

<b>DOCKETED</b>	
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<b>Project Title:</b>	Decarbonizing Buildings
<b>TN #:</b>	223802
<b>Document Title:</b>	Carbon Footprint Cooling Sector
<b>Description:</b>	Presentation by Aanchal Kohli at June 14, 2018 IEPR Workshop on Achieving Zero Emission Buildings
<b>Filer:</b>	Stephanie Bailey
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# CARBON FOOTPRINT COOLING SECTOR

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Aanchal Kohli, D. Env.

Integrated Energy Policy Report Workshop

June 14<sup>th</sup> 2018

# Goal

Reduce the carbon footprint of  
cooling equipment in buildings

# Global Warming Potential (GWP)

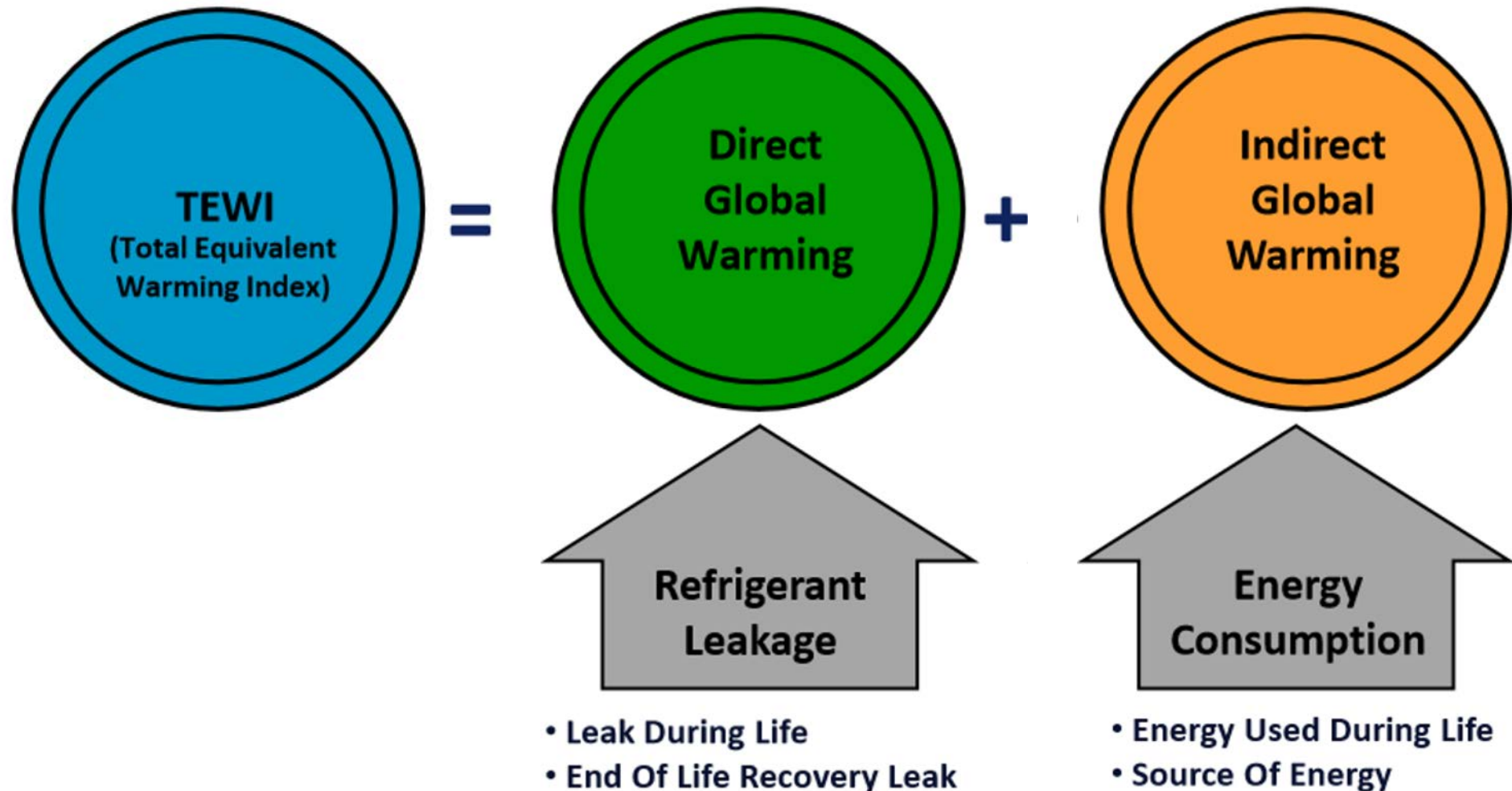


4,360

Miles driven  
by an average  
passenger  
vehicle

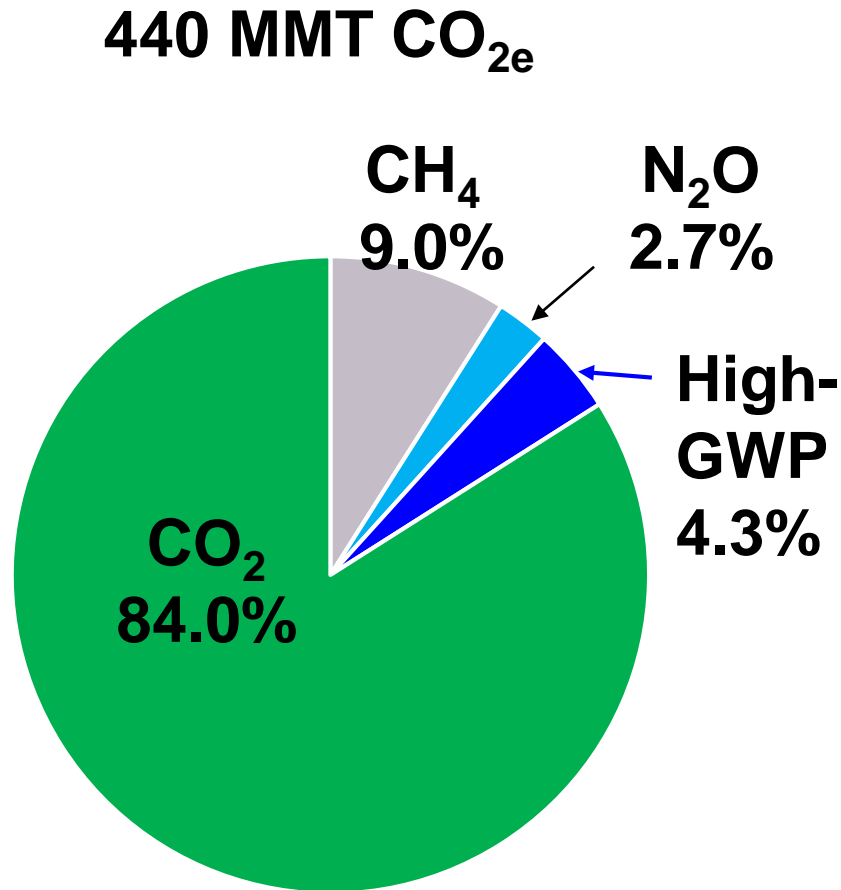
