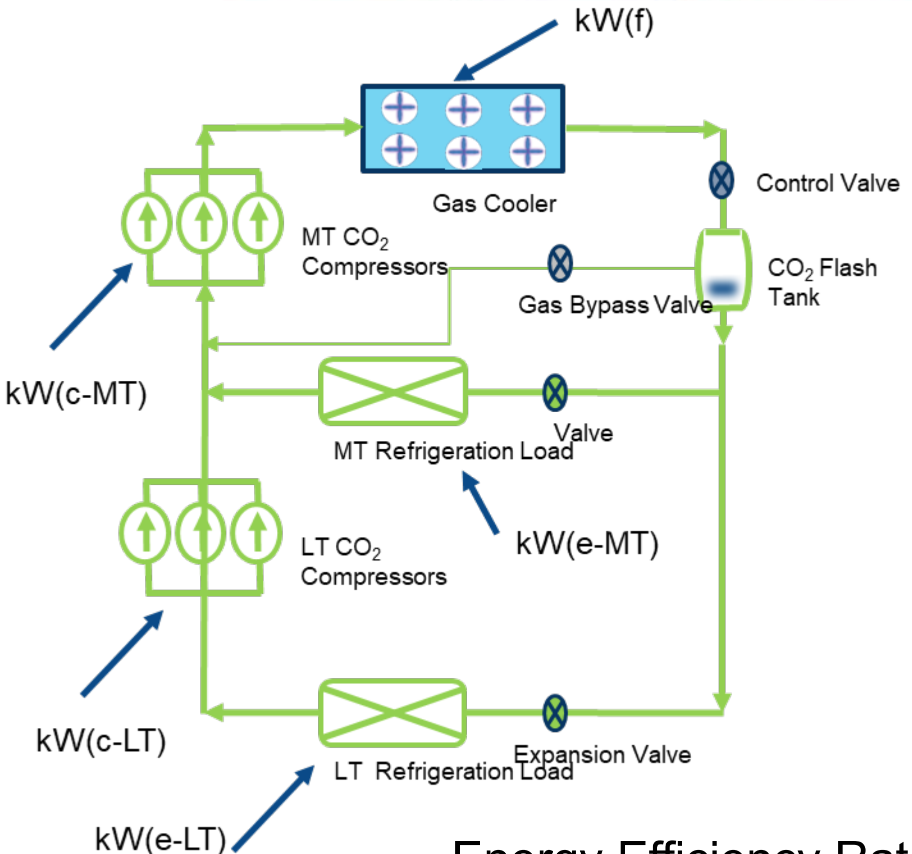
NORTHEAST (NE) COMMISSARIES

Goal

Understand the performance of CO_2 refrigeration systems compared to hydrofluorocarbon (HFC) systems, using three parameters:

1. Energy efficiency ratio (EER) = Refrigeration load (BTU)/refrigeration power (W)
2. Maintenance effort
3. Carbon emissions

Energy Performance Parameter – CO_2 Commissary



Total Refrigeration (MBH) = MBH (LT) + MBH (MT)

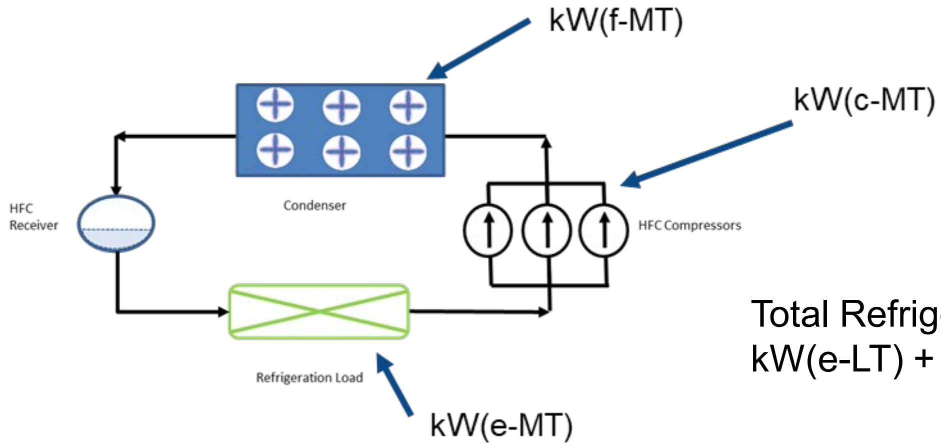
Total Refrigeration Electricity (kW-Ref) =
kW(e-LT) + kW(e-MT) + kW(c-LT) + kW(c-MT) + kW(f)

