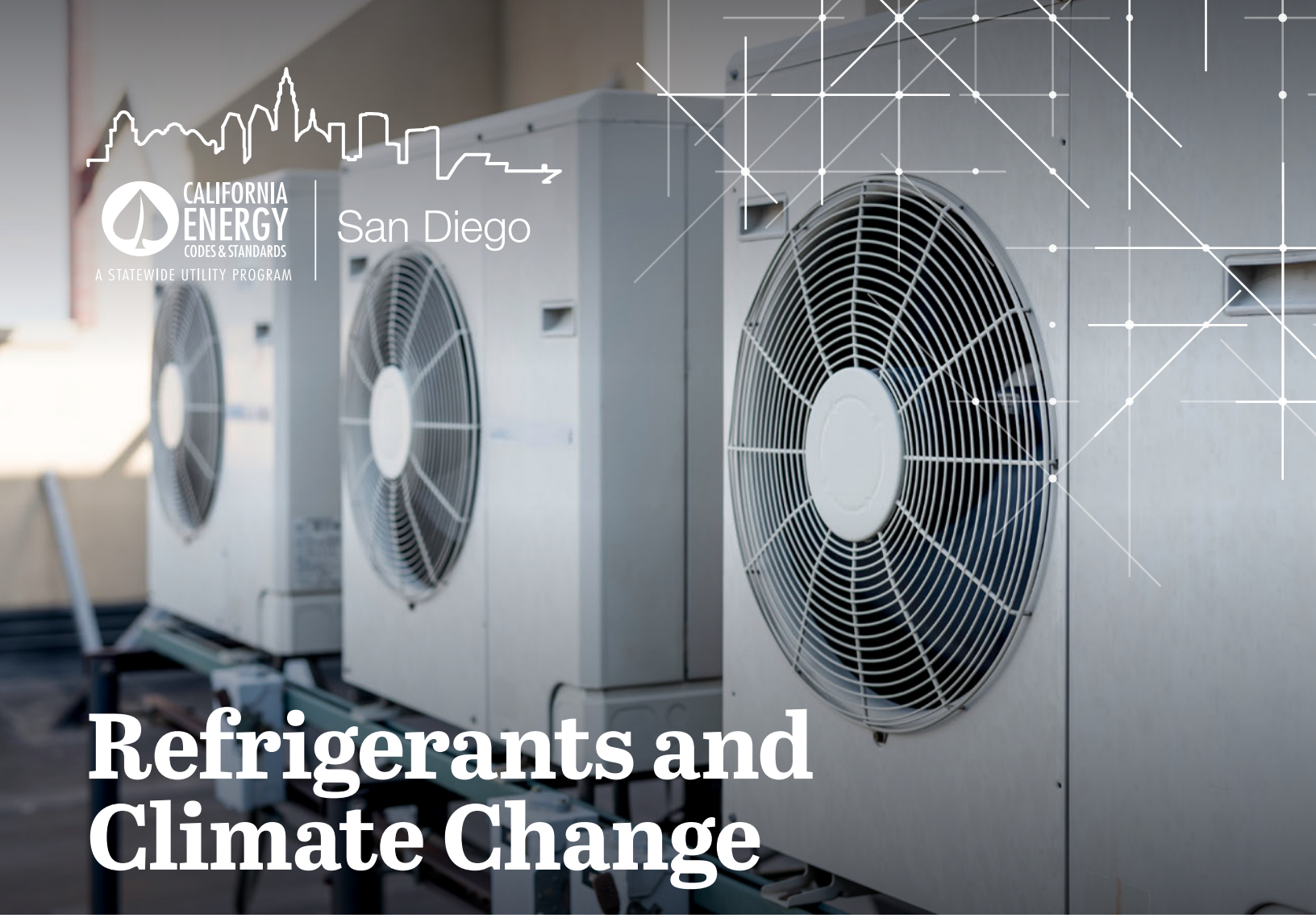


CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM
San Diego

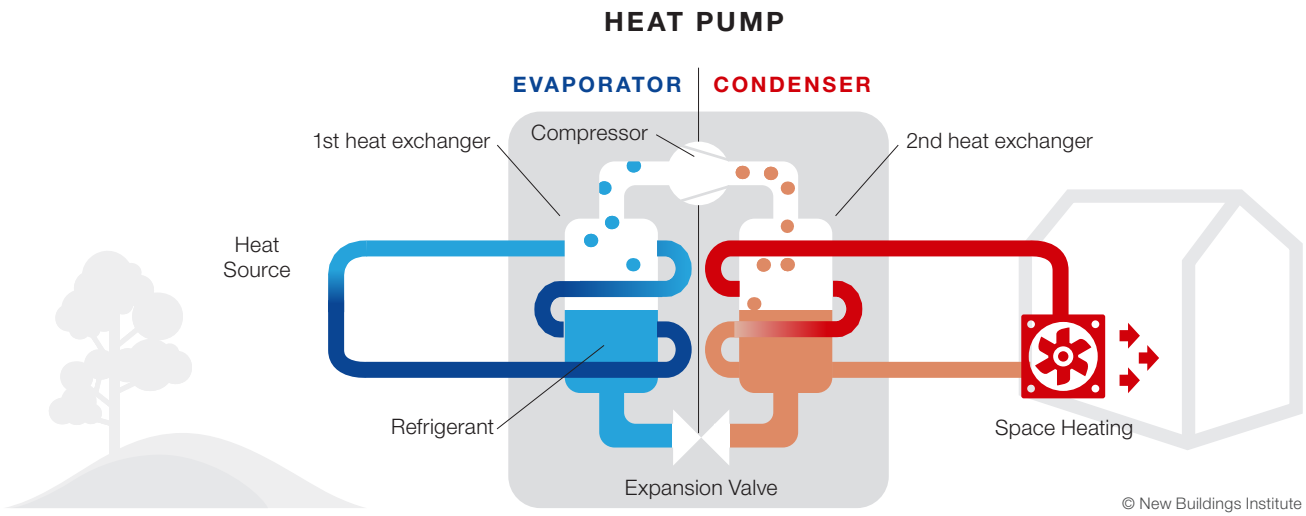
Refrigerants and Climate Change

What are refrigerants?

A refrigerant is a liquid or a gas with a very low boiling point. Refrigerants are used to transfer heat. For conventional air conditioning (AC), the refrigerant absorbs heat from the air inside a building and rejects it to the outdoors. The reverse is true for heat pumps in heating mode.

Why are refrigerants of concern?

Many refrigerants have high global warming potential **(GWP),** so it is crucial that leaks from equipment be repaired promptly, and refrigerants are collected during maintenance and when equipment is retired. Fluorinated gas (F-gas) refrigerants are responsible for 2% of total global **greenhouse gas (GHG)** emissions. Older refrigerants contain high **ozone-depleting potential (ODP)** and high **global warming potential (GWP)** ingredients. Modern refrigerants used in heat pumps have **GWPs** 2,000 times greater than that of **carbon dioxide (CO_2)** over a 100-year period. Refrigerants used in refrigeration systems have a GWP nearly 4,000 times greater than CO_2. Not all refrigerants are equal, though. There are tens of thousands of refrigerants and blends ranging from 0 to 12,500 GWP. According to the International Energy Agency, global refrigerant demand is expected to grow four-fold by 2050 because of increased adoption of highly efficient heat pumps and the increased demand for cooling, especially as global temperatures rise. If unregulated, this expansion in refrigerant use would lead to refrigerants making up a greater percentage of total GHG emissions.



