



# Manufacturer's Roundtable

Low-GWP Refrigerants

April 18, 2024

**nbi** new buildings  
institute

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## WHAT IS CEDA?



The California Energy Design Assistance (CEDA) is the only statewide utility incentive program for new construction and major renovations.

- Promotes **electrification** and **decarbonization**
- CEDA works in collaboration with project teams to reduce energy demand, consumption, and carbon emissions.
- Serves commercial, public, high-rise multifamily, industrial, and agricultural projects in Pacific Gas & Electric (PG&E), Southern California Edison (SCE), SoCalGas (SCG), and San Diego Gas & Electric (SDG&E) service areas.



## WHY PARTICIPATE IN CEDA?



- Receive complimentary **decarbonization** analysis tailored to project goals to identify most effective measures to implement



- Gain analysis of **energy costs and paybacks**
- Receive **financial incentives** to help offset the costs of decarbonization measures



- Demonstrate commitment to high performance building practices and design

## INCENTIVES



- **\$2800 Design team incentive** per project as a thank you for participation
- Based on the project measure package the design team chooses for implementation



## HIGH PERFORMANCE MEASURES



CEDA aims to exceed California's decarbonization standards by identifying high performance measures and providing educational opportunities to explore use cases and best practices.

This not only advances the market, but also qualifies participants for enhanced incentives through our program.

A current list of eligible high-performance measures can be found on our website [here](#).



## HAVE A PROJECT TO DISCUSS?



For more information, please contact our program outreach specialists, visit our website, or fill out an interest form

Scan me to enroll a project

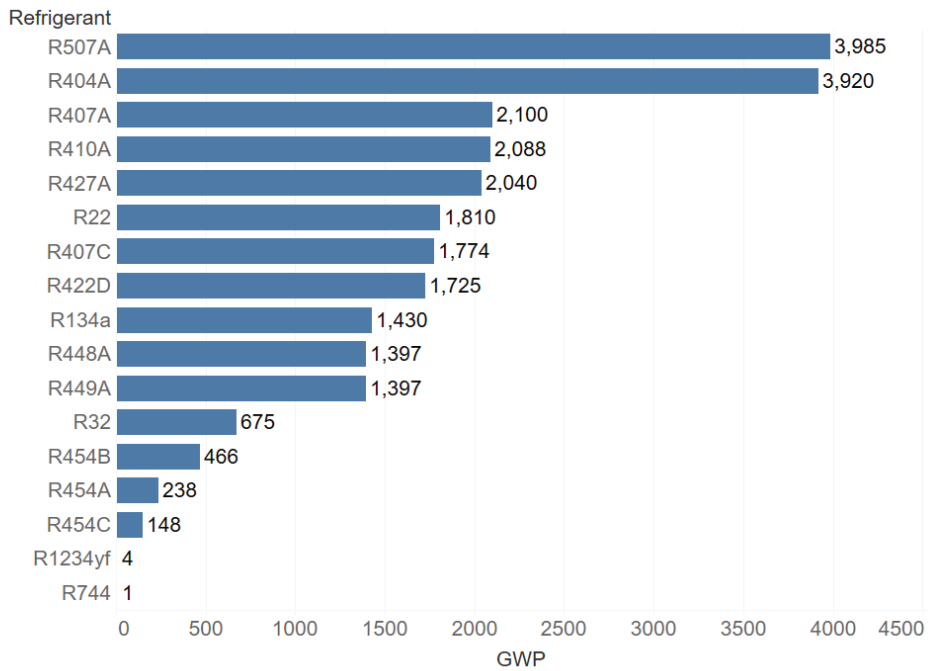


CaliforniaEDA.com



**Tina Hendrix**  
Program Outreach Specialist  
[THendrix@Willdan.com](mailto:THendrix@Willdan.com)  
760.585.7577

# Why Refrigerants?



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# Today's Panelists



**John Milkint**  
Chemours



**Helen Walter-Terrinoni**  
Trane Technologies



**Dustin Wiggins**  
Lochinvar

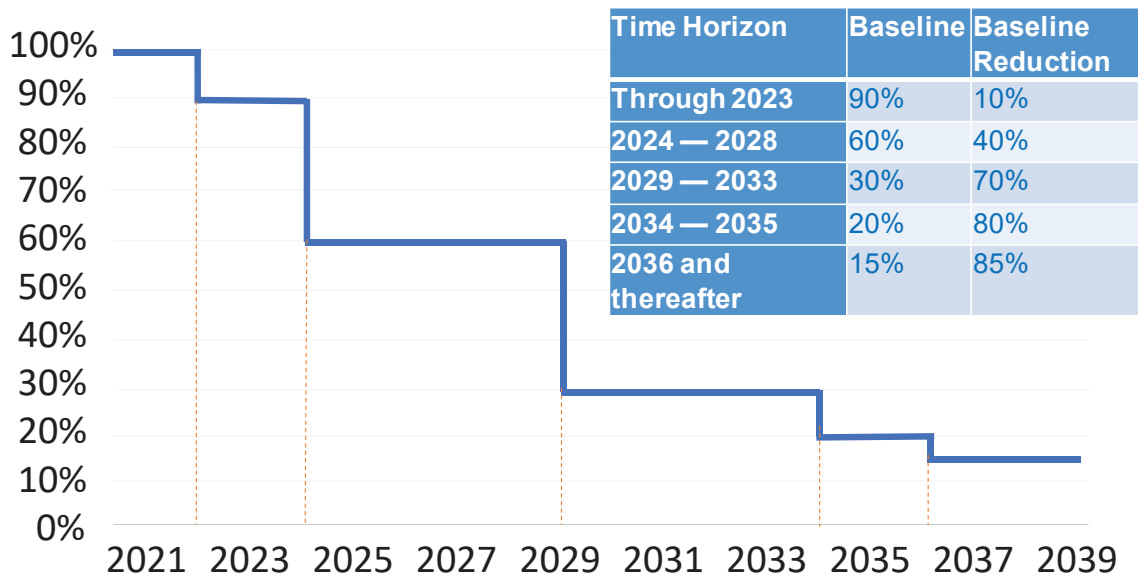
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# Regulatory & Refrigerant Update

John A Milkint: [john.milkint@chemours.com](mailto:john.milkint@chemours.com) (cell: 909-201-1625)  
West Coast Territory Manager

April 18<sup>th</sup> 2024

## AIM Act HFC Phase Down



In September 2022, California Passed Senate Bill 1206 (SB1206).

## No Virgin Refrigerants per the GWP Values Above

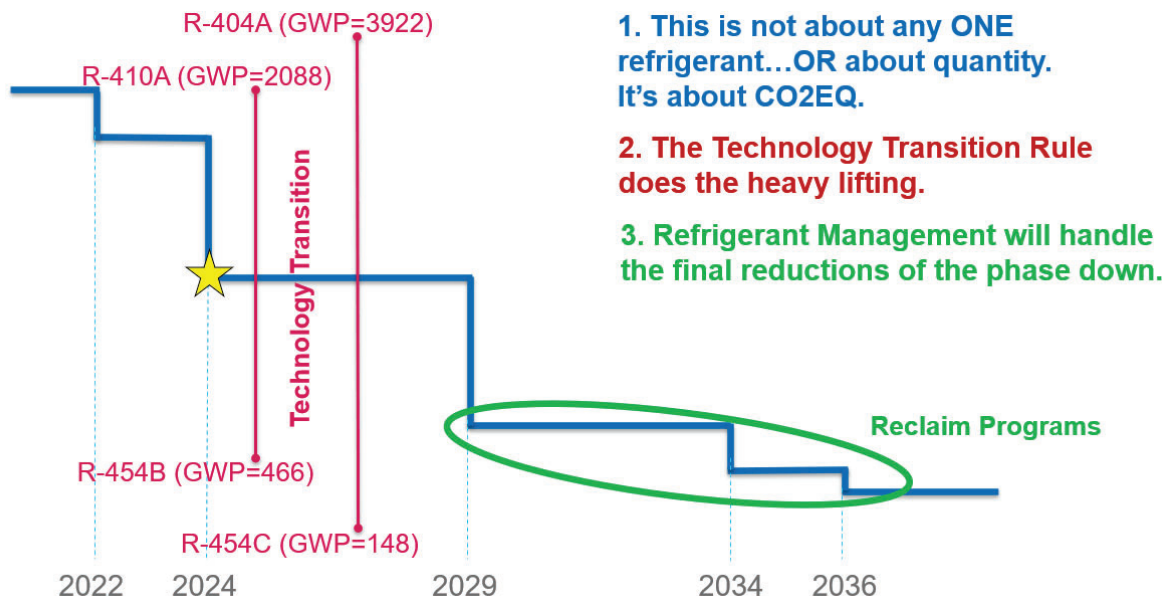
- January 1, 2025: 2,200 GWP [R-404A, R-507]
- January 1, 2030: 1,500 GWP [R-410A, R-407A, R-407C]
- January 1, 2035: 750 GWP [R-134a, R-448A, R-449A]

Beginning January 1, 2025, hydrofluorocarbons with a GWP greater than 750 that are not reclaimed shall not be used to replenish any leaks or otherwise service stationary equipment owned or operated by the state.



