GreenChill Advanced Refrigeration Partnership

Environmental Best Practices for Retrofits

Retrofit Webinar Presenters

- Keilly Witman – U.S. EPA
- Nick Strickland – DuPont
- Craig Thomas – Arkema
- Ron Vogl - Honeywell
- Sean Cunningham – Ineos Fluor

Webinar Agenda

- 2:00 – 2:10 Intro/Ozone Layer Protection/R-22 Phaseout – Keilly
- 2:10 – 2:20 Business Case for Retrofits – Nick
- 2:20 – 2:30 Range of Retrofits/Leak Tightness Improvements – Craig
- 2:30 – 2:40 Factors to Consider when Assessing Retrofit Options – Ron
- 2:40 – 2:50 Retrofit Best Practices – Sean
- 2:50 - 3:00 R-22 End of Life – Nick
- 3:00 – 3:15 Q&A

The Ozone Layer

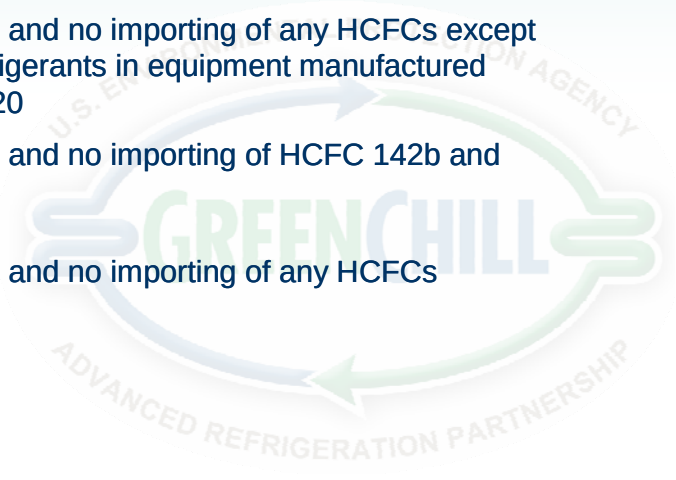
- Ozone layer protects us from ultraviolet radiation from the sun
- A thinner ozone layer allows more radiation to reach the Earth's surface
  - skin cancer
  - cataracts
  - weakened immune systems
  - reduced crop yields
  - disruptions in the marine food chain
- Ozone layer thinning/ozone holes caused by the release of chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and other ozone-depleting substances, which were and are used widely as refrigerants, insulating foams, and solvents.
- When these substances reach the stratosphere, the UV radiation from the sun causes them to break apart and release chlorine atoms which react with ozone, starting chemical cycles of ozone destruction that results in significant thinning of the protective ozone layer. One chlorine atom can break apart more than 100,000 ozone molecules.