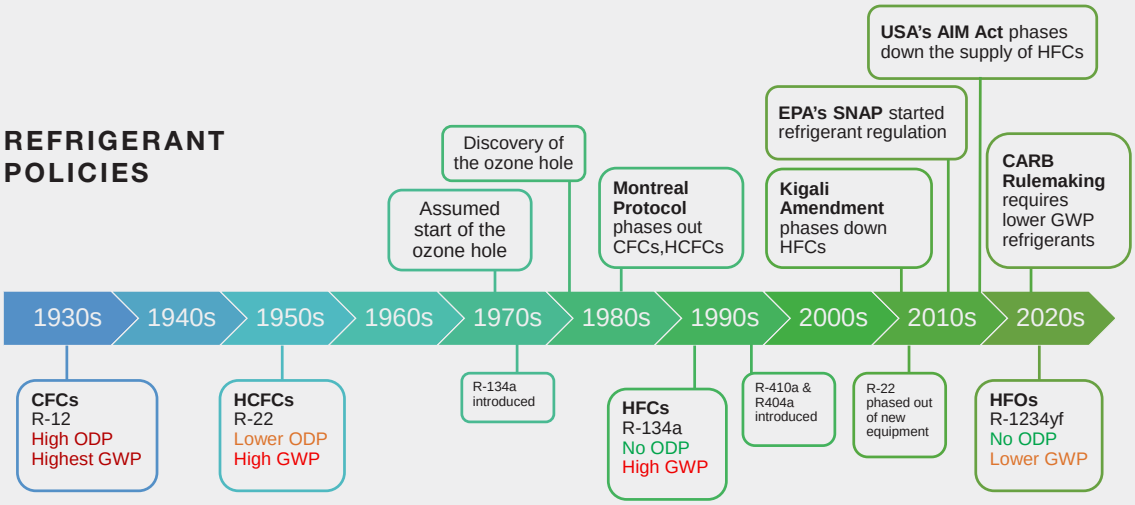
Refrigerant Regulation

In 1987, the **Montreal Protocol** was finalized to phase out ozone depleting refrigerants, like R-22, shifting manufacturers toward **hydrofluorocarbons (HFCs),** like R-410a. In 2016, the Montreal Protocol was amended to phase down the global supply of HFC refrigerants. Although the United States has not yet ratified the **Kigali Amendment,** the **American Innovation in Manufacturing (AIM) Act,** which mandates an 85% phase down in HFC supply by 2036, was enacted in 2020. The U.S. **Environmental Protection Agency (EPA)** started to phase down the supply of HFCs in January 2022 and will essentially ban R-410A for use in new equipment in January 2025. The AIM Act is aligned with the HFC phase down of the Montreal Protocol and is slated to reduce the supply of atmospheric refrigerant emissions equivalent to more than 4 billion metric tons of carbon dioxide by 2036.

California Air Resources Board (CARB) was directed to issue rules to reduce HFC emissions 40% below 2013 levels by 2030. CARB adopted **EPA's Significant New Alternatives Policy (SNAP)** Rule 20, which prohibits higher GWP HFC-based refrigerants.

As of January 2022, CARB finalized their HFC regulations limiting GWP of refrigerants, including:

- Refrigerants used in most refrigeration equipment not to exceed 150 GWP by January 1, 2022
- AC manufacturers must use 10% reclaimed refrigerant annually for 2023 and 2024 through the **Refrigerant Recovery, Recycle, and Reuse (R4) Program** (See Page 4)
- Residential and light commercial stationary AC refrigerants not to exceed 750 GWP by January 1, 2025
  - » Excluding variable refrigerant flow (VRF) equipment which must convert in 2026, and small equipment in 2023



Minimize the Impacts of Refrigerants:

There are three primary ways that project teams can limit the environmental impact of refrigerants:

1 Specify low-GWP refrigerants

2 Limit leakage by ensuring proper handling from production, transportation, installation, operations, and end of life

3 Develop and implement refrigerant management plans to ensure proper system function and optimized energy efficiency

1 Select Low-GWP Refrigerants

CARB's limits the GWP for grocery store refrigeration and freezer systems with 50 pound of refrigerant to 150 (CO2e-100 year). For room AC, residential and commercial AC as well as VRF systems the GWP limit is 750.

CARB lists 14 refrigerants lower than 125 GWP and 23 between 150 and 750 GWP, including natural refrigerants like ammonia. As regulations are implemented, industry innovation will bring new mixes and alternatives to the market.

2 Limit leakage

With proper installation and maintenance, leak rates can be lessened. However, if equipment is not maintained correctly, leak rates can range from 1-10%, with an average of 3%. Applications with building-scale refrigerant loops, like VRF systems, come with higher leakage risks: large refrigerant volumes, long pipes, many flared or brazed joints, and variable installation quality. Proper installation requires pressure checks, vacuum checks, and leak checks. Early detection ensures that leaks do not become large enough to impact emissions and energy efficiency.

Properly managing leaks can limit the cost of recharging refrigerant and service, maximize system energy efficiency, while limiting GHG emissions.