- kW(e) is electricity consumed in evaporator like evaporation fan, case lights, electronic expansion valve (EEV) defrost heaters & door & drain heaters
- kW(c) is electricity consumed in compressors
- kW(f) is electricity consumed in condenser fans

$$\text{Energy Efficiency Ratio (EER)} = \frac{\text{Total Refrigeration MBH}}{\text{Total Refrigeration kW}}$$

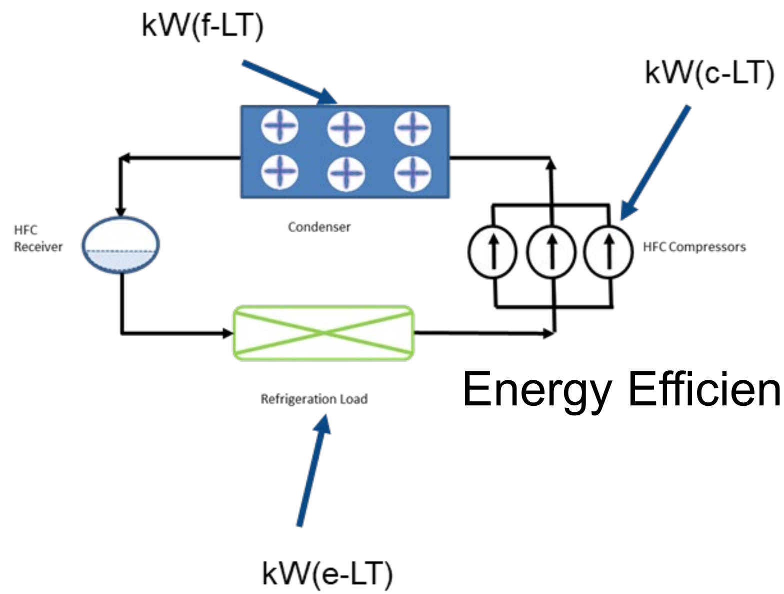
c-MT: Compressor Medium Temp
e-MT: Evap Medium Temp
F: Fahrenheit
kW: Kilowatt
LT: Low Temperature
MBH: Thousand British Thermal Units per hour
MT: Medium Temperature

Energy Performance Parameter – HFC Commissary



Total Refrigeration (MBH) = MBH (LT) + MBH (MT)

Total Refrigeration Electricity (kW-Ref) =
kW(e-LT) + kW(e-MT) + kW(c-LT) + kW(c-MT) + kW(f-LT) + kW(f-MT)



- kW(e) is electricity consumed in evaporator like evaporation fan, case lights, EEV valve defrost heaters & door & drain heaters
- kW(c) is electricity consumed in compressors
- kW(f) is electricity consumed in condenser fans

$$\text{Energy Efficiency Ratio (EER)} = \frac{\text{Total Refrigeration MBH}}{\text{Total Refrigeration kW}}$$

System Comparison – CA Commissaries

Edward-CO2				China-Lake-R407a				% Diff MBH
Suction Gr	Ckt#	Sat Suct T	MBH	Suction Gr	Ckt#	Sat Suct T	MBH	
CS1-LT	1-6	-16F	84.8	CS1-LT	1-8	-16F	82.5	
CS2-LT	7-11	-16F	72.9					
	Total LT =		157.7		Total LT =		82.5	-48%
CS3-MT	12-24	+17F	276.4	CS2-MT	1-29	+18F	442.2	
CS4-MT	25-37	+17F	425.2					
	Total MT =		701.6		Total MT =		442.2	-37%
Total Refg MBH			**859.3**	**Total Refg MBH**			**524.7**	-39%