Ozone Layer Protection

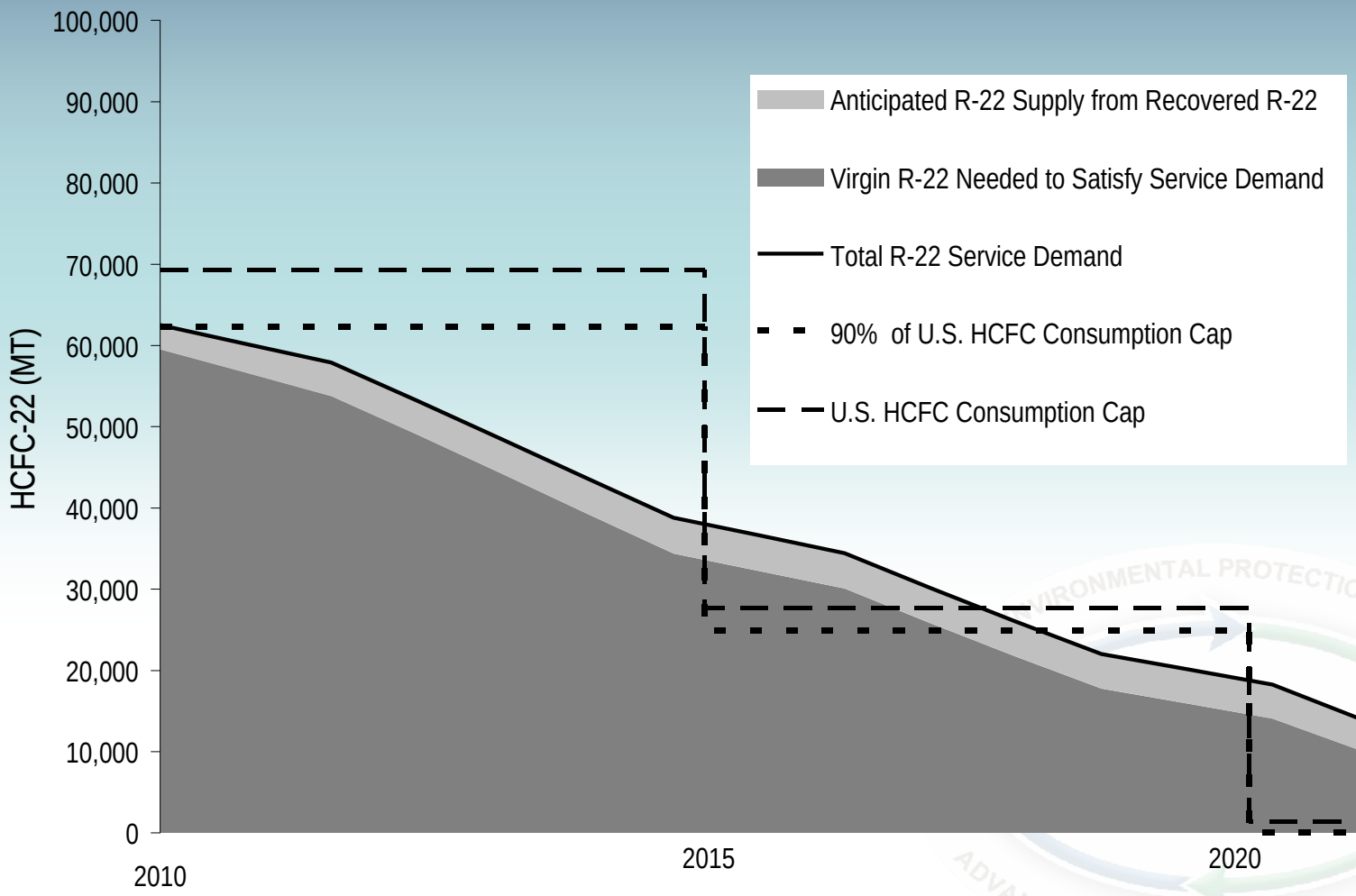
- Montreal Protocol
  - International treaty signed by the U.S. & 179 other countries, developed & developing nations
  - purpose is to repair and protect the earth's ozone layer so we remain safe from the harmful effects of ultraviolet (UV) radiation
  - mandated the complete phaseout of CFCs
  - Gradual phaseout of HCFCs started in 2004 according to a schedule agreed upon by the signing parties, including the USA.
- The U.S. incorporated the Montreal Protocol requirements into Title VI of the United States Clean Air Act
  - Title 40, Part 82 of the Code of Federal Regulations contains EPA's regulations to protect the ozone layer
  - EPA's Stratospheric Protection Division manages these programs
- Outstanding environmental and health benefits
  - 6.3 million U.S. skin cancer deaths prevented by 2165

EPA ODS Phaseout Plan

Montreal Protocol		United States	
Implementation Year	% Reduction in Consumption and Production Using the Cap as the baseline	Implementation Year	Implementation of HCFC Phaseout through Clean Air Act Regulations
2004	35%	2003	No production and no importing of HCFC 141b
2010	75% (Reduced in 2007 from 65%)	2010	No production and no importing of HCFC 22 and HCFC 142b except for use in equipment manufactured before 1/1/2010 (no new production or importing for NEW equipment using these refrigerants)
2015	90%	2015	No production and no importing of any HCFCs except for use as refrigerants in equipment manufactured before 1/1/2020
2020	99.5%	2020	No production and no importing of HCFC 142b and HCFC 22
2030	100%	2030	No production and no importing of any HCFCs



HCFC-22 Supply and Demand



Source: EPA's Vintaging Model (VM IO file_2007_11-12-07)

Estimated R-22 Supply and Demand

Equipment Type	2010	2015	2020
Total AC	41,700	25,900	11,300
Total Refrigeration	20,800	12,800	7,000
Estimated Demand of R-22	62,500	38,800	18,200
Estimated Supply (90% of cap for R-22)	62,345	24,938	0