1 pound of R-404A  
GWP = 3922

# A Holistic Approach to Evaluate Technologies

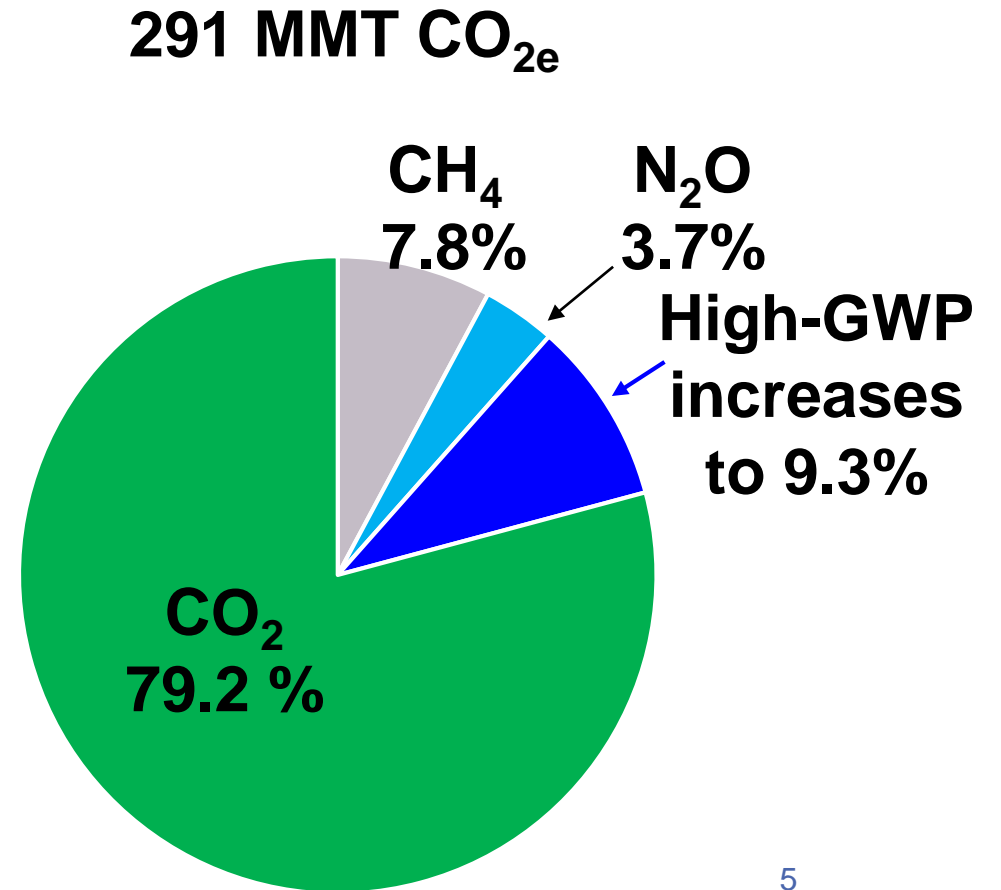


# Growing HFC Emissions in CA: 2015 and 2030 BAU

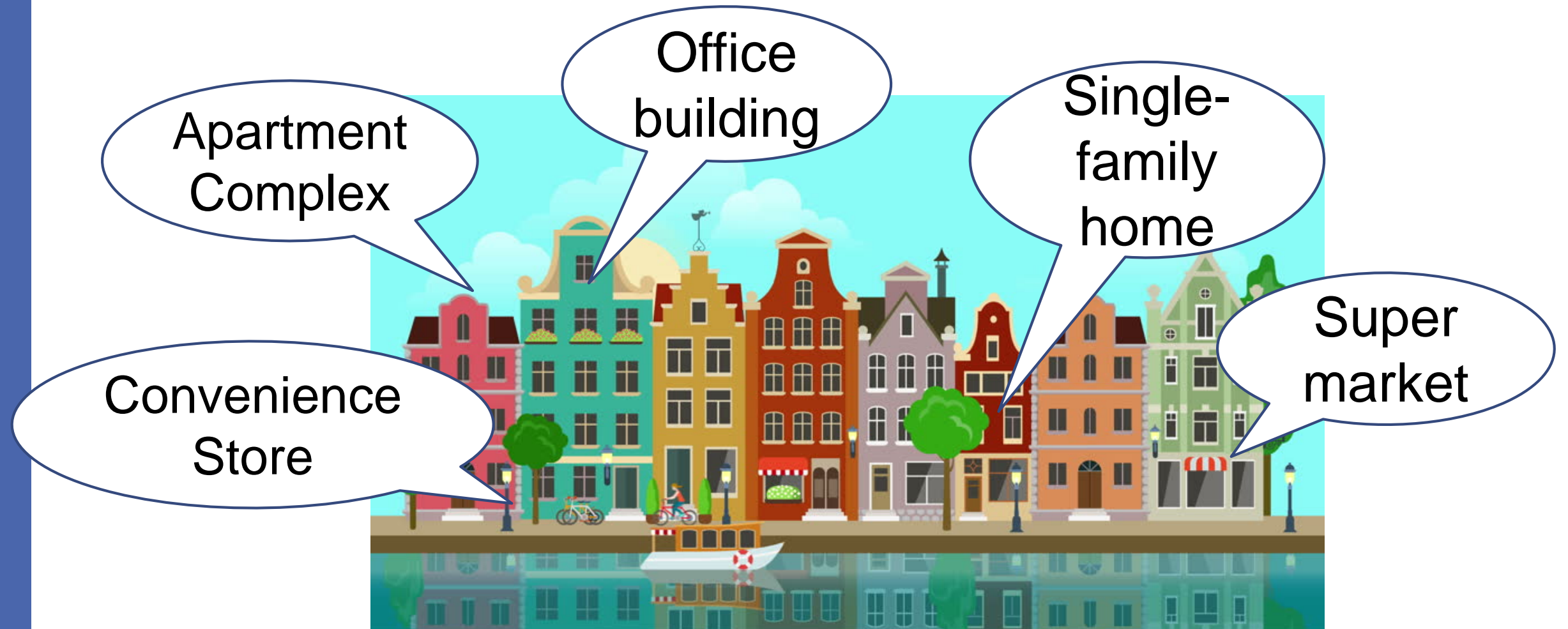
2015 GHG Distribution



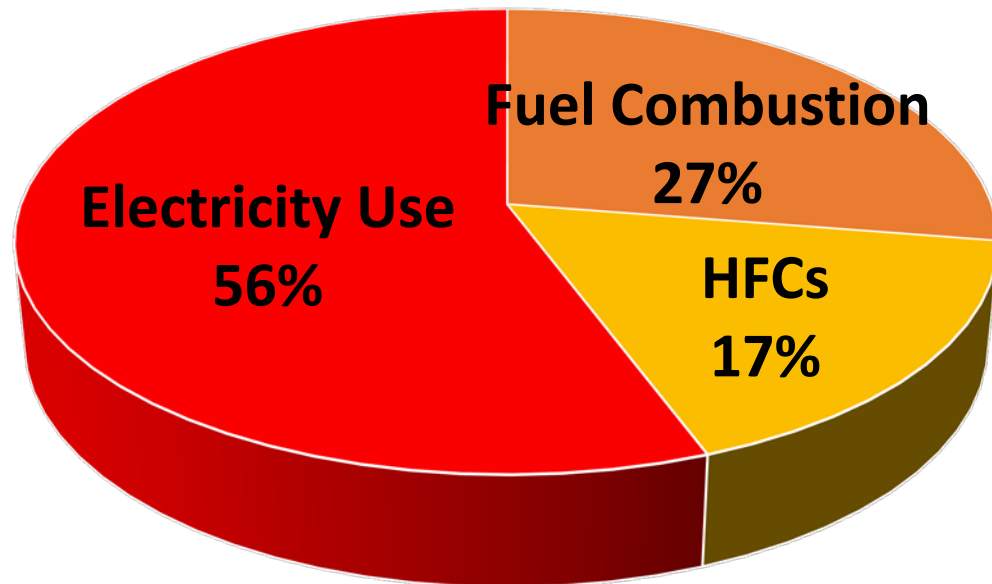
2030 BAU GHG Distribution



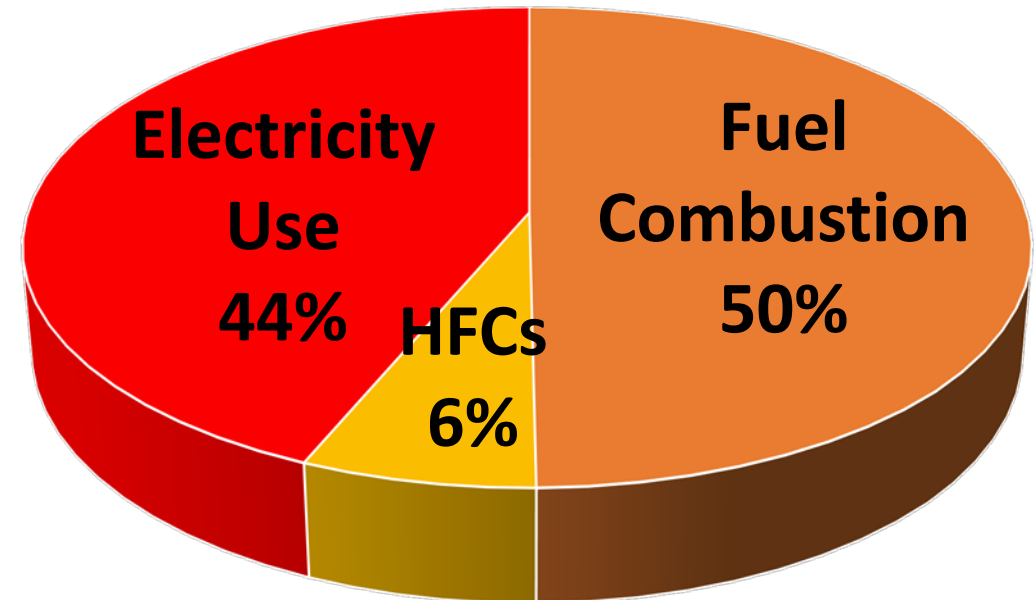
# Existing Buildings > 50% of total HFC emissions