Leak detection can be performed manually and/or through electronic controls in the system. Manual inspection requires the examiner to evaluate joints using soap at joints to look for bubbles, a hand-held chemical detector, or ultraviolet or fluorescent dye injected into the system, and a UV lamp to look for escaping dye. Several different electronic technologies can be permanently installed in the HVAC system to provide more precise and efficient confirmation of leaks. Technologies include heated diodes and infrared detectors. Electronic technologies require annual maintenance to ensure they are working correctly.

3 Refrigerant Management Plan

CARB's Refrigerant Management Program (RMP) requires owners and operators of refrigeration systems containing more than 50 pounds of 150+ GWP refrigerant to conduct and report periodic leak inspections, promptly repair leaks, and keep service records on site. Facilities that use only ammonia or carbon dioxide as refrigerants are not subject to the rule.

Refrigerant management programs safeguard system operations. The plan often includes maintenance actions, key roles and responsibilities, and compliance needs. Plans may also include initial equipment cutsheets, registration, related organizational policies, reporting, leak repair, maintenance logs, refrigerant phasedown plans, leak rate calculations, and correction opportunities. While no two plans are alike, plans should be evaluated on a set schedule.

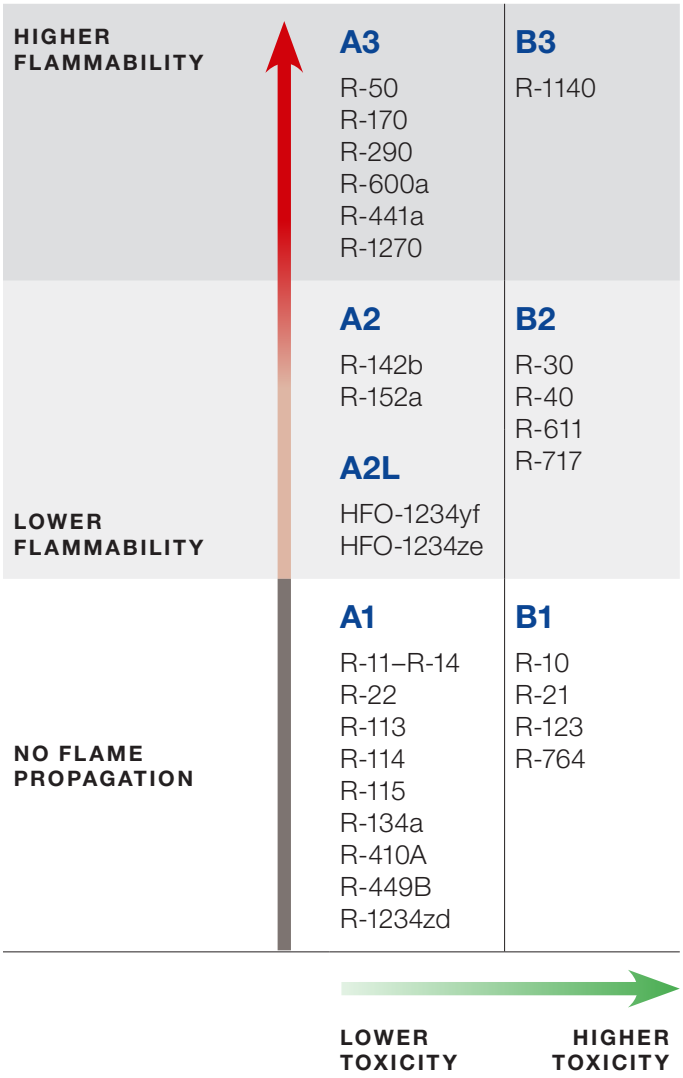
A2L: The Next Generation of Refrigerants

A2L refrigerants are sometimes referred to as next-generation or fourth-generation refrigerants because they have lower GWP values and short atmospheric lifecycles. However, A2L refrigerants have a safety classification meaning they have low toxicity but are slightly flammable, further necessitating refrigerant management.

A2L refrigerants have been well-studied and safe to use in buildings where the building code allows them. In 2019, A2L refrigerants were introduced as a separate safety group with their own requirements in several conventional standards, including ASHRAE 15, ASHRAE 34, and UL 60335-2-40. The table illustrates the different classes of refrigerants and their associated toxicity and flammability rating. Class 3 (A3 and B3) refrigerants are the most flammable and are listed as "Higher Flammability." Examples include hydrocarbons like propane and isobutane. Class 1 refrigerants are the least volatile and are listed as "No Flame Propagation," such as R-410A or R-22. Class 1 refrigerants are often described as "nonflammable," but many can still combust and burn at higher pressures and temperatures.

