



REEF

REFRIGERANT EMISSIONS ELIMINATION FORUM

REEF QUARTERLY WEBINAR SERIES

HEAT PUMPS FOR THE FUTURE

DESIGN, DEPLOYMENT, AND PREPARING
THE U.S MARKET FOR WHAT'S NEXT

March 24, 2026

12:00 - 1:00 pm PT

**Heat Pumps for the Future:
Design, Deployment, and Preparing
the U.S. Market for What's Next**

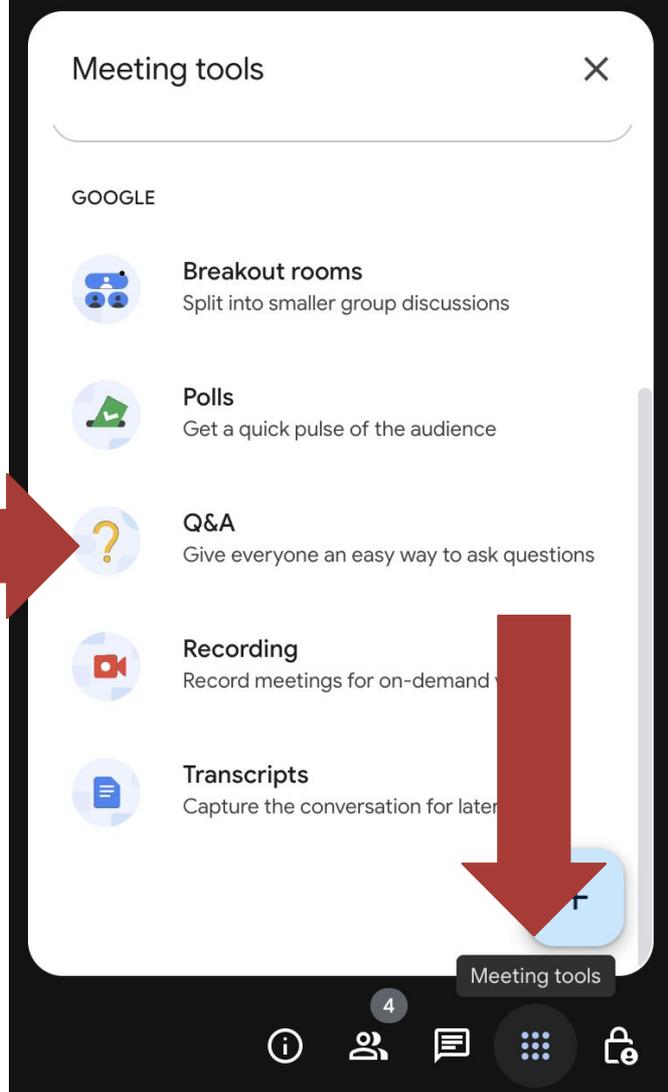
Aleisha Khan

Executive Director
REEF



Navigating Google Meet

How to Submit Questions for Moderator and Speakers





PANEL SPEAKERS

Agenda



Welcome (5 minutes)



Framing the Moment
(10 minutes)



Policy Signals & Market Transformation (15 minutes)



R290 Heat Pumps in the Field
(15 minutes)



Audience Q&A
(15 minutes)

Webinar Objectives

— — —

- Frame the conversation around how policy, deployment, and standards are evolving in parallel to enable ultra-low-GWP heat pump technologies
- Position R290 adoption as no longer theoretical—real projects, regulatory signals, and safety work streams are already underway
- Show how demonstrations, regulatory signals, and safety standards must move together to build market confidence



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REFRIGERANT EMISSIONS ELIMINATION FORUM



Refrigerant gasses are powerful and overlooked drivers of climate change. They are EVERYWHERE. Collectively, refrigerants are also the world's fastest growing category of greenhouse gases.



IMMEDIATELY

Convene an AHJ/Fire Marshal/Air Regulator/Insurance/Union/Industry working group to participate in DOE projects updating guidelines for safe design, mitigation, installation, permitting, and emergency response for R-290 low-risk indirect heat pump systems.

2026 Q1-3

Convene AHJs to develop guidance for permitting R-290 low-risk indirect heat pump demonstration projects. Launch a manufacturer challenge to participate in public building demonstrations.

ANNUALLY

Share learnings with the DOE Better Buildings Program and integrate them into statewide AHJ training. Launch statewide installer certification programs, with mandatory annual licensing for contractors working on R-290 equipment.

2028

Finalize revisions to refrigerant-equipment GWP baselines to meet AIM Act technology-transition deadlines. Eliminate incentives for non-compliant equipment.

2027 Q1-4

Initiate demonstration projects showcasing safe R-290 heat pump configurations and performance in public buildings, with data collection on energy use, climate conditions, and leak events, to be published annually through 2030.