Servicing Existing HCFC-22 Appliances after 2010

- In 2015, HCFC-22 needs will exceed the 2015 cap by more than 10,000 metric tons
- Recovery and reuse needed to provide room under the cap and meet demand for all HCFCs
- What can you do?
  - Improve service practices (recover, recycle, reclaim)
  - Fix leaks
  - Retrofit/Replace where economical

During the Transition Period

- **Businesses have three options:**
  - Convert existing system to alternative refrigerant
  - Buy a new system that uses an alternative refrigerant
  - Continue to operate existing system
- **Establish a plan to replace/repair leaking equipment**
- **Recover and reuse refrigerant from equipment that is discarded**
- **Begin to transition to alternative refrigerants**
  - Many businesses have started to switch
  - Consider amount of time needed to convert

GreenChill Best Practices Guideline Commercial Refrigeration Retrofits

- Mission: provide food retailers with fact-based, neutral information on best practices for every aspect of the HCFC-22 conversion process

- Retrofit Guideline is at http://epa.gov/ozone/partnerships/greenchill/downloads/RetrofitGuidelines.pdf

Contact Info – Phaseout and Regulatory

- **Phaseout: Cindy Newberg, newberg.cindy@epa.gov, 202-343-9729**

- **For Sec. 608: Julius Banks, banks.julius@epa.gov, 202-343-9870**

- **Additional Info:**

http://www.epa.gov/ozone/title6/phaseout/classtwo.html

http://www.epa.gov/ozone/title6/allowance.html

Contact Information – Retrofit Guidelines

- **US EPA - Keilly Witman**
  - **202-343-9742**
  - **witman.keilly@epa.gov**
- **GreenChill Advanced Refrigeration Partnership**
  - **www.epa.gov/greenchill**
- **GreenChill Partners – Retrofit Team**
  - **Arkema – Craig Thomas 215-419-7938**
  - **DuPont – Nick Strickland 302-999-2709**
  - **Honeywell – Ron Vogl 716-827-6205**
  - **INEOS Fluor – Sean Cunningham 225-642-6235**

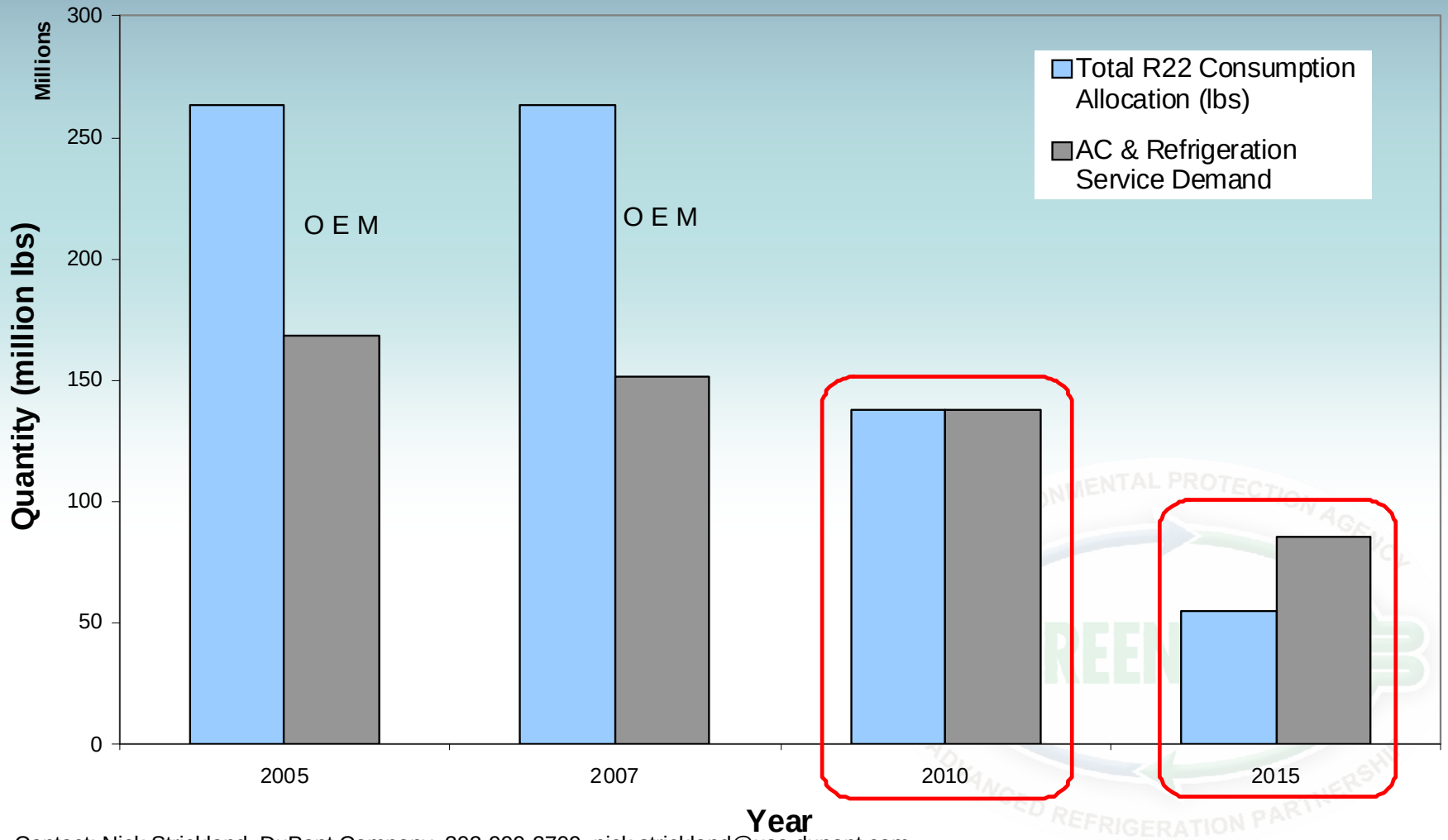
HCFC Replacement Refrigerants – The Business Case