# HFCs are Large Portion of Building GHG Emissions



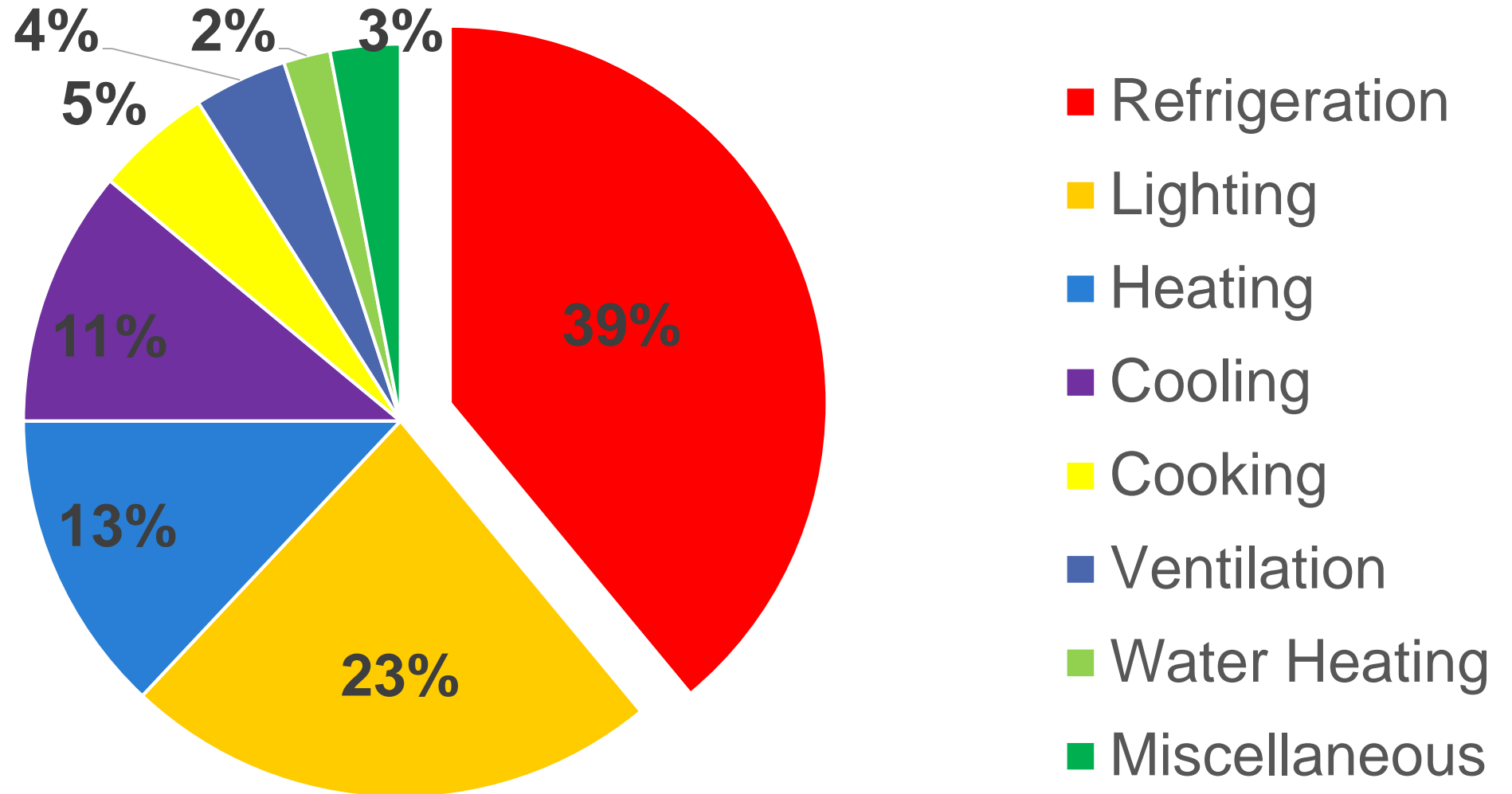
**Commercial**



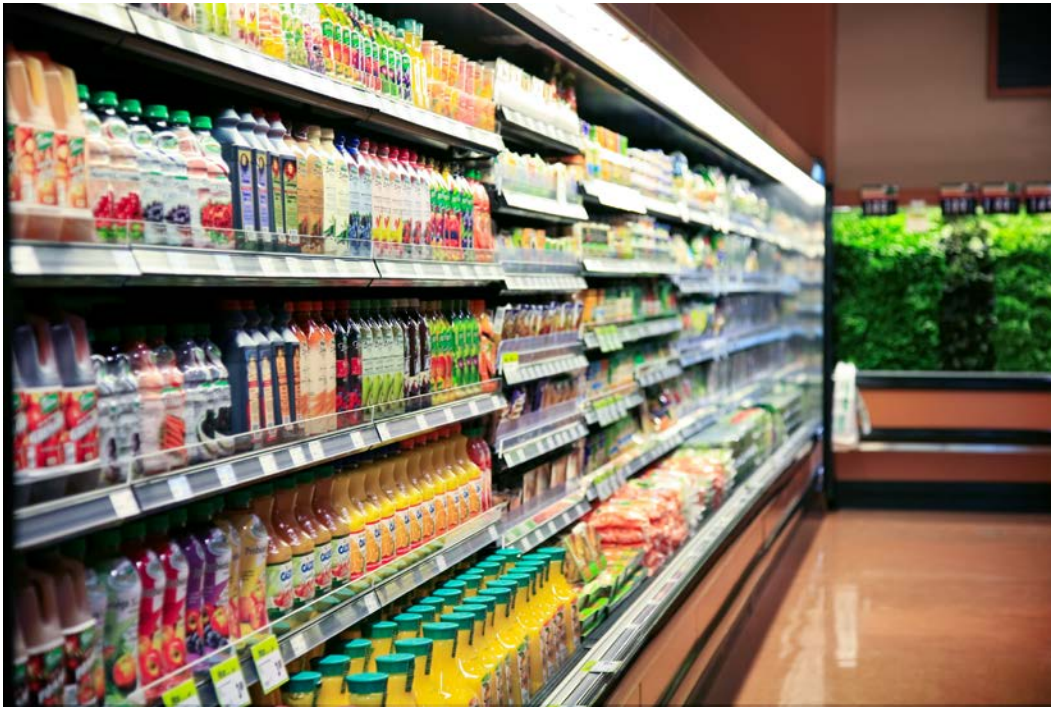