The time to act is **now.**

ABOUT PROPANE



Propane (R-290) is a safe, climate-friendly, natural refrigerant with tremendous potential to reduce greenhouse gas emissions from supermarket refrigeration, but current U.S. charge-size limits prevent it from reaching full potential as a climate solution. As a nontoxic hydrocarbon with no ozone-depleting properties, an ultra-low global warming potential, and strong thermodynamic performance, propane is more energy efficient than many HFC refrigerants, representing one of the most effective pathways for reducing HFC emissions in grocery stores.

KEY ACTIONS MOVING FORWARD

TAKE STOCK

BENCHMARK CURRENT USE & APPLICATIONS

Review U.S. & international uses of R-290 across HVAC, refrigeration, & water-heating applications.

CLARIFY AUTHORITY FOR PERMITS

Determine local & national code officials' authority to permit A3 heat pump & refrigeration installations through alternate means & methods.

ENABLE THE MARKET

ENGAGE STAKEHOLDERS

Convene code officials, fire safety professionals, industry representatives, & contractors early to plan pathways for the safe use of R-290.

DEVELOP THE WORKFORCE

Train code officials on safe installation practices & require technician training on A3 refrigerants with periodic refreshers.

SUPPORT DEMONSTRATION PROJECTS

Fund and evaluate demonstration projects in state buildings with structured data collection & annual performance reports.

CREATE STRUCTURE & CERTAINTY

CONSIDER STATE REGULATORY APPROACHES

Regulatory objectives provide manufacturers with needed planning signals.

DEVELOP TIMELINE FOR ACTION

Establish clear timeline for enabling R-290 adoption.

ENFORCE REFRIGERANT RECOVERY & REPORTING

Require reporting on refrigerant purchases & recovery returns with 3-year record-keeping & recovery-rate audits.

SUPPORT SAFETY STANDARDS & INSURANCE COVERAGE

Participate in developing safety standards, building code updates, & insurance requirements related to A3 refrigerants.

Christopher Douglass

Climate Policy Analyst
Environmental Investigation
Agency (EIA)



Standard and Code Restrictions on A3 (Flammable) Refrigerants

Higher Flammability	A3	B3
Flammable	A2	B2
Lower Flammability	A2L	B2L
No Flame Propagation	A1	B1
	Lower Toxicity	Higher Toxicity