- HCFC-22 is going away
- HCFC-22 price volatility likely
- Use HCFC-22 from retrofits to service other stores
- Retrofitting is the lowest cost Zero ODP solution
- Avoid back room investments to free up cash for the higher ROI business investments

Contact: Nick Strickland, DuPont Company, 302-999-2709, nick.strickland@usa.dupont.com

HCFC22 Is Going Away

Estimated US R22 Supply Demand for AC & Refrigeration



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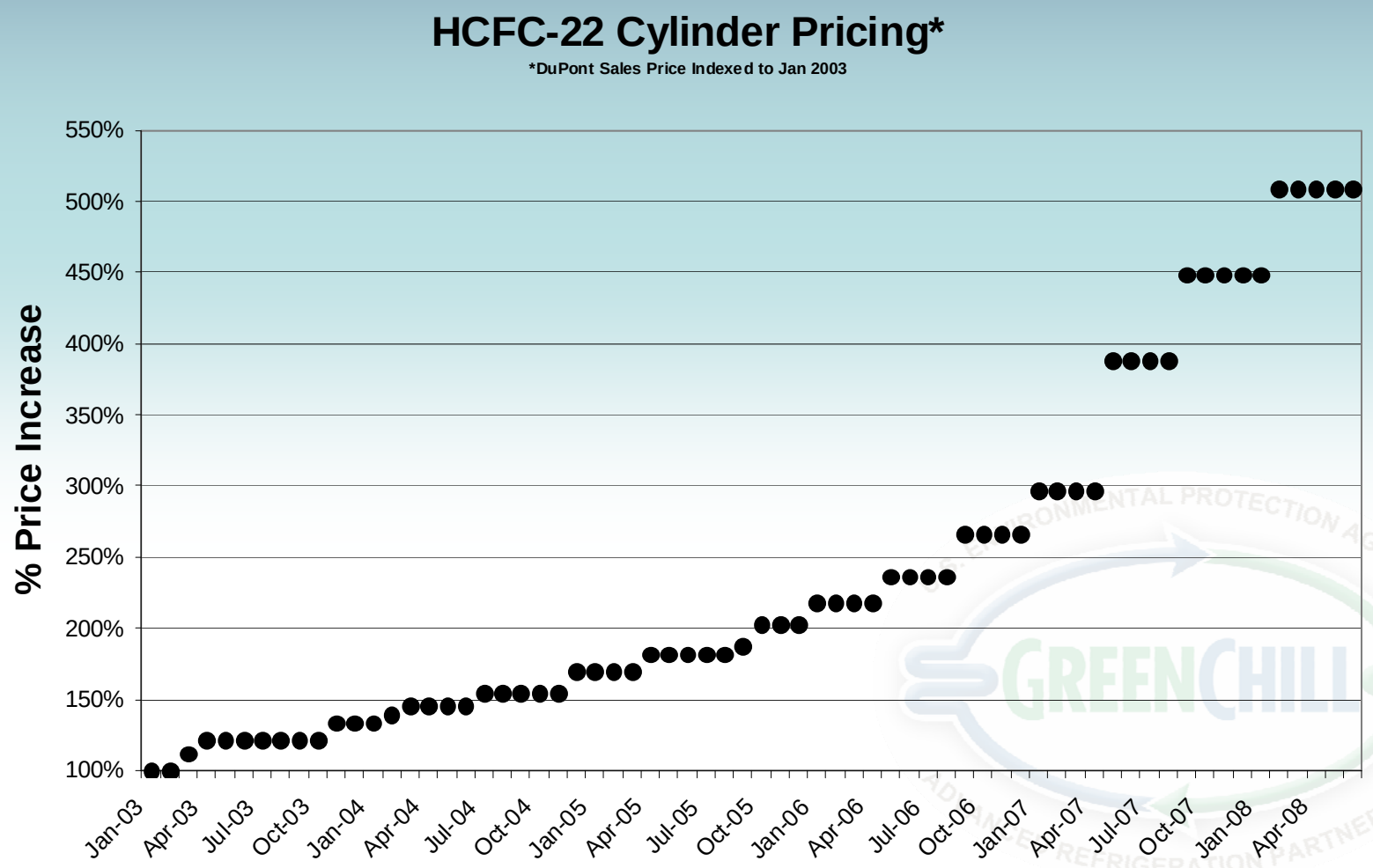
HCFC-22 Price Volatility Likely