**Residential**



# Energy Consumption for a Supermarket



# Emissions: Supermarket Refrigeration System



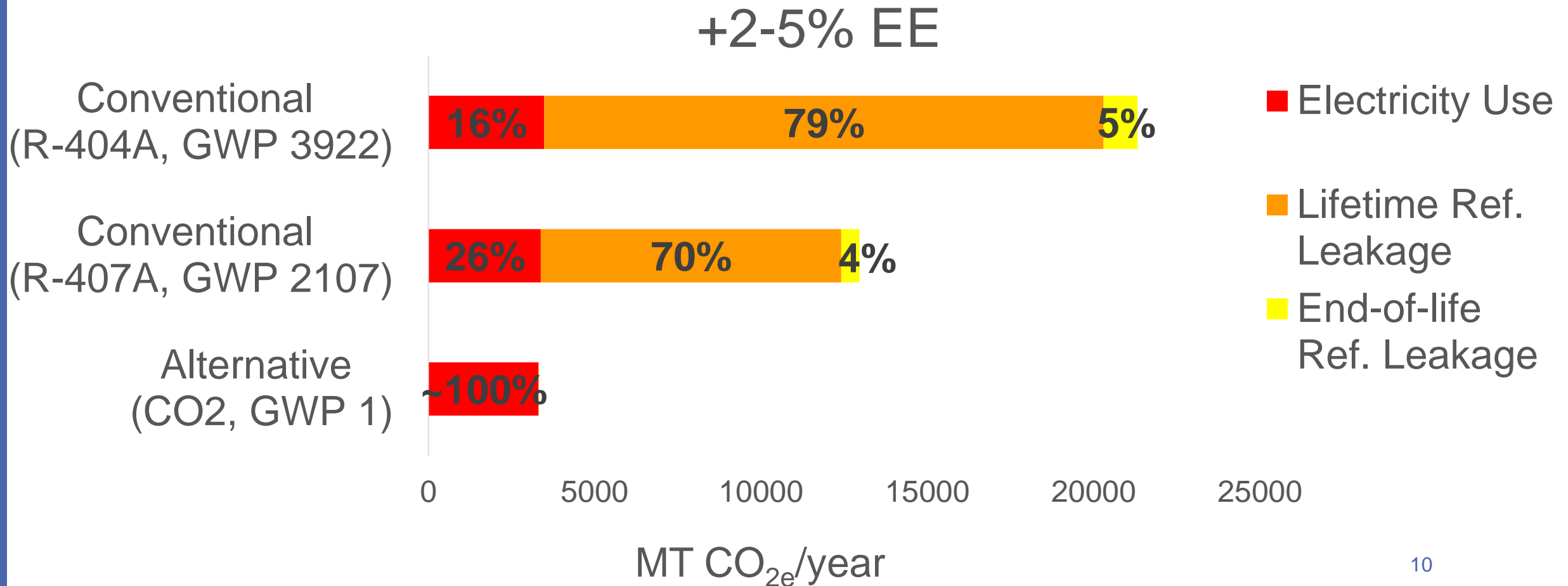
## **Direct Emissions – Refrigerant leakage**