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## EPA AIM Act – How it all works together



# The Solutions

## A1 and A2L Refrigerants

Walk-ins, chillers,  
freezers

**R-22**  
(HCFC)  
GWP: 1,810

(R-449A)  
GWP: 1,397

(R-454C)  
GWP: 148

walk-ins, freezers,  
blast chillers

**R-404A/507**  
(HFC)  
GWP: 3,922

(R-449A)  
GWP: 1,397

(R-452A)  
GWP: 2,141

(R-454A)  
GWP: 239

(R-454C)  
GWP: 148

A/C (screw chillers),  
refrigerators

**R-134a**  
(HFC)  
GWP: 1,430

(R-513A)  
GWP: 631

(R-1234yf)  
GWP: 4

A/C

**R-410A**  
(HFC)  
GWP: 2,088

(R-454B)  
GWP: 466

(R-32)  
GWP: 675

Lower GWP  
Non-Flammable  
Replacement

A2L Replacement

Available for OEM testing.  
U.S. commercialization  
pending codes & standards.



# The Solutions

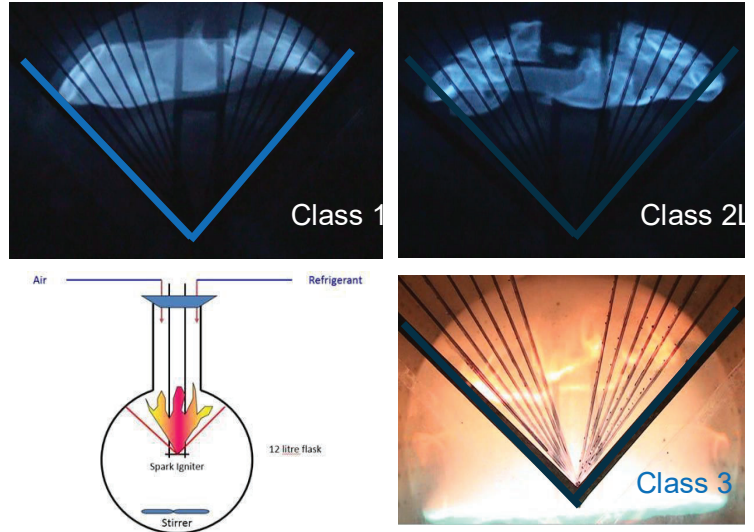
## A1 and A2L Refrigerants

- Air Conditioning Refrigerants
- R-410A [50% R-32: 50% R-125] (2,087 GWP), POE 32
- R-32 (675 GWP), POE 46
- R-454B [68.9% R-32: 31.1% R-1234yf] (466 GWP), POE 32



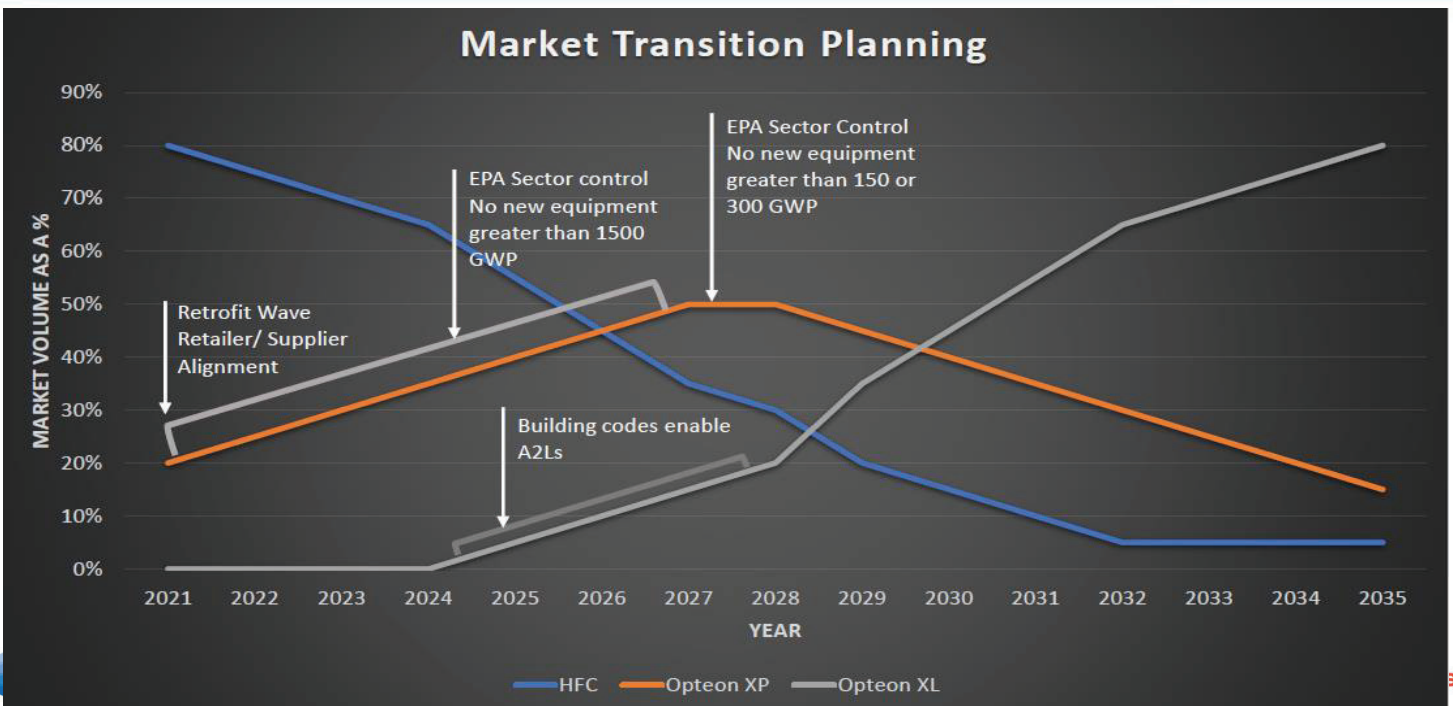
# ASTM E681 Test Examples

- Flame spread  $> 90^\circ$  indicates “flammability”
- Based on the spread beyond  $90^\circ$ , as well as the **speed at which the flame spreads**, defines the degrees of ‘flammability’
  - 2L – lower flammability
  - 2 – flammable
  - 3 – higher flammability



# Where do we go from here

## Market Transition Planning







## Dustin Wiggins

Segment Development Manger – Commercial Water Heating

### Current Regulation Landscape

- Policy makers are focused on reducing greenhouse gas (GHG) emissions:
  - The pathway for reducing direct (operational) emissions entails a significant increase in heat pump (HP) adoption. (i.e. *Energy efficiency standards, building codes, electrification policies*)
  - The pathway for reducing indirect emissions entails regulations limiting the use of high GWP refrigerants (such as HFCs)
- The WH sector has been focused on reducing **direct emissions** by increasing HPWH production and adoption as well as reducing **indirect emissions** by introducing low GWP refrigerants in several HPWH product offerings.
- Due to historically low shipments, HPWHs have not been included in (non-market based) refrigerant regulations. However, a New York State proposal has recently proposed very stringent (ultra-low GWP) minimums in a very short timeframe.
- Enabling the transition to ultra-low GWP refrigerants for HPWHs in a way that does not dampen HPWH adoption will require significant planning, research, and regulatory coordination.

## Industry Trends

### Tailwinds

- The HVAC sector has been working to enable the use of low-GWP refrigerants for over a decade, including significant R&D investment in refrigerant options.
- New refrigerant blends are becoming available.
- WH sector can leverage lessons learned from HVAC sector transition.