Condenser Type =	**BAC Trillium**	**Condenser Type =**	**BAC Trillium**
Precool Temp	**70F**	**Precool Temp**	**75F**
WI Fan Motors	**ECM**	**WI Fan Motors**	**ECM**
WI Lights	**T8/LED**	**WI Lights**	**T8/LED**
Case Fan Motors	**ECM**	**Case Fan Motors**	**ECM**
CaseLights	**Mostly LED**	**CaseLights**	**Mostly LED**
Case Night Set backs	**Yes (except 38 doors)**	**Case Night Set backs**	**Yes (except 12 doors)**

BAC: Baltimore Aircoil Company
Ckt: Circuits
ECM: Electronically Commutated Motors
Gr: Group
Sat Suct T: Saturation temperature
LED: Light-emitting Diode
WI: Walk-ins
VFD: Variable Frequency Drive

System Comparison – NE Commissaries

Newport-CO2			
Suction Gr	Ckt#	Sat Suct T	MBH
CS1-LT	1-12	-15F	170.5
	Total LT =		170.5
CS2-MT	14-28	+18F	151.9
CS3-MT	30-44	+24F	417
	Total MT =		568.9
Total Refg MBH			**739.4**

New London-R404a				% Diff MBH
Suction Gr	Ckt#	Sat Suct T	MBH	
CS1-LT	1-6	-22F	122.3	
CS2-LT	21-26	-13F	58.5	
CS2S-LT		-13F	52	
	Total LT =		180.8	6%
CS3-MT	31-43	+18F	295	
CS3S-MT		+18F	63	
CS4-MT	51-62	+26F	431.7	
CS4S-MT		+16F	63	
	Total MT =		852.7	50%
Total Refg MBH			**1034**	40%

Condenser Type =	**BAC Trillium**	**Condenser Type =**	**Hussmann Air Cooled with VFD**
Precool Temp	**73F**	**Precool Temp**	**Not Applicable**

WI Fan Motors	**ECM**	**WI Fan Motors**	**ECM**
WI Lights	**T8/LED**	**WI Lights**	**T8/LED**

Case Fan Motors	**ECM**	**Case Fan Motors**	**ECM**
CaseLights	**Mostly LED**	**CaseLights**	**Mostly LED**
Case Night Set backs	**No (always ON)**	**Case Night Set backs**	**Yes (except 12 doors)**

Power Measurements

Total Refrigeration — Transformer Load (XTMR) = Net Refrigeration

Total Refrigeration (Comp, Condenser, Evaporation Fans, Case Lights, Defrost Heaters, Miscellaneous load etc.)

–

Miscellaneous Load (Evaporation Fans, Case Lights, Defrost Heaters, Miscellaneous load etc.)

=

Refrigeration (Comp + Condenser)

Energy Comparison – Monthly Trend

EDWARDS - CO2

Month	OAT	Total Refg kW	XFMR kW	Net Refg kW	EER Total Refg	EER Net
Mar	51.6	74.0	0.0		11.8	
Apr	60.8	80.1	17.6	62.5	10.9	14.5
May	71.7	84.3	30.3	54.0	10.3	16.2
Jun	77.9	87.6	30.4	57.2	9.9	15.4
Jul	84.2	90.2	30.0	60.2	9.6	14.6
Aug	85.7	99.8	31.2	68.6	8.8	12.9
Sep	77.6	89.6	30.1	59.5	9.8	14.9
Oct						
Avg	**72.6**	**86.4**	**24.0**	**62.4**	**10.2**	**14.3**

CHINA LAKE - R407a

Month	OAT	Total Refg kW	XFMR kW	Net Refg kW	EER Total Refg	EER Net
Mar						
Apr	76.2	37.9	12.0	25.9	14.6	22.1
May	80.1	39.7	11.6	28.1	13.7	19.7
Jun	86.3	40.1	10.8	29.3	13.3	18.4
Jul	92.9	41.4	10.9	30.4	12.8	17.6
Aug	93.7	44.3	11.2	33.1	12.0	16.1
Sep	86.6	40.7	11.1	29.6	13.2	18.6
Oct						
Avg	**87.0**	**41.0**	**11.2**	**29.8**	**13.1**	**18.4**