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Future Availability of HCFC22 Replacement Refrigerants

- Product acceptance
- Producer commitment to supply
  - Look for products major refrigerant producers select after careful consideration of options
- Distribution commitment to service retail locations

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Retrofitting to HFC's provides…

- A lower cost supply of R22
- The lowest total cost refrigeration technology

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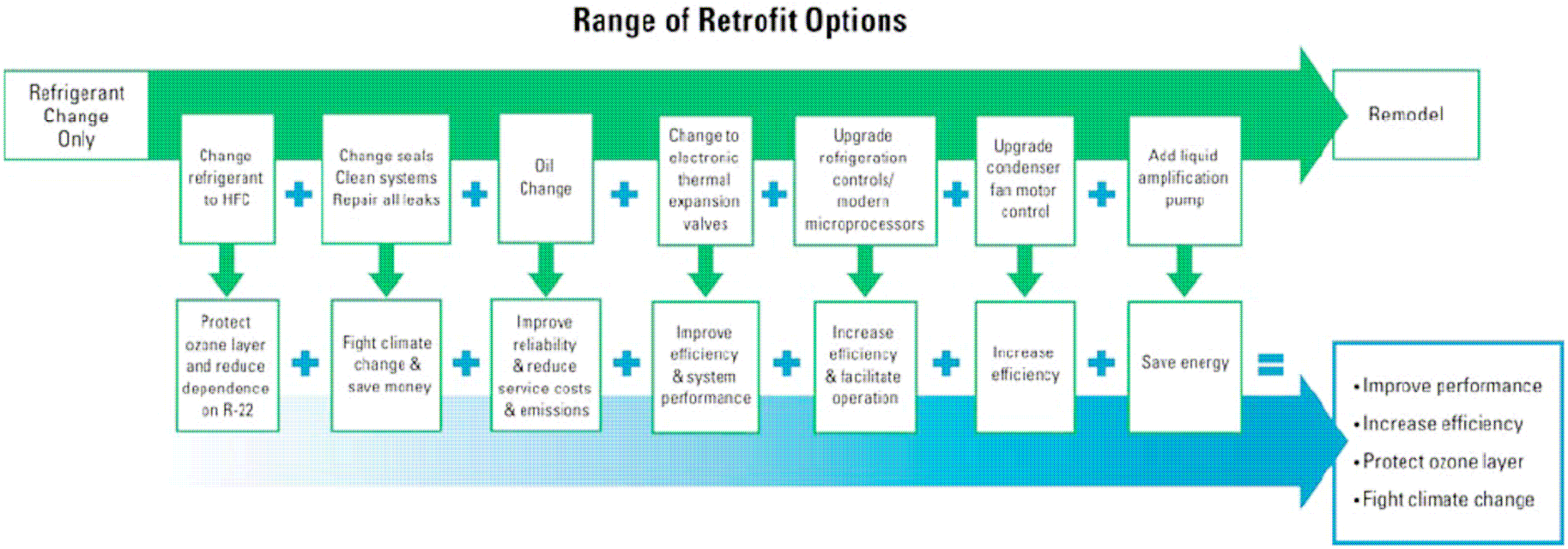
HFC Retrofit Options
October 14, 2008