### Headwinds

- More work is needed to understand the WH-specific considerations for the use of low-GWP refrigerants.
- Regulatory framework (EPA SNAP) not in place for WH application.
- Significant work is needed to enable the use of flammable refrigerants in HPWHs.
- Building Codes not yet adopted to allow flammable refrigerants

## Common Refrigerants



R134a- GWP 1,430  
R513A- GWP 573



R410A- GWP 2,088  
R32- GWP 675  
R454B- GWP 467



R744(CO2)- GWP 1

# Low GWP Refrigerant Trade Offs

Water outlet temperatures  
~160°F  
Low pressures  
Wide product service  
availability  
Limits on ambient  
temperature range (~20-  
25°F minimum)  
Multi pass and single pass  
Can handle recirc loop  
temperature maintenance  
without an extra tank

Can operate in cold climates  
(<0°F)  
Mildly flammable  
Water outlet temperature is  
limited (~140°F max, less as  
ambient temp decreases)  
Multi pass and single pass  
Can handle recirc loop  
temperature maintenance  
without an extra tank

Most systems can provide  
160°F water at 0°F  
(CO<sub>2</sub>) uses a transcritical cycle,  
which is different from the  
other refrigerants  
High operating pressures  
(1,000 psi+) require thicker  
materials and components (\$\$)  
Service personnel availability  
more challenging  
Single pass only and swing tank  
required for recirc loop

## What about R290?

Water outlet temperatures ~170°F

Low ambient performance <0°F

Multi pass and single pass

Widely used in hydronic applications in Europe

Not allowed in the US per UL standard and ASHRAE 15/15.2

Except up to 114g of charge

Not allowed per building codes

Except limited site certification

We are actively working to help the industry move forward on this topic

# VERITUS

AIR SOURCE HEAT PUMP WATER HEATER



- Coefficient of performance (COP) up to 4.61
- Operates at ambiances as low as 23°F
- Modular Design Concept
- Low Global Warming Potential (GWP)
- 513A Refrigerant
- 5 Sizes
- UL 60335-2-40

## Modular Design Concept



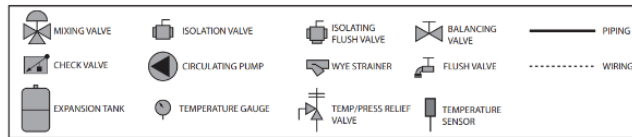
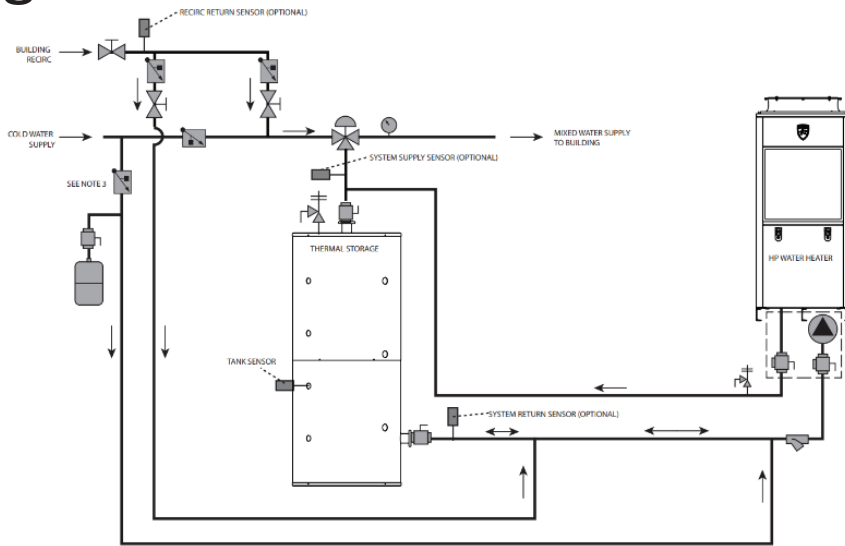
- Two Base Models
  - AHP060 (30" w x 34" d x 72" h)
  - AHP140 (41" w x 34" d x 72" h)
- Combine for total of 5 Models
  - AHP060
  - AHP140
  - AHP200 (71" w x 34" d x 72" h)
  - AHP280 (81" w x 34" d x 72" h)
  - AHP350 (111" w x 34" d x 72" h)

### Standard Features

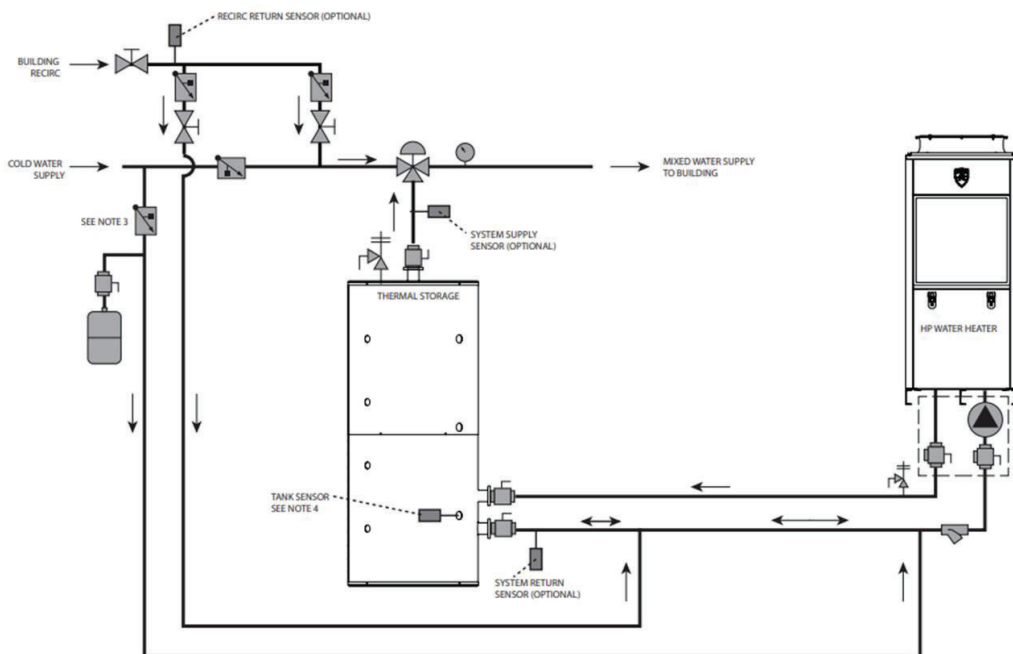
- 480 Volt 3 Phase
  - Optional Step-Up Transformer
- Maximum Setpoint of 160F
- System Control Panel (SMART TOUCH)
- Scroll Compressor
- Manifold Piping Assembly
- Variable Speed Pump and Evaporator Fan



# Single Pass



# Multi Pass



# Appendix

## SMART TOUCH™

- Cascade Sequencer up to 64 heat pump modules
- Removable from the unit for installing at alternate locations for convenience in adjustment & monitoring
- Fault Logging
- Alarm Contact
- Backup Enable
- BACnet MSTP (Optional)
- Modbus
- Building Automation Integration with 0-10 VDC input
- Freeze Protection

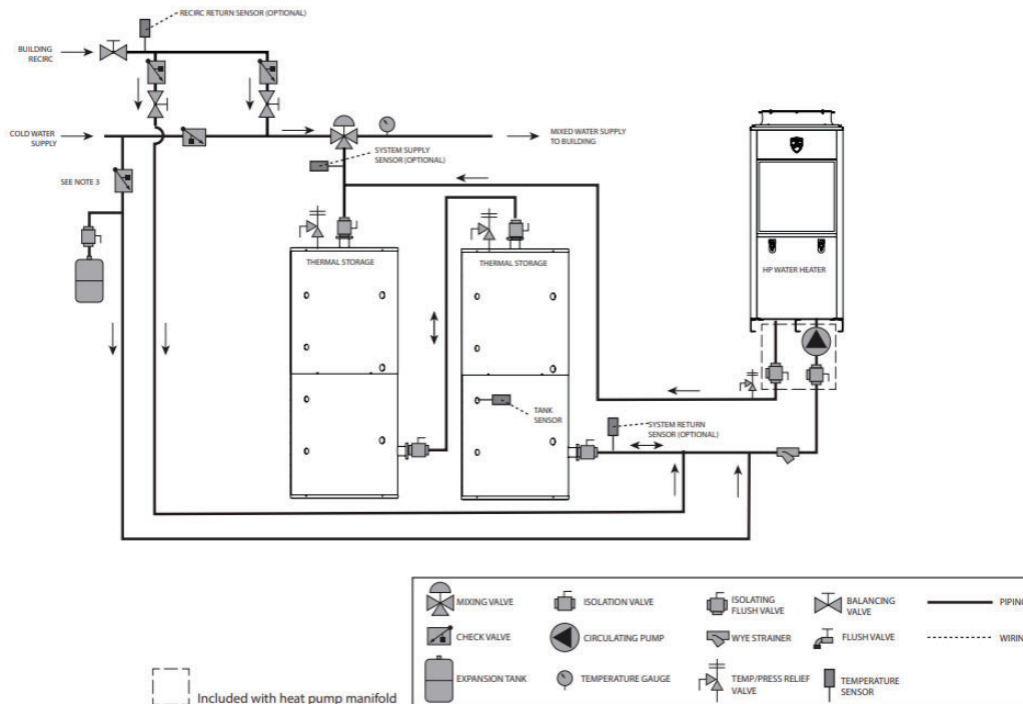


## High Coefficient of Performance (C.O.P)

- Measurement of input power versus output power.
- C.O.P of 4.5 is providing 4.5 times more power output than used
  - AHP060 4.61
  - AHP140 4.27
  - AHP200 4.44
  - AHP280 4.27
  - AHP350 4.38