NEWPORT - CO2

Month	OAT	Total Refg kW	XFMR kW	Net Refg kW	EER Total Refg	EER Net
Mar	44.8	72.3	0.0		10.2	
Apr	46.6	74.1	12.3	61.5	10.0	13.8
May	57.2	81.3	39.0	42.2	9.2	18.3
Jun	69.1	91.6	39.4	52.1	8.1	14.7
Jul	75.9	102.4	39.9	62.4	7.3	12.3
Aug	75.0	104.8	40.0	64.7	7.1	11.9
Sep	68.2	94.1	39.7	54.3	7.9	14.2
Oct	63.1	97.9	39.2	58.6	7.7	13.4
Avg	**62.5**	**89.0**	**30.4**	**58.4**	**8.5**	**13.7**

NEWLONDON - R404a

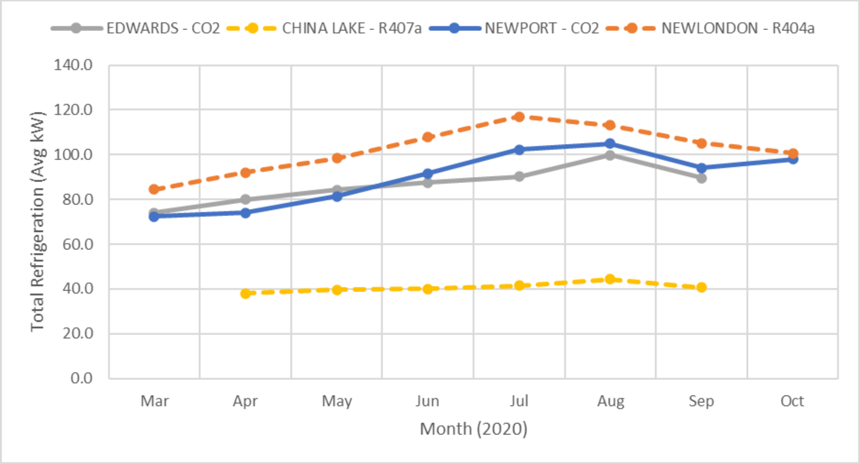
Month	OAT	Total Refg kW	XFMR kW	Net Refg kW	EER Total Refg	EER Net
Mar	45.1	84.5	0.0		12.4	
Apr	47.7	91.9	12.6	79.3	11.7	15.3
May	60.1	98.5	45.4	53.1	10.7	20.6
Jun	72.4	107.9	46.9	61.0	9.7	17.9
Jul	79.1	117.0	48.5	68.5	9.0	15.8
Aug	76.7	113.1	47.7	65.4	9.3	16.7
Sep	67.4	105.1	48.5	56.7	10.0	19.4
Oct	59.5	100.6	49.2	51.4	10.4	21.5
Avg	**65.8**	**104.3**	**39.5**	**64.8**	**10.2**	**17.4**