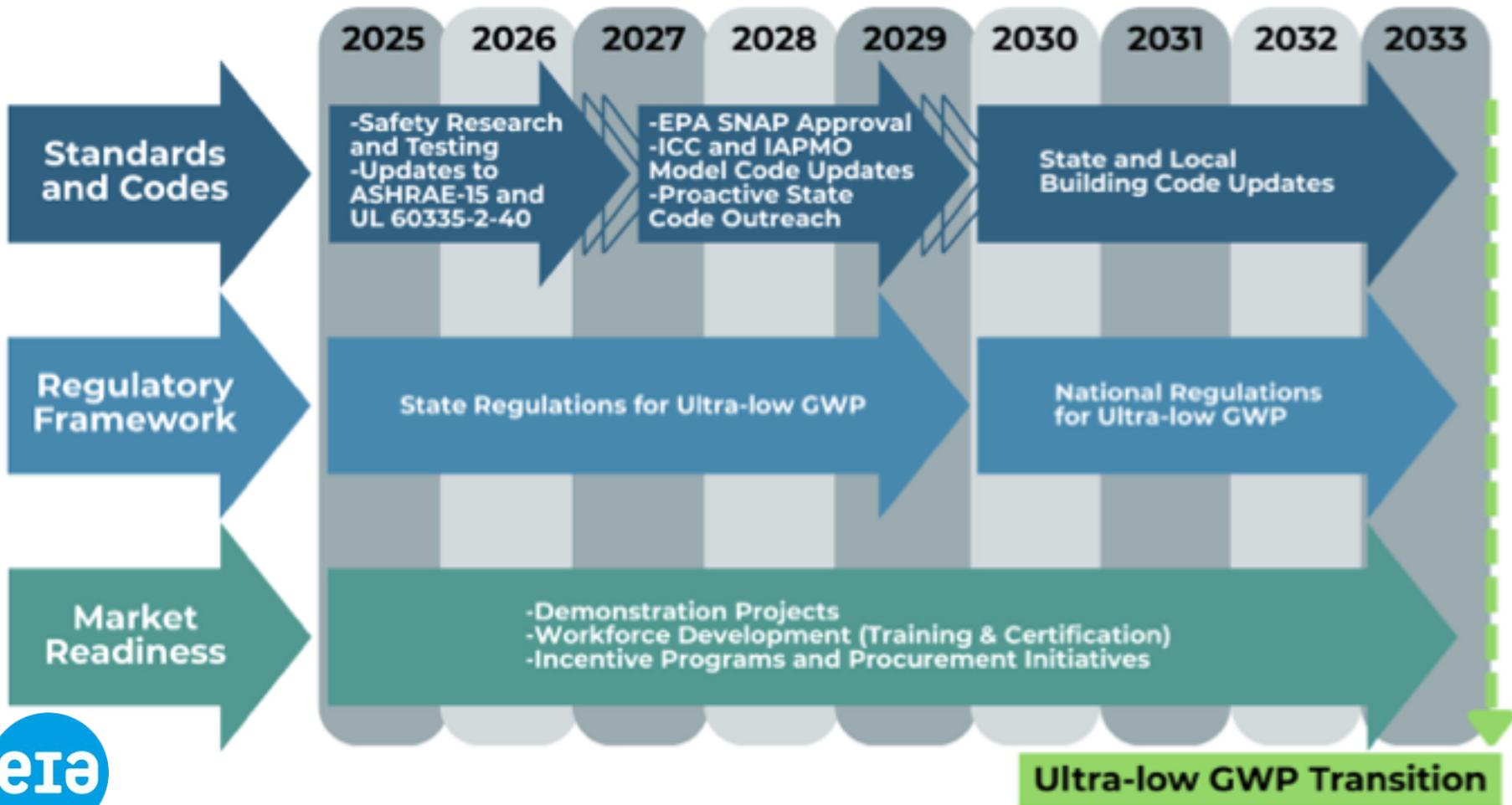
Charge Size IEC vs UL



Table 1. Maximum Charge Limits under IEC v UL Safety Standards for AC/HPs

Standard	ASHRAE 34 Refrigerant Safety Classification	Maximum Charge Limit (MCL)			
		Fixed installation			Non-fixed
		M1 (no mitigation)	M2 (minimum room size + other mitigation)	M3 (outdoors/ indirect systems)	
IEC 60335-2-40 Edition 7 (2022)	A2L	6xLFL=1.8kg R32	52xLFL=15.9kg R32	260xLFL=79kg R32	2xM1 = 3.68kg R32
	A2/A3	4xLFL=152g R290	26xLFL=988g R290	130xLFL=4.94kg R290	2xM1=304g R290
UL 60335-2-40 Edition 4 (2022)	A2L	6xLFL=1.8kg R32	52xLFL=15.9kg R32	260xLFL=80kg R32	1xM1=1.8kg R32
	A2/A3	3xLFL=114g R290	3xLFL=114g R290	3xLFL =114g R290 (M1 as per Annex GG 2.1)	M1=114g R290

U.S. Roadmap to Ultra-low GWP AC/HPs



Timeline



	2025	2026	2027	2028	2029	2030	2031	2032	2033
Safety Research and Testing	Progress bar (light green)								
UL 60335-2-40 /ASHRAE-15 Proposals	Progress bar (blue)								
ICC/IAPMO Model Codes (2030)			Progress bar (light green)						
EPA SNAP Rule			Progress bar (blue)						
State and Local Building Code Updates			Progress bar (light green)						

US AC/HP system types likely at conclusion of this cycle*

On-going research and risk assessments:

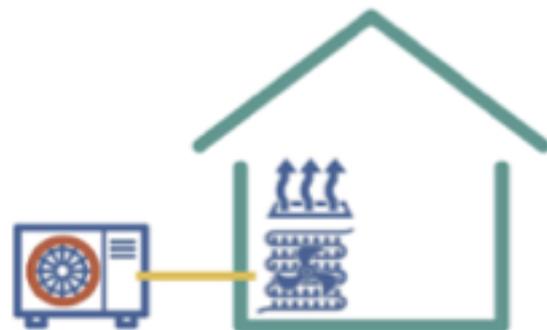
- Residential Monobloc Air-to-Water HP Configurations
- Self-Contained ACs and Heat Pumps, including Heat Pump Water Heaters

Also, Commercial Small-to-Medium-Size Chillers & Air-to-Water Heat Pumps and Residential HWHPs

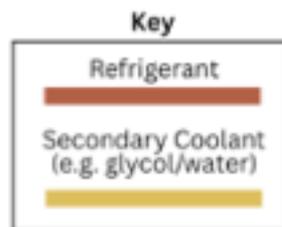
*Assumes research is concluded in time for standard committee review and favors safe development of A3 technology in certain applications



Small self-contained/plug-in



Air-to-water/monobloc



Indirect self-contained

Partial Harmonization with IEC 60335-2-40 - Low-hanging Fruit



- Narrow updates to safety standards enable A3s in self contained (up to 988g) and indirect systems (up to 4.94kg)
- Covered by currently funded safety research and testing projects
- Majority of AC/HP sector is unaddressed, fails to align with global markets
- Any transition to A3s for central AC/HPs (split & packaged) would rely on re-design as indirect (air-to-water) systems