HFC Refrigerant Retrofit Options



There are two main approaches to retrofitting supermarkets from HCFC-22 to HFCs:

1. Replacing only the refrigerant with minimal changes or adjustments to the refrigeration system.

2. Using new mechanical systems, which may include compressors, condensers and refrigerated cases, along with a change to an HFC refrigerant.

HFC Refrigerant only Retrofit

Advantages

- Minimal Retrofit Costs
- Minimal disruption to store ops
- Possible lower dischage temps
- Zero ozone depleting refrigerant

Disadvantages

- Possible efficiency decline
- Possible oil change required
- Possible compatibility issues with seals and valves

Retrofitting with new mechanicals will help reduce issues related to new HFC refrigerants and help improve efficiency.

1. **Improving control strategies- floating head pressure control, liquid amplification, etc.**
2. **Advances in compressor and motor design, improved microprocessor controllers, variable frequency drives**

Reducing leaks is also a useful while completing a retrofit, it reduces cost and helps the environment by reducing greehouse gas emmisions

Factors to Consider

- **Capacity**- what is the available capacity?
- **Efficiency**- there may be a reduction in capacity with a retrofit from HCFC 22
- **Mass Flow**- could be an issue for expansion device selection
- **Equipment change**- will there need to be a change due to extreme differences in capacity, mass flow, efficiency, etc.
- **Lubricant Compatibility**- understanding of oil return when retrofitting is important
- **Compressor Mfctr Approval**- Understand the compressor manufacturers recommendations
- **Global warming potential**- Effect of emissions on the environment
- **Dispruption to store operations**

Value/Cost Calculation

First Cost

- **Labor-** Engineering, Installation
- **Materials-** Refrigerant quantity, Oil, Expansion valves, etc.

Future Operating Costs

- **Energy**
- **Compressor Life**
- **Service Refrigerant Cost**
- **Service Labor Cost**

Assessing Retrofit Options

Factors to Consider

- Capacity
- Efficiency
- Resultant Mass Flow
- Equipment Changes
- Lubricant Compatibility
- Compressor Manufacturer Approval
- Global Warming Impact
- Disruptions to Store operations

Capacity

- The capacity of an existing refrigeration system is determined by the selected refrigerants (R22) refrigerating effect per lb circulated and the weight of refrigerant circulated per unit time.
  - The compressor(s) displacement was selected on R22 values resulting in the systems capacity at selected conditions.
  - Retrofit fluids with characteristics different that those of R22 will deliver different capacity values.
    - Gas volume at suction conditions
    - Enthalpy
    - Pressure drop effects
- Moderate capacity shortfalls of alternative refrigerants may be addressed with system modifications.
  - Modify operating conditions
  - sub cooling
- A thorough analysis of the thermodynamics, the existing system and compressor manufacturers data is warranted to predict a replacement refrigerants performance in **your** system.
  - Review compressor manufacturers data carefully , often the printed capacity is the result of standardized testing using high return gas temperatures and all superheat is calculated as useful cooling.

Efficiency

- COP – The coefficient of performance of a refrigeration cycle is the ratio of the heat absorbed to the heat energy equivalent of the energy supplied to the compressor.
  - Simple thermodynamic calculations can be and indicator of cycle efficiency.
  - System efficiency is the result of minimizing loses in the cycle by utilizing efficient compressors, narrowing compression ratios, minimizing pressure drop etc.
  - R22 is a good refrigerant , retrofitting to a refrigerant with properties as close to those of R22 may maintain system efficiency.
    - Some retrofit candidates benefit significantly by applying sub cooling which can help the low temperature system efficiency.

Mass Flow

- A better expression would be “resultant mass flow”.
  - In a retrofit situation we are working with established compressor displacement selected to “pump” the proper amount of R22 to satisfy the refrigeration load.
    - Retrofit refrigerant selections with suction vapor volumes different than R22 will produce higher or lower resultant mass flows.
  - Significantly higher or lower mass flows can affect system performance.
    - TXV’s in particular may require changing if the mass flow varies significantly. (+ - 30%)
    - High mass flows may increase piping pressure losses and degrade system efficiency.