Mostly Summer Months

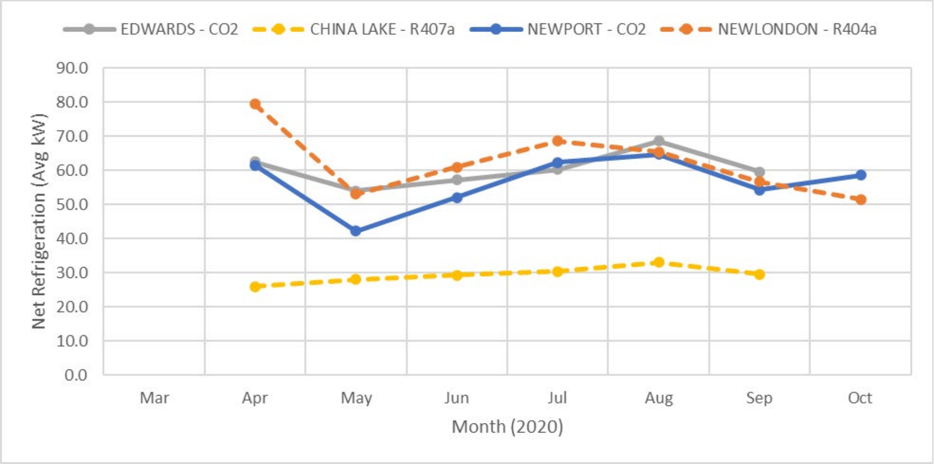
OAT: Outside Air Temperature

Energy Comparison – Monthly Trend

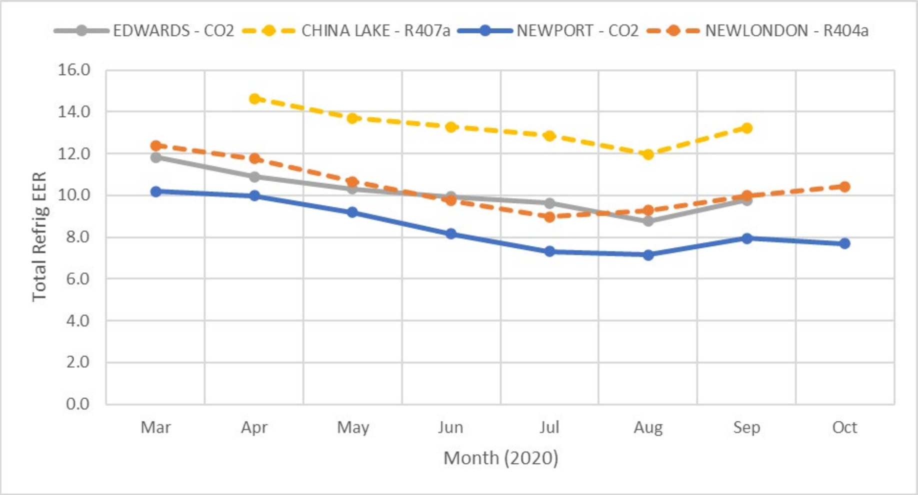
Total Refrigeration (Avg kW)



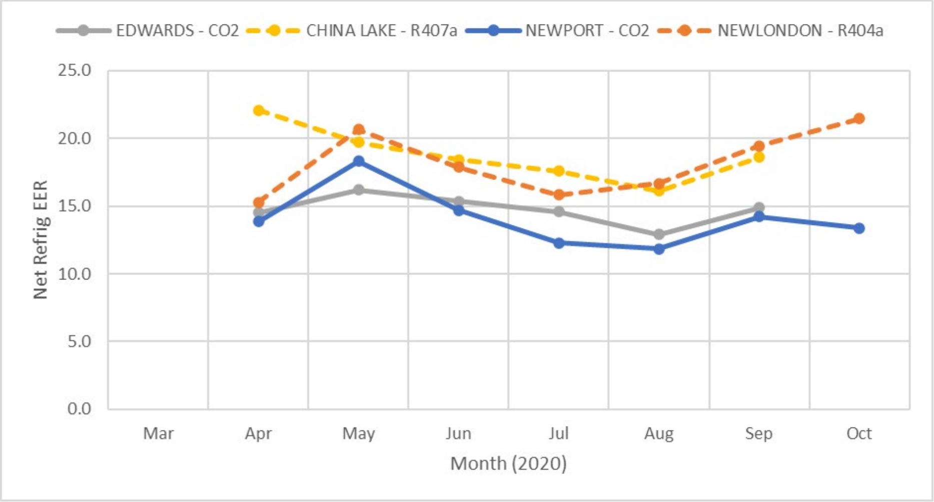
Net Refrigeration (Avg kW)



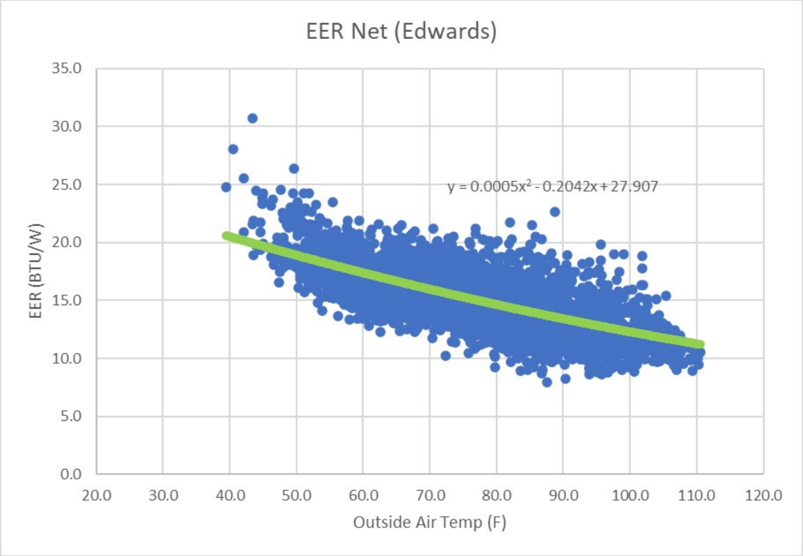
Total EER (BTU/W)