Full Harmonization with IEC 60335-2-40 - Realistic Path

- Full harmonization with IEC for all system types enables self contained and indirect systems up to 1.5kg, direct expansion split or packaged systems for central AC/HPs
- Potentially enables broader adoption of A3s in 78-88% of new central AC/HPs to be designed
- Central AC/HP systems up to ~40-50k BTU/hr enabled (depending on charge optimization and system type)
- Remaining 10-20% of central AC/HP market relies on indirect systems for A3 use or gets displaced by other systems

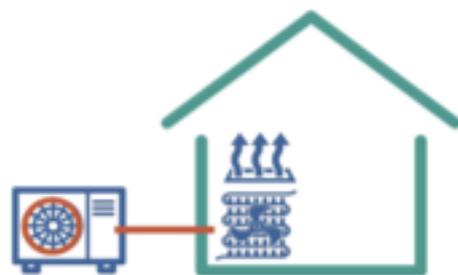
Still require
research to enable
most US equipment

Beyond IEC 60335-2-40 - Global Leadership by US Industry

- US safety standards consider proactive examination of extended A3 charge limits beyond IEC for direct systems up to 1.5kg, considering additional mitigation needed
- Enables ~97% of new central AC/HPs as currently designed to used A3s without reliance significantly on system changes/indirect systems, some charge optimization still required
- Early IEC proposal under discussion, additional safety research and testing likely required.

US AC/HP System Types

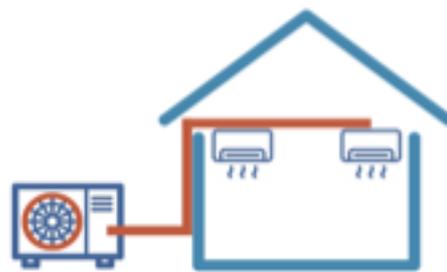
Common AC/HP System Architectures in the U.S.



Ducted single-split



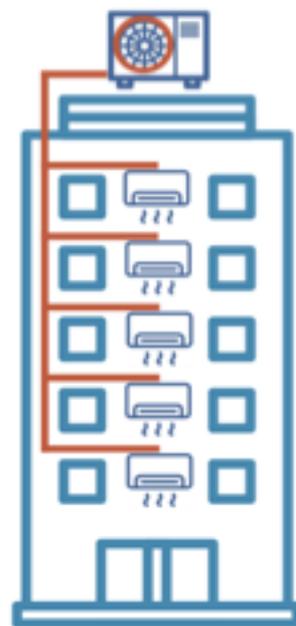
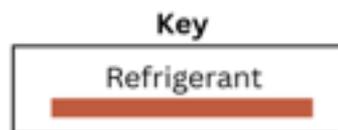
Packaged/Rooftop Units (RTUs)



Mini-split systems



Small self-contained/plug-in



Multi-split systems

Recommendations

- OEMs can drive innovation to lead US and Global markets as demand surges
- Invest in research for direct mini split and Ducted Central AC/HP Systems (Split and Packaged), and RTUs.

Contact Information

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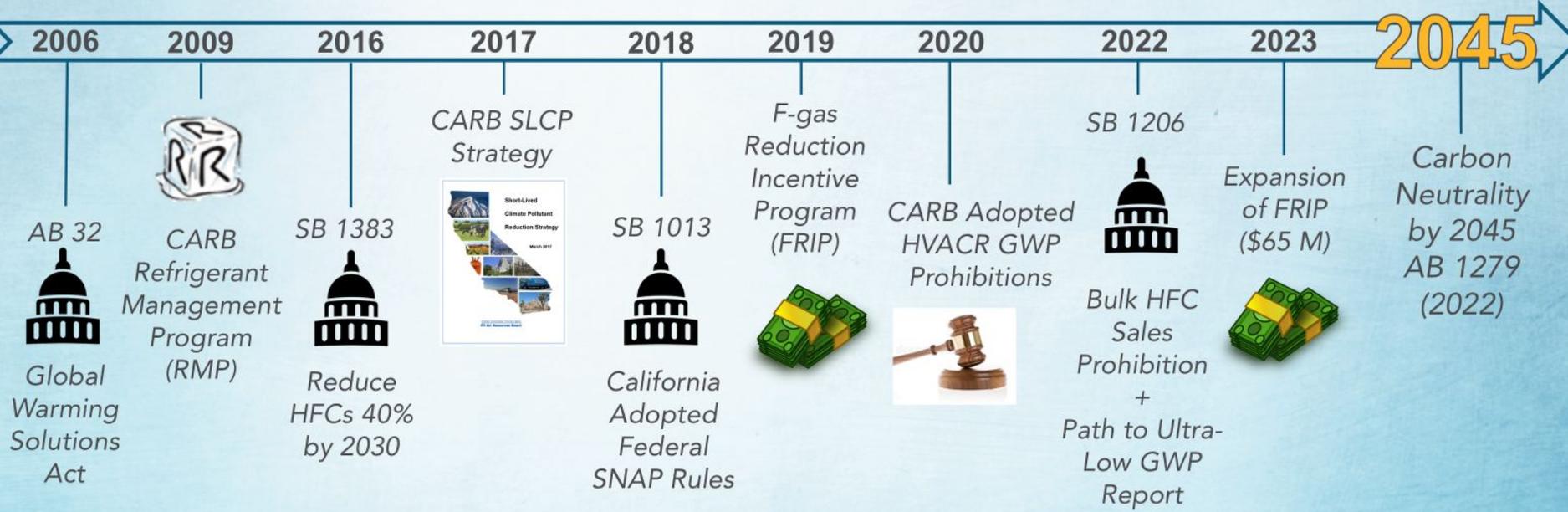
eia.org