- 3500 lbs. of R-404A (GWP=3922)
- 18% annual refrigerant leak rate
- 20% end-of-life leak rate
- \$40,000-\$50,000/year

## **Indirect Emissions - Electricity Use**

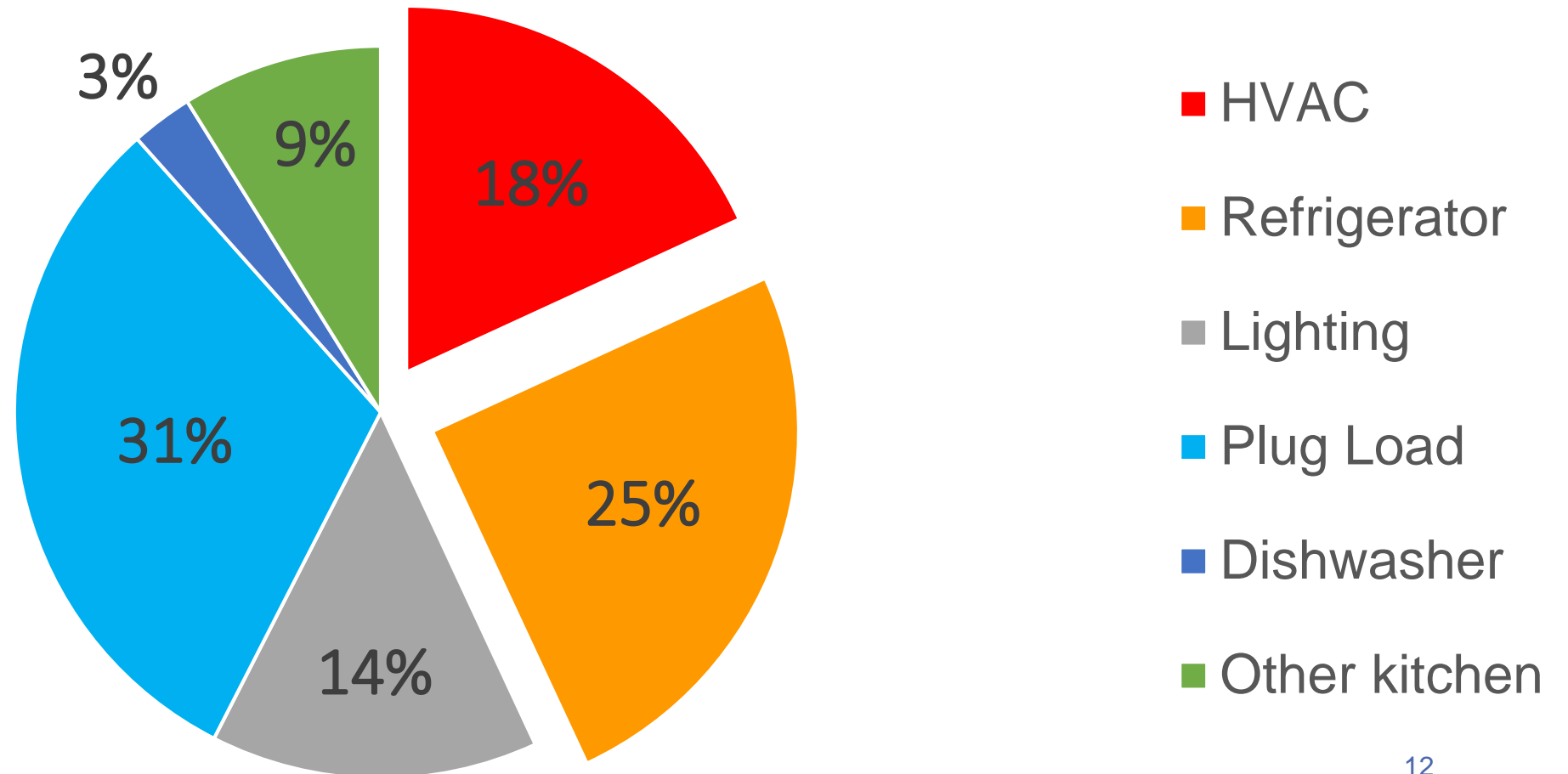
- 2-3 M kWh/year
- \$250,000 - 350,000/year