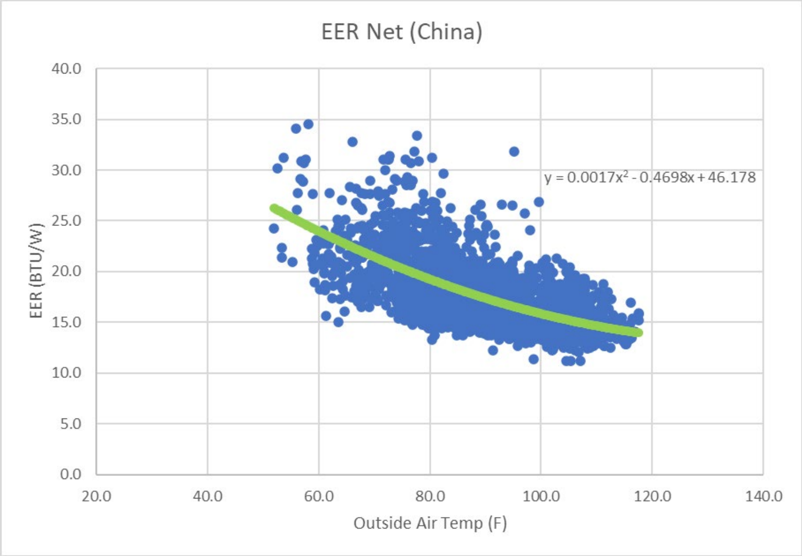


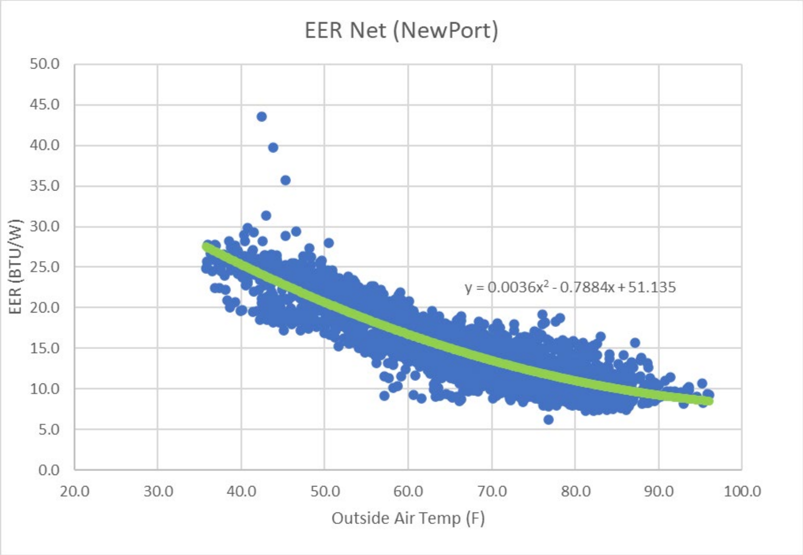
Net EER (BTU/W)