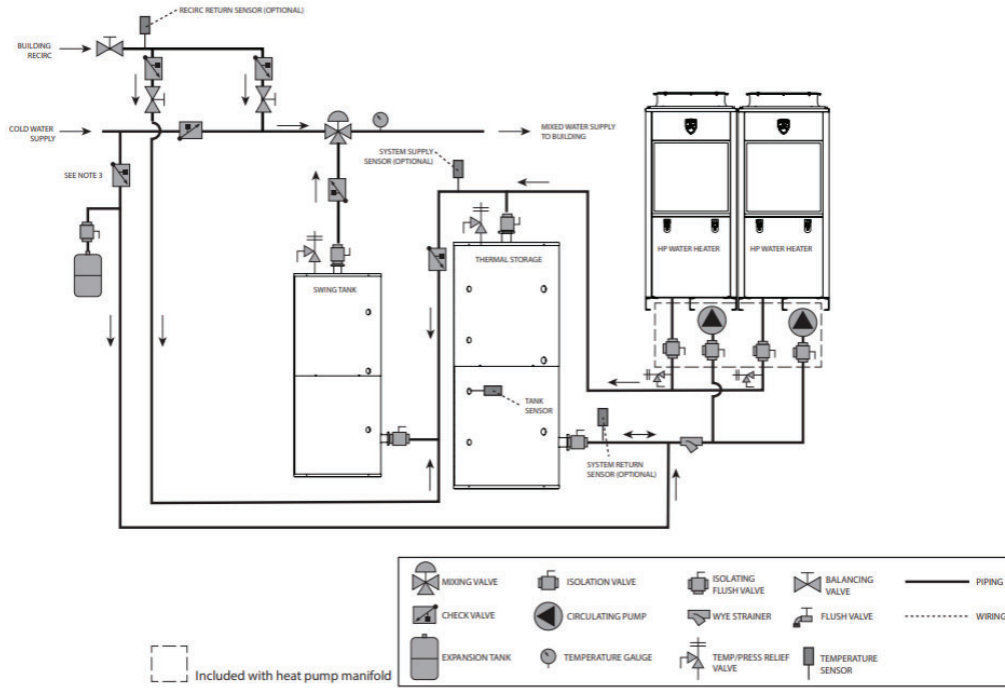
COP testing done by DOE Standard @ 80° Ambient