Cheryl Winfield

Air Resources Engineer
CA Air Resources Board (CARB)
Research Division



California's Commitment to HFC (Hydrofluorocarbon)/Refrigerant Reductions



CARB's HFC Regulation (2020) and the National HFC Phasedown

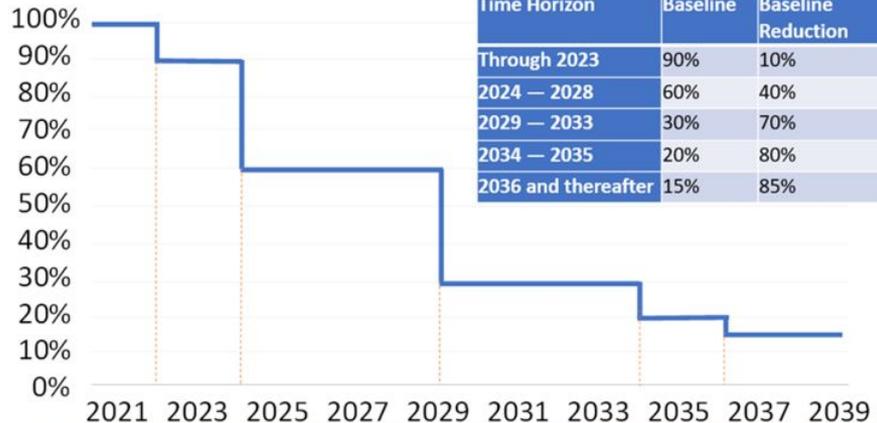
Stationary HVAC

GWP < 750

Stationary Refrigeration (> 50 lbs.)

GWP < 150

AIM Act HFC Phase Down



**Similar GWP limits were adopted by the U.S. EPA
under the AIM Act**

California SB 1206 (2022): The Future of HFCs in California

Bulk HFC Sales Prohibition Aligns with National HFC Phasedown

2025	2030	2033
> 2,200 GWP	> 1,500 GWP	> 750 GWP

Assessment Report: Plan to transition California to ultra-low-GWP (<10 GWP) and no-GWP alternatives by 2035

- Sector specific approach
- Maximize recovery and reclamation
- Increase the adoption of new technologies
- Workforce training and certification recommendations & role of incentive funding

California's Future is Ultra-Low-GWP and HFC Free

What is FRIP?



- Role of Incentives – Market Transformation
- Round 1: \$1 million from CA Legislature (2019-20)
- Round 2: \$65 million from CA Legislature (2022-23, 2023-24)
- Selected the North American Sustainable Refrigeration Council (NASRC) as Round 2 Administrator





FRIP | F-gas Reduction Incentive Program

- **Commercial and Industrial (C&I) Refrigeration:** funding grants for existing facilities to install ultra-low-GWP (<10 GWP) technologies.

Number of Projects Awarded	Total Incentives Awarded	Total MTCO _{2e} Emissions Reduced	% of Projects in Priority Communities	\$/MTCO _{2e} Reduced
61	\$19M	535K	74%	\$36

- **Workforce Development:** increase recruitment and train 500+ technicians in ultra-low-GWP refrigeration technologies.
- **Literature Review & White Papers:** environmental and health impacts of HFCs and HFC alternatives' degradation products (TFA and others).
- **REFRESH Pilot:** residential HVAC recovery and reclamation pilot, partnering through CEC's Equitable Building Decarbonization program.
- **Risk Assessment of Residential A3 Air-to-Water Heat Pumps.**



Risk Assessment of Residential A3 Monobloc Air-to-Water Heat Pumps (ATWHPs) Awardee

- Air-Conditioning, Heating, and Refrigeration Technology Institute (AHRTI)
 - Project Partners Include:
 - Air-Conditioning, Heating, and Refrigeration Institute (AHRI)
 - Oak Ridge National Lab (ORNL)
 - Fire service representatives from city, local and State agencies



Risk Assessment of Residential A3 ATWHPs

Key Tasks & Goals

Establish an Advisory Panel

- HVAC OEMs, industry trade groups, contractor trade groups, NGOs, standard setting organizations, and fire service personnel.