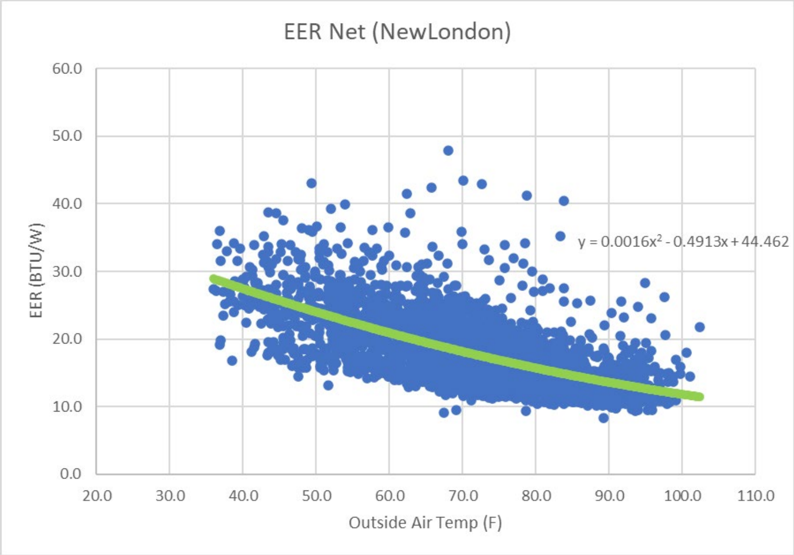


Weather Normalized – Net Refrigeration

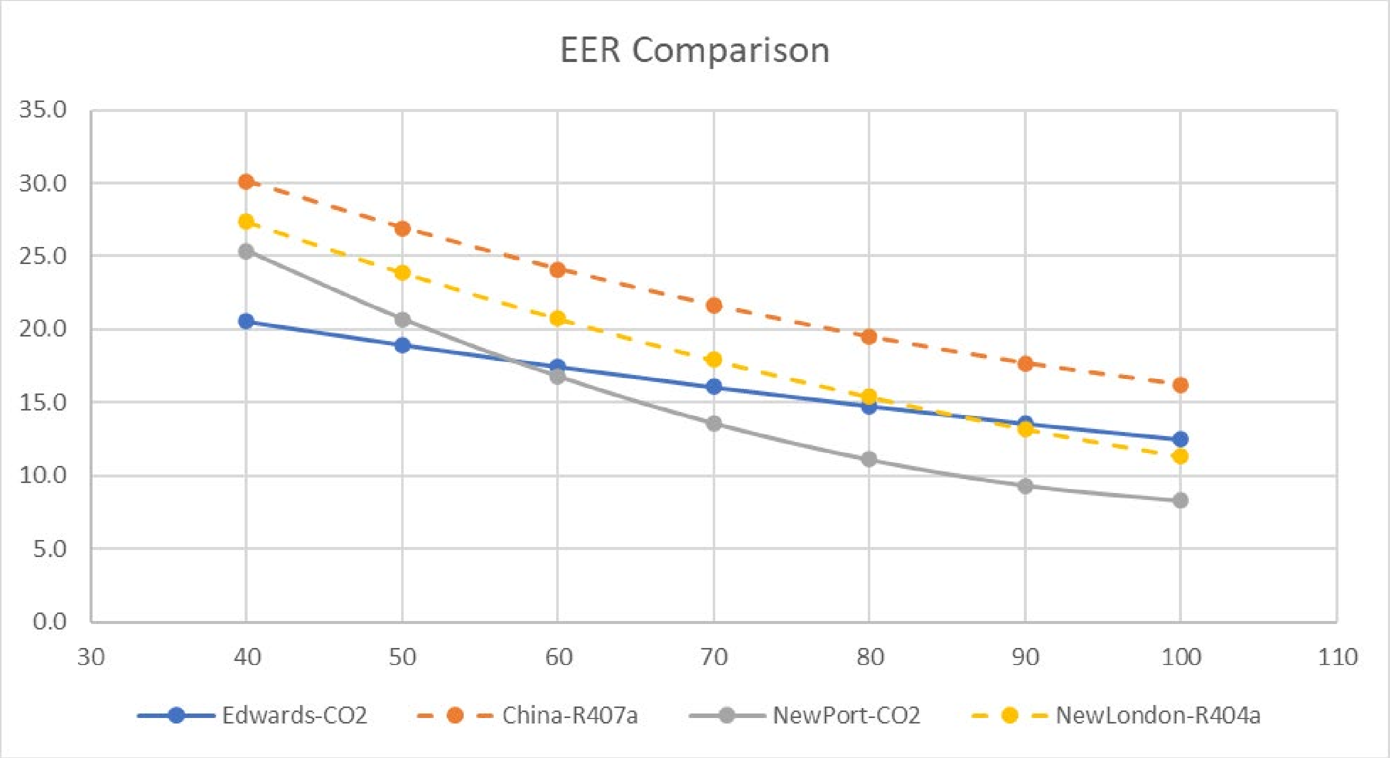








Weather Normalized



OAT	Edwards-CO2	China-R407a	NewPort-CO2	NewLondon-R404a
40	20.5	30.1	25.4	27.4
50	18.9	26.9	20.7	23.9
60	17.5	24.1	16.8	20.7
70	16.1	21.6	13.6	17.9
80	14.8	19.5	11.1	15.4
90	13.6	17.7	9.3	13.2
100	12.5	16.2	8.3	11.3