## Single Pass | 2 Tanks

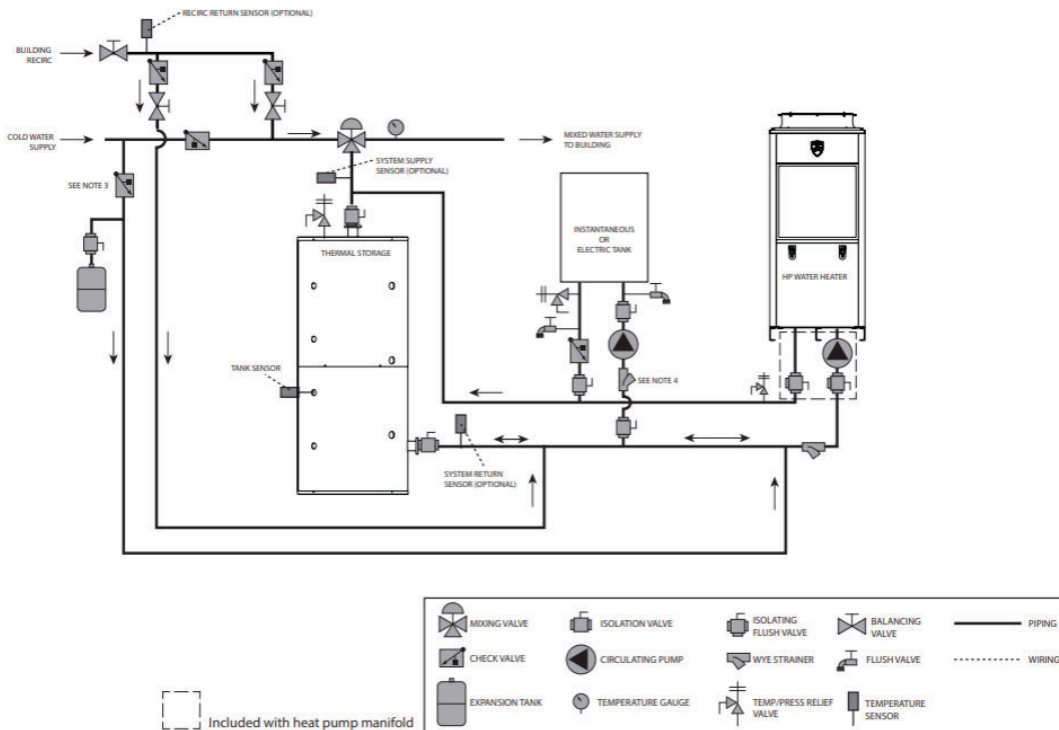




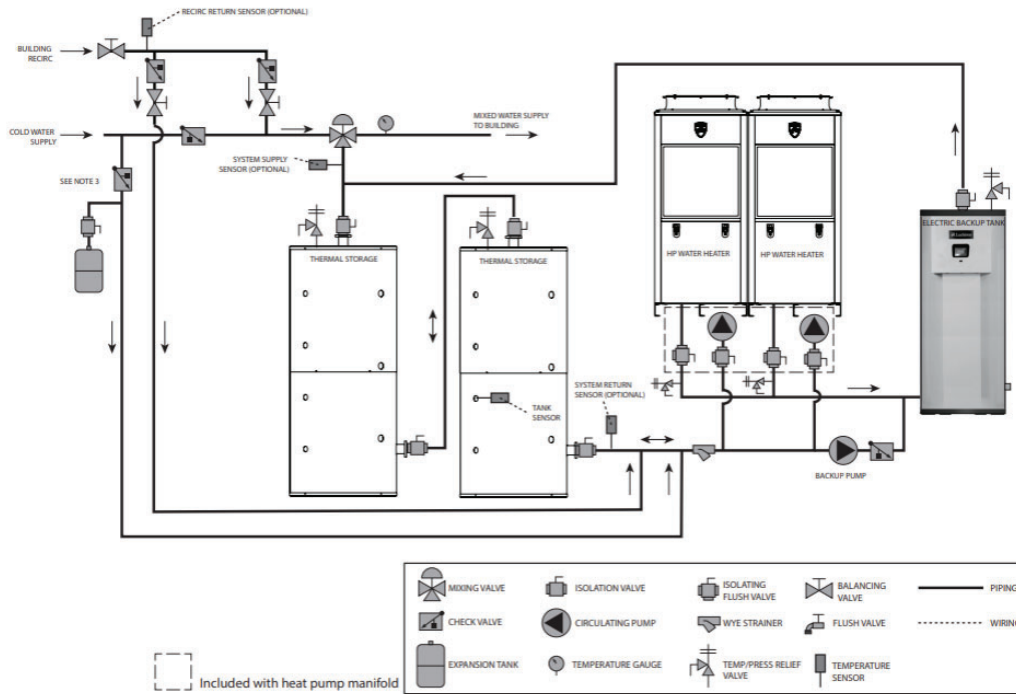
# Single Pass with Swing Tank



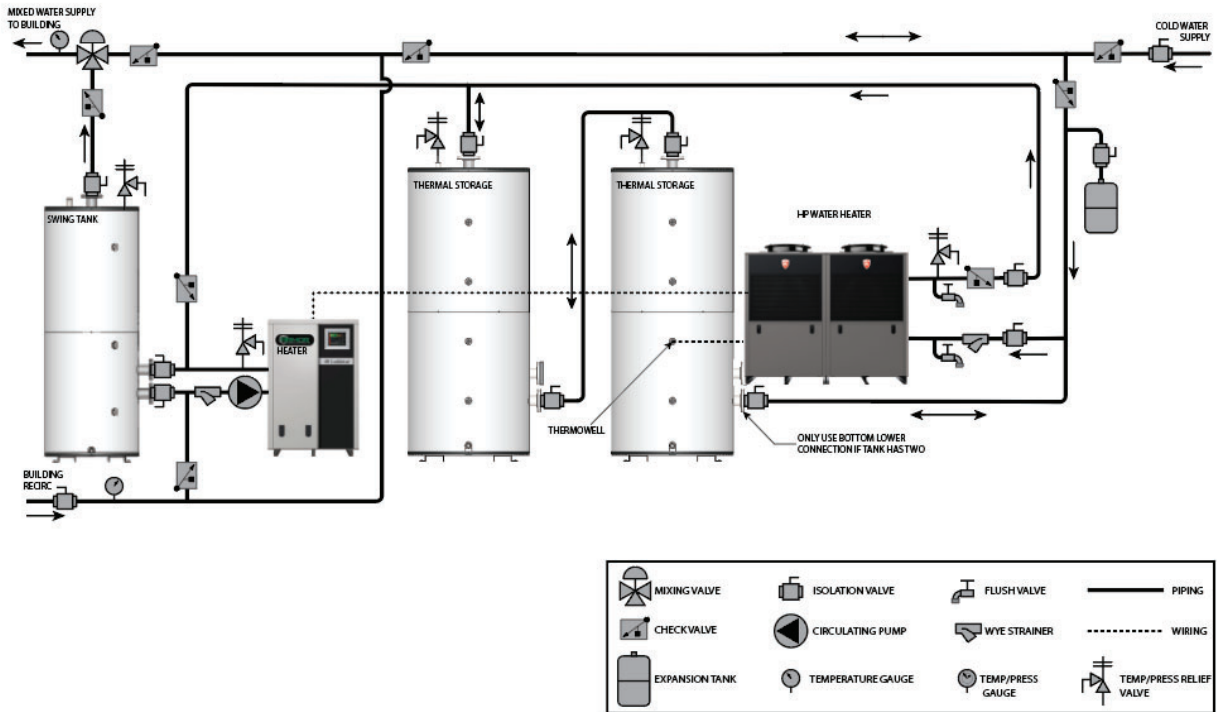
# Single Pass with Backup



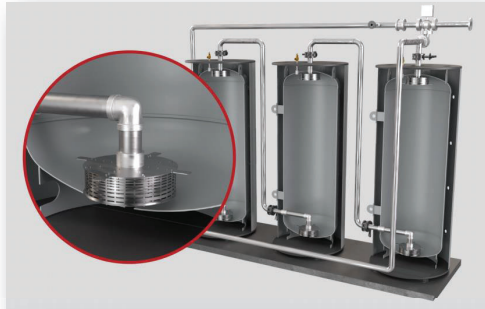
# Single Pass with Electric Backup



# Single Pass with Gas Backup



## Thermal-Stor™ Tank



HP1000G HP750G HP500G HP250G

- Heat Pump Thermal Storage – optimized to efficiently store thermal energy
- Unsurpassed Stratification
- R30 Insulation (indoor)
- Industry Leading 95% Drawdown
- Patent Pending Stratifying Baffle Design
- 4 Sizes 250 – 850 gallons

## Outdoor Thermal-Stor

- 4 Sizes
- Seismic Rated
- R22 Insulation

Model Number	Capacity (Gal)
HP0250-O	250
HP0500-O	450
HP0750-O	650
HP1000-O	850

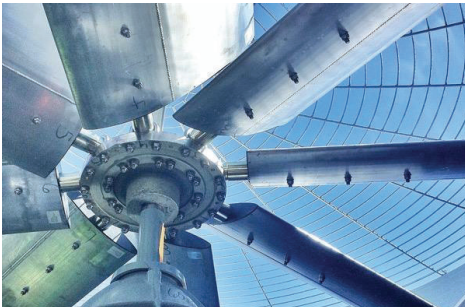


# Next Generation Refrigerants

Trane Technologies  
Helen Walter-Terrinoni  
[Helen.walter-terrinoni@tranetechnologies.com](mailto:Helen.walter-terrinoni@tranetechnologies.com)  
April 2024



## OUR BUSINESSES CORPORATE OVERVIEW



### COMMERCIAL HVAC

Air conditioning systems, services and solutions. Innovative solutions geared toward making high-performance buildings reliable and safe, as well as healthy, comfortable and efficient



### RESIDENTIAL HVAC & SUPPLY

Heating, cooling, thermostat controls and home automation for the residential market and a complete selection of innovative parts, options and accessories for optimal performance and reliability



### TRANSPORT REFRIGERATION

Manufacturing and innovation of transport temperature control systems for a variety of mobile applications, including trailers, truck bodies, buses, shipboard containers and rail cars





## Gigaton Challenge

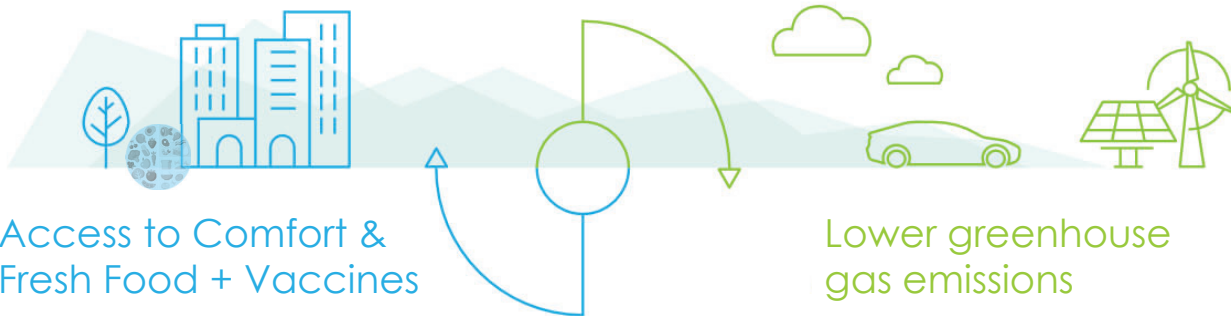
Bold commitment to reduce one billion metric tons of greenhouse gas emissions (CO<sub>2</sub> eq) from our customers' climate footprints by 2030.

- High Efficiency Equipment
- Electrification
- Refrigerant Transition Management

TRANE  
TECHNOLOGIES

## The dual challenge

### Advancing Equity and Climate



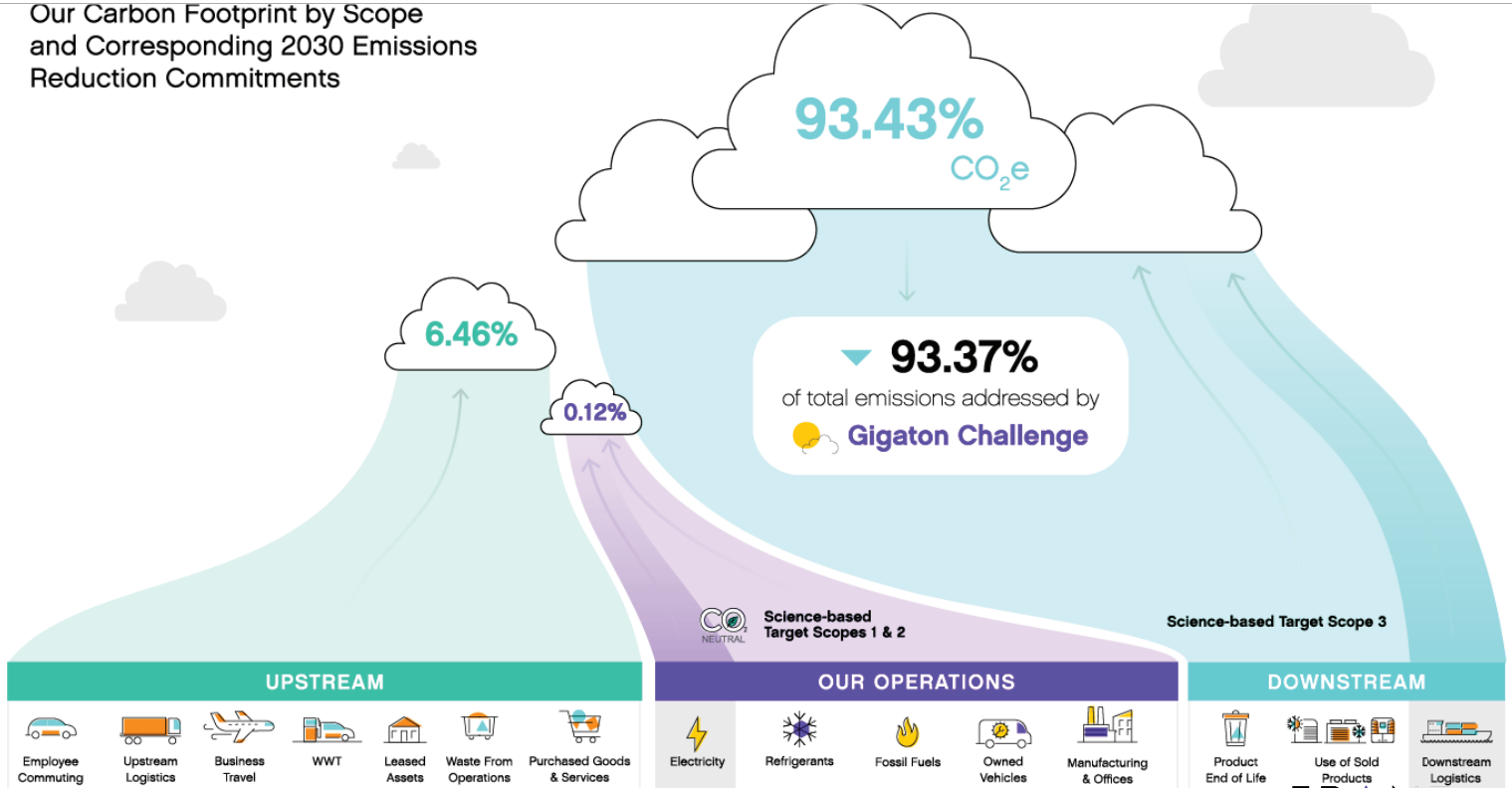
Access to Comfort &  
Fresh Food + Vaccines