Perform CFD Modeling and Field Testing

- Use Computational Fluid Dynamics (CFD) modeling to model leak dispersion and flammable concentrations of refrigerant for at least 20 different modeling scenarios.

Final Risk Assessment Report

- Complete risk analysis and effectiveness of potential mitigation strategies for the North American market. Final report will be shared with standard setting organizations.



FRIP

F-gas Reduction
Incentive Program

Thank you!

HFC Team: HFCReduction@arb.ca.gov

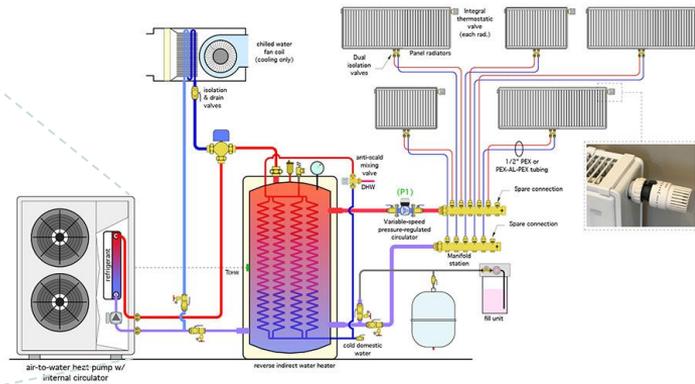
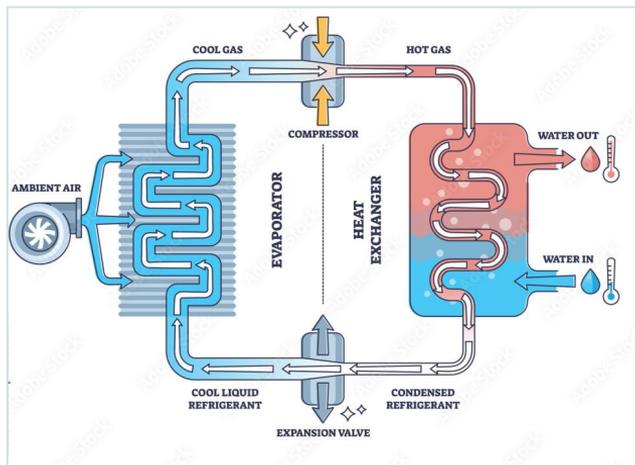
FRIP Team: FRIP@arb.ca.gov

Robert Benjamin

Founder & CEO
Aris Hydronics



What is an Air to Water Heat Pump?



Factory charged refrigerant Air-to-water heat pumps consolidate all refrigerant in factory-charged self-contained, outdoor located equipment; reducing refrigerant use and leakage compared to split heat pumps



Hydronic thermal distribution Air-to-water heat pumps generate heating, cooling, and hot water, delivered through closed-loop low-pressure hydronic piping; integrate with fan coils, air handlers, radiators, radiant floors

Why R290 in Air to Water Heat Pumps?

REFRIGERANT CRITICAL TEMP

96°C

vs 69–78°C for alternatives

GWP

< 1

vs 675–2,200 for alternatives

MAX SUPPLY WATER TEMP

70°C

at –15°C outdoor air



Single-component, natural refrigerant R290 is pure propane – a non-proprietary single-component refrigerant with zero glide, no blend composition drift, no mixed-refrigerant-complexity.



Lower charge required Enthalpy of phase change at 65°C sat. = 245 kJ/kg, (vs 90-154 for alternatives)
More BTU for less refrigerant - emerging standards will regulate allowable A3 charge limits



Higher supply water temperatures possible 70°C supply at –15°C OAT means better compatibility with existing hydronic emitters.

How R290 Stacks Up

Refrigerant	Critical Temp	h_{fg} @ 65 °C (kJ/kg)	GWP ₂₀ ^{A,B}	GWP _{B100} ^A	Typical Cold Climate Performance	Pure	PFAS Risk
R454B	69°C	126	1,854	531	~60°C max , ~50°C at -10°C OAT	blend	Yes
R410A	72°C	90	4,715	2,255	~55-60°C max	blend	Yes
R32	78°C	154	2,690	771	~65°C max, ~60C at -10C OAT	Yes	No
R290	96°C	245	<1	<1	70°C at -15°C OAT	Yes	No

A. ATMOSphere (n.d.) *Refrigerants: Real GWP and PFAS. Impact of Refrigerants Fact Sheet #2*. Available at:

https://atmosphere.cool/fact_sheets/refrigerants-real-gwp-and-pfas/

B. IPCC (2021) *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press. doi: 10.1017/9781009157896.



AWHPs reduce emissions regardless of refrigerant compared to split-unitary heat pumps, AWHPs can reduce on site refrigerant charge, reduce technician accidental releases, and reduce operational leaks

Early Deployments

Lessons from the first pilot R290 hydronic heat pump installs in the Pacific Northwest.