Maintenance Summary

Store Name	# of Refrigeration Issues
EDWARDS – CO_2 (Jan-May 2020)	4
CHINA LAKE – R407A (Jan-May 2020)	9
NEW-PORT – CO_2 (Jan-Sept 2020)	15
NEW LONDON – R404A (Jan-Sept 2020)	13

Maintenance Needs Are Similar

Equivalent 1000MBH Store

Bin Analysis Using Weather Model Generated

OAT	BIN Hrs	Edwards-CO_2			China Lake-R407a		
		EER	Refg kW	Refg kWh-(1000MBH)	EER	Refg kW	Refg kWh-(1000MBH)
112.5	19	11.3	88.8	1687.0	14.8	67.4	1280.2
107.5	69	11.7	85.2	5880.5	15.3	65.3	4503.9
102.5	275	12.2	81.8	22486.4	15.9	63.0	17312.9
97.5	398	12.8	78.4	31214.2	16.5	60.5	24072.9
92.5	335	13.3	75.2	25194.4	17.3	57.9	19401.0
87.5	492	13.9	72.1	35478.3	18.1	55.3	27203.2
82.5	598	14.5	69.1	41345.1	19.0	52.7	31490.1
77.5	667	15.1	66.3	44217.2	20.0	50.1	33384.8
72.5	615	15.7	63.6	39095.7	21.1	47.5	29211.8
67.5	700	16.4	61.0	42678.7	22.2	45.0	31514.3
62.5	798	17.1	58.5	46673.1	23.5	42.6	34021.0
57.5	722	17.8	56.1	40519.4	24.8	40.3	29130.4
52.5	779	18.6	53.9	41961.5	26.2	38.2	29733.8
47.5	656	19.3	51.7	33927.0	27.7	36.1	23683.9
42.5	649	20.1	49.7	32237.8	29.3	34.2	22163.7
37.5	472	21.0	47.7	22527.0	31.0	32.3	15249.8
32.5	286	21.8	45.9	13120.1	32.7	30.6	8744.8
27.5	133	22.7	44.1	5866.9	34.5	28.9	3850.1
22.5	68	23.6	42.4	2885.6	36.5	27.4	1864.6
17.5	29	24.5	40.8	1184.3	38.5	26.0	753.7
			Total Annual kWh=	530,180		Total Annual kWh=	388,571

Annual Energy Difference= 141,609 (CO_2 Store is higher)

GWP Analysis

ENERGY DIFFERENCE:

Annual Energy Difference=	**141,609**	**(CO2 Store is higher)**
lbs of CO2 per kWh (EIA Source)=	0.99	
lbs of CO2 (GWP) due to higher kWh =	140,193	

REFRIGERANT LEAK EFFECT:

lbs of R407a in China Lake =	1400	(524 MBH REFRIGERATION)
Normalized 1000 MBH Refg lbs of R407a required =	2672	
Annual Leak rate of 20% =	534	
lbs of CO2 per lb of R407a (EIA Source)=	2100	
Total equivalent lbs of CO2 =	1,122,137	(HFC STORE IS HIGHER)
Net GWP of HFC store higher than Transcrital CO2 store (estimated) =	**981,944**	

Lbs: Pounds
EIA: Energy Information Administration
GWP: Global Warming Potential

Summary

- Energy
  - HFC stores performed better by almost 28-30%
- Maintenance
  - They seem to have similar maintenance needs
- GWP
  - CO_2 store has significantly lower GWP (even when higher energy is factored in)

What Now?

- Continue the study through the winter to capture a full year's worth of operation. Expecting CO_2 systems to perform better in the winter months.

- Both CO_2 systems could be fine tuned to perform better. Condenser not running optimally.

Contacts and Additional Information

Contact Information

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Upcoming Webinars

Date	Webinar Topic
12/8	Small and Independent Grocers Partnering with GreenChill

Join our webinar invitation list or request today's slides: EPA-GreenChill@abtassoc.com

View past GreenChill webinars: www.epa.gov/greenchill/events-and-webinars