Lower greenhouse  
gas emissions

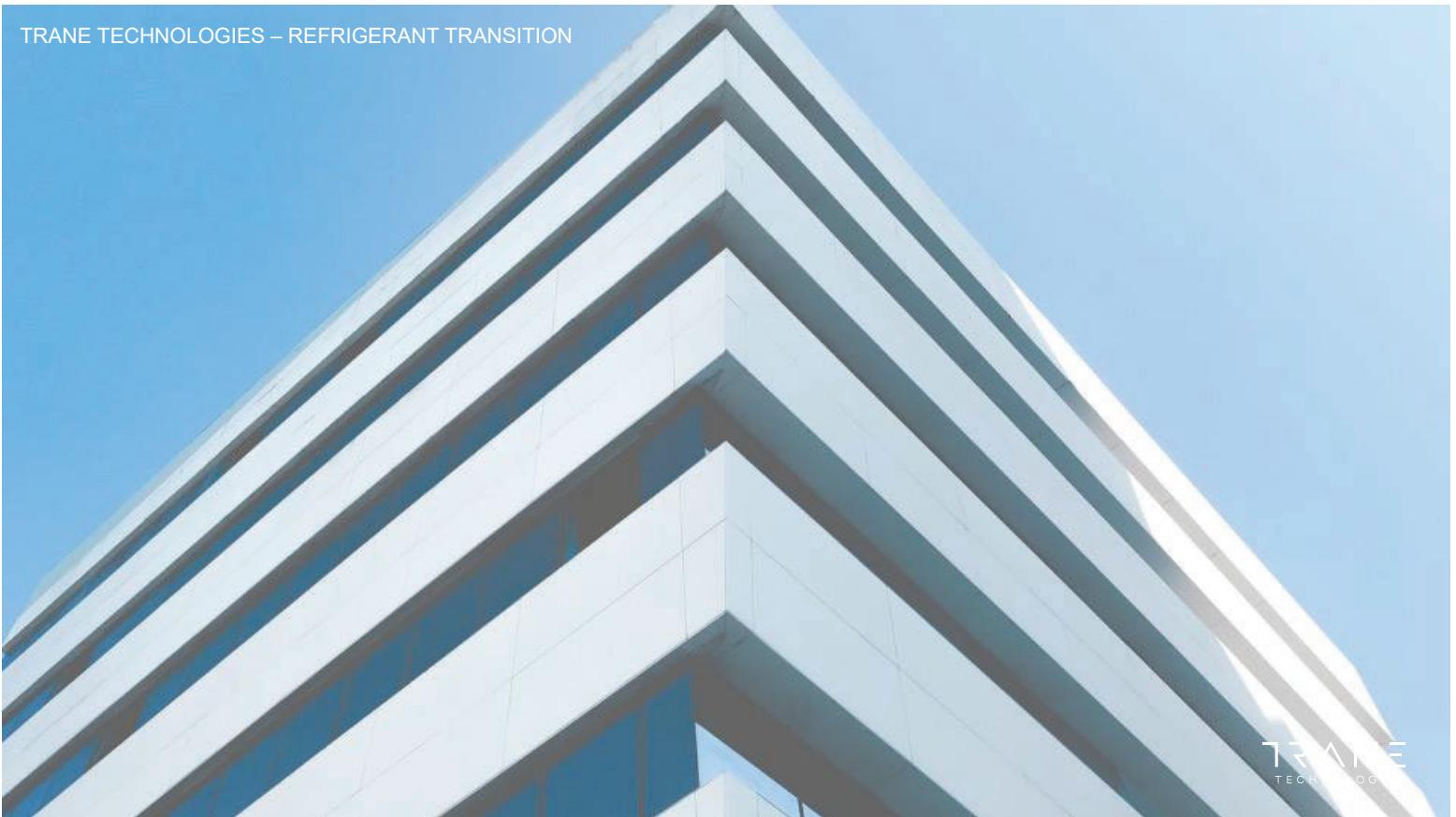
Increasing population and prosperity  
expected to grow demand ~40% by 2030

Need to fall by ~50% by 2030 to be on  
track to meet Paris climate goals

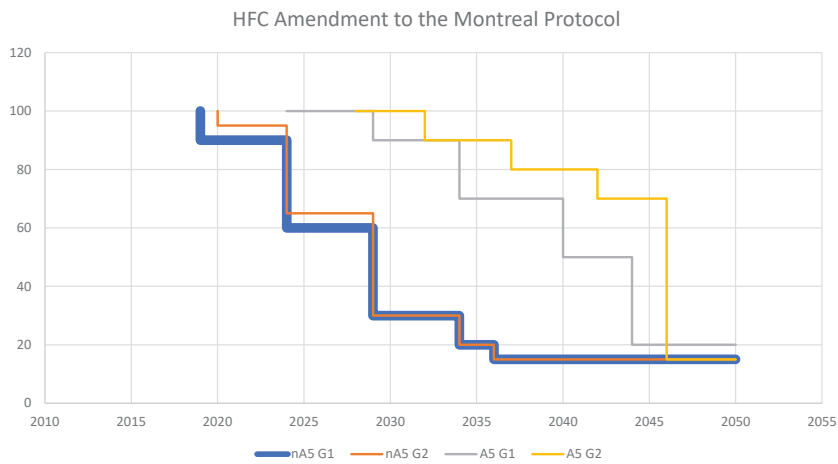
Our Carbon Footprint by Scope and Corresponding 2030 Emissions Reduction Commitments



TRANE TECHNOLOGIES – REFRIGERANT TRANSITION



# HFC Phase-down in United States



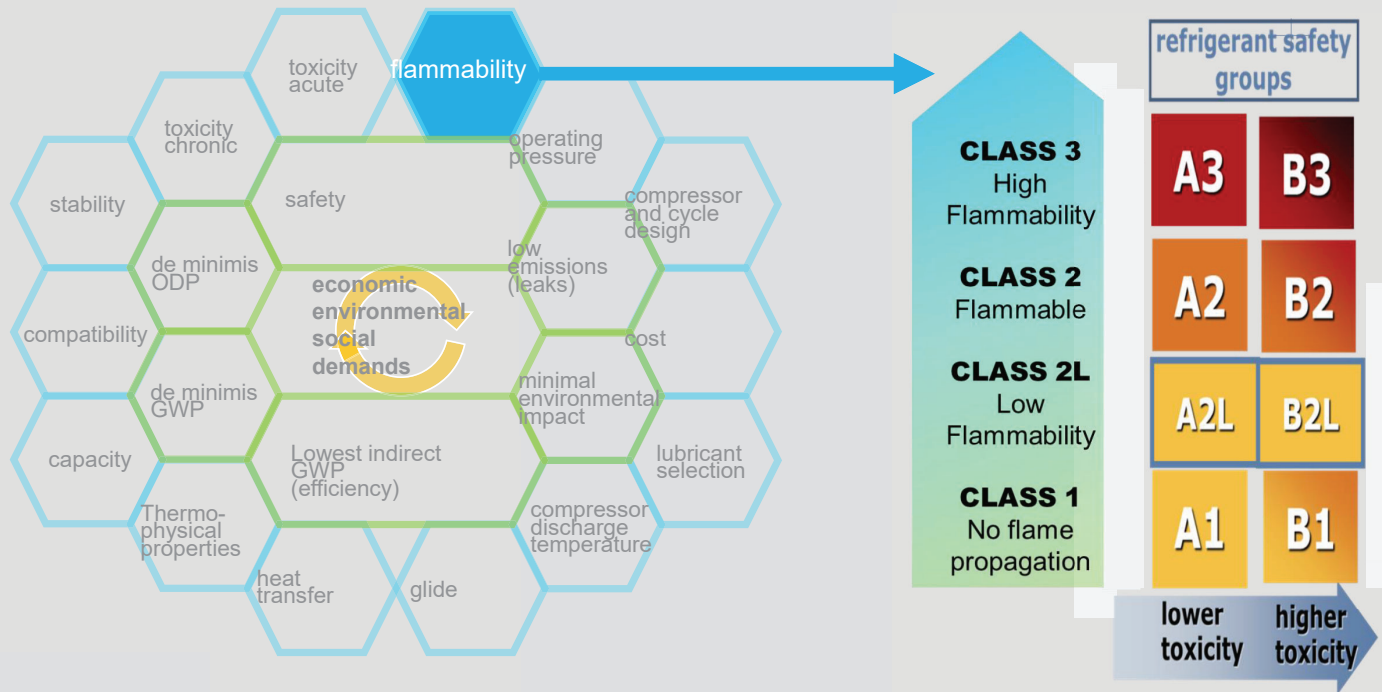
- “Consumption” = Supply = import + production - export
- Supply baseline ~ equivalent to 300 thousand kilotonnes (kts) of CO<sub>2</sub>
- Additional influencers on available GWP
  - Servicing
  - Commercial refrigeration
  - Reused refrigerant
  - Imported Products Containing HFCs (IPC)

## Next-Generation Refrigerants is About Balancing Critical Factors



**There is No Perfect Refrigerant**

# Next Generation Refrigerant Safety



## Closer Look - Low Pressure Options

		Baseline	Ultra-Low GWP	
		R-123	R-514A	R-1233zd(E)
Flammability	ASHRAE Class	1	1	1
Toxicity <sup>1</sup>	ASHRAE Class	Higher (B)	Higher (B)	Lower (A)
	OEL (ppm)	50	320	800
Efficiency (COP)		8.95	8.91	8.87
Capacity Change		baseline	~5% loss	~35% gain
GWP <sup>2</sup>		77	1.7	1
Atmospheric Life		1.3 years	22 days	26 days

<sup>1</sup>None of these refrigerants shown in the table are considered "toxic" or "highly toxic" as defined by the IFC, UFC, NFPA 1 or OSHA regulations.