Equipment Change

- There is no “drop in” for R22 and the systems components must be evaluated when considering a retrofit fluid.
  - Consult compressor manufacturers for suitability of replacements in their units both from a materials compatibility and capacity standpoint. Motors and starters should also be evaluated.
  - Valve manufacturers should be consulted for operation suitability and materials of construction compatibility.
  - Pressure drop in evaporator distributors should be evaluated.
  - Elastomers-seals and gaskets must be changed during a retrofit.
  - While not a “change”. Retrofit candidates with high glide may require TXV adjustment.

Lubricant Compatibility

- In general, R22 systems utilize mineral oil and the oil /refrigerant relationship is well understood and system piping practices and oil separation technology is well established.
- HFC's and Synthetic lubricants were engineered to reproduce the HCFC/mineral oil relationship.
- HFC/HC Blends offer the possibility of using mineral oil with HFC's. This approach should be evaluated carefully and many supermarkets have successfully used various HFC/HC blends with mineral oil. In some cases the addition of synthetic lubricants to the mineral oil may be required to obtain adequate oil return.
- Compressor and system manufactures should be consulted when selecting lubricants.
- Synthetic lubricants (POE) have proven to be a good solvent. Monitoring system cleanliness after a conversion to this lubricant is warranted.

Compressor Manufacturers Approval

- Compressor manufacturers have established guidelines for retrofit fluids.
  - Warranties can be void if unapproved refrigerants or lubricants are used.
  - Some older compressor models are not suitable for HFC/synthetic lubricants.
  - Compressor manufacturers extensive reliability and capacity analysis is extremely useful in selecting a retrofit fluid.
    - Revised electrical data
    - Capacity tables
    - Lubricant recommendations

GWP

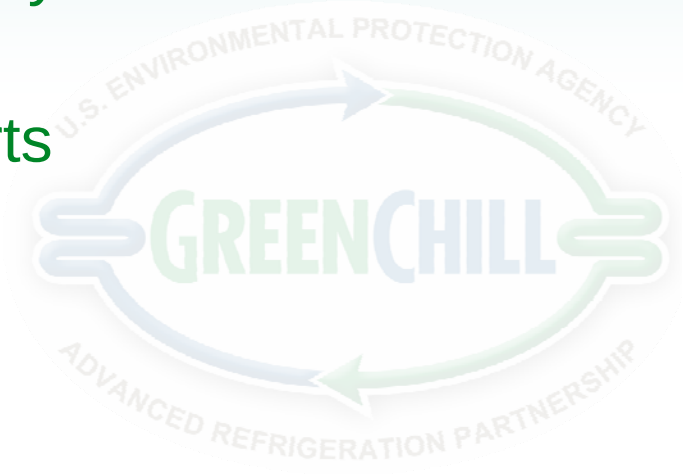
- While not a design or operational consideration the GWP of a replacement refrigerant should be considered when evaluating prospective retrofit candidates.
  - Possible regulatory action around the GWP of refrigerants in the future make the selection of fluids with lower values a prudent choice.
  - Reduction in carbon footprint
  - Commercial LEED certification is evolving
  - Opportunity to achieve GreenChill Certification with low GWP refrigerants

Disruption to Store Operations

- A refrigerant only retrofit could minimize sales floor disruption provided:
  - Retrofit fluid mass flow and pressures are close enough to those of R22 to avoid TXV changes.
  - Seal and gasket replacement is back room work.
  - Minimal or no re-piping is necessary

Best Practices –Preparation

- Decide on Refrigerant and Oil
  - Different grades of POE
- Check Elastomer and Equipment Compatibility
- Ensure all materials are on-hand
  - Spare refrigerant
  - Replacement equipment. What you will need and what you might need.
  - Refrigerant labels and P-T charts
  - Refrigerant leak detector



Best Practices – Preparation

- Record system performance
- Check existing system for any leaks and repair

Best Practices – Oil change

- Changing from Mineral Oil to POE
  - Are there existing oil return issues
  - What is the existing oil analysis
  - Measure how much oil is taken out
  - Check with refrigerant manufacturer number of flushes required.
  - POE/R22 has different swell characteristics for elastomers. Check system for any leaks.