1

Early Demonstrations

NATIONAL MALL

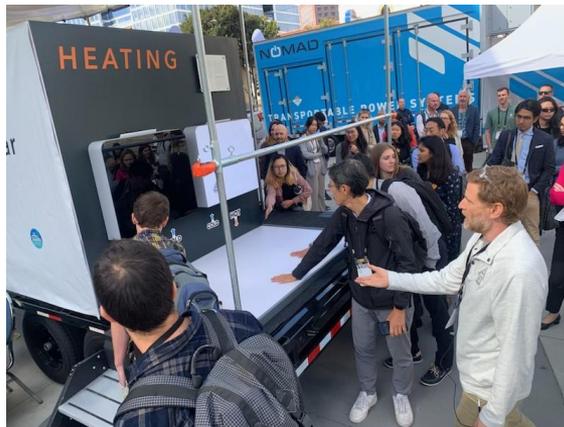
First full R290 A2W HVAC demonstration in North America. HUD Innovative Housing Showcase 2023, Verge Microgrid Demonstration 2023

2

Pilot Installs

MILWAUKIE, OR

Side-by-side R290 vs. R32 hydronic configuration. Two full heating and cooling seasons. Documented energy use, comfort, and performance comparisons.



Grant Funded Projects

Research and demonstration projects in progress for multifunction R290 AWHPs in multifamily

1

DOE: LBNL + VEIC + The Veterans' Place

MONTPELIER, VERMONT

Single room occupancy transitional housing for veterans. 3x AWHPs, ductless fan coil units, dual volume TES modules provide heating and cooling for 11 bedrooms, and DHW for 5 shared baths and commercial kitchen.



2

NYSERDA: RMI + WINN CO

ALBANY, NEW YORK

Demonstration project in the contracting and planning stage. 4-6 Unit in larger builder for combi heating, cooling, and hot water. RMI as prime with WinnCo. Site selection in progress.



Learning and Challenges



AWHPs Underutilized

AWHPs are common globally, but limited in North America. Existing split-unitary market can not incorporate R290 easily — AWHPs unlock enormous untapped opportunity.



Lessons from pilot installs

Site needs, risk tolerances, permitting gaps — all identified from real installs. Working to advance design methods and update documentation, install methods, and site monitoring.



Product design intelligence

Streamlining technology adoption and installation through modularization, end-to-end system integration, IoT intelligence, automated system design and sizing.



Contractor Training

HVAC professionals familiar split unitary heat pumps need facilitated introduction to design, installation, and maintenance for hydronics. R290-specific curriculum needs.



Permitting

Current R290 projects collaborate closely with AHJs to demonstrate safety, negotiate compliance for pre-commercial products, and develop precedents.



Seeking Collaboration

Looking for partners — utilities, housing authorities, manufacturers, contractors. If you want to advance adoption of R290 AWHPs in North America, let's connect.