<sup>2</sup>GWP values reported are per the Fourth Assessment Report (AR4) of the IPCC (Intergovernmental Panel on Climate Change).

\*Modeling Conditions: 100% isentropic compressor efficiency, 95°F/44°F, 0 superheat, 0 subcooling

**R-514A & R-1233zd(E) Both Good Choices  
Non-Flammable (Class 1), Ultra Low GWPs with High Efficiency Available Now**



## Closer Look - Medium Pressure Options



		Baseline	Lower GWP		Ultra-Low GWP	
		R-134a	R-513A	R-515B	R-1234yf	R-1234ze(E)
Flammability	ASHRAE Class	1	1	1	2L 	2L 
Toxicity <sup>1</sup>	ASHRAE Class	Lower (A)	Lower (A)	Lower (A)	Lower (A)	Lower (A)
	OEL (ppm)	1000	650	810	500	800
Efficiency (COP)		8.47	8.27	8.32	8.17	8.45
Capacity Change		baseline	similar	~25% loss	~5% loss	~25% loss
GWP <sup>2</sup>		1430	630	298	6	4
Atmospheric Life		13.4 years	5.9 years	3.1 years	11 days	18 days

\*Modeling Conditions: 100% isentropic compressor efficiency, 95°F/44°F, 0 superheat, 0 subcooling  
 \*R-513A introduced for ice rinks applications in 2019

**R-513A & R-515B Good Solutions for Existing Mechanical Rooms  
 Longer Term – Flammable Solutions Required to Meet GWP Goals**

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## Closer Look – High Pressure A/C Options

		Baseline	Lower GWP	
		R-410A	R-454B	R-32
Flammability	ASHRAE Class	1	2L 	2L 
Toxicity <sup>1</sup>	ASHRAE Class	Lower (A)	Lower (A)	Lower (A)
	OEL (ppm)	1000	850	1000
Efficiency (COP)		7.99	8.16	8.22
Capacity Change		baseline	~3% loss	~8% gain
GWP <sup>2</sup>		2088	467	675
Atmospheric Life		17 years	3.6 years	5.2 years

Glide: difference between when a refrigerant condenses (dew point) and when it boils (bubble point) at constant pressure

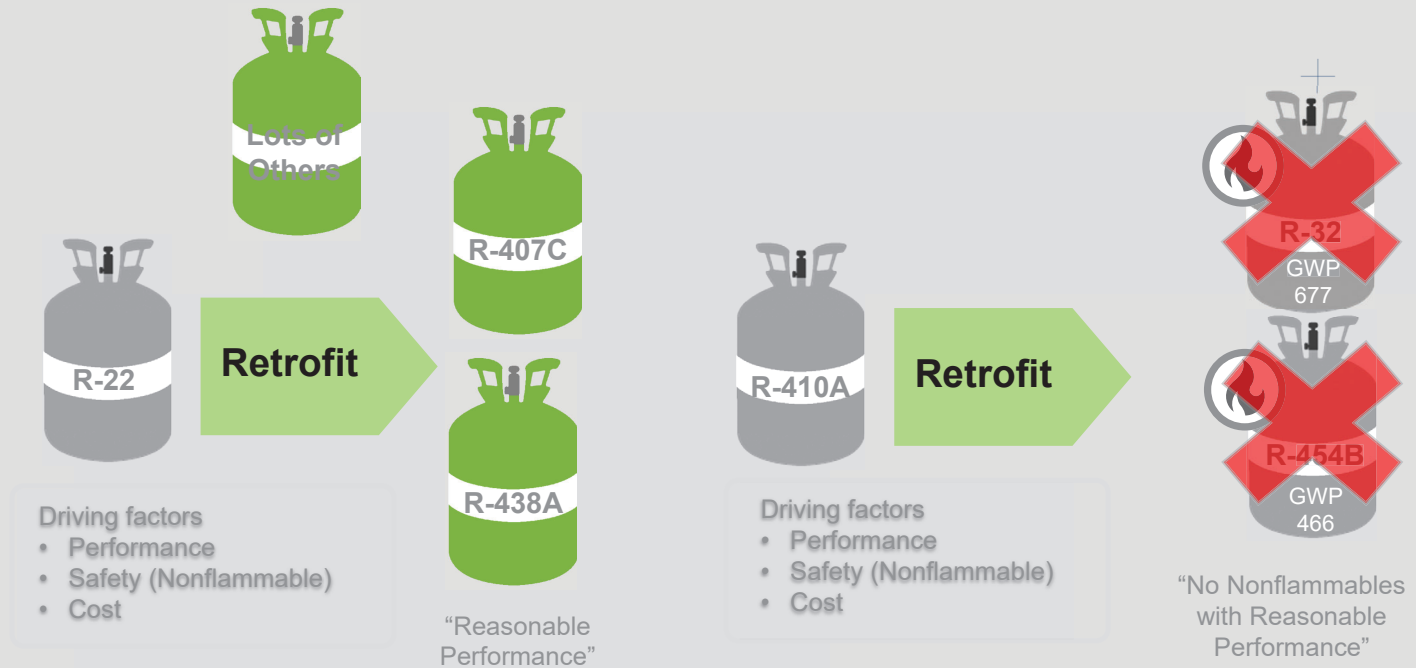
Comparing refrigerants R454B vs R32

\*Modeling Conditions: 100% isentropic compressor efficiency, 95°F/44°F, 0 superheat, 0 subcooling

**R-454B & R-32 Good “Interim” Solutions  
 R-454B Offers Best Choice of GWP vs Available Allocation  
 Over the Phase Down**

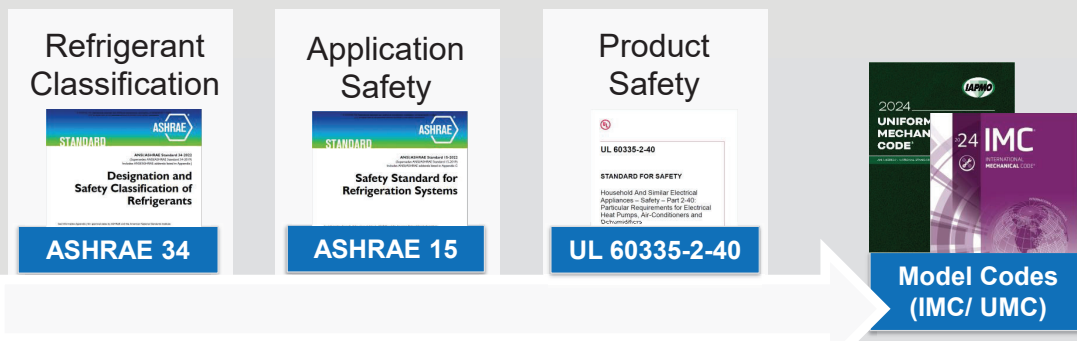
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# R-410A Retrofits or Conversions