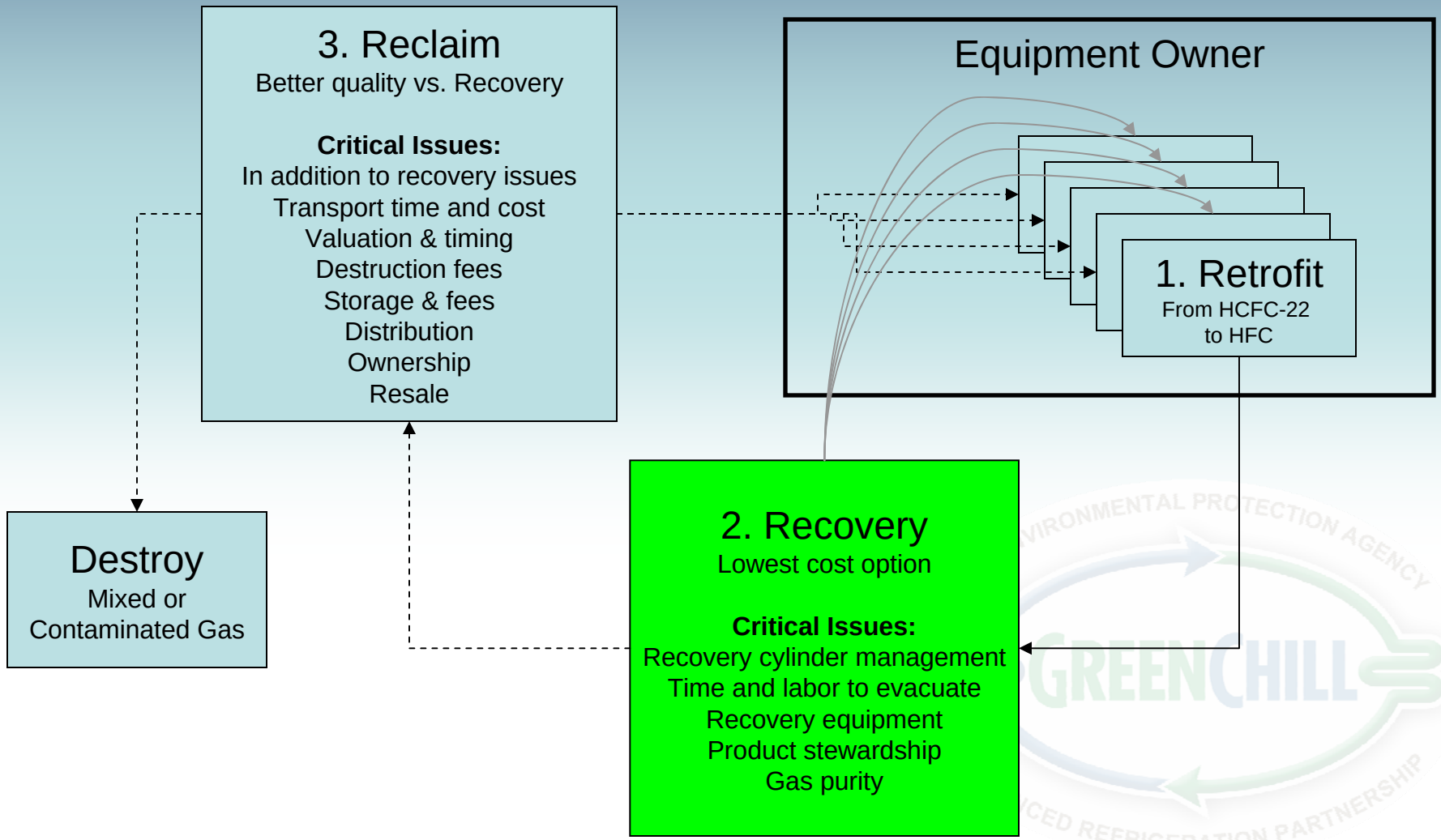
Best Practices – Leak Reduction

- Replacing seals and valves will minimize leaks
  - Receiver sight glass
  - Receiver isolations
  - Old ball valves
  - Repair/replace solenoid valves
  - Replace any opened seal
- Use of valve retrofit caps
- 500 micron vacuum before adding refrigerant

Best Practices – Refrigerant change

- For 400 series Blends, charge liquid
- Check for any leaks
- Set correct superheat and subcool
- Calculate superheat from Dew Point and Subcool from Bubble Point
- Use retrofit as an opportunity to set the system up properly to maximize energy performance

End of Life Considerations for HCFC-22 refrigerants



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