# 85% GHG Reductions in Supermarkets

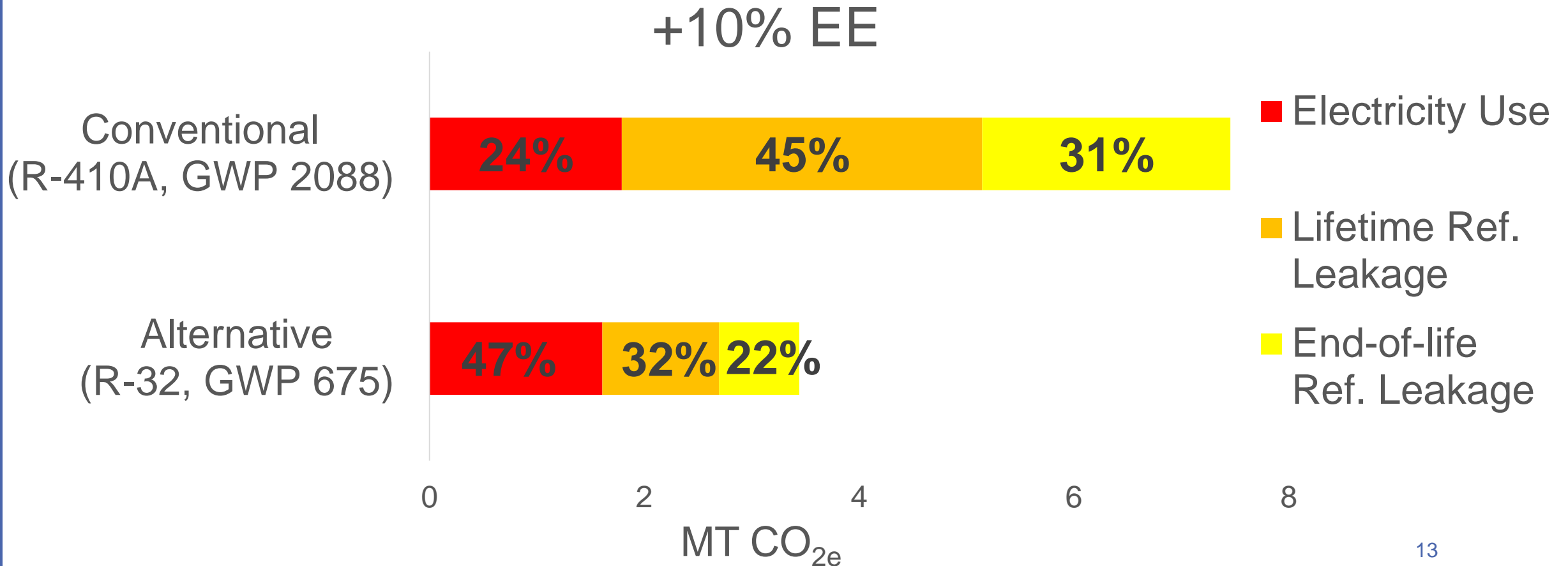




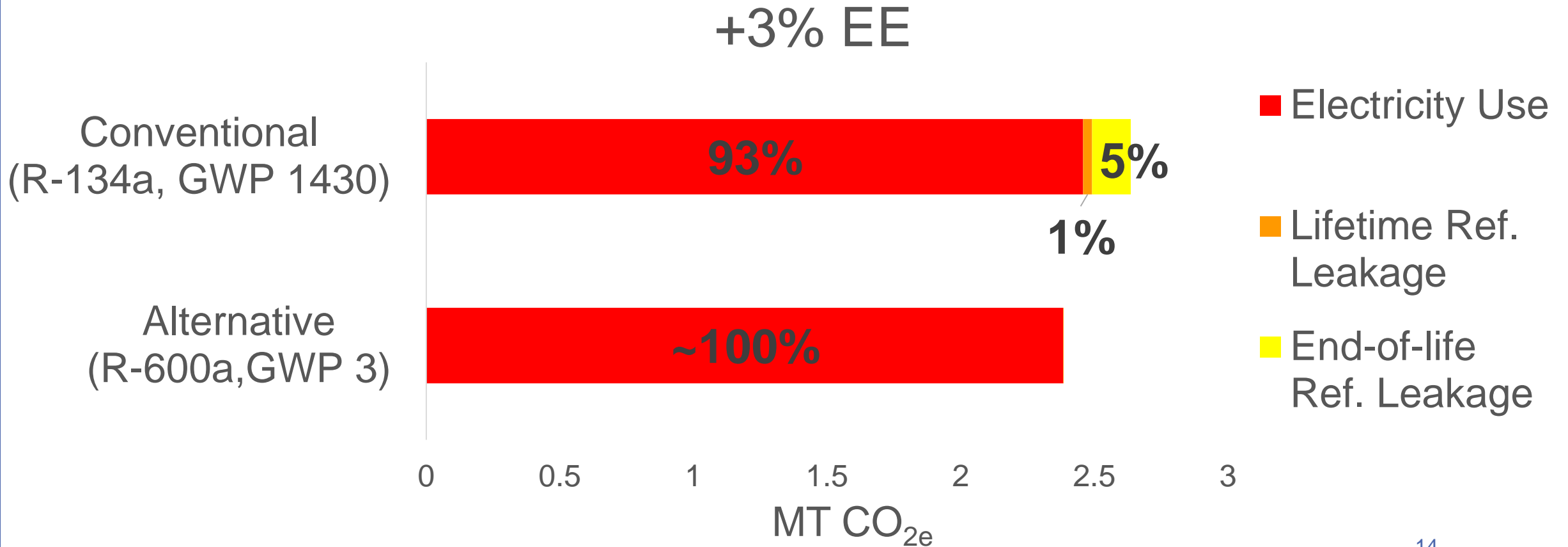
# California Apartment – Electricity Use