**A2L Flammable Refrigerants Not Allowed to Retrofit A1 Equipment**

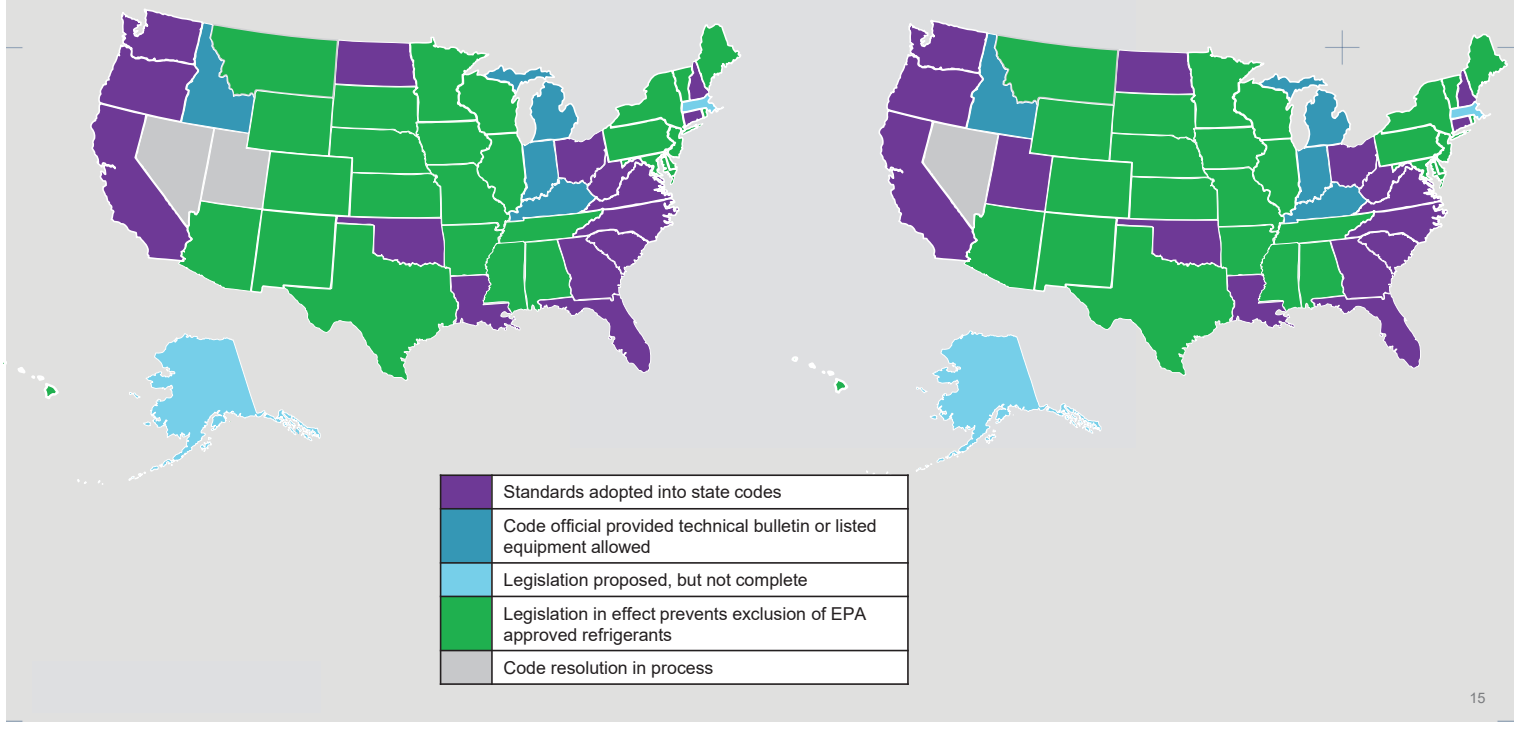
# Updated Safety Standards and Model Codes



- **Indirect Systems (chillers)**
  - 2021 UMC/IMC (ASHRAE 15-2019 + UL 60335-2-40 2019)
- **Direct Systems (Unitary/VRF) 22**
  - 2024 UMC/IMC (ASHRAE 15-2022 + UL 60335-2-40 2022)

**Building Code – Direct Systems**  
April 15, 2024

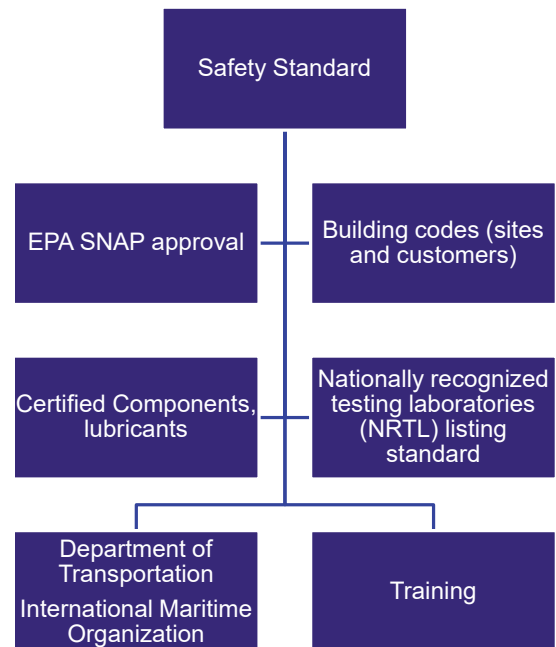
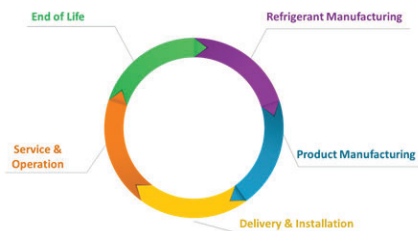
**Building Code – Indirect Systems**  
April 15, 2024



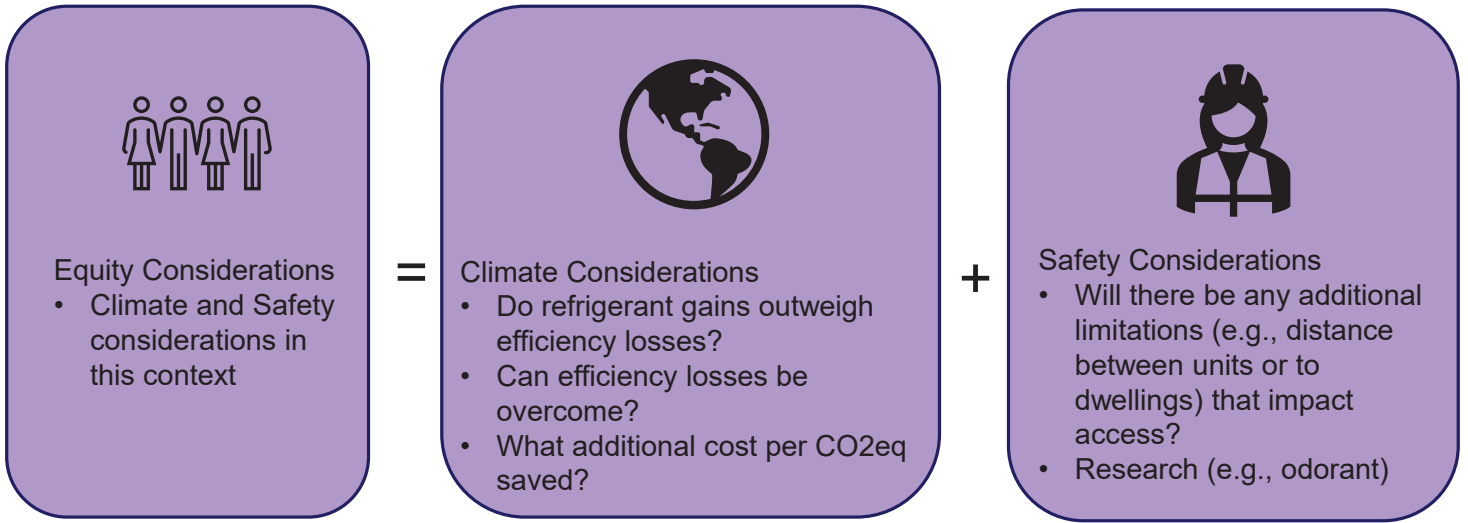
Additional policy considerations

Gaps: Risk assessment → mitigation strategy and standard development

- Modeling
- Leaks
- Heat Transfer
- Performance



# Workstreams

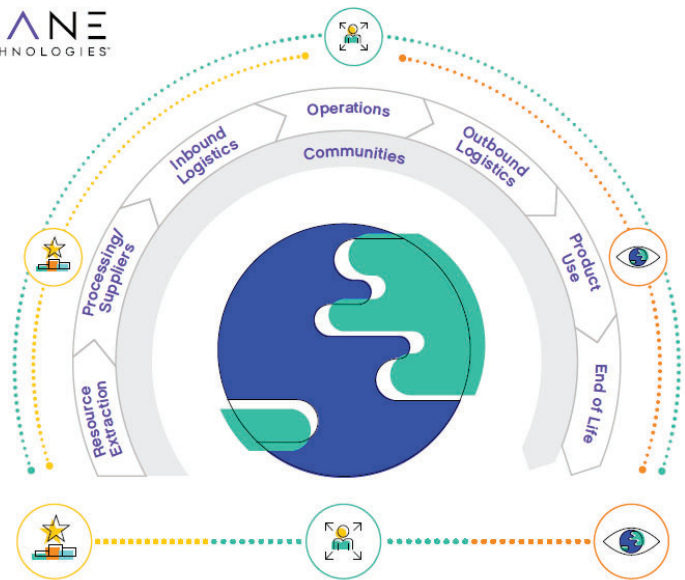


How do we expediently answer these questions for ourselves and policymakers?

***“What we do today will create a better, stronger world tomorrow.”***

--Dave Regnery, Chair & CEO Trane Technologies

**THANK YOU**



**Leading by Example**

- Carbon neutrality
- Zero waste to landfill
- Net positive water
- Absolute energy reduction

**Opportunity for All**

- Diversity & Inclusion
- Gender equality
- World-class safety
- Corporate citizenship
- Competitive wages, benefits & wellness globally

**Gigaton Challenge**

- Reduce customer footprint by 1 gigaton
- Design systems for circularity
- Provide access to comfort & fresh food