~960 Blue Rhino cylinders × 9 kg = 8,640 kg propane

The Propane Opportunity

 **SCENARIO A — BURN IT**

410 Million BTU

One-time combustion energy — gone forever

VS

 **SCENARIO B — USE AS R290 REFRIGERANT**

16.2 Trillion BTU

8,640 kg ÷ 1.6 kg/unit = **5,400 heat pumps**

× 80,000 BTU/hr × 2,500 hrs/yr × 15 years

= 3 billion BTU per unit over lifetime

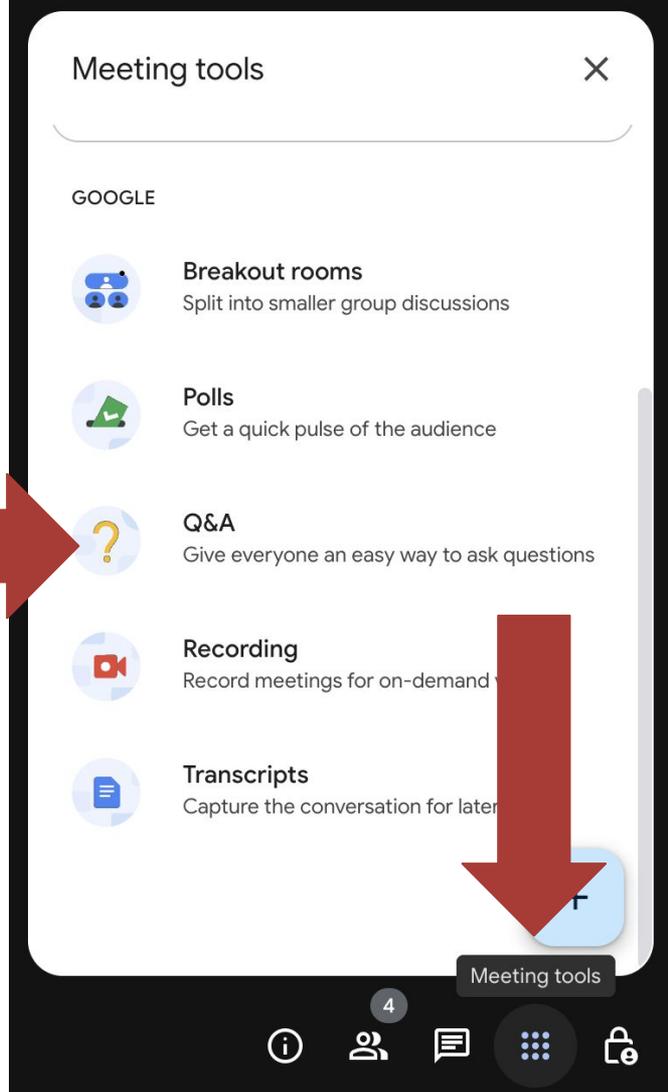
× 5,400 units = 16.2 trillion BTU total

~39,500×

more useful energy delivered
as a refrigerant vs. fuel

Navigating Google Meet

How to Submit Questions for Moderator and Speakers



Closing: What Success Looks Like



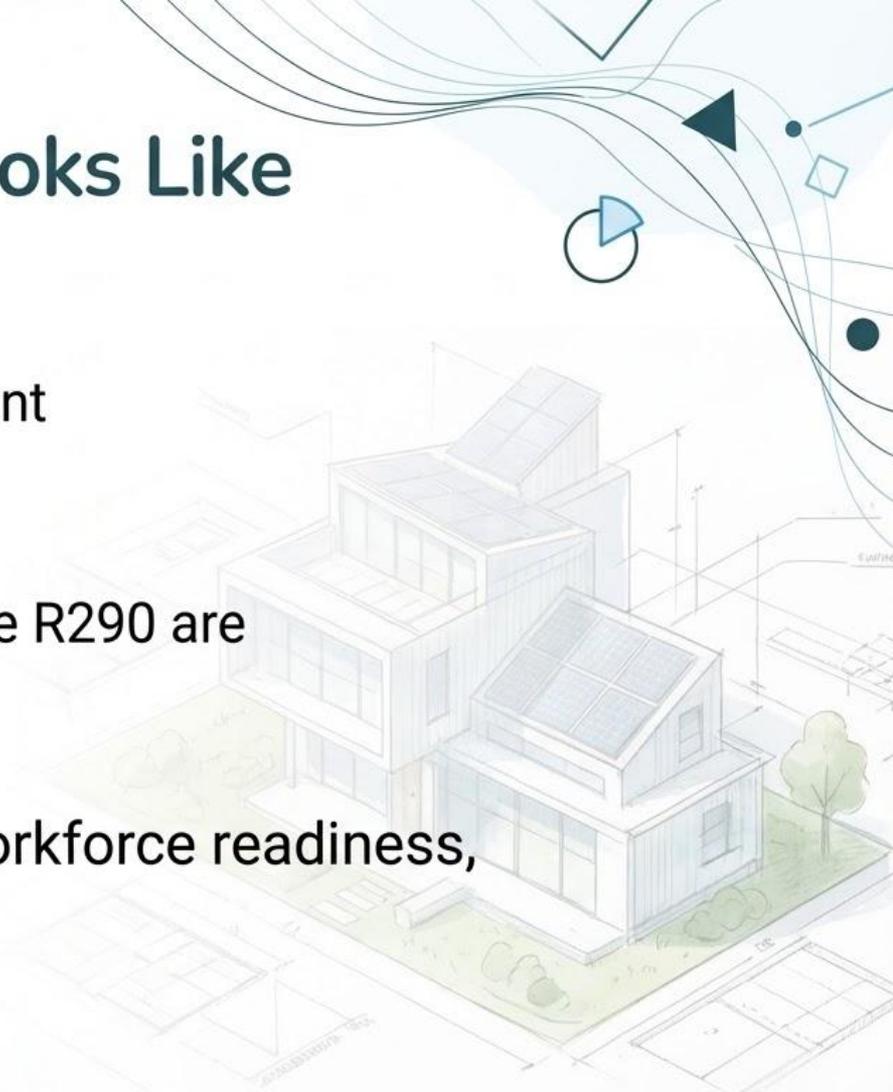
Electrification without refrigerant reform is incomplete



Near-zero-GWP refrigerants like R290 are essential to net-zero buildings



Design, safety standards, workforce readiness, and policy move together



contact@reefclimate.org