# 55% GHG Reductions over HVAC Lifetime



# 10% GHG Reductions over Refrigerator Lifetime







# Impactful Steps to Reduce Emissions

- **Switching to lower GWP refrigerants**
- Improving equipment energy efficiency
- Reducing the initial charge of refrigerant
- Reducing annual leak rates
- Strengthening reclaim and recovery programs to reduce EOL loss

# Overcoming Barriers

Piecemeal approach for evaluating emissions



Holistic approach for evaluating emissions

Lack of knowledge and unfamiliarity



Guidance documents and case studies

Codes and Standards lagging behind technology



Faster Codes and Standards process

Higher upfront cost



Incentive funding for early adopters

Lack of trained technicians



Workforce training and certification

# Contact Information

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# References

- Pictures
  - 404A can - <https://refrigeranthq.com/wp-content/uploads/2014/11/r404a-24lb.jpg>
  - TEWI – Emerson presentation (<https://www.epa.gov/sites/production/files/documents/RefrigerantUpdates.pdf>)
  - Buildings cartoon - <https://ak7.picdn.net/shutterstock/videos/13064087/thumb/1.jpg>
  - Supermarket picture - [http://www.carnotrefrigeration.com/cache/0x0/img\\_1537.jpg](http://www.carnotrefrigeration.com/cache/0x0/img_1537.jpg)
  - Made in USA logo - <http://domania.us/gts-today/thetractorguys/GB-Made-In-Usa-Logo-2.jpg>
- Apartment Case Study
  - Electricity usage data – UCLA Engage Research Study (Chen et al. 2014), RECS 2009
  - R-32 Energy Efficiency (DOE Report, SLCP Appendix F, Daikin Report)
  - Hydrocarbon refrigerator Energy Efficiency (SLCP Appendix F)
  - Leak rates, EOL rates – ARB Emission Inventory 2015
- Supermarket Case Study
  - Stats - US EPA GreenChill Factsheet, Armines 2009
  - Electricity usage data – Armines 2009
  - Leak rates, EOL rates – ARB Emission Inventory 2015

# Supermarket Case Study Assumptions

	Value	Source
GWP of 404A	3922	IPCC AR 4
GWP 407A	2107	IPCC AR 4
GWP of CO <sub>2</sub>	1	
Initial charge of Refrigeration System (lbs)	3500	EPA GreenChill FactSheet
Annual leak rate	18.0%	CARB RMP data (CA specific)
EOL charge (18% less than initial charge) (lbs)	2870	CARB Emission Inventory 2015
EOL leak rate	20%	CARB Emission Inventory 2015
# Supermarkets	135	CARB RMP data
Energy use CO2 (5% EE above 404A)	95%	ALDI Grocery Store data
Energy use of 407A (2-4% more EE than 404A)	97%	Arkema Test Data
Carbon Intensity Factor CA (lbs CO2/kWh)	0.525	<a href="https://www.eia.gov/electricity/state/california/">https://www.eia.gov/electricity/state/california/</a>
Equipment lifetime for Ref. system (yrs)	15	Industry Standard

# Apartment Case Study Assumptions

	Value	Source
GWP of 410A	2088	IPCC AR 4
GWP of R32	675	IPCC AR 4
Initial charge of Central AC (lbs)	3.75	(Assumed 1/2 of typical HVAC system, CARB Emission Inventory 2015)
Annual leak rate	6.3%	CARB Emission Inventory 2015
EOL charge (18% less than initial charge) (lbs)	3.05	(Assumed 1/2 of typical HVAC system, CARB Emission Inventory 2015)
EOL leak rate	80%	CARB Emission Inventory 2015
Energy use R-32 (10% EE above 410A)	90%	DOE Data, Daikin FactSheet, LBNL Reports
# A/C Units (central)	9500000	CARB Emission Inventory
GWP 134a	1430	IPCC AR 4
GWP of 600a (Isobutane)	3	IPCC AR 4
Initial charge of Refrigerator (lbs)	0.342	(Assumed 1/2 of typical HVAC system, CARB Emission Inventory 2015)
Annual leak rate	1.0%	CARB Emission Inventory
EOL charge (18% less than initial charge) (lbs)	0.29	(Assumed 1/2 of typical HVAC system, CARB Emission Inventory 2015)
EOL leak rate	77%	CARB Emission Inventory
Energy use R-600a (3% EE above 410A)	97%	SLCP Appendix F
# Refrigerator Units	17984000	CARB Emission Inventory
Carbon Intensity Factor CA (lbs CO2/kWh)	0.525	<a href="https://www.eia.gov/electricity/state/california/">https://www.eia.gov/electricity/state/california/</a>
Equipment lifetime for Ref. system (yrs)	15	Industry Standard

# Cost Barrier: Policy in the Pipeline

- California Cooling Act (SB 1013)
- CEC Food Production Investment Program Incentives
- SMUD Natural Refrigerant Incentive program