"Slightly flammable" can be a worrying term, but research has shown that A2L refrigerants do not need to cause concern. Air-Conditioning, Heating, and Refrigeration Institute (AHRI) conducted research with the UL Firefighter Safety Research Institute and members of the fire service to test the differences between refrigerants in real fire scenarios. One test studied the "heat release rate" to quantify the amount of heat an A2L refrigerant added to a fire and found that the heat release rate was higher for R-410A, a common non-A2L refrigerant than for R-32, the A2L refrigerant in the study.

The heat the refrigerant created was equivalent to a small plastic trashcan fire. There was no flash fire or deflagration observed. AHRI concluded that overall average risks related to using A2L refrigerants are significantly lower than the risks of everyday hazard events associated with other causes and well below risks commonly accepted by the public.



Refrigerant Recovery, Recycle, and Reuse (R4) Program

The R4 program was developed before the enactment of the AIM Act and intended to jump-start demand for reclaimed refrigerant, encouraging recovery at the end-of-life of equipment when a system is decommissioned due to the resale value of refrigerant. The refrigerant can be recovered for later use when a system is decommissioned. CARB estimates that only 2% or less of refrigerant is recovered from smaller air-conditioning units in California, which has the best recovery and enforcement in the country.

- **Recovered** refrigerant is removed from an appliance and stored in an external container without necessarily testing or processing it in any way before returning to the same system or another system owned by the same owner.
- **Recycled** refrigerant is extracted from an appliance and cleaned for reuse in equipment of the same owner without meeting all of the reclamation requirements.
- **Reclaimed** refrigerant is extracted from equipment and sent to a reclaimer to clean it. The purity must meet levels as specified in the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 700-2016, and verify this purity using the analytical methodology prescribed in the standard.

With the enactment of the AIM Act, demand is increasing for reclaimed refrigerants, and recovery of refrigerant has become an important aspect. CARB is working with stakeholders to find ways to support increased reclamation within the state.

Global Warming Potential of Refrigerants

Source: CARB

Refrigerant Name	Trade or Common Name	Global Warming Potential*
R-717	Ammonia	0
R-1234ze(E)	Solstice ze	1
R-1224yd(Z)	AMOLEATM 1224yd	1
R-744	CO_2	1
R1234zd(E)	Solstice zd	1
R-514A	Opteon XP30	2
R-290	Propane	4
R-600a	Isobutane	5
R-170	Ethane	6
R-601	Pentane	11
R-161	HFC-161	12
R-123	HCFC-123	77
R-225ca	HCFC-225ca	122
R-152a	HFC-152a	124
R-454B	Opteon XL41	466
R-225cb	HCFC-225cb	595
R-450A	Solstice N13 (R-134a)	601
R-124	HCFC-124	609
R-513A	Opteon XP10	631
R-32	HFC-32	675
R-452B	Opteon XL55	676
R-141b	HCFC-141b	725
R-466A	R-32/R-125/ R-131	733
R-401C	Suva MP-52 (R-22)	933
R-410a	Puron, AZ-20	2088
R-12	CFC-12	10900

*Over a 100 year time period.

Resources

NBI maintains a collection of ZNE resources, including case studies, research, and tools and guides for getting your project to ZNE. Visit gettingtozeroforum.org.

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The Codes & Standards program is designed to improve compliance with the state's building and appliance energy codes and standards. The program aims to advance the adoption and effective implementation of energy efficiency measures and building practices to lock in long-term energy and GHG savings to meet California's ZNE, decarbonization and climate goals. The program recognizes that codes and standards are one of the most effective pathways to ensuring sustained market transformation—and that key to making them work well are well-informed industry professionals and consumers.

nbi new buildings institute

New Buildings Institute (NBI) is a nonprofit organization driving better energy performance in commercial buildings. We work collaboratively with industry market players—governments, utilities, energy efficiency advocates and building professionals—to promote advanced design practices, innovative technologies, public policies and programs that improve energy efficiency. We also develop and offer guidance and tools to support the design and construction of energy efficient buildings.

This program is funded by California utility customers and administered by San Diego Gas & Electric® Company under the auspices of the California Public Utilities Commission.